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# Access to information and farmer's market choice: The case of potato in highland Bolivia

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**Abstract**

Potato incomes are critical determinants of Andean farmers' household well-being. Efforts to improve incomes of producers should recognize the role of access to market information. In highland Bolivia, market information has entered the digital age. Cell phones are ubiquitous, and networks lubricated by cellular technologies are affecting traditional means of gathering information. Andean markets are characterized by the heavy involvement of women. Lower information costs could change market choices and roles of men and women. This study explores the effects of information access on market choice near Cochabamba. It diagnoses the roles of men and women and investigates decision-making and changes in it.

The research confirms the importance of gender and cell phones to market access. Market decisions are made jointly by men and women, but women take a leading role in marketing. Women dominate marketing by negotiating favorable prices with buyers who are also women. Marketing networks have not changed substantially since the introduction of new information technologies. While cellular technology has broadened access to information and quickened its flow, it has not fundamentally changed network structures.

The study provides recommendations about improving competitiveness of small-scale potato producers: (1) increasing access to information by expanding the information content of existing networks; (2) expanding cell phones access; (3) consideration of the important roles intermediaries play; and (4) more technical support for market and information access.

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**Keywords**
Bolivia, cell phones, gender roles, information, potato market, social networks

## Introduction

Markets are transmission mechanisms between growth in the wider economy and the lives of the poor. They help determine the speed and extent of poverty reduction and create linkages between local, national, and global economies. However, markets can fail, and they often fail for the poor (Department for International Development (DFID), 2000). Markets may fail when some are unable to access them or can only access them on unfavorable terms. In rural areas of developing countries, markets may be too thin — leading to market power by agents — or the risks and costs of participating may be high (Hussain, 2003). Imperfections in information markets make costs of obtaining reliable information prohibitively high, creating welfare losses for participants and barriers to entry for others (DFID, 2005).

In the Andean region of South America, most communication is still oral, and people obtain their information from informal social networks. These networks have become expressions of individual and group social capital that support members in production and marketing. Although social networks continue to be important for acquiring information, they are being transformed by forces such as increased market integration (Escobal, 2001). As producers in remote areas become more integrated into regional markets, the value of information to them increases and new information sources emerge. To increase incomes and reduce vulnerability, disadvantaged populations need better access to information and markets (Alwang, Siegel, & Jorgensen, 2001).

Market failure is more likely to be severe and distorting when there is asymmetric or missing information (Tracey-White, 2003). Improved telecommunications can lower the cost of acquiring information, lower risks, and improve market efficiency. These services can offer previously unconnected farmers access to up-to-date price information and broaden market participation (Ferrand, Gibson, & Scott, 2004).

Time and money can be saved by substituting travel to markets with telecommunications, and these savings can be especially important for small-scale sellers. Information and communication technologies (ICT) allow potential participants to gather and communicate information through means such as radio, cell phones and computer networks. ICT reduce costs of connecting buyers and sellers. These cost savings, combined with quick access to information and instant communication with trade partners, open new market possibilities (Lyon, 2004).

Gender may also affect market access; networks linking farmers to markets may be dominated by men or women. Gender biases can affect the quality of information received as well as bargaining power. Knowledge and information embodied in different stages of a value chain may be gender-specific. As a result, market access can be affected by the channels by which men and women receive information. In fact, some evidence points to significant gender disparities in access to ICT (World Bank, 2008).

Bolivia's rural reality is framed in traditional agriculture characterized by small production units, traditional technologies, and low productivity (Alemán, 2002). Throughout the Andes, men and woman jointly participate in agricultural activities, and women's contribution to food production is significant (Grynspan, 1999; Duryea, Jaramillo & Pagés, 2002). In rural highland Bolivia, agriculture is the main economic activity of women, and about 84% of the female working population is engaged in agricultural-related activities (Instituto Nacional de Estadistica (INE), 2000; Alemán, 2002). Women dominate Andean potato markets as buyers and sellers, but female potato producers tend to confine themselves to local markets, where access and networks are easier for them to negotiate. Reliance on traditional networks in familiar markets, however, may limit the ability to receive higher prices. Furthermore, discriminatory cultural attitudes may prevent women farmers from entering higher-valued market chains (World Bank, 2007).

This study's three objectives were to explore the role of social networks and gender in market information in potato markets in the Jatun Mayu watershed, located in Tiraque Province, near Cochabamba, Bolivia. The objectives are to (1) analyze and describe the roles of men and women in potato production and marketing; (2) understand how marketing decisions are made and how gender roles and access to information affect these decisions; and (3) explore the effects of new information technologies on gender relations, access to information, and marketing decisions.

**Literature Review**

The topic of market access has received little attention in literature on Bolivian agriculture. Reports include descriptions of crop supply chains with information about prices, infrastructure, and market locations (Guidi & Mamani, 2000). Little is known about why producers choose specific markets and how access to information affects market choices. There is evidence from Bolivia of gender biases in market access, but the specific relationship between gender and marketing strategies has received little attention (Figueroa, 2008).

Women deserve special attention when addressing agricultural market access because they make up a disproportionate share of the poor in developing countries (Cox, Farrington & Gilling, 1998), and they make up a large proportion of poor farmers (Doss, 2001). In addition, women are at a disadvantage compared to their male counterparts because of lower levels of asset ownership; higher stress on their time; less secure property rights, including formal titles to their land; and less access to markets, extension, and new technology (Quisumbing & Pandolfelli, 2010).

There are high hopes that ICT can play an important role in reducing gender inequalities (Balakrishnan, 2002). ICT services have proven effective in bringing market information to both men and women. There are two main themes in the literature on gender and marketing decisions related to ICT: (1) access by women to new communications technology, and (2) the "gendered" nature of market knowledge.

Compared to men, rural women are less likely to own communication assets such as a radio or cell phone (World Bank, 2008). Reports indicate the presence of gender differences in access to technologies, but these reports are hampered by lack of reliable statistics on women's use of ICT in developing countries (International Telecommunication Union (ITU), 2000, 2001). ICT clearly lower the cost of accessing information and, thus, should be relatively egalitarian in their impacts on market access, but if asset or cultural barriers reduce women's access, this cost reduction may not benefit women (Balakrishnan, 2002).

A key determinant of the impact of information-enhancing technologies is the degree to which market knowledge is "gendered" or situated (Gururani, 2002; Sachs, 1996). For example, enhanced information may have different values to men and women because the latter value different attributes in the marketing process, such as long-lasting ties to traditional marketing agents or risk-reducing social ties (Rubin, Manfre, & Barrett, 2009). Under such circumstances, more freely flowing information to women is likely to have a different impact on market outcomes compared with information flowing to men.

