Factors Influencing Smallholder Potato Farmers' Choice Decisions of Market Outlets in Musanze and Nyabihu Districts, Rwanda: A Multivariate Probit Model

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ABSTRACT

Potato (*Solanum tuberosum L.*) is an important crop that plays a major role in food security and poverty reduction to a large proportion of rural farmers in the North West than other parts of Rwanda. However, potato is a perishable product which necessitates an effective choice decision of the market outlet. This paper presents factors influencing smallholder potato farmers' choice decisions for market outlets in Rwanda. Through a multistage sampling technique, cross-sectional data were collected from 585 smallholder potato farmers in Musanze and Nyabihu Districts.Both descriptive statistical methods and econometrics methods were used for data analysis. Multivariate probit model was used to determine the factors influencing smallholder potato farmers' choice decision to sell to particular market outlets. Results showed that farming experiences, level of education of decision maker, household size, household income, household assets, access to market information and distance to market significantly influenced the smallholder potato farmers' choice decisions of selling to consumer, retailer, wholesaler, cooperative, collection centres and processors market outlets. The study recommends establishment of structured market systems to improve access to potato market information. This should be supported by agricultural financingfor improved seeds acquisition and other productive inputs to enable farmers to increase surplus potato supplied to market. Improving the farmers' education in marketing would also help them to effectively deliver potato to efficient market outlet.

KEYWORDS: Smallholder potato farmers, Choice decision of market outlet, Multivariate probit model, Musanze and Nyabihu Districts

1. BACKGROUND

Statistics have shown that Rwanda is an agricultural based economy. Its contribution of 32 percent to the GDP and 45 percent of Rwanda's exports earnings (NISR, 2017) which make the sector a critical component of the programs to reduce poverty and attain food security. Similarly to other country in SSA, the sector remains subsistence and characterised by poor infrastructure, land fragmentation, limited access to modern agricultural practices and under investment. However, following the sharply increased demand for food and consumption habits due to demographic factors, Rwanda is currently pursuing its policy of transforming and adjusting the agricultural sector from the subsistence agricultural production to market oriented agricultural production (MINECOFIN, 2013). The policy focuses on expanding the production area to improve productivity at farm level. Though, the process requires increased investment in presence of massive marketing opportunities (Martey *et al.*, 2012), it can increase the income and improve the livelihoods of millions smallholder farmers. Despite the

significant development of agribusiness sector and the role played by smallholder farmers in supplying the products, agricultural marketing remain a critical issue in Rwanda. Linkage between smallholder farmers with the potential markets is the persisting challenge for actors in agricultural value chains including smallholder potato farmers in Rwanda. Potato (*Solanum tuberosum L.*) is important crop introduced in Rwanda by German soldiers and Belgium missionaries in earlier 20th century(Nelson *et al.*, 2016). The crop underpins the Rwanda's food security, nutrition, employment and socio-economic improvement of farmers (Tenge *et al.*, 2012). Moreover, the crop contributes to poverty reduction to a large proportion of rural farmers in the North West than other parts of Rwanda. Though farmers dispose enough potentialities of increasing potato productivity many factors still limit smallholder potato farmers to access to potential markets (GIZ, 2016) and reduce their expected profitability from growing potatoes. Access to market information and other marketing facilities enable smallholder farmers to

increase their production and decide about the market outlet to sell their produce. Nevertheless, agricultural marketing plays not only a role in stimulating production and consumption, but also plays key role in accelerating the pace of economic development. Therefore, the problems related to access to agricultural markets and choice of market outlets need to be adequately addressed.

Farmers would be better off when they can benefit from increasing market opportunities through effective participation to markets and market outlets. The objective of this paper was to determine the factors that influence smallholder potato farmers' choice decisions of market outlets in Musanze and Nyabihu Districts, Rwanda.

