# Explaining Marketing Strategies among Bolivian Potato Farmers

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## Abstract

Improving market access and promoting participation in more lucrative markets among semi-subsistence farming households is crucial for poverty alleviation. This paper analyzes joint decisions about market participation and market choices among Bolivian potato farmers. First, stochastic dominance analysis is used to identify market choices that have high pay-off and limited risk; these are referred to as optimal marketing strategies. Second, a system of equations is estimated to identify factors contributing or restricting market entry, volume sold, and adoption of optimal marketing strategies. Proportional and fixed transaction costs reduce income-generating opportunities associated with markets for all three dimensions considered in this study. Our analysis also suggests the possible existence of poverty traps since fetching higher price requires liquidity and high volume, while land and farm equipment are needed to achieve necessary volumes of production.

**Keywords**: market participation, volume sold, marketing strategy, potato, Bolivia
**JEL:** Q12, Q13

## 1 Introduction

Participation in agricultural markets is recognized as a sustainable path by which small-scale farmers can move out of semi-subsistence farming and poverty (BARRETT and SWALLOW, 2006). Markets are important engines for economic development, but markets need to be accessible to the poor if they are to benefit from market access-related economic growth. A successful transition from subsistence agriculture to a more market-oriented agriculture will benefit rural and urban households. Agricultural market participation, by contributing to rural poverty alleviation, will limit rural-urban migration and increase food supplies. Since market access is a powerful tool for poverty alleviation, determinants of participation and factors affecting quantity sold in markets need to be better understood.

Literature suggests that transaction costs are important barriers to market participation (ALENE et al., 2008; GOETZ, 1992; KEY et al., 2000; RENKOW et al., 2004). Trans-

action costs (TCs) can be categorized into fixed and proportional transaction costs. Fixed transaction costs (FTCs) include search costs (e.g. looking for a buyer or market price information), negotiation and bargaining costs, and costs of enforcing contracts. FTCs do not vary with the quantity sold and can be considered as a lump sum or tax equivalent. For example, search costs are the same whether a farmer wants to sell 100 kg or 1,000 kg of a crop. Proportional transactions costs (PTCs) are volume dependent. The major PTCs are the unit cost of transporting the crop to the market.

In the market participation literature, GOETZ (1992) was the first to differentiate between the decision of whether or not to participate in the market (a discrete decision) and the decision of how much to sell or buy (a continuous decision). This distinction reflects the reality that high fixed costs can prevent poor households from participating in the market. His theoretical model was applied using data from coarse grains producing households in Senegal. Results show that different variables affect the decision to participate in the market and that of how much to sell. KEY et al. (2000) build on GOETZ's work and identify the role of fixed and proportional transactions costs on marketing decisions. The authors show that both types of transactions costs impact market participation but that, conditional on market participation, the supply decision (i.e. how much to sell) is affected only by PTCs. The major implication arising from this study is that FTCs can be used to identify factors affecting selection into market entry.

PTCs usually depend on factors such as distance to market, infrastructure, and access to transportation assets while FTCs are more likely to depend on information variables. Therefore, the task of quantifying FTCs is more complex than for PTCs. PTCs can often be directly measured (e.g. through transportation costs) while FTCs cannot. RENKOW et al. (2004) develop a conceptual framework to quantify FTCs, expressed as a tax equivalent, semi-subsistence Kenyan maize farmers face. The FTC tax equivalent is defined as the "amount that a household must receive over its autarky price in order to cover the fixed transaction costs of market entry" (p. 352). The authors find that on average the FTC tax equivalent is 15 percent.

Market participation alone is not sufficient for households to fully enjoy gains from trade. As BOUGHTON et al. (2007) state, there are "sharp differences in the apparent returns to participation in different markets" (p. 65). Studies on market choice, while less common than studies on market participation, provide valuable information on factors explaining sales in more remunerative markets. For example, FAFCHAMPS and HILL (2005) identify factors distinguishing between the decision to sell at the farmgate (less remunerative) or travel to market (more remunerative) among Ugandan coffee farmers. They find that the probability of selling at market is positively associated with the quantity sold and proximity to the market. Wealthier farmers are less likely to sell

at the market, suggesting that they have higher opportunity costs of time than poor farmers. However, as quantity sold increases, poor farmers are less likely to travel to the market and wealthier farmers are more likely, suggesting that liquidity constraints restrain poor farmers. Wealthier farmers are also more likely to travel to distant markets. This has important implications since the price received can make the difference between long-term near subsistence and gradual exit from poverty traps (FAFCHAMPS and HILL, 2005).

BOUGHTON et al. (2007) examine whether participation in higher-return markets requires a different asset portfolio than participation in less remunerative markets for Mozambican farmers. Three crops were considered: i) maize, with a spot market characterized by high transaction costs and low returns; ii) cotton, where the market is a contracted cash crop with moderate risk and low transaction costs; and iii) tobacco which is a contracted production-market system with potential higher financial returns and risk. Results indicate that ownership/access to private assets, such as land, labor, and animal traction are positively associated with participation in all three markets. Sales for contract production of cash crops require a broader range of private assets such as livestock and equipment, suggesting that asset endowment may restrict participation in higher-return markets.

Most studies analyze market participation decisions or market choices. Having a rich household dataset from Bolivian potato producers and GIS data, we examine these different dimensions of household commercialization decisions. The objectives of this study are to: i) identify barriers to market participation; ii) identify factors influencing volume sold; and iii) identify determinants of participation in more lucrative markets. This study contributes to the literature by identifying barriers to market participation for Bolivian potato farmers and, conditional on market participation, means of stimulating sales. The study area is appropriate as robust markets have formed for highland potatoes and even relatively isolated producers can choose from alternative markets. We also analyze marketing choices, focusing on factors that explain ability to select the most lucrative but less risky markets, bringing a new dimension to the analysis of market choice. This requires resorting to stochastic dominance analysis, which to our knowledge is a novelty in the market participation literature. By jointly analyzing market participation and marketing choices, the study sheds light on the role of markets in poverty alleviation. We find that transaction costs faced by the household are the main barrier to market entry. Land holding has the greatest impact on volume sold. Those selling in distant markets achieve higher incomes without increased price-related risk. Geographic isolation and lack of marketable surplus and liquidity restrict entry into more remunerative markets.

The remainder of the paper is organized as follows. Section 2 describes the survey area, sampling and survey methods, and data on potato production and commercialization. The third section presents the conceptual framework. The empirical models are discussed in section 4. The econometric results and discussion are presented in the fifth section. The paper ends with concluding remarks.

