Determinants of marketed quantities of potato in tete province of Mozambique

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ABSTRACT

In Mozambique 88% of the area allocated to potato production comes from Tete province, mainly on the districts of Angonia and Tsangano, and no studies have evaluated the determinants of the marketed quantities of this food crop, in this region. Hence, this study addressed this knowledge gap. The study used primary data. The primary data were obtained in February 2021 through the administration of the structured questionnaires to 453 smallholder potato farmers in Angónia and Tsangano districts. Descriptive statistics and a quantile regression model were the tools applied to analyze data. Results showed that the area allocated to potato production, cost of fertilizer per hectare, and cost of hired labour per hectare were significant at 1% confidence interval with volume sales of potatoes at all three levels of median studied. These are indications that an increase in any of these variables would increase the productivity of potatoes and hence the quantities available for market. Some of the constraints reported by the potato farmers were incidence of pests and diseases (100%), lack of credit access (100%), lack of certified seed (100%), lack of collective action on setting price (100%), inadequate storage materials (100%), poor road quality to access markets (79%), lack of funds to hire labour (36.2%), low level of extension services (36.9%), inadequate price information (17.9%) and inadequate fertilizer application (2%). To increase potatoes productivity, condition to increase marketed quantities, certified seeds, fertilizers and good storage materials should be made available to potato farmers.

Keywords: *Constraints, Determinants, Marketing, Mozambique, Potato, Quantile regression.*

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Highlights of this paper:

- The research outcomes emphasize the importance of potato production and marketing, by smallholder potato farmers, in Tete province of Mozambique.
- The findings also recognize that smallholder potato farmers are getting food and cash from this farming activity.
- Therefore, supportive institutions should provide to smallholder potato farmers with fertilizers at subsidized prices so as to improve potato productivities and increase quantities available for market which will reduce deficit on potato supply in the country.

1. INTRODUCTION

Potato is an important tuber food crop that belongs to the *Solanaceae* family and ranks fourth after Wheat, Rice and Maize in the world context. It has been pointed out to provide a high-nutritive food for a large population, livestock feed and raw materials for local industries. Potato is an affordable commodity economically and there is a demand for it always which can stimulate economic development. In addition, given their characteristics, potatoes are a bulky commodity that requires good storage facilities as well as special transportation conditions. More over, countries such as China, India, and Russia are major producers of potatoes in the world, Islamova, et al. [1].

In Mozambique potatoes are mainly cultivated in the highlands of Tete province, between 1000 to 2000 meters of altitude, where significant areas of their productions are located in the districts of Angónia and Tsangano. That is, 88% of the total area allocated to potato production in the country is located in this province, Ministério da Agricultura e Desenvolvimento Rural [2], representing 1.6% of the area of production that is explored by all the smallholder farmers in Mozambique, Schelling [3]. Additionally, in the study area the rain-fed period of potato production is from November to March, and in the remaining period the potato production is done by irrigation, Martinho, et al. [4]. It is being pointed out that among potatoes that are produced, significant quantities are marketed by the smallholder farmers at different markets, to get cash for sustainable production.

According to Kumar, et al. [5] this quantity of potatoes that is available for sale in the market place, after some quantities were left for consumption and seed is known as the marketable quantity. In a similar understanding, marketable quantity is the amount of potatoes, that may be in excess of domestic requirements. The other related concept is marketable surplus of agricultural product which is unlike agricultural commercialization. That is, agricultural commercialization deals with the increase in quantity marketed by farmers when the main intention is to produce for sell in order to maximize profit. Marketable surplus exists in any system of production adopted, subsistence or commercial, by providing the excess of the product for sale after the producers' requirements have been fulfilled. Therefore, the market availability of agricultural production output makes the marketable quantity possible since stimulates economic activity. Additionally, Olukosi and lsitor [6] noted that the forces of agricultural marketing make the produce to move from the point of production to the point of consumption.