2. Methods
2.1. Description of the study area
The study was carried out in the North West volcanic zone in the two main potato growing districts Musanze and Nyabihu, particularly inKinigi, Gataraga, Nyange sectors of Musanze district and Jenda, Karago and Mukamira of Nyabihu district. Musanze district is located in Northern province at geographical coordinates 1°30' 27'' S 29°36' 24'' E, Nyabihu district is located in Western Province at geographical coordinates 1° 39' 10" S 29° 30' 25" E respectively (https://www.citipedia.info/province/general/Rwanda). The two districts were purposively selected for their agro ecological potentials including volcanic soils, high altitude, and abundant rainfall favourable to potato production (figure 1 shows the study area).
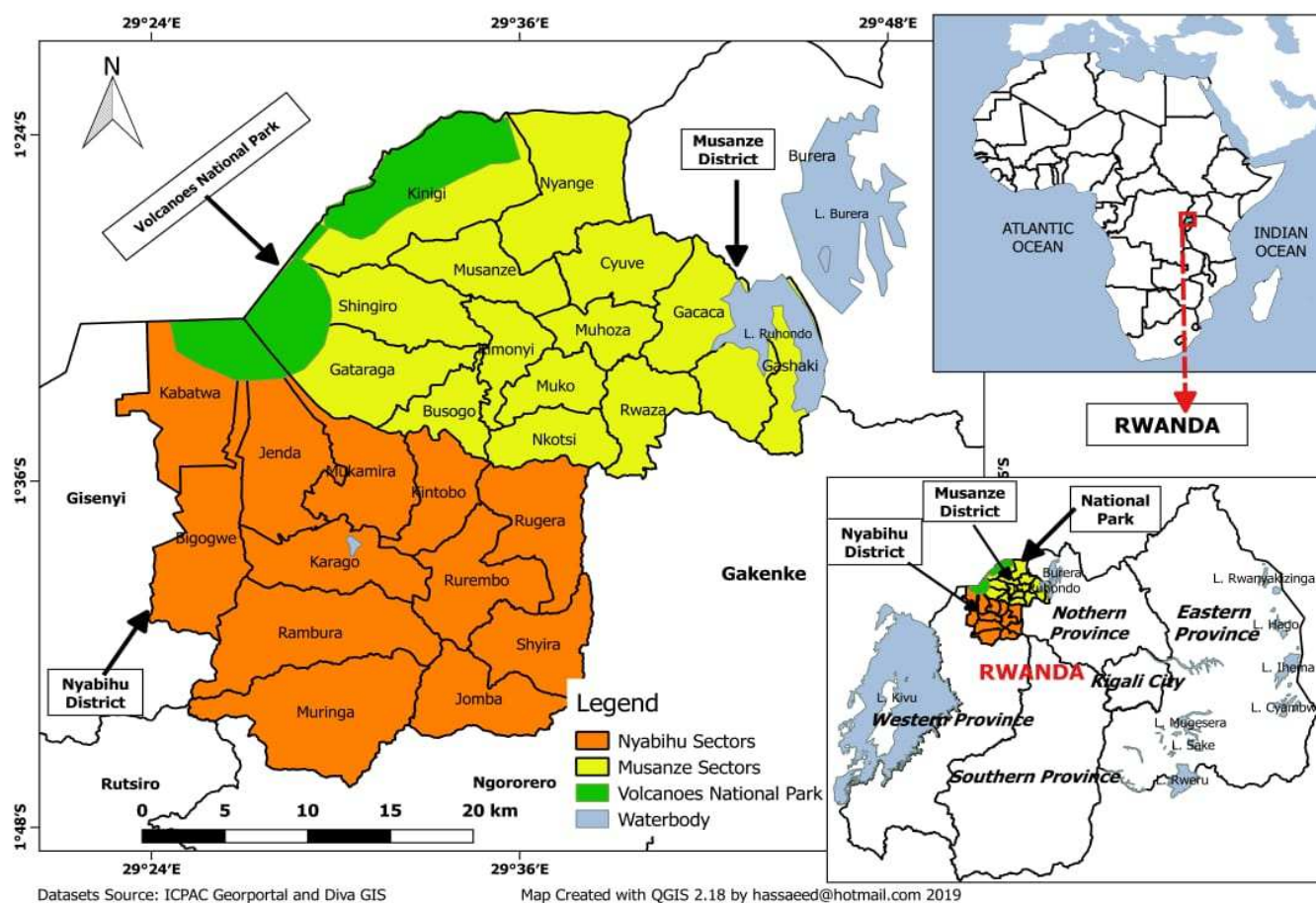

Figure 1: Map of Africa and map of Rwanda showing the study area
Source: ICPAC Georportal and Diva GIS

2.2. Sampling procedure and collection of data
A combination of probability and non-probability sampling methods were used to select the respondents. In other to select a representative sample, the study adopted a multistage sampling procedure to select the sample size of 585 potato farmer households to interview.

The two districts were purposively selected based on their agro ecological potentials favourable to potato production. 3 sectors from each district (Kinigi, Nyange and Gataraga of Musanze District, Jenda, Mukamira and Karagao sectors of Nyabihu District) were also selected purposively based on the production level and diversity of potato activities in the sector. Both primary and secondary data were collected. A semi structured questionnaire with both open and closed ended questions have been used to collect primary data. The respondents were randomly selected from farmers of different potato farming organizations (Table 1 shows the distribution of the sampled potato farmers). 6 focus groups discussions, each group comprised of 8 to 10 people and 10 key informant interviews were also conducted to enrich the data Secondary data were collected from academic journal and relevant reports from sector's agricultural development officers and cooperatives officers. SPSS and STATA statistical packages were used respectively for descriptive statistics analysis and of econometric analysis.