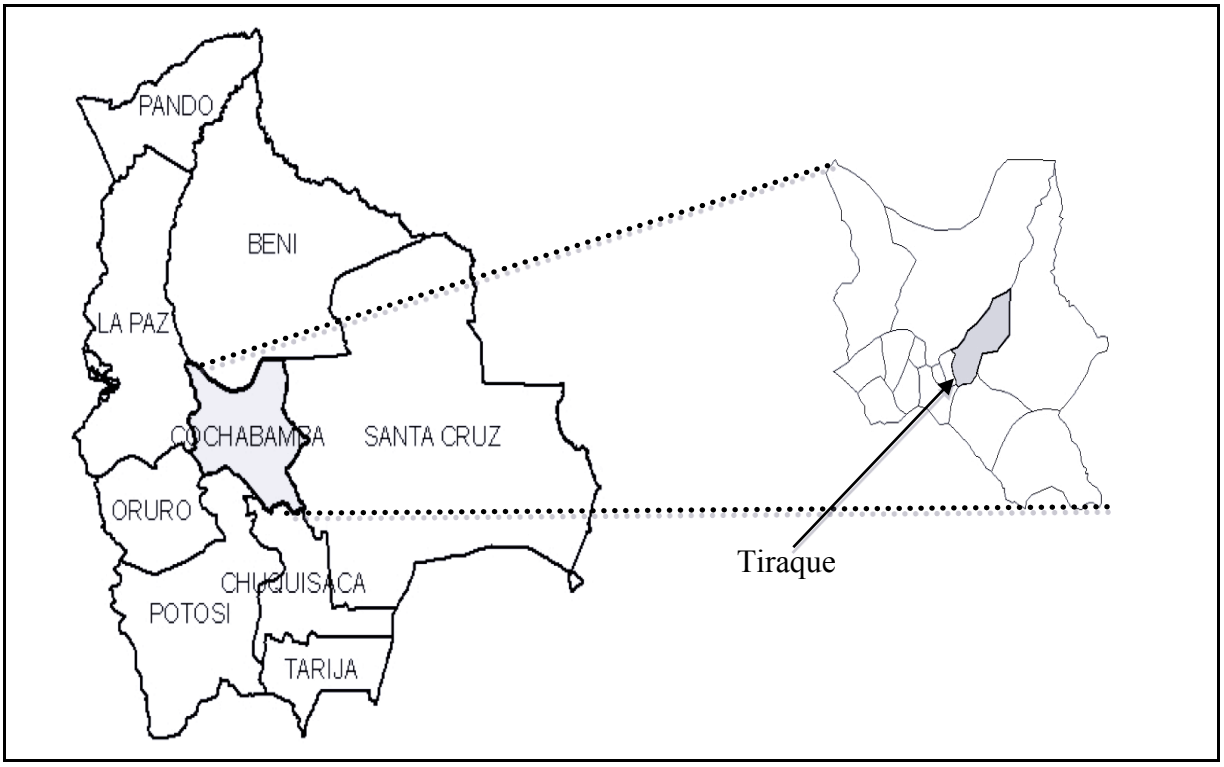
## 2 Study Area and Data

This study makes uses of data collected in the Jatun Mayu River watershed, Tiraque Department, Bolivia from August to December 2007 (Figure 1). The area is characterized by an arid and cold climate and mountainous terrain, with elevation ranging from 3,000 to 4,200 meters above sea level (masl). The economy depends on small-scale agriculture. Potato is the most important cash and staple crop but bean and cereal production and livestock are also common. The watershed is of particular interest because it is renowned for its production of the widely demanded "waycha" potato variety and Tiraque potatoes are sold in the major markets of Cochabamba and Santa Cruz (ALWANG and GANDARILLAS, 2012).

The sub-watershed of the Jatun Mayu River is divided into three zones according to elevation. The low, medium, and high elevation zones are composed of 2, 10, and 2 communities, respectively. Average community size is about 72 households and there are slightly over 1,000 households in the entire sub-watershed. The sampling methodology consisted of first stratifying the sample according to these three zones. Based on the total number of households living in each zone, the minimum number of farmers to be interviewed to provide a representative sample of the zone was computed. Then, farmers in each zone were randomly selected and interviewed. To complement the survey and achieve greater variation in distances to Tiraque markets, four communities located outside of the watershed boundaries were included. Overall, 43, 205, 37, and 104 households were randomly selected and interviewed in the low, medium, high, and outside zones. In total, the survey includes eighteen communities and 389 farmers.

The questionnaire comprised 24 modules that aimed at gathering information on household socio-economic conditions and demographics, main agricultural activities such as land area, input use and harvest, ownership of land and agricultural equipment, market participation decisions, revenues, and gender division of labor, among others. The latitude and longitude of the dwelling was recorded. This allowed us to obtain precise measures of travel-path distance from the dwelling to main markets. The average duration of the interview was two hours, and was conducted either in Spanish or Quechua.

**Figure 1. Map of Bolivia by provinces, and Cochabamba by departments**




Source: authors

We consider only households who reported cultivating potatoes, leading to a sample of 354 households[1]. Potato sales represent 79.5 percent of crop revenues and 49.5 percent of total household revenues (which includes revenues from other crops, livestock revenues, wages, remittances, etc.). Total annual average household income is 10,386 Bolivianos (Bs), equivalent to about $US 3,250. Ninety percent of households reported participating in the potato market and those who did sold on average 4,914 kg (equivalent to 64 percent of their production), keeping the remainder for own consumption and potato seeds. Important variations in quantity sold among households provide an opportunity to understand determinants of market participation and factors affecting volume sold.