Intermediaries play an important role in Bolivian potato markets by pooling risk, providing financial and technical services, storing goods, and transporting and organizing sales (Jones, 1985; Medeiros, Crespo, & Sapiencia, 2007). Some evidence indicates that intermediaries abuse poor potato producers by exploiting asymmetric information and market power (Guidi & Mamani, 2000). Competition might increase and intermediaries' market power might diminish if information were more readily available to the farmers themselves (Eggleston, Jensen, & Zeckhauser, 2002). Alternatively, information might contribute to declining importance of social networks, depending on the degree to which the knowledge and the networks are gendered. ICT can improve the competitiveness of potato markets by reducing price dispersion across spatially separated markets, lowering transactions costs, and reducing gender

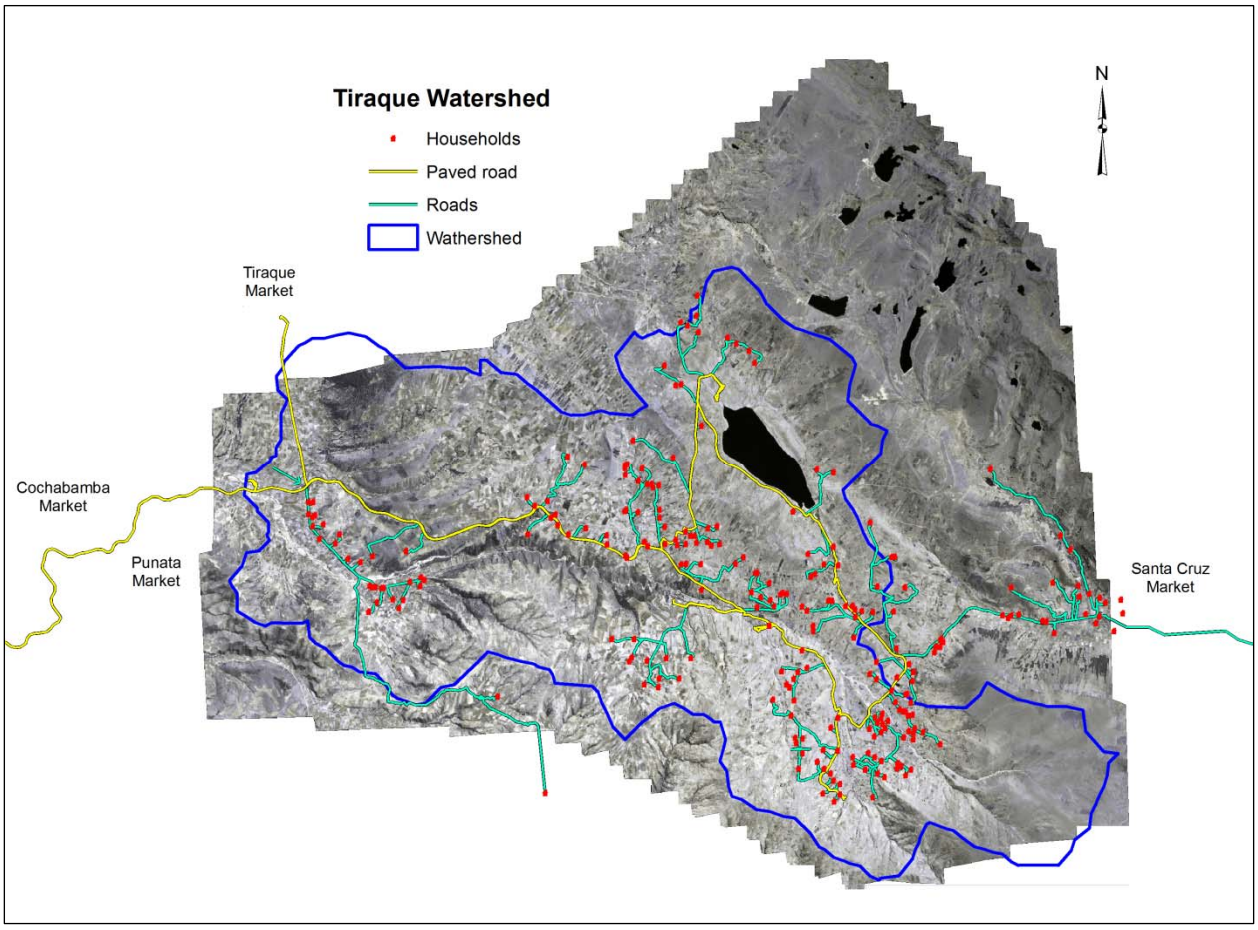
differentials in information access (Hafkin & Taggert, 2002; Jensen, 2007; Lyon, 2004).

Information and communication technologies have helped remove information asymmetries that often prevent the poor in remote areas from accessing markets (Von Braun, 2009). Studies have shown a wide range of positive impacts of ICT, including increased market integration and improved livelihoods (Leff, 1984; Tschang, 2002; Tye & Chau, 1995). Since information costs are not proportional to distance to markets and the marginal cost of providing information to new players is near zero, ICT can become a crucial stimulant to market participation.

Worldwide, ICT services have proven effective in bringing market information to men and women (World Bank, 2008). Women can benefit more from these services because they have less mobility and literacy, and may be excluded from traditional information networks. In some countries, however, women face barriers of unequal access to ICT as cultural attitudes discourage their use of technology (World Bank, 2008).

Aker (2008) studied the impact of the introduction of cell phones on grain market performance in Niger between 2001 and 2006 and found that the primary effect of cell phones was a reduction in search costs. Internet kiosks providing price information to soybean farmers in India were found to be associated with an increase in price received of 1% to 5% (Goyal, 2008). In Bangladesh, Bayes (2001) reported that agricultural output prices are higher when villages are equipped with pay phones.

**Figure 1. Map of Study Region: Tiraque, Bolivia**



In Ghana, access to mobile phones was found to make traders more efficient by reducing transaction costs (Overa, 2006). Jensen (2007) found that cell phones stimulated sales across markets by fishermen in India; mobile phones helped fishermen choose markets to maximize their price received, reduce waste from spoiled fish, and increase profits. Cell phones increased the probability of banana sales in Uganda by 20% (Muto & Yamano, 2009). In Bolivia, access to cell phones is widespread, yet little is known about how such access affects market decisions and household well-being.

## Applied Research Methods

The study area is located in Tiraque Province, about 70 km (43 miles) from Cochabamba, Bolivia. The watershed covers 117 km² (45 square miles), ranges 3,000-4,200 meters (9,843–13,780 feet) above sea level, and comprises 14 communities with a population of approximately 3,000 (see figure 1). Economic activities include small-scale agricultural production and livestock. Large volumes of crop output are sold, and household income depends critically on these sales. Marketing problems include high transactions costs, low prices, lack of market information, and weak bargaining power (Sustainable Agricultural Natural Resource Management (SANREM), 2007).

The main crop in the area is potato, which is sold in the rural markets of Tiraque and Punata, and in the urban markets of Cochabamba and Santa Cruz. In general, urban markets offer higher prices but are located far away, implying high transportations costs and more risk. As a result, few farmers sell there, and most farmers consider Tiraque to be their main sales point (SANREM, 2007). Verbal communication remains the most important form of information acquisition, but radio programs transmitting market information in Quechua (the most common language in use in the area) and cell phones are gaining prominence.

Potato production and marketing are important for farmers in the area, but they face market-level constraints, especially lack of information. Anecdotal information shows that cell phone technologies are affecting market dynamics. The area offers an ideal setting for exploring the effects of access to information through cell phones and gender relations on market performance.

### *Methods*

Our analysis is based on qualitative information supplemented with a household survey. Rapid market appraisal (RMA) tools and individual household case studies are used to gather information at different stages of the potato market chain. For the case studies and household survey, we chose households with access to cell phone signals and others without access to cell phone signals. This stratification allows us to compare differences based on access.

Qualitative methods help us observe decision-making through participants' eyes and provide insights into and explanations behind marketing decisions. The quantitative and qualitative methods complement each other. RMA provides an effective way of analyzing the potato marketing system. Our RMA was based on methods developed by Holtzman (2003) and relied on semistructured interviews conducted between February and July 2008 with key informants at different links of the value chain. Four types of interviews, differentiated by actor, were used. In total, we interviewed 25 key informants, including farmers, wholesalers, retailers, and indirect actors (staff of nongovernmental organizations (NGOs), local governments and extension offices). The RMA identifies functions at each point in the chain, prices, market constraints and opportunities, and investigates roles that cell phones and gender play within the chain.