However, the availability of marketable quantity of potatoes is subject to some constraints such as agricultural inputs, marketing system, availability of transportation, availability of storage, access to credit and price fluctuation. These constraints can limit the availability of marketed quantity of potatoes and generate deficit on supply to the demanded markets. Meaning, there are research gaps on the requirements and constraints to achieve an adequate marketable surplus of potatoes. Despite the identified gap, little are the studies that have looked at the factors affecting potato production and marketing in the study area. The few studies conducted in Mozambique on potato production and marketing include that of Schelling [3], Demo, et al. [7] and António, et al. [8] who did not study the topic in debate. This study was required to respond to the observed gap and contribute to the current literature.

2. LITERATURE REVIEW

2.1. Theory of Production

The theory of production looks at the change in output (final products) that is explained by a change in one of the used productive inputs (raw materials). According to Nicholson and Snyder [9] in economics, for the objectives of this analysis of production transformation, it is more appropriate to use a simplified production function. The production function for a singular commodity, q, indicates the maximum quantity of the commodity that can be obtained by using alternative combinations of capital and labor. The mathematical definition of the crop production by farmers or the quantity marketed by traders is given as follows:

$$q = f(a_t, b_t, c_t) \qquad (1)$$

Where,

q	Agricultural productivity for a specific crop for farmers, or the quantity of the products. that traders are able to supply to the market per week.
a	Farmer's characteristics or trader's characteristics.
b	Climatic variables.
c	Endogenous variables.
t	Subscript t, indicates the time or the observed year.

2.2. Theory of Cost

The cost function is derived from the production function which describes the efficient methods that are available for the production at any period of time given. Cost function states a functional relationship between total cost and related factors. The related factors that determine the total cost of production of a firm are the output, level of technology, price of factors, and fixed factors, Nwokoye and Ilechukwu [10], as follows:

$$C = f(q, t, p_t, k) \qquad (2)$$

Where,

C	Total cost of production.
q	Quantity of output.
t	Technology.
pt	Prices of the factor input.
k	Fixed factors.

3. MATERIALS AND METHODS

3.1. Study Area

Tete is a province in Mozambique that is located in Central Region. Tete lies between latitude 14°00 and 17°42 South and longitude 30°13 and 35°20 East. This province occupies a land area of 100, 742 km² with a population estimated to be around 2.2 million. Tete province is located at an elevation that lies between 200 meters to more than 1000 meters above sea level with a tropical dry and humid climate. The mean yearly temperature lies between 22°C to 32°C and the mean yearly rainfall is 180 to 360 millimeters, Governo da Província de Tete [11]. The province has 15 districts and the study was conducted in two of these districts which are Angonia and Tsangano that are located on the high elevation of the province.

3.2. Sampling Frame and Sample Size

This study surveyed potato farmers in Angónia and Tsangano districts of Tete Province in Mozambique. A multi-stage sampling method was used, where in stage one province of Tete was purposively selected. In the second stage, the districts of Angónia and Tsangano were purposively selected. In the third stage, randomly, four localities were selected in Angonia and three localities were selected in Tsangano. Finally, in the fourth stage, randomly, 220 smallholder potato farmers were selected in the localities of Angonia and 233 smallholder potato farmers were

selected in the localities of Tsangano. In total, 453 smallholder potato farmers were surveyed. The instruments for the collection of primary data for this research included the administration of structured questionnaires and focus group discussions.

3.3. Analytical Techniques

The econometric model used on identifying factors affecting the amount of potatoes sold to the markets is the Quantile Regression Model that was first introduced by Koenker and Basset [12]. According to Baum [13] this model has an advantage over the Standard Linear Regression Model in its ability to summarize the average relationship between a set of independent variables and the dependent variable at different points in the conditional distribution, which is not affected by extreme values. The conditional median function is given by $Q_q(y|x)$, and the quantile q or the 50th percentile is the median of the empirical distribution. The $q \in (0,1)$ is the y which splits the data into proportions q below and $1-q$ above, that is: $F(y_q) = q$ and $y_q = F^{-1}(q)$ for the median which is q=0.5.