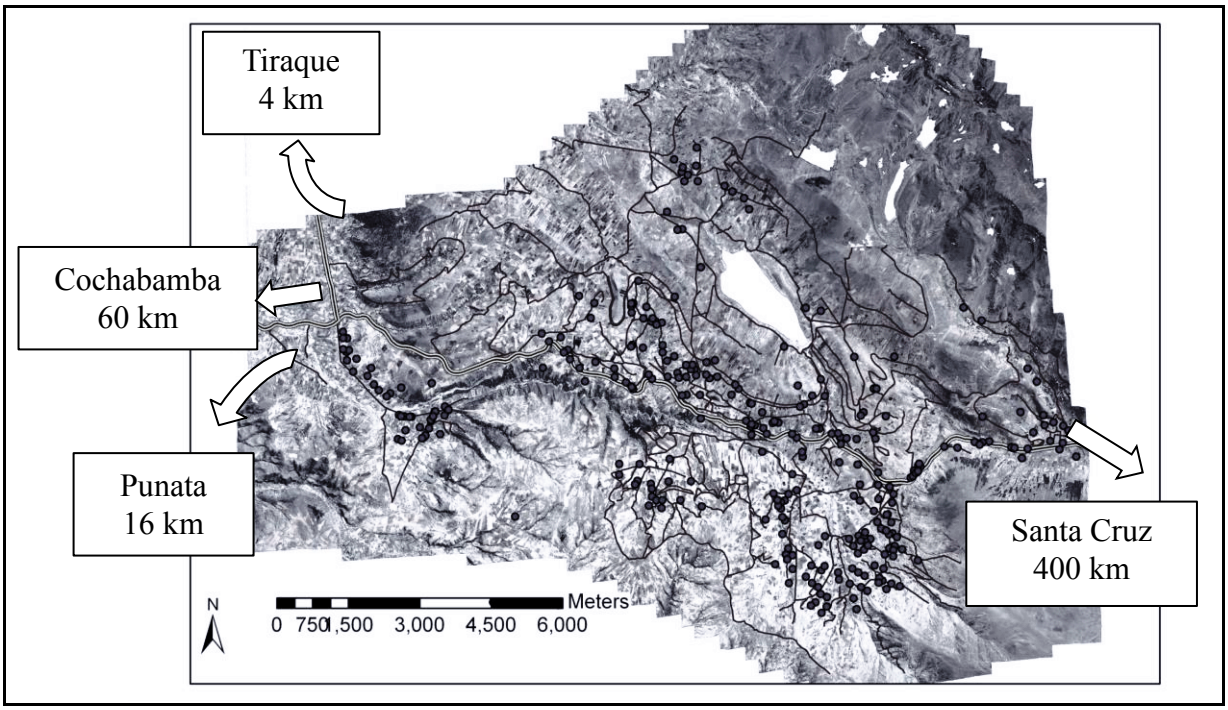
Potatoes are sold quickly after harvest since there is no storage facility in the area[2]. Sales occur at two local rural markets – Tiraque and Punata –, and two distant urban markets – Cochabamba and Santa Cruz. Average distances between households and

[1] After also eliminating few households that produce potatoes but had missing entries and potential outliers.

[2] In addition, potato weight decreases after harvesting, which motivates farmers to sell quickly.

Tiraque, Punata, Cochabamba, and Santa Cruz markets are 18, 36, 78, and 399 kilometers, respectively (Figure 2). Sales at the Tiraque market are the most common; 71.9 percent of market-participating households reported potato sales in this market. This is expected since the Tiraque market is nearest, and the least costly to reach. Among households participating in the markets, about 40, 19, and 8 percent reported sales in Punata, Cochabamba, and Santa Cruz markets, respectively. Selling at multiple markets is not uncommon; 24 percent, 7 percent, and 1 percent of farmers sold potatoes at two, three, and four markets, respectively.

**Figure 2. Study area, household location, and distance to markets**




Source: authors

For each transaction performed, information was collected on quantity sold and price received. Using these transaction-specific data, a household market average price was computed, weighted by volume transacted. Since we are interested in identifying the most lucrative marketing strategies, transportation costs must be factored in. For households selling potatoes in more than one market, a household average transportation cost was computed.[3] The (weighted average) market price net of (average) trans-

[3] Unfortunately, information on transactions for each specific location is not available. Instead, general information on where potatoes were sold during the season and how much was spent on transportation are reported. For households selling potatoes in more than one market, average transportation costs could not weighted by the volume sold in each market. This could result in under- or over-estimating the effective price (computation explained below) if volume sold across

portation cost is the *effective price*[4] (Table 1). On average, households received an effective price of 140 Bs per 100 kg of potato sold.

We use the term *marketing strategy* to define commercialization decisions relative to market choices. Having four markets to select from, where 1, 2, 3, or 4 markets can be chosen, and considering the different combinations leads to 15 exclusive marketing strategies. Of these 15 strategies, 13 were observed among our surveyed households (Table 1). Selling potato at the Tiraque market only is the most common strategy (43.0%), followed by selling at both local markets, Punata and Tiraque (17.5%). The third most common marketing strategy is selling potato at the Punata market only (15.3%), and the fourth one, at the Cochabamba market (5.7%).

**Table 1. Average household potato effective price[5] (BS/100 kg) by marketing strategy**

| Marketing Strategies | | % HH | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|---|
| 1 | Tiraque | 42.99 | 139.13 | 27.18 | 75.00 | 213.69 |
| 2 | Punata | 15.29 | 137.26 | 31.77 | 75.00 | 196.00 |
| 3 | Cochabamba | 5.73 | 144.15 | 30.78 | 86.73 | 185.00 |
| 4 | Santa Cruz | 4.46 | 133.56 | 22.50 | 108.57 | 183.54 |
| 5 | Tiraque/Punata | 17.52 | 140.35 | 31.30 | 82.00 | 246.50 |
| 6 | Tiraque/Cochabamba | 4.46 | 131.24 | 27.42 | 93.50 | 175.50 |
| 7 | Punata/Cochabamba | 0.96 | 132.95 | 14.32 | 120.29 | 148.50 |
| 8 | Tiraque/Santa Cruz | 0.32 | 190.50 | - | - | - |
| 9 | Cochabamba/Santa Cruz | 0.96 | 172.74 | 33.71 | 149.00 | 211.33 |
| 10 | Punata/Tiraque/Cochabamba | 5.41 | 147.42 | 21.63 | 87.00 | 175.67 |
| 11 | Punata/Tiraque/Santa Cruz | 0.64 | 169.97 | 3.34 | 167.61 | 172.33 |
| 12 | Tiraque/Cochabamba/Santa Cruz | 0.32 | 142.33 | - | - | - |
| 13 | Tiraque/Punata/Cochabamba/Santa Cruz | 0.96 | 120.25 | 55.92 | 64.50 | 176.34 |
| Sample | | 100 | 139.64 | 28.85 | 64.50 | 246.50 |

Source: computations based on household survey

markets differs greatly for a given household. We believe, however, that the risk of bias is minimal since 68 percent of households sold potato in only one market. Moreover, for households selling potato in more than one market, the most common marketing strategy is sales at Punata and Tiraque, and the per unit transportation costs to reach these markets are nearly identical.

[4] The weighted market price is the market price weighted by volume sold. For example, 100 kg of potatoes sold at 150 Bs/100 kg and 200 kg sold at140 Bs/100 kg corresponds to the weighted average market price of 143.33 Bs/100kg. Considering that sales took place in Punata and Cochabamba markets, where costs to market are 4 and 6 Bs/100 kg respectively, leads to an average transportation cost of 5 Bs/100 kg. Consequently, the effective sale price for this household would be (143.33-5)138.33 Bs/100kg.

[5] The average effective price is the difference between the weighted average market price and average transportation cost.

The correspondence between effective prices and marketing strategies reveals that the most lucrative marketing strategies are infrequently selected. The marketing strategy with the highest average effective price involves combined sales in Tiraque and Santa Cruz markets. However, only one household employed this marketing strategy. Farmers choosing – Cochabamba/Santa Cruz – and – Punata/Tiraque/Santa Cruz – as marketing strategies also received effective prices well above average, but again these marketing strategies were infrequently selected (Table 1). The marketing strategy resulting in the lowest effective price is selling potato in the four markets. Due to the importance of price received for poverty alleviation, it is crucial to investigate determinants and barriers to market choices and to focus on constraints to adopt most profitable and less risky marketing strategies.