We also conducted case studies (CS) of six potato-producing households, three with access to a strong cell-phone signal and three without. This method provides deep understanding of the subject by addressing questions of how and why, and contextualizes findings from other methods (Yin, 2003). The case studies were conducted in April through July 2008 and included semistructured interviews, secondary data, direct observation, and participatory tools. Interviews focused on the dynamics of marketing decision processes, the

influence of access to information on marketing decisions, and gender roles.

The qualitative analysis was complemented by analysis of a random household survey. The survey contained nine modules covering household demographics, education, participation in the labor force, agricultural practices, assets, marketing activities, and measures of income and household consumption. It was administered at the start of the 2008 growing season by four bilingual enumeration teams composed of men and women. The total number of households for which complete data were obtained was 303, including 164 with access to cell-phone signals and 139 without such access. We estimated a multinomial logit model that treats market choice as a function of a set of independent variables including access to a cell phone.

**Table 1. Summary Statistics from Household Survey in Tiraque, 2007** (*N*=303)

| Variable Description | Mean (SD) | *Cell phone ownership* | |
|---|---|---|---|
| | | Yes | No |
| | | Mean (SD) | Mean (SD) |
| Age of household head | 47 (15) | 45 (13) | 49 (16) |
| Members per family older than 15 | 6 (3) | 6 (3) | 5 (3) |
| % female headed households | 14% (35) | 12% (32) | 17% (37) |
| % household heads literate | 82% (39) | 86% (35) | 77% (42) |
| % households receiving a loan | 18% (39) | 25% (44) | 11% (32) |
| % households owning cell phones | 50% (5) | | |
| % households owning radio | 83% (37) | 92% (27) | 74% (44) |
| % households with access to cell-phone signal | 46% (50) | 90% (30) | 0% (0) |
| Farm size (hectares \| acres) | 2.36 \| 5.83 (3.14 \| 7.76) | 2.87 \| 7.09 (3.63 \| 8.97) | 1.83 \| 4.52 (2.44 \| 6.03) |
| Number of plots | 5 (2) | 6 (3) | 5 (2) |
| % households with access to irrigation | 73% (45) | 77% (42) | 69% (47) |
| Total quantity of potato produced (kg \| lb.) | 6,897 \| 15,205 (7017 \| 15,470) | 8,590 \| 18,938 (8350 \| 18,409) | 5,169 \| 11,396 (4765 \| 10,505) |
| % households attending Tiraque market | 75% (43) | 73% (45) | 77% (42) |
| % households attending Punata market | 43% (50) | 42% (50) | 44% (50) |
| % households attending Cochabamba market | 23% (42) | 26% (44) | 19% (40) |
| % households attending Santa Cruz market | 7% (26) | 12% (33) | 2% (14) |
| % households selling at farm gate | 1% (6) | 1%(8) | 0% (0) |
| Distance to Tiraque (hours) | 0.67 (0.19) | 0.60 (0.17) | 0.73 (0.18) |
| Distance to Punata (hours) | 1.31 (0.18) | 1.26 (0.17) | 1.37 (0.16) |
| Distance to Cochabamba (hours) | 2.45 (0.25) | 2.37 (0.21) | 2.54 (0.25) |
| Distance to Santa Cruz (hours) | 12.35 (0.27) | 12.43 (0.22) | 12.27 (0.28) |
| Distance to nearest paved road (hours) | 0.05 (0.09) | 0.05 (0.08) | 0.05 (0.09) |
| Gross income from potato sales (Bolivianos)[a] | 6,715 (9018) | 8,650 (11037) | 4,740(5725) |

Note: variables reported here were used in the market access model whose results are shown in table 4, appendix. The percentages reported here were derived from categorical (0/1) variables and those variables are used as dummy variables in the table 4 analysis.
[a] US$1.00 = 7 Bs (bolivianos)

## Results

The average household in the watershed has six members, about three of whom are working age (table 1). All respondents speak Quechua; most men also speak Spanish. Literacy is relatively high (82%) and in our RMA and CS all interviewees were literate. The primary economic activity is small-scale agriculture, with an average holding size of 2.4 hectares (5.9 acres), but production is spread across many plots. Potato is the main source of food and income; fava beans, cereals, and vegetables are also common. Approximately 14% of households are headed by women. These households have on average 1.5 hectares (3.7 acres) less land than men, and the limited resources do affect potato production and sales. The survey showed that women-headed households produce 46% less than those headed by men.

About 70% of gross income depends on potatoes. Some farmers borrow to cover potato production costs, but only 18% of surveyed farmers borrowed from formal sources (table 1). Some receive loans from wholesalers, but most self-finance their input purchases. The survey also showed the importance of secondary economic activities, such as agricultural and construction labor, and transportation.

The CS interviews uncovered commonly encountered problems, such as limited access to land and labor, poorly maintained roads, and deficient market services and infrastructure. These interviews also showed that migration has reduced the male labor pool in Tiraque, which in turn has increased wages and female participation in activities that were previously exclusively male. Female participation in potato production activities has broadened into pest-control and other activities that had formerly been the exclusive purview of men. Migration also generates remittances and motivates the use of cell phones as a means of maintaining contact between families. Five of six CS families reported purchasing cell phones initially to maintain contact with migrating relatives. (Table 2 contains CS descriptive statistics.)

The case study and RMA interviews asked about potato marketing decisions. The quantity of potato produced clearly influences market decisions. The survey showed that households sell about 70% of their production, using the rest for self consumption and seed. Tiraque is by far the most common sales

**Table 2. Summary Statistics of Case Study Families**

| Variable Description | CS-1 | CS-2 | CS-3 | CS-4 | CS-5 | CS-6 |
|---|---|---|---|---|---|---|
| Families* | I.Z. | L. O. | O.D. | S.C. | J.V. | P.A. |
| | A.M | B.F. | S.M. | C.M. | R.A. | M.R. |
| Community | Toralapa Baja | Damy Rancho | Cebada Jich'ana | Sankayani Alto | Kayarani | Koari Alto |
| Market(s) where potatoes are sold | Tiraque | Tiraque, Punata | Santa Cruz, Cochabamba | Tiraque | Tiraque, Punata, farm gate | Tiraque, Punata, Santa Cruz |
| Total quantity produced (kg \| lb.) | 1,950 \| 4,299 | 2,312 \| 5,097 | 7,000 \| 15,432 | 8,700 \| 19,180 | 1,500 \| 3,307 | 5,232 \| 11,535 |
| # of family members | 6 | 5 | 6 | 7 | 5 | 11 |
| # of plots owned | 3 | 2 | 3 | 3 | 3 | 8 |
| Farm size (has \| acres) | 0.25 \| 0.62 | 0.22 \| 0.54 | 1.50 \| 3.71 | 1.05 \| 2.59 | 0.30 \| 0.74 | 4.41 \| 10.90 |
| Age | 28 | 26 | 28 | 43 | 65 | 51 |
| Literate | Yes | Yes | Yes | Yes | No | Yes |
| Access to loan | Yes | No | Yes | No | No | No |
| Cell phone ownership | Yes | Yes | No | Yes | Yes | No |

* Initials of family members are used to maintain confidentiality.

point, followed by Punata (table 1). Distance and travel time are related to market choice; Santa Cruz is the most distant market, and relatively few farmers sell there. RMA interviewees stated that they only go to Santa Cruz when they are certain that the price is substantially higher than in Tiraque and when they have large quantities to sell. The CS households and RMA respondents stated that marketing in Santa Cruz is gradually increasing with more access to information. Farmers view increased marketing to Santa Cruz as a positive trend.