Table1: Distribution of sampled potato farmers

District	Sectors	Pooled(N=585)	
		Frequency	Percentage
Musanze District	Gataraga	151	25.81
	Kinigi	65	11.11
	Nyange	66	11.28
Nyabihu Ditrict	Jenda	80	13.68
	Karago	159	27.18
	Mukamira	64	10.94

Source: Author's Field work 2019/2020

2.3. Analytical methods

The smallholder farmers' decision to sell to particular market outlets respect the random utility theory whereby farmers evaluate the market outlets and select those maximizing their utilities (Baltas & Doyle, 2001).

Descriptive statistics such as percentage, frequency, means, maximum, minimum and standard deviation were used to describe the socioeconomic characteristics of smallholder potato farmers in the study area.

Multivariate Probit model (MVP) was used to determine the factors that influence potato farmers' choice decision to sell to particular potato market outlets in Rwanda.

Apart from Multivariate probit model, multinomial logit would also be used to analyse the categorical choice of dependent variables. The studies conducted by (Xaba & Masuku, 2012; Singh, 2018; Nxumalo *et al.*, 2019) have used multivariate logit, multinomial logit/probit to analyse the factors affecting producer's choices of market outlets. Whereas (Sori & Aman, 2017; Tarekegn *et al.*, 2017; Melese *et al.*, 2018; Tura & Hamo, 2019; Dlamini-Mazibuko et al., 2019; Abate et*al.*, 2019; Kassaw *et al.*, 2019) have used multivariate probit too analyse the factors affecting farmers' choice of market outlets.

However, the choice decision by farmers is inherently a multivariate decision. In this study, the potato farmers have possibilities of simultaneously choosing one or more market outlets among the seven market outlets (direct consumers, retailers, collection centres, cooperatives, brokers, processors and wholesalers). Therefore, the choice decision by farmers is inherently a multivariate decision. Multivariate probit model is a simultaneous system of several binary probit of M-dimensions. It models the influence of the set of explanatory variables on choice market channels, while allowing for the potential correlations between unobserved disturbances, as well as the relationships between the choices of different market channels (Belderbos *et al.*, 2004). Consequently, using multinomial models (MNM) for market outlet choice would not be viable because the farmer would be limited to choose only one market outlet from the set of mutually exclusive and collectively exhaustive choices.

MVP is preferred over MNM because of the independence of irrelevant alternative assumptions and relevant risks of choosing one outlet can be affected by the relative risk of choosing the other outlet (Greene, 2002). Multivariate Probit (MVP) is an appropriate model for multiple choice problems for this study to estimate numerous correlated binary outcomes that capture the influence of a set of independent variables on each of different choices of market outlets. The farmer household's choice decision to sell to one or more market outlets is led by the farmers' willingness to maximize their expected utility than otherwise (Fafchamps & Hill, 2005) and is conditioned to a number of factors like socioeconomic, institutional, production and market related factors (Arinloye *et al.*, 2015; Tarekegn *et al.*, 2017).

Consider the ith farmer household (i=1,2,3,........N) facing decision problem of whether or not to choose the available market outlets *(k=1,2........m).* Let U$_k$ represents the benefit of famer to choose the kth market outlet where *k* denotes the choice of consumers (Z_1), retailers *(Z_2),* collection centres (Z_3.), cooperatives (Z_4), brokers *(Z_5),* processors *(Z_6)* and wholesalers *(Z_7).*

The potato farmer householdi^{th} has a set of alternatives (*k*=1, 2, 3,....., *m*) which provide a certain level of utility U_{ik} from each alternative.

The model is written as: $Z_{ik} = X_{ik}\beta_{ik} + \varepsilon_{ik}$ ....(1)

Where, (*k*=Z_1,Z_2, Z_3, Z_4, Z_5,Z_6 and Z_7) representing the dependent variables of potato market outlets to be selected by the ith farmer household (*i*= 1,2,...N). The X_{ik} is a 1*k independents variable that influence the choice of market outlet decisions, β_{ik} is k*1 vector of unknown parameters to be estimated and ε_{ik} are the error terms distributed as multivariate normal. The farmer decides to choose k^{th} market outlet if Z*$_{ik}$ =U*$_k$-U$_0$>0 where U$_0$ denotes the utility to the farmer from not choosing none of the market outlets and U$_k$ represents the utility of using the kth market outlet. The benefit Z*$_{ik}$ that a farmer derives from the choice k^{th} market outlet is the latent variable determined by observed and unobserved explanatory characteristic.