## 3 Conceptual Framework

Our conceptual framework is based on KEY et al. (2000) and RENKOW et al. (2004). We assume that household maximizes expected utility, a function of consumption of potatoes ($C_P$) and other food and non-food items ($C_x$). Expected utility varies with exogenous household consumption shifters ($z^c$). Expected utility is maximized subject to three constraints: i) cash, ii) a resource balance constraint, and iii) the production technology. The constrained household maximization problem is represented by Equation 1:

*Max EU ($C_p$, $C_x$, $z^c$)* subject to:

$$\begin{aligned} &\text{C1. } \sum_{i=p,x} C_i P_i^m - R_p - T = 0 \\ &\text{C2. } \sum_{i=p,x} C_i + x_i + q_i^M = Q_i \\ &\text{C3. } G(Q_i, x_i; z^p) \end{aligned} \tag{1}$$

The cash constraint indicates that expenditures on consumption of potato and other goods ($\sum_{i=p,x} C_i P_i^m$) cannot exceed revenues ($R_i$) and transfers ($T$), where $P_i^m$ is the market price of potato and other goods. Revenues can be obtained from potato production, other farming activities and non-farm activities. Transfers are revenues available in the form of savings, remittances, and asset liquidation. The resource balance constraint ensures that amount consumed ($C_i$), used as input ($x_i$), and marketed ($q_i^M$) is equal to the quantity produced ($Q_i$). G is the production technology that relates inputs to outputs, and also depends on exogenous household production shifters ($z^p$).

Based on the conceptual framework, market participation is considered a choice variable, along with quantity consumed, produced, and used as input. Household-specific transaction costs play an important role in these decisions. For example, households with high transaction costs might opt for a more diversified production portfolio, leading to no or little marketable surplus. Those with low transaction costs are expected to achieve higher utility through specialization and thus, produce larger volume with more market orientation (OMAMO, 1998).

The market participation decision is made by comparing the expected utility derived from selling in the market from that of self-sufficiency while internalizing constraints. For simplicity, consider potato only and drop the subscript $i$. When comparing utility from market participation, utility is evaluated at the market price ($P^m$) minus PTCs and FTCs and at the autarky price ($P^a$). Since utility is increasing in price for sellers, the market participation decision can be simplified as follow (RENKOW et al., 2004).

$$\text{If } P^a < P^m - PTCs - FTCs, then\ M = 1\ \&\ q^M > 0 \quad (2.a)$$

$$\text{If } P^a \geq P^m - PTCs - FTCs, then\ M = 0\ \&\ q^M = 0 \quad (2.b)$$

The decision to participate in the market (M=0/1) depends on both FTCs and PTCs, and TCs can explain why some households fail to participate in the market (GOETZ, 1992; RENKOW et al., 2004). TCs reduce the price received by sellers, creating a wedge around the market price. The existence of TCs also means that a minimal quantity must be sold in order to cover the lump sum FTCs associated with market participation and make the decision to join the market profitable (DE JANVRY and SADOULET, 2006). Missing markets can occur when transaction costs are very high or marketable surplus minimal making it impossible to cover FTCs (KEY et al., 2000).

Farmers who participate in the markets are also subject to market price risk (FINKELSHTAIN and CHALFANT, 1991). Because of this uncertainty, some households might adjust their consumption decision, and thus market surplus, with changes in output price. Moreover, risk tolerance is expected to influence the optimal level of marketed output. More risk averse farmers might opt for a more diverse production portfolio, leading to little market surplus or autarky. Farmers can manage price risk to some extend by selecting degrees of self-sufficiency, where poorer farmers are more likely to opt for greater self-sufficiency (HELTBERG and TARP, 2002).

Once the decision to join the market is made, FTCs do not affect volume sold (KEY et al., 2000; RENKOW et al., 2004). However, since the output price and transaction costs vary by market, we must assume that the decision to join the market is market specific. For example, the potential higher output price in a distant market must be weighed against higher TCs and uncertainty. It might be more difficult to find price information

and enforce contracts in distant markets, increasing price uncertainty. Moreover, higher FTCs mean that greater volumes are required to make selling in distant markets profitable and transportation costs are greater, requiring additional liquidity (FAFCHAMPS and HILL, 2005).

In an attempt to disentangle these different effects on market choice, we employ stochastic dominance (SD) to analyze the correspondence between marketing strategies and effective prices. Based on the assumption that farmers are risk averse, utility is maximized by selecting the marketing strategy with the highest effective price and lowest variability. This requires resorting to second-order stochastic dominance (SOSD). First-order stochastic dominance (FOSD) can be used to identify the alternative with the highest paid-off while SOSD is required to identify the preferred alternative for a risk averse farmer, i.e. the alternative with the highest paid-off and lower variance. Since risk aversion is assumed, marketing strategies meeting the SOSD criterion are considered to be *optimal marketing strategies*. SOSD implies FOSD while the reverse does not hold.

SOSD requires two assumptions regarding utility: i) positive marginal utility, and ii) decreasing marginal utility for all values of x, where x is the effective price[6] of potatoes, which is bounded by $\underline{x}$ and $\bar{x}$, the lower and upper price recorded. Under SOSD, marketing strategy 1 ($MS_1$) dominates marketing strategy 2 ($MS_2$) if:

$$\int_{\underline{x}}^{x} F_1\,(x|MS_1)dx \leq \int_{\underline{x}}^{x} F_2\,(x|MS_2)dx \quad \textit{for all } x \textit{ in } [\underline{x}, \bar{x}] \tag{3}$$

where $F$ describes the cumulative distribution function. The 13 marketing strategies identified above are assessed against each other, and those that are not dominated according to the SOSD criterion are considered optimal. The expected utility associated with selecting an optimal marketing strategy will be greater than that for all other marketing strategies. Effective price should be higher and price uncertainty lower for marketing strategies that meet the SOSD criteria compared to those that do not.