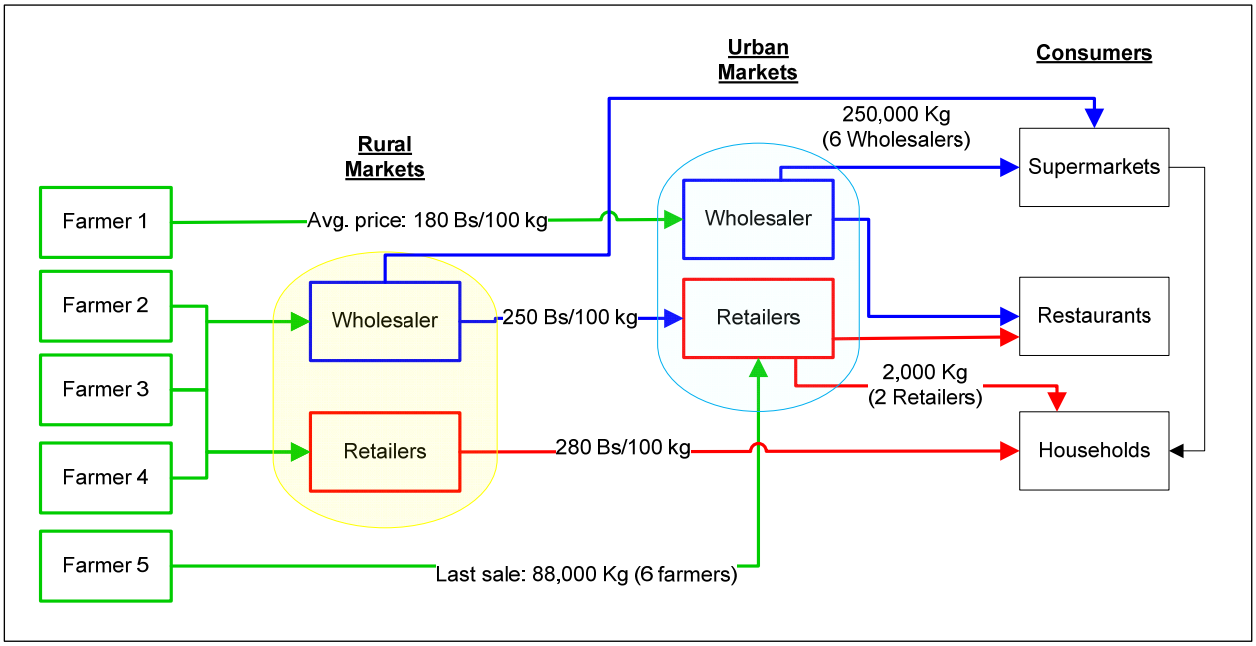
Farmers have different degrees of access to information about prices and markets. The CS interviewees reported that the principal means of gathering market information is through cell phones and radio. They revealed a subtle gender-related attribute of cell-phone ownership: household members consider the cell phone to be a joint household asset. In none of the cases did we hear that the man or woman "owns" the cell phone. Despite this finding, as we see below, men control access to cell phones for certain uses. The survey found that 50% of households own at least one cell phone, and many who do not state they have access to cell phones through their social networks. More than 80% of households own a radio, also an important source of market information (table 1).

*Potato Markets*

We identified two potato marketing channels through the RMA (see figure 2). The first begins with purchases at the farm gate, in which the producer waits for the wholesaler to collect the product, and producers are paid in cash. This situation limits the ability of the seller to negotiate with the wholesaler. In the last 10 years, as transportation has become more accessible and information about conditions in markets more widespread, this practice has been abandoned, and less than 1% of surveyed households and one out of six families interviewed during the CS sell at the farm gate.

The second channel the RMA identified is composed of farmers delivering their potatoes to market. Producers transport their own crop using public transportation (buses, rented trucks or taxis), their own transportation, or by joining with other farmers. At the market, they sell directly to wholesalers or retailers. Wholesalers can be classified into two types: (1) those collecting potatoes

**Figure 2. Potato Market Chain in the Tiraque Region**




Source: RMA and case study analysis.

**Table 3. Characteristics of Tiraque-Area Potato Markets**

| | Rural Market | | Urban markets | |
|---|---|---|---|---|
| **Characteristics** | **Tiraque** | **Punata** | **Cochabamba** | **Santa Cruz** |
| Schedule | Thurs.–Fri. | Mon.–Tues. | Mon.–Sat. | Every day |
| Highest price | 300 Bs/100 kg (June–Aug) | | 400 Bs/100 kg (July–Oct) | |
| Lowest price | 60 Bs/100 kg (April–May) | | 100 Bs/100 kg (April–May) | |
| Average time to market | 30 min.–1 hr. | 1–2 hrs. | 2–3 hrs. | 10–12 hrs. |
| Transportation cost[a] | 2.5–4 Bs/100 kg | 4–8 Bs/100 kg | 8–10 Bs/100 kg | 10–20 Bs/100 kg |
| Market sales fee[a] | 2 Bs/100 kg | 3 Bs/100 kg | 0 | 2 Bs/100 kg |

Source: RMA. [a] US$1.00 = 7 Bs (bolivianos)

from rural markets; and (2) those who have shops in urban markets and wait for farmers to come to them. Both types resell potatoes to retailers and consumers. The RMA found that 80% of buyers in the rural and Cochabamba urban markets are women. In Santa Cruz, female and male participation is more balanced, but women still predominate as buyers.

The Tiraque market is among the largest potato markets in rural Cochabamba. More than 2,000 producers from more than 110 communities attend this market (see table 3). The Tiraque market has about 20 large wholesalers, only five of whom are men. An important feature of the Santa Cruz market is that it is the only market where the municipality obligates both buyers and sellers to weigh the potatoes. This provision allows for exact pricing, but reduces room for negotiation. In the other markets, weight is estimated according to the size of the bag, and sales-price negotiations often include discussions about the size of the bag.

Although few potato farmers own their vehicle, transportation is widely available. Transportation costs depend on the distance and quantity of goods transported. According to the household survey, the average cost of leasing transport over all markets was 7 bolivianos[1]/100 kg. Since the fixed costs of obtaining market information can be spread over higher volumes when the quantity transported grows, larger-scale farmers are more likely than small-scale farmers to travel to more distant markets. Because roads are in various states of despair and poorly maintained, time to markets can vary greatly. We found from the CS and the RMA interviews that farmers reduce their market-related risk and transaction costs by using cell phones to coordinate transport and market trips.

*Farmer Market Choice*

Interviews with selling households in the CS and RMA indicate that market choice is determined by the quantity produced, distance to markets, degree of paved roads, transportation costs, expected prices, quality requirements, access to information, and market management conditions. These determinants of market choice were validated using a multinomial logit model (MNL) applied to the survey data. This model predicts the probability that a household chooses one of five market choices (each of the four markets or multiple markets) as a function of the independent variables.

The market choice model shows that access to cell phones, availability of a cell-phone signal, distance to the Tiraque and Santa Cruz markets, access to a paved road, and farmer age all influence market choices[2], but have different impacts depending on

[1] US$1.00 = 7 Bs (bolivianos)

[2] These results are shown in table 3. This table shows the marginal effect estimates, interpreted as the change in

the market. The results are all logical and were confirmed with CS interviews. For instance, older farmers are more likely to attend closer markets. However, when older farmers own cell phones, they are less likely to go to Tiraque and more likely to go to farther markets.