If ϵ_i is the prediction error for the model, Ordinary Least Squares Regression minimizes $\sum_i e_i^2$ and the Median Regression minimizes $\sum_i |e_i|$. Therefore, the Quantile Regression minimizes a sum that gives asymmetric disadvantages, $(1-q)|e_i|$ for overprediction and $q|e_i|$ for underprediction. Hence, the estimator of the Quantile Regression is asymptotically normally distributed.

Median regression is more robust to outliers than least squares regression and it is semiparametric since it avoids assumptions about the parametric distribution of the error terms. The study used quantile regression to model conditional quantiles of the joint distribution of the outcome variable (y) and the regressors (x).

Let $\hat{y}(x)$ indicate the predictor function and $e(x) = y - \hat{y}(x)$ indicate the predictor error. Hence, Equation 3 presents the loss related to the prediction errors,

$$L(e(x)) = L(y - \hat{y}(x)) \quad (3)$$

If $L(e) = e^2$, error losses are squared and the least squares regression is the optimal predictor. If $L(e) = |e|$, the optimal predictor is given by the conditional median, $med(y|x)$, with $\hat{\beta}$ as the predictor which minimizes the Equation 4,

$$\sum_i |y_i - x_i'\beta|. \quad (4)$$

The loss functions for squared error and for absolute error are symmetric. In this case, if q differs from 0.5 it generates an asymmetric disadvantage, given that asymmetry increases as q approaches 0 or 1. Theoretically, the quantile regression estimator for q minimizes the objective function that is presented in Equation 5,

$$Q(\beta_q) = \sum_{i:y_i \geq x_i'\beta}^{N} q|y_i - x_i'\beta_q| + \sum_{i:y_i < x_i'\beta}^{N} (1-q)|y_i - x_i'\beta_q| \quad (5)$$

The simplex method is the proper mechanism to minimize this non-differentiable objective function, which is trusted to yield a solution in a finite number of iterations. Standard errors are estimated using the bootstrapping method.

Based on Waldmann [14] the empirical estimation of the basic model structure for the Quantile Regression Technique adopted in this study considered the qth quantile for the response y_i given x_i that takes the form of the Equation 6 presented as follows:

$$Q_q(Y) = \beta_0(q) + \beta_1(q)X_1 + \beta_2(q)X_2 + \cdots + \beta_p(q)X_p + \epsilon \quad (6)$$

where

$Q_q(Y)$	Conditional qth quantile of the dependent variable, Y, marketed quantity.
$x_1, x_2, \ldots, x_p$	Predictor variables proposed to affect marketed quantities handled by the household heads are:

Age (years).
Education (number of years spent in school).
Household head (number).
Planted area (hectare).
Price per kg (MZM/kilogram).
Price information (yes, no)
Cost of potato seed (MZM/hectare).
Cost of fertilizer applied (MZM/ hectare).
Cost of agro-chemicals (MZM/hectare).
Cost of hired labour (MZM/hectare).
Distance to the main market (Kilometer).
Frequency of production (number of productions/year).
Extension service (yes, no) .

Note: MZM- Mozambique Metical (Mozambique currency)

The assessment of the relationship between the dependent variable and independent variables was done simultaneously at three points of the outcome variable, q=0.25 (lower median), q=0.50 (median), and q=0.75 (upper median).

4. RESULTS AND DISCUSSIONS

4.1. Factors Influencing Farmers' Marketed Quantities of Potatoes

The result in Table 1 from the output of quantile regression indicates that the model has well explained the relationship between the three different points of the dependent variable (at the lower median, at the median, and at the upper median) and the independent variables. The variables such as area allocated to potato production (X_4), cost of fertilizer per hectare (X_8), and cost of hired labour per hectare (X_{10}) were significant and had a positive correlation with the marketed quantities ($\rho<0.01$). The distance to market (X_{11}) was significant at q25 of the outcome variable ($\rho<0.05$). The household size (X_3) was significant at q50 of the outcome variable ($\rho<0.05$) and the cost of pesticides variable (X_9) was significant at q75 of the outcome variable ($\rho<0.01$). This implies that an increase in any of these independent factors will lead to an increase in potato productivity, and hence more marketed quantities could be available.