## 4 Empirical Specification

The first order utility maximization problem described above can yield to three reduced form equations to explain household marketing decisions, which are represented by the flowing system:

[6] One could argue that price is endogenous. However, it has been considered as an exogenous variable in several studies on market participation (GOETZ, 1992; MATHER et al., 2013; RENKOW et al., 2004; STEPHENS and BARRETT, 2011).

$$y_1 = f(x_1, x_2, x_3, x_4, x_5 \mid \gamma) + \mu_1$$
$$y_2^* = f(x_2, x_3, x_4, x_5 \mid \beta) + \mu_2 \qquad \mu_1 + \mu_2 + \mu_3 \sim N(0, \Sigma) \quad \Sigma = \begin{bmatrix} 1 & \sigma_{12} & \sigma_{31} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & 1 \end{bmatrix} \Rightarrow \rho_1 * \rho_2 * \rho_3 \neq 0$$
$$y_3^* = f(y_2^*, x_1, x_2, x_5, x_6 \mid \delta) + \mu_3$$

$$X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} = \begin{bmatrix} FTCs \\ PTCs \\ Q \\ C \\ Z \\ I \end{bmatrix} \tag{4}$$

The first equation explains the discrete decision of whether to participate in the market ($y_1$). Conditional on market participation, the second and third equations represent quantity marketed ($y_2^*$) and market choice ($y_3^*$). More precisely, the dependent variable in third equation is a binary variable distinguishing between selecting an optimal versus suboptimal marketing strategy as defined in our conceptual framework. The vector $x_1$ represents FTCs, and $x_2$, PTCs. $x_3$ includes factors explaining potato production (Q). $x_4$ is a vector characterizing household consumption of potato (C), which is expected to vary with household composition and preferences. $x_5$ includes exogenous household shifters (Z). $x_6$ captures access to liquidity (I), and will depend on household revenues and transfers.

This system of equations has a selectivity and recursive component. Selectivity occurs since quantity marketed and market choice are observed only for market participants (i.e. if $y_1 > 0$). Handling autarkic behavior by assuming that volume sold is zero, without correction for potential selectivity, could lead to biased results (GOETZ, 1992). The same logic holds regarding modeling optimal versus suboptimal marking strategies. Recursiveness results from the fact that quantity sold, an endogenous variable, is a determinant of the market choice. Quantity marketed enters the market choice equation because larger volumes might be required to make selling in distant market profitable. This system could be estimated equation-by-equation but simultaneous estimation, by taking into account the full covariance structure of the error terms, will lead to more efficient estimates (ROODMAN, 2011). The assumption is that correlation ($\rho$) between equation errors is nonzero.

The first two equations, $y_1$ and $y_2^*$, are estimated using a Heckman type approach, controlling for potential selection bias (GOETZ, 1992). Market participation and volume sold are assumed to depend on PTCs, potato production and consumption, and household characteristics. PTCs are captured in our model by distances (km) from the

household to the Tiraque and Santa Cruz markets.[7] Physical distance to market is widely used in the literature to represent TCs (for examples, see GOETZ, 1992; KEY et al., 2000; RENKOW et al., 2004). Distance variables reflect the transportation costs of potatoes from the field to the market and the opportunity cost of time to reach the markets. Higher PTCs should reduce incentives to participate in the market, and might negatively affect quantity sold. Factors explaining household productive capacity are farm size (ha), value of agricultural equipment (Bs), and labor force. Labor consists of three variables: i) household size, ii) share of laborers, i.e. the number of persons in the economically active age (15-65 years old) divided by household size, and iii) share of male household members, i.e. number of males divided by household size. *Ceteris paribus*, households with greater productive capacity should be in a better position to generate market surplus, and thus more likely to participate in the market. Conditional on market participation, these variables should also be positively associated with quantity marketed. These three labor variables are also considered determinants of potato consumption. Consumption should increase with household size, the share of economically active age members, and the share of male members, reducing quantity available to be sold in the markets. Household exogenous shifters considered are age[8], education, and gender of the household head, which represent preferences for quantity produced, consumed, and marketed. These variables are also indicators of human capital and might affect production and transaction costs (discussed below).

FTCs influence the market participation threshold and variability in them will help identify the effect of market choice on quantity sold. Higher (lower) FTCs require larger (smaller) quantity for households to enter the markets, such that FTCs can be spread over more units. Once the decision of selling in a market is made, FTCs become irrelevant to quantity sold (de Janvry and Sadoulet, 2006). As a result, FTCs are used as exclusion restrictions; they are included in the market participation equation but excluded from the equation explaining quantity sold. Since FTCs are not directly observable, observed exogenous factors affecting these costs are included in the FTC vector. Variables considered are radio ownership, population density[9], and

[7] Due to the high correlation between distances to various markets, we employ distance to the closest and most frequently visited market (Tiraque) and the farthest market (Santa Cruz). Colinearity between distance to Tiraque and to Santa Cruz is lower since the two markets are located in opposite directions. Distance to Santa Cruz is normalized by the distance to Tiraque.

[8] Potential non-linearity in the influence of age on commercialization decisions is considered by including age and its square in all equations.

[9] Population density was obtained by combining the household location with GIS data of population density in 2000 from http://www.diva-gis.org/gdata. The raster file has cells with 30 seconds resolution (~0.8km$^2$).

bicycle ownership[10]. Owning a radio can facilitate access to market price information (SVENSSON and YANAGIZAWA, 2009; ZANELLO, 2012). Obtaining market price information is easier in more densely populated areas as information spillovers are more likely (BARRETT, 2008). The majority of households in our sample (~73%) reported friends, family, and neighbor as main sources of price information. Therefore, the cost of acquiring such information should be lower for those living in more densely populated areas and owning a bicycle. Ownership of transportation mode has frequently been used in the literature to explain FTCs. For examples, GOETZ (1992) used ownership of carts, KEY et al. (2000), pick-up truck, and RENKOW et al. (2004) considered several transportation modes (truck, bicycle, and animal).

Several other observed factors included in our model such as distance to markets and household head characteristics can also influence FTCs but cannot be used as exclusion variables because they might directly affect quantity sold. About 19 percent of households reported obtaining output price information by visiting the markets, which is less costly to acquire for those living nearby markets. Education should make accessing and processing information easier, reducing FTCs, and which in turn should stimulate market entry. Older household heads might have better established networks, which should also facilitate obtaining market price information. In sum, less costly market information effectively lowers FTCs increasing the probability of market participation. In addition, access to market information can reduce perceived price risk and increase farmers' bargaining power, which will in turn stimulate market entry (BOUGHTON et al., 2007).

The third regression($y_3^*$) explains the selection of an optimal marketing as a function of quantity sold, FTCs, PTCs, access to liquidity, and household shifters. This decision is estimated using a probit model while considering the endogenous nature of quantity sold and selectivity. The variables capturing household productive capacity and demand for potatoes served as instrumental variables for quantity sold since marketable surplus is the difference between household production and consumption of potato. These variables (farm size, value of equipment, household size, share of laborers, and share of male household members) should not influence adoption of an optimal marketing strategy other than through their impact on volume sold. The magnitude of the FTCs and PTCs is expected to vary with markets, and increase with distance to markets. If FTCs are high enough, it might discourage some from joining these markets. As volume sold increases, we expect households to be more willing to travel to distant markets as fixed costs can be spread over a larger volume. However, larger quantity transacted and sales in distance markets imply larger PTCs, which might require

[10] None of the households in our sample reported bicycle as the mode of transportation of potato to the market. Therefore, bicycle ownership should be irrelevant in explaining PTCs.

greater liquidity. FAFCHAMPS and HILL (2005) found that as quantity sold increases, wealthier farmers are more likely to travel to distant market but poor farmers are less likely. This suggests the presence of liquidity constraints. Liquidity is captured here using two variables: i) a dummy indicating whether there is a wage earner in the household, and ii) household wealth, measured by the value of livestock ownership. For rural households in developing countries, livestock ownership is a common means of storing wealth, and, when needed, can be converted into cash. Distant markets are more costly to reach meaning that liquidity-constrained households might not be able to participate in them.