Farmers with larger quantities to sell and better access to information are more likely to sell in the more distant Santa Cruz market. The total quantity of potato produced is a statistically significant determinant (at a 10% confidence level) of the probability of sales to Santa Cruz. Better access to cell-phone technology and transportation were also statistically significant determinants of probability of sales in distant urban markets. Cell-phone ownership is associated with an increased probability of going to urban markets — by 2.5% in the case of Cochabamba, and by 7.2% for Santa Cruz, all else constant. This result is confirmed by the qualitative analysis, which found that cell phones have become important marketing tools for farmers. CS and RMA respondents highlighted the role of cellular technologies in reducing marketing risks.

Access to cell-phone signal does not have a large effect on the ability to use cell phones to obtain market information. Even in areas without cellular signals, farmers still use cell phones. The CS showed that they employ several strategies for obtaining access to signals, including climbing to nearby hilltops and traveling short distances.

*Wholesalers*

The RMA shows that wholesalers have good knowledge of markets, long-term experience in the potato business, comprehensive market information, strong social networks, and limited economic power. They are aware of prices paid by other market actors and use this information during negotiations with sellers. The wholesaler network is dominated by women. Although some male buyers are found, they are usually employed by women, and women make the purchasing decisions. Through their contacts with other women in the market, intermediaries assume and pool risk, reducing individual seller (farmer) risk and allowing the markets to be more efficient.

The CS and the RMA responses showed linkages between buyers and sellers to be long-term; selling households and market intermediaries report relationships spanning multiple generations. Nevertheless, trust is conditional; sellers claim that wholesalers do not provide accurate market information, and wholesalers claim, in turn, that farmers hide lower quality potatoes within potato sacks.[3] Both factors increase bonds between buyers and sellers since the parties have incentives to deal with familiar counterparts. Linked contracts, such as buyer-provided credit, further solidify bonds between buyers and sellers. Even though only 3% of the surveyed farmers reported access to loans through wholesalers, the RMA indicated that many farmers received money and inputs (e.g., seeds, fertilizers, and transportation) on a regular basis from wholesalers. These links imply conditions; for instance, farmers who receive services from intermediaries claim to have less ability to influence the prices they receive.

Although most farmers have long-lasting bonds with their wholesalers, they state that they are frequently exploited. One CS respondent voiced the following: "Wholesalers do not work as hard as we do, they just buy potatoes at lower prices and sell them at higher prices, and without much work they earn high profits." CS and RMA farmers state that even though there is substantial negotiation and they do their best to obtain high prices, wholesalers are able to keep prices low. Sellers perceive a power imbalance; this imbalance is most pronounced in Santa Cruz, where long travel distances preclude sellers from withdrawing their potatoes from the market.

*Indirect Actors*

The RMA interviews revealed several indirect actors who focus on helping farmers with production activities by providing inputs and training

probability associated with participating in each market given a one-unit change in the independent variable.

[3] Potatoes are sold in 50 kg sacks and in all markets except Santa Cruz the sack, not its weight, is the unit.

(such as the Foundation for Promotion and Research of Andean Products, or PROINPA), but few institutions in the area assist with marketing activities. An Agricultural Product Market Information System (SIMA) was created in 2004 by a private foundation, the Foundation for the Development of Agricultural Technology of the Valleys, or FDTA-Valles. SIMA collects and disseminates market information through the radio. This information is intended to support farmers in marketing. All the farmers we interviewed listen to this show.

*Market Negotiations*

Even though market information flows freely, negotiations between farmer/sellers and intermediaries are not easy. The RMA interviews showed that farmers sense that they are at a disadvantage, and find it difficult to follow through on the ultimate threat — returning from the market with their potatoes. Thus, before they go to the market, they determine an initial reference price that they use during negotiations. This price is based on production costs, information on prices received from SIMA, discussions with neighbors, family and friends, and cell-phone calls to friends, relatives, and others.

The main innovation provided by the cell phone in this process is to enable sellers to acquire more up-to-date information on prices, and to obtain, on a real-time basis, information on volumes and conditions in multiple markets. CS interviews and discussions with RMA participants found that sources of information, however, are almost always the same as were used prior to the introduction of cell-phone services.

Independent of the relationship between farmers and intermediaries, the time taken to negotiate a final price in rural markets can vary from half an hour to 2 hours. In urban markets, the RMA participants report less give and take compared to rural markets and prices are arrived at in less time. Almost all negotiations are heated, and this is one reason why males say they avoid it. Male and female interviewees state that women are better negotiators and many men feel that strong arguments with women buyers are not consistent with culturally defined male roles. This can be clearly observed in the following quotations from a CS interviewee:

> Since I can remember in the markets, there has always been greater participation of women (farmers and intermediaries). That is one reason why I prefer that my wife sells potatoes in the markets. She expresses herself better than I do, knows how to talk to intermediaries, and thus sells faster and at higher prices. Besides, it is not viewed favorably for men to discuss or argue with women. —*L.O. & B. F.*

> In markets there have been always more women than men, because they sell better than us and have more ability to talk and discuss with the rankeras [intermediaries — note the use of the female noun implies that rankeras are women]. We just help them transport potatoes. Also since most rankeras are women, I prefer that my wife is in charge of the sales because, between women there is better understanding. The rankeras are always trying to bother and intimidate us [men] by calling us names so they can pay us lower prices. —*I. Z. & A.M.*

Through the RMA, we found that factors affecting negotiations are the origin and quality of the potato, the age and gender of the seller, the type of relationship between buyer and seller, and access to information. When farmers and intermediaries have long-term relationships, it is rare that they do not reach agreement. Wholesalers reportedly take advantage of the old, the young, and men. Respondents all claim that men are not good negotiators in potato markets.

*Gender Roles and Decision-Making*

Even though the entire family participates in potato production and marketing, responsibilities are differentiated by gender. The CS interviews show that men take a leading role in potato production and women in marketing. Marketing is culturally a woman's purview, and the tradition is reinforced by the ability to negotiate favorable prices. Relationships with wholesalers, most of

whom are women, build on this advantage. Most men we interviewed in the CS and RMA stated that they are verbally abused by female wholesalers if they engage in negotiations. Wholesalers, in turn, state that they prefer to negotiate with men since they are easier to convince and more easily intimidated. A representative comment from the RMA is illuminating:

> The Tiraque market opens every Friday, and typically entire families come to visit it, since it is a social event. Overall, more women are present. When I sell potatoes, I always come to the market with my wife to help her with transport and security. She is in charge of sales. I prefer not being involved in sales, because most wholesalers are women and they are always trying to make us, men, feel bad. They call us names, say that our wives are our bosses, and ridicule us for getting involved in a woman's activity. Therefore, I let my wife talk to them because she is not easily intimidated and a man should not argue with a woman. Also my wife is in charge of handling the money from the sales.

A high proportion of women is a well-known feature of Andean markets. According to all the RMA interviewees, potato markets are controlled by women. Basically the nature of potato marketing networks can be summarized by the saying: "Among women, there is a better understanding." Gender differentiation is most pronounced in rural markets where negotiation skills are needed most. The RMA found that males prefer to attend urban markets, where there is less bargaining. Since having cell phones increases the likelihood of participating in urban markets, male roles in marketing may increase over time in this area.