However, the dependent variables are polychotomous variables indicating that farmer household may sell potato at more than one relevant market outlet. By using the indicator function, the econometric approach for this study was the unobserved preferences translated into the observed binary equation for each choice as follows:

$Z_k^* = X_k\beta_k + \varepsilon_k$ Z$_{ik}$=1 if Z*$_{ik}$>0, Z$_{ik}$=0 otherwise, for k= Z_1,Z_2, Z_3, Z_4, Z_5,Z_6, Z_7.......(2)

$Z_1^* = X_1\beta_{1+}\varepsilon_1$ Z$_1$=1 if Z*$_1$>0, Z$_1$=0 otherwise

$Z_2^* = X_2\beta_{2+}\varepsilon_2 Z_2 = 1$ if $Z^*_2 > 0$, $Z_2 = 0$ otherwise

$Z_3^* = X_3\beta_{3+}\varepsilon_3 Z_3 = 1$ if $Z^*3 > 0$, $Z_3 = 0$ otherwise

....

$Z_7^* = X_7\beta_{7+}\varepsilon_7 Z_7 = 1$ if $Z^*_7 > 0$, $Z_7 = 0$ otherwise

In the MVP model, the error terms jointly follow a multivariate normal distribution (MVN with zero conditional mean and variance normalized to unity where $(U_1, U_2, ... U_m) \sim MVN (0, \Omega)$ and the symmetric covariance matrix of Ω is given as:

$$\Omega = \begin{vmatrix} 1 & \rho x_1 x_2 & \rho x_1 x_3 & \rho x_1 x_4 & \rho x_1 x_5 & \rho x_1 x_6 & \rho x_1 x_7 \\ \rho x_2 x_1 & 1 & \rho x_2 x_3 & \rho x_2 x_4 & \rho x_2 x_5 & \rho x_2 x_6 & \rho x_2 x_7 \\ \rho x_3 x_1 & \rho x_3 x_2 & 1 & \rho x_3 x_4 & \rho x_3 x_5 & \rho x_3 x_6 & \rho x_3 x_7 \\ \rho x_4 x_1 & \rho x_4 x_2 & \rho x_4 x_3 & 1 & \rho x_4 x_5 & \rho x_4 x_6 & \rho x_4 x_7 \\ \rho x_5 x_1 & \rho x_5 x_2 & \rho x_5 x_3 & \rho x_5 x_4 & 1 & \rho x_5 x_6 & \rho x_5 x_7 \\ \rho x_6 x_1 & \rho x_6 x_2 & \rho x_6 x_3 & \rho x_6 x_4 & \rho x_6 x_5 & 1 & \rho x_6 x_7 \\ \rho x_7 x_1 & \rho x_7 x_2 & \rho x_7 x_3 & \rho x_7 x_4 & \rho x_7 x_5 & \rho x_7 x_6 & 1 \end{vmatrix} ....(3)$$

Whereby, ρ_{im} denotes the pair wise correlation coefficient of the error terms, corresponding to any two choice equations to be estimated in the model and the off-diagonal elements in the covariance matrix the unobserved correlation between the stochastic components of different types of market outlets. The market outlet choices that are along the farmer household's decision involved in alternatives are represented in model as:

$\rho x_1, \rho x_2, \rho x_3, \rho x_4, \rho x_5, \rho x_6$ and ρx_7 for households who choose direct consumers, retailers, collection centres, cooperatives, brokers, processors and wholesalers to sell potato.

The above assumption becomes a MVP model that jointly represents decision to choose particular market outlet.

This specification with non-zero off diagonal elements allows for correlation across error terms of several latent equations, which represents unobserved characteristics that affect the choice of alternative outlets. Following the formula used by Cappellari & Jenkins (2003), the log likelihood function is given by:

$$\ln L = \sum_{i=1}^{N} \omega_i \ln \Phi(\mu_i, \Omega) \quad ....(4)$$

Where ω is an optional weight for the observation i and Φ_i is the multivariate standard normal distribution with arguments μ_i and Ω where μ_i can be denoted as:

$\mu_i = K_{i1}\beta_1 x_{i1}, K_{i2}\beta_2 x_{i2}, ... K_{im}\beta_m x_{im}$, with $K_{ik} = 2y_{ik} - 1$, for each i, k = 1, ..., 3.

Matrix Ω has constituent elements Ω_{mk}, where $\Omega_{im} = 1$ for m = 1, 2.....m

$\Omega_{21} = \Omega_{12} = K_{i1}K_{i2}\rho_{21}$; $\Omega_{m1} = \Omega_{1m} = K_{im}K_{i1}\rho_{m1}$; $\Omega_{m2} = \Omega_{2m} = K_{im}K_{i2}\rho_{m2}$ ....(5)

The dependent variable (choice of market outlet) is discrete variable with *M* alternatives market outlets. These are the path ways where the farmer expects to pass through to reach theend markets. Farmers expect to choose the best market through which they can sell their products depending up on various criteria. The farmer is likely to simultaneously choose more market outlets in order to maximize the expected utility and due to this there is some overlapping and many farmers sell to more than one market outlet. The Multivariate probit model takes into account the potential interdependence in market outlet choices and possible correlation in the choice of alternative outlets. Table 2 describes the variables used in this study.