# 5 Results

## 5.1 Descriptive Statistics and SOSD

Descriptive statistics support the *prima facie* hypothesis that transaction costs restrict market participation. Market participants are statistically more likely to own a radio (83 vs. 51%), a bicycle (64 vs. 46%), and live in more densely populated areas (16 vs. 12 individual/0.8km$^2$) than autarkic farmers (Table 2). Market participants also reside significantly closer to Tiraque than non-participants (17.9 vs. 21.4 km). Moreover, market participants own significantly more land (2.2 vs. 1.0 ha) and agricultural equipment (value of 1,979 vs. 452Bs) than self-sufficient farmers, highlighting the positive correlation between household productive capacity and ability to produce marketable surplus. Household size, the share of laborers, and share of male household members do not statistically differ between the two groups. Household head characteristics do not significantly differ by market participation. About 86 percent of households are male-headed, where 16 percent of heads have no formal education, 78 percent some primary education, and 5 percent attended secondary school.

A pairwise comparison of marketing strategies[11] was performed and those dominated according to the SOSD criterion were eliminated. Four marketing strategies comprised the efficient set: 1) Santa Cruz, 2) Cochabamba, 3) Punata/Tiraque/Cochabamba, and 4) Punata/Tiraque/Santa Cruz. These strategies consist of either selling solely at one urban/distant market or combining sales in both rural/local and urban/distant markets. Only 11 percent of market participating households[12] selected one of the four optimal

[11] Two marketing strategies, i.e. Tiraque/Santa Cruz and Tiraque/Cochabamba/Santa Cruz, were selected by only one household making it impossible to compute their CDFs and integrals, and thus were omitted from the SOSD analysis.

[12] Three households were dropped from the previous estimations due to unavailable market information.

marketing strategies (high price, low variance), suggesting the existence of market constraints.

**Table 2. Summary statistics of variables explaining market participation and volume sold**

| Variables | Sample | Non-market participants | Market participants |
|---|---|---|---|
| | Mean | Mean | Mean |
| Market Participation (1=Yes) | 0.90 | - | - |
| Quantity sold (kg) | 4 400.80 | 0.00 | 4 914.45 |
| Population density (pop/0.8 km$^2$)*** | 15.54 | 11.97 | 15.95 |
| Radio ownership (1=Yes)*** | 0.80 | 0.51 | 0.83 |
| Bicycle ownership (1=Yes) ** | 0.62 | 0.46 | 0.64 |
| Distance to Tiraque (km) ** | 18.27 | 21.36 | 17.91 |
| Distance to Santa Cruz[a] | 27.04 | 27.12 | 27.03 |
| Household size | 5.63 | 5.70 | 5.62 |
| Share of laborers HH members | 0.58 | 0.55 | 0.59 |
| Share of male HH members | 0.46 | 0.46 | 0.46 |
| Agricultural equipment (Bs)*** | 1 820.25 | 452.38 | 1 979.90 |
| Farm size (ha)*** | 2.07 | 1.02 | 2.19 |
| HH head age | 46.86 | 46.68 | 46.88 |
| HH head gender (1=Male) | 0.86 | 0.78 | 0.87 |
| *HH head education* | | | |
| None | 0.16 | 0.19 | 0.16 |
| Primary | 0.78 | 0.76 | 0.79 |
| Secondary or higher | 0.05 | 0.05 | 0.05 |
| Number of observations | 354 | 37 | 317 |

Notes: ***, **, * signifies that means between market and non-market participant households are statistically different at the 1, 5, and 10 percent. [a] Distance to Santa Cruz is normalized by distance to Tiraque. HH= Household.

Source: computations based on household survey

Possible constraints to selecting an optimal marketing strategies include low marketable surplus, high fixed and proportional transaction costs, lack of liquidity, high opportunity costs of time, etc. Households adopting an optimal marketing strategy had statistically greater market surplus (8,793 vs. 4,335 kg) than those with suboptimal market choices (Table 3). The former group is more likely to own a radio, a bicycle,

and live in more densely populated areas, an indication of lower fixed transaction costs. Distance to reach the Tiraque market is similar for households with optimal and non-optimal marketing. However, those making optimal market choices reside closer to Santa Cruz relative to Tiraque. For these households, the distance to reach the Santa Cruz market is about 24 times greater than to get to Tiraque market while this ratio increases to 28 for those selecting suboptimal marketing strategies. Household head characteristics also differ significantly accordingly to household marketing strategy. Households adopting an optimal marketing strategy are more likely to be male-headed (95% vs. 86%), and the head is less likely to have no formal education (8% vs. 17%) and more likely to have attended primary school (89% vs. 77%). The value of livestock ownership is higher among adopters of an optimal marketing strategy (14,016 vs. 11,660 Bs).

**Table 3. Summary statistics of variables explaining selection of optimal marketing strategy**

| | **Sample** | **Sub-optimal MS** | **Optimal MS** |
|---|---|---|---|
| Variables | Mean | Mean | Mean |
| Quantity sold (Kg)*** | 4 874.94 | 4 335.45 | 8 793.34 |
| Population density (pop/0.8 km$^2$)** | 15.93 | 15.64 | 18.00 |
| Radio ownership (1=Yes)*** | 0.83 | 0.82 | 0.95 |
| Bicycle ownership (1=Yes) *** | 0.64 | 0.62 | 0.82 |
| Distance to Tiraque (km) | 17.89 | 17.87 | 17.97 |
| Dist. to Santa Cruz[a] *** | 27.10 | 27.58 | 23.55 |
| HH head age | 46.87 | 47.40 | 43.05 |
| HH head gender (1=Male)** | 0.87 | 0.86 | 0.95 |
| *HH head education* | | | |
| None* | 0.16 | 0.17 | 0.08 |
| Primary** | 0.79 | 0.77 | 0.89 |
| Secondary or higher | 0.05 | 0.06 | 0.03 |
| Livestock value (Bs)* | 11 945.33 | 11 660.20 | 14 016.29 |
| Wage earner (1=Yes) | 0.45 | 0.45 | 0.47 |
| Number of observations | 314 | 276 | 38 |

Notes: ***, **, * signifies that means between households selecting an optimal vs. sub-optimal marketing strategy are statistically different at the 1, 5, and 10 percent. [a] Distance to Santa Cruz is normalized by distance to Tiraque. MS= Marketing strategy, HH= Household.