*Social Networks*

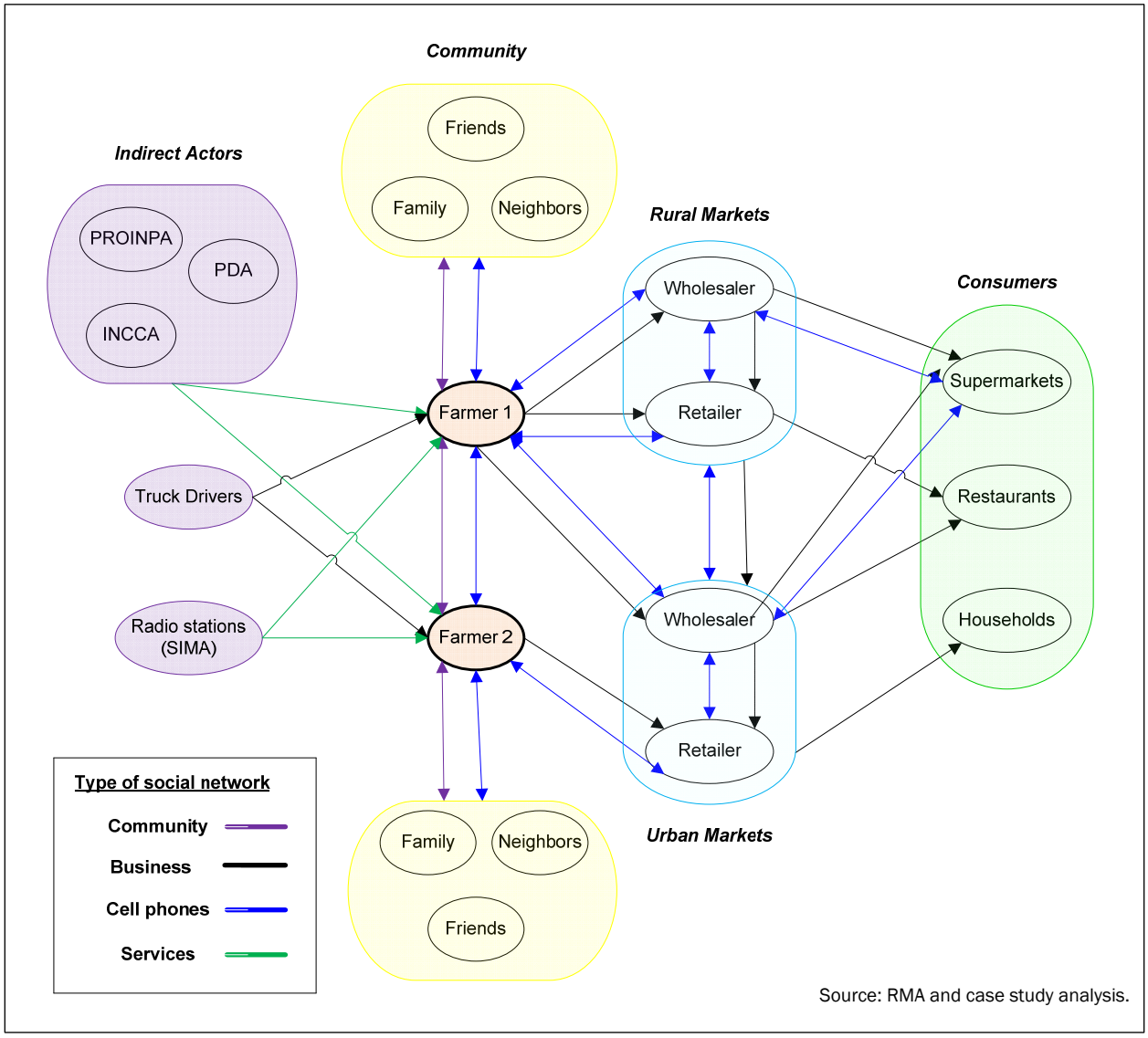
Better transportation and access to cell phones have clearly improved the bargaining position of small-scale sellers. During the RMA, wholesalers stated that it is now harder to convince farmers to accept the price they offer, and sellers are more likely to refuse to sell. Our qualitative analysis shows that even though information networks have not changed substantially since the introduction of cell phones, the relative strength of bargaining positions has changed — and sellers have benefited most from the change. Furthermore, this analysis shows that cell phones have become an important information-gathering tool used mainly by men to collect information from their regular networks.

We found from the CS that before the spread of cell phones most households had established business networks, but generally in only one market, and frequently in the areas closest to their communities. Incomplete information confined sales to local markets. Access to radio and cell phones has made the task of gathering market-price data cheaper and faster. Cell phones reduce search costs and open market opportunities. Access to information affects marketing choices and is particularly important for sales in more distant markets. Having this information before heading to market allows farmers to evaluate costs and prices in multiple markets before embarking on a sales trip.

Based on the qualitative analysis, we constructed representations of social networks (see figure 3, next page). Dimensions of the networks include business, community, cell phones and services received from institutions. Business and community networks overlap with information networks connected by cell phone. In particular, the CS interviews showed that cell-phone connections create stronger links between already-existing nodes (e.g., family, friends, and neighbors), and new nodes (e.g., intermediaries, indirect actors, and truck drivers). This technology allows farmers to expand their links to new nodes (business networks) and to more distant markets.

*ICT and Potato Marketing Decisions*

The CS interviews uncovered subtle dimensions of potato marketing. Prior to departing for the market, marketing decisions are made by men and women together. Men conduct a preliminary search for market information by using cell phones to access their traditional information networks. Cell-phone access has not affected their sources of information, just the ease and speed of obtaining it. The men then communicate this information to




their wives, and together they devise a marketing strategy. It was surprising to find that the network by which market information is gathered has not changed since the introduction of improved ICT.

Women still lack direct access to information, and, despite women having a better overall sense of conditions within markets, they have not assumed a greater role in gathering information. Men state that they continue to be the gateway to market information because they are the heads of households and providers for their families. Men have historically been in charge of gathering market information, and this has not changed. Males maintain influence over the marketing process through their continued control of information.

The CS interviews confirm the quantitative findings that market information clearly affects decisions about which markets to attend. The success of cell phones as a market data–gathering tool relies on the strength of pre-existing individual farmer social networks. Larger social networks imply more representative and trustworthy sources of information, allowing farmers to take better decisions. Cellular technology has not greatly

expanded these networks, but has allowed information to flow more quickly and at less cost. This information flow has helped expand their market choices.

More than 50% of the farmers interviewed in the RMA claimed to use cell phones in their potato marketing activities. The RMA also found that other actors along the chain also rely on cell phones. When we compare total revenues generated from potato sales, our analysis of the household survey data showed that farmers with cell phones receive twice as much as farmers who do not have them. Clearly, one cannot presume causality; cell phones may increase revenues, but it also may be that higher-volume farmers are more likely to own cell phones. Qualitative evidence indicates that cell phones are indeed causing some of these changes. All farmers stated that their marketing process and indeed their lives have improved since the appearance of cell phones.

Cell phones expand opportunities, reduce search costs, strengthen farmer bargaining power, improve market efficiency, and lower risks. All these factors make farmers better off. They are now more competitive in the potato market chain; they use different markets more frequently and base these decisions on information they receive via information networks. Market information networks exist side by side with social networks and the two interact and reinforce one another, but men have used these technologies to reinforce their positions as information brokers.

## Conclusions

This multi-method study explored relationships between access to information and gender relations in the potato market chain in highland Bolivia. Objectives were to analyze the roles of men and women in potato production and marketing; understand how marketing decisions are made and how access to information affect these decisions; and explore the effects of new information technologies on marketing decisions. We find that cell phone technologies allow farmers to market their potatoes at more distant and lucrative markets, and have subtle impacts on information and social networks.

Potato production activities are shared among men and women, but marketing roles are gender-differentiated. Men use cellular phones to receive market information. They share this information with their wives and jointly make decisions about where to sell their potatoes. The products are transported to markets jointly, but once in the market, the women take over.