Table 2: Description and measurement of explanatory variables used in Multivariate probit model

Variables	Variable description	Measurement	Expected sign
Dependent variable			
MktOutlet	Choice decision of market outlet where production is sold	Categorical 0=Wholesalers 1= Processors 2= Brokers/Middleman 3= Collection centres 4= Cooperatives, 5= Retailers 6= Consumers	
Explanatory variables			
Age of HH head	Age of household head	Years	+
Sex of HH head	Sex of the household head	Dummy 1=male, 0=female	+/-
MaritStatHH	Marital status of the household head	Dummy 1=Married, 0 otherwise	+

EducHH	Level of Education of household head	Categorical 0= no formal education 1=Primary level 2=Secondary level	+
HSize	Household size	Number of people in household	+
TotfarmSizPotH	Total farm size under the cultivation of potato	Continuous(Ha)	+
HHFarmexp	Farming experience		+/-
HIncome	Household's total annual income	Continuous (Frw)	**+**
HHMembFarmOrg	Whether household head is Member of farming organization	Dummy 1=yes, 0=no	+
DistanMkt	Distance between household farm gate and nearest potato market (Km)	Continuous (Km)	-
HHAssetsTrans	Whether household head own transport assets (facilities equipment)	Dummy 1=yes, 0=no	+
Trust	Trust between farmer and buyer	Dummy 1=Yes, 0=No	+/-
AccMktInf	Access to market information	Dummy 1=Yes, 0=No	+
HHTrainPotato	Whether household head received training in potato production practices	Dummy 1=yes, 0=no	+/-
VisitExtenOff	Visited by extension officer (access to extension services)	Dummy 1=Yes, 0=No	+/-

Note: +/- implied that positively or negatively influence the likelihood for the market outlet choice.

2.4. Results and Discussion

The socioeconomic characteristics of sampled potato farmers are summarized in table 2. The results of the study indicated that their age ranges between 26 and 63 years with a mean of 41.49 and standard deviation of 8.77. The mean household size was 4.97 people in family with a standard deviation of 1.5. The household size in study area was nearly approaching the average household size 4.3 persons per family at national level (NISR & MINECOFIN, 2014).From 585 households interviewed, 61.54 percent were male headed whereas 38.46 percent were female headed households. This implied that by interacting with many people, male gains many market networks and can easily have access to market information than female headed households who always stay at home taking care of the children. These enabled him to compare many alternatives of selling potato produce. Similarly, from the interviewed sample, 87.86 percent were married, 12.14 percent were unmarried (widow, single separated and divorced).The study showed that13.68 percent had no formal education, 52.99 percent attended primary education and 33.33 percent had attended had secondary or high education. According to NISR (2012), the 2012 Rwanda Population households Census (RPHC) showed that 68 percent of Rwandan population aged 15 and above were literate, with 12.4 percent attended secondary education. This implied that the level of farmers with high education in the study area was above the average of persons with secondary education level in Rwanda.

The farmers involved in the survey are smallholder potato farmers with the mean farm size 0.4957 Ha under potato cultivation. The high farm size under cultivation is assumed to yield high production and hence positively effect on smallholder potato farmers' choice decisions of market outlets.

The interviewed sampled farmers have long experience in potato farming whereby 11.6 percent were between 1-5 years of potato farming experience while 84.2 percent were above 5 years of potato farming experience. These implied that the farmers in the study area had longer experience in potato farming and are expected to significantly increase the production and sell to different market outlets. The results showed that 86.84 percent have access to market information. This explained the importance of market information for choosing the appropriate market outlets for agricultural produce. Similarly, 61.35 percent of sampled farmers were members of farming groups and associations. Adhering to farming groups or associations facilitates farmers to access to market information, reduce transaction costs and thus to enable farmers to tradeoff between different market outlets.

Table 2: Socio economic characteristics of farmers in the sample

Variables		Sample N=585	
		Mean	Standard deviation
Age (years)		41.4855	8.76795
Household size		4.96752	1.495646
Farm size		0.4957	0.74051
Variables		Frequency	Percentage
Sex of the respondent	Female	225	38.46
	Male	360	61.54
Marital status of farmers	Single	21	3.59
	Married	514	87.86
	Widow	48	8.21
	Separated	1	0.17
	Divorced	1	0.17

		No formal education	80	13.68
Education		Primary education	310	52.99
		Secondary education	195	33.33
Farming Experience in potato (Years)		Below 1	24	4.1
		Between 1-5	68	11.6
		Between 6-10	172	29.4
		Between 11-15	202	34.5
		Above 15	119	20.3
Access to market information		No	77	13.16
		Yes	508	86.84
Group membership		No	223	38.65
		Yes	354	61.35

<div align="center">Source: Field work 2019/2020</div>

2.5. Factors influencing smallholder potato farmers' choice decisions of market outlets

Potato farmers in Musanze and Nyabihu districts have seven alternatives to sell their production. Farmers have choices of selling to direct consumers, retailers, collection centres, cooperatives, brokers, processors and wholesalers. Significance of the factors influencing farmers' choice decisions of market outlets were discussed based on the results from the multivariate probit model.