Source: computations based on household survey

## 5.2 Econometric Analysis

The system of equations was estimated using a limited-information maximum likelihood (FIML) estimator[13]. A Wald test for the overall performance of the model is chi-squared distributed with a p-value of zero, suggesting the strong explanatory power of the right-hand side variables (Table 4). The test for the independence of the error terms between Equations 1 – market participation – and Equation 2 – volume sold – has a p-value of 0.07, suggesting that selection bias might be of concern when explaining quantity sold. The hypothesis of independence of the error terms between equations one and three (optimal marking strategy) is also rejected (p-value of zero), justifying controlling for selectivity bias. In both cases, the rho term ($\rho_{12}$ $and$ $\rho_{13}$) is negative indicating that unobservable preferences and characteristics negatively influencing market participation positively affect quantity sold and the selection of optimal marketing strategies. Marginal effects and corresponding standard errors[14] for the selection equation, i.e. for the discrete decision of whether or not to participate in the potato market, quantity sold, and adoption of an optimal marking strategy are presented in Table 4.

### 5.2.1 Market Participation Decision

A test that TCs variables are jointly equal to zero is rejected (p-value =0), indicating that fixed and proportional transactions costs have significant influences on market participation. In addition, when tested individually, all marginal effects are statistically different from zero (at p-value < 0.1) with the exception of radio ownership. A one-unit increase in population density (population/0.8 km$^2$) is associated with a 0.6 percentage point increase in the likelihood of joining the market while owning a bicycle increases the probability of market participation by 3.6 percentage points. These results support the assertion that lower search costs related to market price information facilitate potato market participation. As expected, distance to markets is a strong and negative predictor of market participation. A one-kilometer increase in the distance between the dwelling and the Tiraque market decreases the probability of market participation by 1.2 percentage point. Distance to the Santa Cruz market also reduces the likelihood of market entry as indicated by its highly significant and negative coefficient. These results suggest that household economic isolation reduces income-generating opportunities associated with market participation.

[13] Estimation was performed in Stata 13 using the user-written command 'cmp' (ROODMAN, 2011).

[14] Standard errors are made robust and clustered at the zone-level. The sampling design was clustered in four zones, based on differences in altitude within the survey area. Agricultural production and access to market vary across zones but are correlated within zones.

Household composition can affect market participation through two mechanisms: potato consumption and labor available for potato production. Household size, the share of laborers, and the share of males are jointly significant in explaining market participation. In terms of individual coefficients, only the share of male members is significant and positive in explaining market participation. This might indicate that production effect dominates the consumption component. Value of agricultural equipment and farm size, also related to productive capacity, are not significant in explaining the decision to enter the markets.

**Table 4. Marginal effects for the decision to participate in the market, volume sold, and selecting optimal marketing strategies**

| | **Market Participation** | | **Volume sold** | | **Optimal MS** | |
|---|---|---|---|---|---|---|
| Variables | dy/dx | P-value | dy/dx | P-value | dy/dx | P-value |
| Radio ownership (1=Yes) | 0.055 | 0.22 | | | 0.022 | 0.12 |
| Pop. Density (pop/0.8 km$^2$) | 0.006 | 0.03 | | | 0.001 | 0.08 |
| Bicycle ownership (1=Yes) | 0.036 | 0.04 | | | 0.049 | 0.12 |
| Distance to Tiraque (km) | -0.012 | 0.00 | -272.49 | 0.00 | -0.007 | 0.00 |
| Distance to Santa Cruz [a] | -0.005 | 0.00 | -101.08 | 0.00 | -0.009 | 0.00 |
| Household size | -0.004 | 0.48 | -20.86 | 0.90 | | |
| Share of laborers HH members | 0.064 | 0.20 | -1327.97 | 0.14 | | |
| Share of male HH members | 0.072 | 0.06 | -3078.52 | 0.02 | | |
| Ag. equipment (1,000 Bs) | 0.054 | 0.37 | 605.28 | 0.03 | | |
| Farm size (ha) | 0.040 | 0.30 | 887.00 | 0.00 | | |
| HH head gender (1=Male) | -0.047 | 0.01 | 1426.67 | 0.00 | -0.059 | 0.00 |
| *HH head education (Base=none)* | | | | | | |
| Primary | 0.049 | 0.27 | -8.96 | 0.96 | 0.040 | 0.52 |
| Secondary & + | 0.146 | 0.00 | -1057.60 | 0.02 | -0.004 | 0.96 |
| HH head age | 0.001 | 0.00 | -41.13 | 0.00 | -0.001 | 0.70 |
| Livestock value (1,000Bs) | | | | | 0.004 | 0.04 |
| Wage earner (1=Yes) | | | | | 0.012 | 0.62 |
| Volume sold (1,000 kg) | | | | | 0.020 | 0.00 |
| | **Coeff.** | **P-value** | | | | |
| $\rho_{12}$ | -0.62 | 0.07 | | | | |
| $\rho_{13}$ | -0.57 | 0.00 | | | | |
| $\rho_{23}$ | 0.34 | 0.52 | | | | |
| Log pseudolikelihood | -3314.29 | | | | | |
| Chi-squared | 7.97E+09 | | | | | |
| Prob > chi2 | 0 | | | | | |

Notes: standard errors are made robust and clustered at the zone-level. [a] Distance to Santa Cruz is normalized by distance to Tiraque. MS=Marketing Strategy, HH= Household.

Source: based on household survey

Household head characteristics are jointly and individually significant in explaining the market participation decision. Male-headed households are about 5 percentage points less likely to participate in markets compared to female-headed households. This is not surprising considering that women are responsible for marketing potatoes in Bolivia (URQUIETA and ALWANG, 2012). Households whose head attended secondary school are 14.6 percentage points more likely to participate in the potato market than households whose head is uneducated. This result is consistent with BARRETT (2008) who reports that insufficient education can be a barrier to market entry. Last, the age of the household head has a positive impact on market entry.

### 5.2.2 Volume Sold

PTCs strongly influence volume sold, an indication that welfare losses are associated with isolation from markets. A one-kilometer increase between the dwelling and the Tiraque market reduces volume transacted by 272 kg, representing a reduction in volume sold of 5.5 percent at sample mean. As the distance to Santa Cruz relative to the distance to Tiraque increases by one-fold, the quantity of potato sold decreases by about 100 kg. Our results conform to previous studies reporting that quantity transacted is reduced as distance to market increases (ALENE et al., 2008; OUMA et al., 2010). Transportation-induced transaction costs influence agricultural productivity by altering relative prices and influencing input use (STIFEL and MINTEN, 2008). JACOBY and MINTEN (2009) also note that chemical fertilizers and modern agricultural techniques, such improved planting and weeding methods, are less likely to be adopted in remote areas, where remoteness is defined based on transport costs. Thus, remoteness from markets might have additional negative effects on volume sold (other than through higher transportation costs) through its impact on input use, productivity and marketable surplus.