Farmers with cell phones have better access to market information, affecting decisions about where to sell. Increasingly, distant urban markets are being viewed as a viable sales outlet. Furthermore, cell phones reduce risk and improve marketing efficiency. Farmers who wish to exploit distant market opportunities need substantial production volume and time to travel to distant markets, but lowered information costs are improving access to these markets. Farmers who use cell phones are better off than those who do not.

The advent of the cell phone has not fundamentally altered the sources of market information, but has widened the information network and speeded up the flow of information through it. Farmers do not generally trust intermediaries, and the speed of information flow through the cellular networks provides a counterbalance to perceived intermediary market power. Even though intermediaries fill important roles, according to farmers they take advantage of them, mainly through control of information. The ability to do so has been reduced. Even though women conduct most of the potato marketing, men are still primarily responsible for gathering market information.

Farmers stated that their lives have improved with cell phones, but they still rely heavily on their social networks. If the impact of new information technologies on marketing decisions is mediated through existing social networks, the former reinforces the latter. These structures have not changed significantly; women continue to dominate within the potato markets, and men continue to gather market information.

Impacts of cellular technologies are nuanced and could not be uncovered using a wholly quantitative approach. Mixed-method research tools allowed us to uncover subtleties associated with how cell phones are used, how networks are reinforced by enhanced access to information, and how decision-making is affected by new technologies. The qualitative methods substantially deepened our understanding of these processes. The tools used for this research complemented each other. This complementarity makes findings more understandable and builds our confidence in them.

**Recommendations**

The Tiraque watershed could develop its potential as a high quality potato producer by reducing market-related constraints. Production volumes are relatively high, and Tiraque potatoes are recognized as high quality in the Cochabamba and Santa Cruz market. To make farmers more competitive in the potato market, access to information still needs to be improved. One method of achieving this goal could be through expansion of cell phone access. This could be achieved by promoting markets for used phones and identifying or establishing cellular "hot spots" in isolated areas. Furthermore, farmer groups could be organized to collect market information from their various markets and spread information through text messaging or automatic dialing.

Any effort to improve the efficiency of the potato chain should consider the important roles that intermediaries play. Intermediaries fill several marketing roles, which assistance efforts need to recognize. For instance, institutions should include intermediaries in market support projects and work closely with them since they support the market network in many ways.

More support is needed in the area to improve access to markets and information, particularly for women. None of the institutions in the study area provide market-related services. Instead, they focus on technical assistance to help farmers produce more efficiently and diversify production. Women are least likely to participate in such assistance, and given their important role in the potato value chain, technical and marketing assistance should be focused on women. NGOs should reorient their assistance towards more comprehensive objectives, including marketing and organization-building. For instance, they could facilitate access to transportation, information, and markets. They could work through existing producer organizations to coordinate marketing activities; increased marketed volumes will lower costs of marketing in distant markets and might increase seller bargaining power.

Further research might investigate how information technology can be used to group farmers into marketing units or encourage farmer groups to sell at higher-return markets, how improved market information affects price dispersion across spatially separated markets, the effects of information on relative returns to sellers and buyers (market power), and the dynamics of gender roles in decision-making and marketing. Research in all these areas would assist development practitioners in designing programs to improve conditions in potato markets. While this research has shed some light on each of these areas, further analysis is needed to understand completely how market performance can be improved in the presence of current information and communication technologies.

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## References

Aker, J. C. (2008). Does digital divide or provide?: The impacts of cell phones on grain markets in Niger. *Working Paper 154*. New York: Center for Global Development.

Alemán, S. (2002). Las mujeres rurales de Bolivia: la dimensión oculta de los poderes económicos, sociales, políticos y culturales. Paper presented at VII CLAD international meeting about state reform and public administration. Lisbon, Portugal: Food and Agricultural Organization of the UN.

Alwang, J. P., Siegel, P. B., & Jorgensen, S. L. (2001). Vulnerability: A view from different disciplines. *SP Discussion Series 0115*. Washington, DC: World Bank.

Balakrishnan, R. (2002). Harnessing ICTs for the advancement of rural women. Paper presented at UN meeting on ICTs and their impact on and use as an instrument for the advancement and empowerment of Women. Seoul, Korea.

Bayes, A. (2001). Infrastructure and rural development: Insights from a Grameen bank village phone initiative in Bangladesh, *Agricultural Economics, 25,* 261–272. http://dx.doi.org/10.1111/j.1574-0862.2001.tb00206.x

Cox, A., Farrington, J. & Gilling, J. (1998). Reaching the poor? Developing a poverty screen for agricultural research proposals, *ODI Working Paper 112*, London: ODI.

Department for International Development. (2005). Making market systems work better for the poor (M4P). Paper presented at ADB-DFID "learning event" ADB Headquarters. Manila, Philippines.

Department for International Development. (2005). *Growth and poverty reduction: The role of agriculture.* London, England: DFID.

Doss, C. R. (2001). Men's crops? Women's crops? Gender patterns of cropping in Ghana. Paper presented at 2001 Annual meeting, American Agricultural Economics Association. Chicago, IL.

Duryea, S., Jaramillo, O., & Pagés, C. (2002). *Los mercados de trabajo en América Latina en los noventa: Descifrando la década.* Washington DC: Research Department, Interamerican Development Bank.

Eggleston, K., Jensen, R. & Zeckhauser, R. (2002). *Information and communication technologies, Markets and economic development*. United Kingdom: Open University Press.

Escobal, J. (2001). The benefits of roads in rural Peru: A transaction costs approach. Published by project Market integration and transaction costs in Peruvian agriculture. Lima, Peru: International Development Research Centre and the Canadian International Development Agency.

Ferrand, D., Gibson A., & Scott, H. (2004). *Making markets work for the poor: An objective and an approach for governments and development agencies.* United Kingdom: Department for International Development.

Figueroa, M. (2008). Strategies to develop market access in the Bolivian highlands: two case studies for chuño and tunta (Unpublished master's thesis). University of Missouri-Columbia, Columbia, MO.

Goyal, A. (2008). Information technology and rural markets: Theory and evidence from a unique intervention in Central India. Working Paper. Baltimore: University of Maryland.

Grynspan, R. (1999). *Perspectiva de género y nueva ruralida*d. San José, Costa Rica: Instituto Interamericano de Cooperación para la Agricultura (IICA).

Guidi, A. & Mamani, P. (2000). Características de la cadena agroalimentaria de la papa y su industrialización en Bolivia. *Working Paper 14*. Cochabamba, Bolivia: Papa Andina Project, Fundación PROINPA.

Gururani, S. (2002). Construction of Third World women's knowledge in the development discourse, *International Social Science Journal, 54,* 313–323. http://dx.doi.org/10.1111/1468-2451.00384

Hafkin, N. & Taggart, N. (2002). *Gender, information technology and developing countries: An analytic study.* Washington, DC: USAID.

Holtzman, J. S. (2003). Rapid appraisals of commodity sub-sectors. Working Paper, Bethesda, MD: Abt Associates Inc.

Hussain, A. (2003). Lessons of transition for understanding the functioning of markets. *MMW4P inception report*, Hanoi, Vietnam.

Instituto Nacional de Estadistica. (2000). *Anuario estadístico 2000*. La Paz, Bolivia: Government of Bolivia.

International Telecommunication Union. (2000). *Internet indicators 2000*. Geneva: ITU.

International Telecommunication Union. (2001). *Telecommunication indicators 2001*. Geneva: ITU.