The Wald Chi square statistic, χ^2 = 296.54, and its associated probability value , $p< 0.001$ were strongly significant at 1% significant level, which implied that multivariate probit model is satisfactory fitting the data. The likelihood ratio test of correlations of the seven market outlets was statistically different from zero (χ^2 =267.765 and $p< 0.001$). The null hypothesis of independence for the decision choice between market outlets was significant at 1% significant level.This implied that the univariate probit model for determining factors influencing farmers' choice decision of market outlets was untrue and would bias the results. In other words, the significant likelihood ratio test implied that multivariate probit (MVP) is appropriate for determining the farmers' choice decisions to sell potatoes to multiple outlets because it exploited the correlation structures (interdependencies) among the seven alternatives of market outlets. Therefore the farmer' choice decision to sell to a particular market outlet depended on the choice of another outlet.

Other crucial statistics from multivariate probit model results were the correlation coefficients, which show the direction and strength of the relationship between market outlets (Table 3). The results showed that the correlation coefficients for broker and wholesaler, collection center and wholesaler, collection center, cooperatives and broker, processors, wholesaler and broker and for retailer and consumer were significantly positive, implying that farmers were more likely to sell to outlets at the same time. The correlations between consumer with wholesaler, cooperative, and collection center, together with wholesaler and retailer, cooperative and retailer and collection center and retailer were significantly negative, suggesting less likelihood of producers selling to the outlets at the same time.

<div align="center">Table 3: Estimated correlation coefficients between seven market outlets</div>

	Consumer	Retailer	Wholesaler	Broker	Cooperative	Collection center	Processor
Consumer	1						
Retailer	0.509***	1					
Wholesaler	-0.186**	-0.184**	1				
Broker	0.067	-0.015	0.309***	1			
Cooperative	-0.188***	-0.186***	0.018	0.276***	1		
Collection center	-0.316***	-0.175**	0.176**	0.163**	0.336***	1	
Processor	-0.096	-0.035	0.839***	0.464***	-0.032	0.108	1

<div align="center">Note: ** and *** denote significance at 5% and 1% levels, respectively
Source: Field work 2019/2020</div>

As illustrated in table 4, the first salient multivariate probit result was that none of the covariates included significantly influenced farmers' decision to sell to brokers. Brokers, like other types of middlemen in other agricultural value chains, dominate the potato value chain and have substantial power that enable them to earn high margins(Mitchell, 2011). The high power margin understandably distorts the market because of brokers' influence on prices paid to producers and paid by the final potato consumers. Brokers have access to vast market information about produce prices than farmers. In this study, over three-quarters of farmers had access to market information, thereby increasing their likelihood of not selling to brokers. Table 4also showed that farming experience significantly reduced the likelihood of farmers selling potato to consumers. The relationship could be attributed to farmer knowledge of alternative and more attractive markets that possibly buy in bulk than consumers. Consumers/neighbors are possibly located in the same villages and buy during harvesting times when there is little economic incentive to sell within village becauseof abundance in supply. Furthermore, experienced farmers were more likely to sell to wholesalers at farm gate, especially for farmers farther from collection

points or markets, and the capacity of experienced potato producers to meet the supply quantity requirements of wholesalers. In this regard, wholesalers act like facilitators rather than a barrier to farmers' access to the market. These services, alongside the aggregation ability of wholesalers, may reduce the transaction costs, which makes the wholesalers attractive to farmers. This finding supports results reported by Monson et al.(2008) who argued that experienced farmers are likely to assess the demands of wholesalers making them more likely to sell directly to them than using middlemen.

There is a higher likelihood that farmers with high household income would sell potato to consumers and collection centers. Farmers with better incomes are likely to be better-resource endowed do deploy production models with more compelling reasons to sell directly to consumers or collection centers that focus on farm produce that meet certain quality requirements. Another reason could be farmers with higher incomes are unlikely to be constrained by lack of resources to finance direct marketing to consumers(Rapisarda et al., 2015). For these reasons, since middlemen are less likely to engage in high values markets, income-endowed producers may be attracted to sell directly to collection centers or consumers. In contrast, higher household income reduced the likelihood of farmers selling to wholesalers, which could be attributed to the likelihood of resource-endowed potato producers having personalized relationships with consumers and strong social networks. The negative association between household income and chances of farmers selling to wholesalers contradict the finding by Abebe et al.(2016) who reported that better-resource endowed in Ethiopia were likely to benefit by selling to wholesaler.