Our results indicate a negative relationship between volume transacted and consumption of potato and a positive association with productive capacity, supporting the choice of variables explaining marketable surplus. Once the household made the decision to join the potato markets, a 10 percent increase in the proportion of men within the household reduces market surplus by 308 kg. Household productivity capacity is an important determinant of variation in volume sold. Consistent with prior studies, we find a strong and positive association between land holding and marketable surplus (CADOT et al., 2006; HELTBERG and TARP, 2002). A one-hectare increment in farm size increases volume sold by 887 kg (about 18 percent). Ownership of equipment also stimulates volume transacted, as an increase of 55 percent in the value of farm equipment is associated with an increase of 14 percent of potato sold.

Household headship is a significant determinant of volume transacted. *Ceteris paribus*, quantity sold is 1,426kg greater for male- compared to female-headed households. This result might indicate that female household heads are more concerned about food security than male household heads, retaining a larger share of the harvest for own consumption, despite being more likely to participate in the market. Ouma et al. (2010) also find a significant and negative relationship between female-headed households and quantities transacted, which the authors explain by female-headed households being more negatively affected by transaction costs. Our conclusion about concerns for food security is supported by the data. Female-headed households consume 40.8 percent of their harvest compared to 28.5 percent for male-headed households. An F-statistic indicates that the difference is statistically significant, with a p-value inferior to 0.01. Share of potato seeds preserved for the following season is about 12 percent for both female- and male-headed households, and thus does not contribute to this gender discrepancy.

Households headed by a member who attended secondary school sold significantly less potatoes (1,058 kg) compared to those headed by an uneducated member (only 5 percent of household heads have any secondary education). This result might indicate that more remunerative economic opportunity emerge with education, inducing a shift away from agriculture. The age of the head has a negative impact on volume sold; an additional year reduces quantity sold by about 41 kg. This suggests that the aging of the household head, while positively affecting market entry, reduces household's ability to produce a market surplus.

### 5.2.3 Selection of Optimal Marketing Strategies

While higher revenue should be obtained when selecting one of the optimal marketing strategies, only 11 percent of the households made this choice. Barriers to access to more lucrative markets or combinations of markets warrant further investigation. As previously discussed, the instrumental variables have strong power in explaining variations in volume sold.

As expected, quantity sold is a significant and positive factor explaining selection of an optimal marketing strategy. The probability of making an optimal market choice increases by 2 percentage points for every additional 1,000 kg of potato sold. Since all optimal marketing strategies imply sales at distant markets, this might indicate that greater volumes are required for the benefits to outweigh the higher fixed and intangible costs of traveling to distant markets.

Fixed and proportional transaction costs are jointly significant determinants of choice of marketing strategy.[15] However, when examining coefficients individually, radio and bicycle ownership are found to be insignificant (p-value = 0.12). Population density has a positive impact on the probability of selecting an optimal marketing strategy, in line with survey data indicating that friends, family, and neighbors are important sources of market price information. Living one kilometer farther from Tiraque decreases the probability of selecting an optimal marketing strategy by 0.7 percentage points. As the distance to Santa Cruz increases relative to Tiraque, the probability of making optimal marketing choices decreases. These results confirm our previous findings concerning the cost of economic isolation.

Household head characteristics have a significant influence on market choice, as indicated by a Wald test for the joint significance of these variables (p-value of zero). However, when tested individually, only the coefficient on gender is significant. Female-headed households are about 6 percentage points more likely to select an optimal marketing strategy compared to male-headed households. In Bolivia, women dominate potato markets, both as sellers and traders. Women are responsible for negotiating prices and concluding sales. Women are believed to have better bargaining skills and the majority of wholesalers are women (URQUIETA and ALWANG, 2012).

Variables capturing access to liquidity, i.e. wage earner in the households and value of livestock ownership, are jointly significant (p-value near zero). As expected, livestock ownership has a positive impact on selecting an optimal marketing strategy. An additional 1,000Bs in the value of livestock ownership increases the probability of making an optimal market decision by about 0.4 percentage points (average livestock ownership value for market participating households is about 12,000 Bs). Assuming that livestock ownership is good proxy for household wealth and liquidity, this result indicates that a financial threshold might exist for households to bear transportation costs associated with reaching more distant markets. Since optimal marketing strategies involve sales in distant markets, this limitation might prevent liquidity-constrained households from engaging in optimal strategies.

## 6 Conclusions

Many highland Bolivian farmers are dependent on potato production and sales for their livelihoods. Participation in more lucrative potato markets is a potential route out of poverty and evidence shows that substantial benefits can come from promoting access to markets that have high pay-off and limited risk. The analysis in this paper examined

[15] Joint tests for PTCs, FTCs, and combining PTCs and FTCs have p-value equals to zero.

constraints to market participation and how households make decisions about the location and quantity of potato sales. Results indicate that market participation is influenced by fixed and proportional transactions costs. Distance to lucrative markets is an important obstacle, but better access to information can help overcome distance-related barriers. Better-educated farmers are more likely to sell potatoes at market, but the decision of how much to sell is determined, in part, by household productive capacity. Larger productive areas and more agricultural assets lead to more frequent use of an optimal marketing strategy. Optimal marketing strategies are more likely when transaction costs are low, volume sold is relatively high, and the household has a certain level of wealth and liquidity.

Based on these findings different avenues can be explored to stimulate market participation, increase marketed surplus, and promote more lucrative sales. Interventions that disseminate timely and accurate market price information, such as radio price broadcasting or use of text message-based techniques, can improve information and allow farmers to take advantage of available market opportunities. Access to markets can be enhanced by coordination of producer/seller groups in order to negotiate favorable transport costs and transport schedules. By grouping together, smaller-scale farmers might be able to achieve the scales necessary to sell in more distant markets. In addition, to reducing transaction costs, collective marketing can increase bargaining power, price received, and household income (FISCHER and QAIM, 2014). The *sindicato*, an important form of farmer organization mainly used for technology transfer (URQUIETA and ALWANG, 2012), could be exploited to promote market-oriented organization. The *sindicato* can also be used to diffuse more productive management techniques and boost potato production among area farmers. Low sales volumes are major constraints to adoption of optimal marketing strategies and steps to increase marketed surplus are likely to benefit area farmers.

The analysis suggests the possible existence of poverty traps since selling in lucrative markets requires liquidity and high production volumes. This volume, in turn, requires land and farm equipment. Since land is a limited asset, alternative means of boosting productivity will be essential to spread the economic benefits of market participation. These might include technical assistance and micro-finance programs. Facilitating access to credit will help with the acquisition of agricultural tools and high productivity inputs needed to boost agricultural productivity. It could also attenuate the liquidity constraints, facilitating adoption of more profitable marketing strategies.

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