Jensen, R. (2007). The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *Quarterly Journal of Economics, 122*(3), 879-924. http://dx.doi.org/10.1162/qjec.122.3.879

Jones, J. (1985). *The role of middlemen in potato production in Cochabamba, Bolivia: Financial aspects of sharecropping.* Costa Rica: Centro Agronomico Tropical de Investigacion y Enseñanza.

Leff, N. H. (1984). Externalities, information costs, and social benefit-cost analysis for economic development: an example from telecommunications. *Economic Development and Cultural Change, 32*(2), 255–76. http://dx.doi.org/10.1086/451385

Lyon, F. (2004). Trust, networks and norms: The creation of social capital in agricultural economies in Ghana. *World Development, 28*(4), 663-681. http://dx.doi.org/10.1016/S0305-750X(99)00146-1

Medeiros, G., Crespo, F. & Sapiencia, M. (2007). Estudio de mercados para productos derivados de haba y quinua en Bolivia. Apoyo Programático al Sector Agropecuario (APSA II). Cochabamba, Bolivia: Fundación para el Desarrollo Tecnológico Agropecuario del Altiplano.

Muto, M. & Yamano, T. (2009). The impact of mobile phone coverage expansion on market participation: Panel data evidence from Uganda. *World Development,* 37(12), 1887-96. http://dx.doi.org/10.1016/j.worlddev.2009.05.004

Overa, R. (2006). Networks, distance, and trust: Telecommunications development and changing trading practices in Ghana. *World Development,* 34(7), 1301-1315. http://dx.doi.org/10.1016/j.worlddev.2005.11.015

Quisumbing, A. R. & Pandolfelli, L. (2010). Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. *World Development,* 38(4), 581-592. http://dx.doi.org/10.1016/j.worlddev.2009.10.006

Rubin, D., Manfre, C., & Barrett, K. N. (2009). Promoting gender equitable opportunities in agricultural value chains: A handbook. Report Prepared under the Greater Access to Trade Expansion Project. Washington, DC: USAID. Available at http://www.usaid.gov/our_work/cross-cutting_programs/wid/pubs/GATE_Gender_Ag_Value_Chain_Handbook_11-09.pdf

Sachs, C. E. (1996). *Gendered fields: Rural women, agriculture and environment.* Boulder, CO: Westview Press.

Sustainable Agricultural Natural Resource Management — Collaborative Research Support Program (SANREM). (2007). *Watershed Based Natural Resources Management in Small Scale Agriculture, Sloped Areas of Andean Region: Sub-watershed Jatun Mayu River (Bolivia) Project,* Annual Technical Report 2006-07. Cochabamba, Bolivia.

Tracey-White, J. (2003). Planning and designing rural markets. *Marketing extension guide No. 4*. Rome: Food and Agriculture Organization of the UN.

Tschang, T. (2002). Scaling-up information services for development: a framework of increasing returns for telecentres. *Journal of international development,* 14, 129–141. http://dx.doi.org/10.1002/jid.865

Tye, E., & Chau, P. (1995). A study of information technology adoption in Hong Kong. *Journal of information science*, 21(1), 11-19. http://dx.doi.org/10.1177/016555159502100102

Von Braun, J. (2009). ICT for the next five billion people: Information and communication for sustainable development. Paper presented at Annual Conference. Berlin: International Food Policy Research Institute (IFPRI).

World Bank. (2007). Horticultural exports from developing countries. In *Agriculture Investment Sourcebook*. Washington, DC: The World Bank. http://go.worldbank.org/LWEH6R38H0

World Bank. (2008). Gender in rural infrastructure for agricultural livelihoods. In *Gender in agriculture sourcebook*. Washington, DC: The World Bank.

Yin, R. K. (2003). *Case study research: Design and methods*. London: Sage Publications.

## Appendix

**Table 4. Marginal Effects on Market Channel Choice: Multinomial Logit Results**

| Variable | *Dependent variable: Market channel choice* | | | | |
|---|---|---|---|---|---|
| | **Tiraque** | **Punata** | **Cochabamba** | **Santa Cruz** | **More than one market** |
| **Household characteristics** | | | | | |
| Age of the head of the household | 2.31E-05 | -0.00012 | -7.40E-05 | -0.00016 | 0.000339 |
| | | *-0.016* | *-0.034* | *(0.119***)* | *-0.014* |
| Age-squared | -8.80E-05 | 2.77E-05 | -1.30E-05 | -1.10E-06 | 7.46E-05 |
| | | *-0.001* | *(0.002*)* | *-0.002* | *-0.001* |
| # of members per family older than 15 | -0.01238 | -0.0127 | -9.80E-05 | 4.82E-05 | 0.025131 |
| | | *-0.137* | *-0.185* | *-0.301* | *-0.1* |
| Access to loans | -0.02262 | -0.07389 | -0.00127 | 0.000143 | 0.097633 |
| | | *-0.722* | *-0.809* | *-0.705* | *-0.401* |
| Access to irrigation | -0.14416 | 0.047286 | 0.005578 | 0.000358 | 0.090938 |
| | | *-0.651* | *-1.182* | *-1.408* | *-0.526* |
| Quantity produced | -3.80E-05 | -7.00E-07 | 6.00E-07 | 1.00E-07 | 3.77E-05 |
| | | *0* | *0* | *(0.000**)* | *(0.000**)* |
| **Assets** | | | | | |
| # of plots | -0.04428 | -0.00064 | 0.000283 | 3.64E-05 | 0.044604 |
| | | *-0.127* | *-0.155* | *-0.152* | *(0.088**)* |
| Cell phone ownership | 0.0124 | 0.002479 | 0.02401 | 0.071456 | -0.11036 |
| | | *-0.476* | *-0.606* | *(2.147***)* | *-0.335* |
| Access to cell-phone signal | -0.3522 | 0.169269 | 0.014291 | -0.00045 | 0.169041 |
| | | *(0.813***)* | *(1.221***)* | *-1.521* | *(0.631*)* |
| **Distance to markets** | | | | | |
| Tiraque | 1.2856 | -0.63038 | -0.12842 | -0.00239 | -0.52446 |
| | | *(3.345**)* | *(11.621**)* | *-6.209* | *-2.719* |
| Punata | -0.0438 | 0.356759 | -0.01369 | -0.00093 | -0.29829 |
| | | *-3.078* | *-4.757* | *-4.814* | *-2.677* |
| Cochabamba | 6.0891 | -5.17879 | -0.35261 | -0.00343 | -0.55425 |
| | | *(25.342**)* | *(41.152**)* | *-44.088* | *-19.013* |
| Santa Cruz | 9.1030 | -6.77561 | -0.56017 | -0.00644 | -1.76079 |
| | | *(29.784**)* | *(51.302***)* | *-51.376* | *-22.102* |
| Distance from the farm to the nearest paved road | -17.843 | 13.00537 | 0.924608 | 0.007268 | 3.905792 |
| | | *(54.440***)* | *(91.232**)* | *-98.489* | *-41.569* |

**Interaction terms**

| | | | | | |
|---|---|---|---|---|---|
| Distance to the paved road — # of plots | 0.3838 | -0.16058 | -0.01791 | 0.000641 | -0.2059 |
| | | *(1.406*)* | *-4.187* | *-3.588* | *(0.765*)* |
| Age — cell-phone ownership | -0.0029 | 0.002026 | 2.36E-05 | 0.000131 | 0.000701 |
| | | *-0.029* | *-0.048* | *(0.097***)* | *-0.02* |
| Irrigation — quantity produced | 3.76E-05 | -9.80E-06 | -9.00E-07 | -1.00E-07 | -2.70E-05 |
| | | *0* | *0* | *(0.000**)* | *0* |

*** Denotes significance at 1% significance level. ** significant at 5%, * significant at 10%