As expected the farmers with large farm size would have probability of increasing the production and increasing the quantity supplied to markets. The study showed a positive effect on potato farmers' choice decision of wholesalers and collection centers market outlets. This implied thatan increase in land under potato cultivation is likely to increase the choices of farmers of selling to wholesalers and collection centers than other markets outlets. The results consisted the finding by(Kassaw et al., 2019) who found that farmers with more land holding produced large amounts and preferred to sell large amount of tomato to wholesalers and consumers.

The probabilities of farmers selling potato to consumers and processors were positively and negatively with ownership of transport assets, respectively. The positive association between availability of transport assets and consumers as an outlet of choice was expected. Potato is a bulky agricultural commodity and, thus, ownership of transportation assets represents a significant reduction in marketing costs (transaction costs). Transportation assets provides mobility to farmers which not only allows them to timely deliver potato to the market, but also enables them to have more frequent physical contacts and access to customers, market agents, and information. Crossley et al. (2009)also noted that transportation assets improve marketing efficiency, reducing costs of marketing. On the other hand, the negative association between farmers' likelihood of selling to processor and household ownership of asset could be due processors offering transport services that may not be time-efficient and convenient as self-operated transportation. This finding contradicts the finding by Donkor et al. (2018)who found that ownership of motorbikes and vehicles positively influenced Nigerian farmers' decisions to sell cassava directly to processors.

Based on economic theory, higher levels of education would either diminish the probability of selling potato to retailers or increase probability of selling potato to wholesalers. However, the analysis of this study provided opposite results. While education level of the household increased chances of farmers selling potato to retailers, it reduced the probability of them selling to wholesaler and processors. No immediate explanation can be provided for these unexpected results. However, the education level was used as human capital of the main household decision maker, with highly educated farmers expected to have a better access to market information.

The distance to market was negatively associated with the probability of selling to retailers and processors compared to other market outlets. In other words, the further the farming households are from the market, the lesser likely they sell potato to retailers and processors. Potato is a bulky perishable commodity whose transaction costs hampered or may have confined selling at farm gate or within the production areas than incurring transportation costs and time to deliver to retailers or processors. The results are in line with previous finding by (Tarekegn et al., 2017,Melese et al., 2018, Abate et al., 2019, Kassaw et al., 2019) who found that distance to market significantly affect farmers' choices of market outlets.

Furthermore, the study revealed that the large sized households were less likely to sell potato to wholesalers and processors. In other words, variability in the number of household members plays a significant role in determining farmer's decision of not to sell to wholesalers and processors. This result is reasonable because large sized households have plenty of labor which can be used to transport potato to the nearest markets. Besides, the use of the household labor to directly sell potato to the market enables farmers to earn higher prices because they have direct access to market information that they would have otherwise relied on wholesalers and processors to provide it. This finding is in line with the argument provided by Leroux et al.(2010) that when no buyers collect produce at the farm gate, large-sized household are able to carry the output to the nearest market.

Moreover, the probability of marketing potato produce through cooperatives was positively and significantly determined by the number of contacts they had with extension officers. The numbers of contacts with extension officers possibly enabled farmers to have access to market information which, in turn, influenced their market selection strategies and choices. For instance, farmers could have used the extension information to select cooperatives because producer groups support production processes or offer production and marketing services. On one hand, this finding supports the results reported by Dlamini-Mazibuko et al. (2019) who indicated that access to extension services have significant effect on smallholder vegetable farmers' market outlet selection strategy in Swaziland. On the other hand, the findings of this study is in disagreement with Dlamini-Mazibuko et al.(2019)results that showed that extension services reduced the possibility of farmers choosing to sell vegetables to formal market channels: cooperatives and supermarkets.

Table 4: Factors influencing smallholder potato farmers' choice decisions of market outlets