The area allocated to potato production was positively and significantly related to the level of the marketed quantities of potatoes. In other words, the increase in farmland size would increase the quantity of potatoes in the markets. This finding concurred with Mazza, et al. [15] and Osugiri, et al. [16] that the increase of farm size would increase the marketed quantities and affect income including market participation.

The cost of fertilizer incurred during potato production in each production season appears to increase productivity and hence, marketed quantities. This variable had a positive and significant coefficient in affecting potato production in the study area. Osugiri, et al. [16] also found a positive and significant influence of fertilizer application on the increase of marketed quantities of maize in Nigeria.

The cost of hired labor, as presented in Table 1, was positively significant in explaining the marketed quantities of potatoes. This was so because in Angonia and Tsangano agricultural mechanization is still low, despite the potential in agricultural production, and farmers depended much on hired labour. This agreed with Osugiri, et al. [16] that for intensive production it is necessary to hire labour so as to have more marketed quantities and increase profit.

The household size variable was positively significant and this corresponded with Osugiri, et al. [16] and Mirie and Zemedu [17] that an increase in household members would help tackle and manage all processes of production that consider significant quantities for the market. At the upper median only, the cost of pesticides variable was found positive and significant in influencing the availability of marketed quantities to the markets. This makes sense

since potatoes are very sensitive to some kinds of diseases during production and regular pulverization was needed.The distance to the market was significant at a lower median, where a small number of farmers reported carrying potatoes to the markets so as to sell at good prices rather than selling at the farm gate as a majority do. The majority of farmers sell potatoes after harvest at the farm gate reducing the cost of transportation. In a similar study, Osugiri, et al. [16] and Kangile, et al. [18] found that one of the factors that influence farmers' choice of markets for staple food commodities is the distance to markets. Moreover, Mirie and Zemedu [17] found distance not influencing market participation and intensity of marketed quantities. Kyaw, et al. [19] observed that the volume of rice sold by smallholder farmers in the market is inversely related to the distance to the market, meaning that if the distance is long farmers have less quantities to take and supply the markets.

Table 1. Determinants of marketed quantities of potatoes.

Variables	Coefficients	Std. error	T	Significance
Q25				
Age of the HH	2.915	4.437	0.66	0.512
Education of the HH	43.451	32.906	1.32	0.187
Household size	51.972	38.178	1.36	0.174
Area allocated to potato (ha)	1449.700	282.407	5.13	0.000***
Farm price	-12.672	19.594	-0.65	0.518
Price information	-268.287	190.909	-1.41	0.161
Cost of potato seed/ha (MZM)	0.002	0.019	0.13	0.893
Cost of fertilizer /ha (MZM)	0.069	0.024	2.85	0.005***
Cost of pesticides (MZM/kg)	0.026	0.042	0.62	0.534
Cost of hired labour/ ha (MZM)	0.097	0.035	2.76	0.006***
Distance to the market	20.794	9.724	2.14	0.033**
Frequency of production	34.209	125.473	0.27	0.785
Extension service	-145.188	131.580	-1.10	0.270
Q50				
Age of the HH	8.484	7.523	1.13	0.260
Education of the HH	30.407	38.359	0.79	0.428
Household size	89.629	45.796	1.96	0.051**
Area allocated to potato (ha)	2685.992	762.566	3.52	0.000***
Farm price	-29.183	25.833	-1.13	0.259
Price information	2.458	307.135	0.01	0.994
Cost of potato seed/ha (MZM)	0.030	0.030	1.00	0.317
Cost of fertilizer /ha (MZM)	0.068	0.025	2.74	0.006***
Cost of pesticides (MZM/kg)	0.067	0.079	0.85	0.395
Cost of hired labour/ ha (MZM)	0.198	0.063	3.13	0.002***
Distance to the market	27.788	19.601	1.42	0.157
Frequency of production	103.008	163.593	0.63	0.529
Extension service	-70.996	207.616	-0.34	0.733
Q75				
Age of the HH	6.911	16.307	0.42	0.672
Education of the HH	92.368	81.193	1.14	0.256
Household size	112.856	83.895	1.35	0.179
Area allocated to potato (ha)	5219.017	802.782	6.50	0.000***
Farm price	11.128	39.490	0.28	0.778
Price information	-55.931	468.260	-0.12	0.905
Cost of potato seed/ha (MZM)	0.001	0.067	0.01	0.993
Cost of fertilizer /ha (MZM)	0.127	0.045	2.79	0.005***
Cost of pesticides (MZM/kg)	0.155	0.044	3.53	0.000***
Cost of hired labour/ ha (MZM)	0.267	0.073	3.64	0.000***
Distance to the market	60.299	45.566	1.32	0.186
Frequency of production	65.157	186.082	0.35	0.726
Extension service	-199.256	312.517	-0.64	0.524