	Consumer		Retailer		Wholesaler		Broker	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Age of HH head	0.008	0.009	0.005	0.008	-0.005	0.010	0.001	0.009
Sex of HH head	-0.040	0.140	0.053	0.123	0.048	0.157	0.023	0.141
Marital status	0.008	0.202	-0.051	0.182	0.334	0.240	0.062	0.209
Education	-0.133	0.106	0.247***	0.094	-0.286**	0.119	-0.078	0.108
Household size	-0.019	0.046	0.049	0.039	-0.163***	0.054	-0.023	0.045
Farm size	-0.0376	0.083	-0.073	0.111	0.365***	0.136	-0.063	0.088
Farming experience	-0.137**	0.056	-0.062	0.050	0.115*	0.064	-0.072	0.055
Household income	0.245***	0.080	0.096	0.071	-0.270***	0.093	0.062	0.081
Group membership	-0.133	0.148	-0.082	0.131	-0.017	0.165	0.015	0.150
Distance to market	-0.001	0.003	-0.002*	0.003	-0.019	0.030	0.000	0.003
Transport assets	0.425*	0.255	-0.045	0.246	-0.139	0.383	0.065	0.280
Trust	0.070	0.133	0.151	0.117	0.245	0.144	-0.123	0.134
Access to market information	-0.199	0.327	0.824	0.349	0.410	0.432	-0.211	0.330
Agric. Training	0.123	0.142	0.047	0.127	0.004	0.167	0.011	0.146
Extension contacts	-0.044	0.133	0.026	0.117	-0.209	0.150	-0.082	0.135
Constant	-3.559***	1.143	-2.931***	1.043	2.838**	1.335	-1.131	1.170

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively

Source: Field work 2019/2020

Table 4: Factors influencing smallholder potato farmers' choice decisions of market outlets (continuation)

	Cooperative		Collection Centre		Processor	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Age of HH head	-0.002	0.008	-0.002	0.009	0.002	0.011
Sex of HH head	-0.122	0.125	-0.030	0.137	0.069	0.176
Marital status	-0.010	0.185	-0.172	0.212	0.422	0.277
Education	-0.023	0.096	0.005	0.105	-0.265*	0.135
Household size	-0.042	0.039	-0.041	0.043	-0.130**	0.060
Farm size	0.007	0.153	0.073**	0.111	0.047	0.166
Farming experience	0.000	0.051	-0.006	0.056	0.076	0.068
Household income	0.020	0.071	0.350***	0.081	-0.382	0.104
Group membership	-0.079	0.132	-0.371**	0.149	-0.001	0.180
Distance to market	-0.001	0.003	0.001	0.003	-0.005*	0.013
Transport assets	0.141	0.255	0.193	0.310	-0.282*	0.269
Trust	0.147	0.118	0.134	0.130	-0.111	0.162
Access to market information	-0.420	0.321	0.419	0.309	0.203	0.435
Agric. Training	0.050	0.130	0.057	0.142	-0.143	0.189
Extension contacts	0.276**	0.119	0.081	0.129	-0.121	0.164
Constant	0.725	1.037	-3.745***	1.161	3.933	1.500
Wald χ^2 (98)	296.54***					
Likelihood Ratio χ^2 (21)	267.765***					

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively

Source: Field work 2019/2020

The study also revealed that the probability for potato farmers of choosing to sell to the seven market outlets only 0 .13% which is lower than 3.7% probabilities for farmers of choosing not to sell to the seven outlets at once (table 5). This is justified by the discussed factors that determining the choice of selling to each of the market outlets. The probabilities of potato farmers of selling to direct consumers, retailers, wholesalers, brokers and processors were respectively -82.8%, -24.9%, -116.8%, -88.4% and -15.2%; while probabilities of selling to cooperatives and collection centers were 32.3% and 76.1% respectively.

Table 5: MVP linear and joint predicted probabilities

	Mean	Std. Dev.
Linear probabilities		
Consumer	-0.828	0.287
Retailer	-0.249	0.289
Wholesaler	-1.168	0.646
Broker	-0.884	0.145
Cooperatives	0.323	0.201
Collection centre	0.761	0.335
Processor	-1.520	0.797
Joint probabilities		
Successes	0.0013	
Failures	0.0370	

Source: Field work 2019/2020

Conclusions and Recommendations

Linking smallholder farmers to markets play a critical role in enhancing farmers' livelihoods, hence, there is a need to emphasize more on access to markets and choice of market outlets. Multivariate probit model was used to determine the factors that influence stallholder potato farmers' choice decision of market outlets in Musanze and Nyabihu districts, Rwanda. The study found that education of household head, farming experiences, household income, transport assets, household income, farm size and extension contacts positively and significantly influenced the smallholder potato farmers' choice decisions of selling to consumer, retailer, wholesaler, cooperative, collection centres while education of household head, household size, farming experiences and group membership negatively and significantly influenced the smallholder potato farmers' choice decisions of selling to consumer, retailer, wholesaler, collection centres and processors market outlets. Education level of the household was used to represent the human capital for the household decision making and to accept any market outlet that maximizes his utility or provides higher profit. In the study revealed that high educated farmers are more likely to sell to retailers than selling to other market outlets. High household incomes are likely to sell their produce to consumers and collection centres than selling to other market outlets. .

The study recommends establishment of structured market systems to improve access to potato market information. This should be supported by agricultural financing for improved seeds acquisition and other access to other productive inputs. Improving the farmers' education in marketing would also help them to effectively deliver potato to efficient market outlet.

Conflicts of interests
The authors declare no conflict of interest

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