Note: Dependent variable- Volume sales of potatoes (Marketed quantity),
** P<0.05
*** P<0.01
HH- Household head
Number of observations =453
Pseduo R2 = 0.25 (0.1611); 0.50 (0.2371); 0.75 (0.3807)
Median regression, bootstrap (20).

4.2. Constraints to Farmer's Marketed Quantities of Potato

Table 2 shows the constraints to marketed quantities of potatoes which were ranked in descending order of magnitude based on the farmers' perceptions. The percentages were computed under multiple responses: Incidence of Pests and Diseases (100%), Lack of Credit Access (100%), Lack of Certified Seed (100%), Lack of Collective Action on Setting Price (100%), Inadequate Storage Materials (100%), Poor Road Quality to Access Markets (79%), Lack of Funds to Hire Labour (36.2%), Low Level of Extension Services (36.9%), Inadequate Price Information (17.9%) and Inadequate Fertilizer Application (2%). In the study area, these are the major problems reported by the farmers.

Table 2. Constraints to marketed quantities of potatoes.

Variables	Frequency	Percentage
Incidence of pests and diseases	453.0	100.0
Lack of credit access	453.0	100.0
Lack of certified seed	453.0	100.0
Lack of collective action on setting price	453.0	100.0
Inadequate storage materials	453.0	100.0
Poor road quality to access markets	358.0	79.0
Lack of funds to hire labour (No)	164.0	36.2
Low level of extension services (No)	167.0	36.9
Inadequate price information (No)	81.0	17.9
Inadequate fertilizer application (No)	9.0	2.0

In terms of the constraints to potato production, Table 2 shows that pests, diseases, credits, certified seeds, collective actions on setting prices, and storage materials are the major problems that influence the quantity of potatoes available for marketing.

Some previous studies on food crop production and marketing emphasized some of these problems as the major ones, as well as inadequate market infrastructures, inadequate output price information, and extremes of weather events Mazza, et al. [15] and Osugiri, et al. [16].

5. CONCLUSIONS AND RECOMMENDATIONS

The study examined socio-economic factors that influence potato production and marketing behaviors over strategies applied by farmers through the use of a quantile regression model applied to 453 sampled households in the districts of Angonia and Tsangano in Tete province of Mozambique.

The results showed that area allocated to potato production, cost of fertilizer, cost of pesticides, cost of hired labour and distance to the main market significantly affected potato production and marketing in the study area. Information from producers also indicated that the selling price at the farm gate and even during the market day was very unstable, and hence making producers not to have a good future plan to improve the availability of agricultural production inputs.

Therefore, it is recommended that potato farmers should be supported by providing them improved planting materials, fertilizers at subsidized prices, mechanized method of cultivation, and availability of extension service officers that ensure regular contact with farmers to improve their methods of potato production.

These measures are already documented in several official reports in Mozambique and should be implemented. By doing so, more potato farmers would be attracted and encouraged to increase their participation in the potato market. Hence, this can reduce the deficit on potato supply compared to the actual demand.

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