

MOBILE PHONES AND MARKET PARTICIPATION AMONG SMALLHOLDER  
FARMERS IN THE BOLIVIAN ALTIPLANO

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A Thesis presented to the Faculty of the Graduate School  
University of Missouri

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In Partial Fulfillment  
Of the Requirements for the Degree  
Master of Science

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by  
JASON HOLDERIEATH

Dr. Corinne Valdivia, Thesis Supervisor

JULY 2012

The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

MOBILE PHONES AND MARKET PARTICIPATION AMONG SMALLHOLDER  
FARMERS IN THE BOLIVIAN ALTIPLANO

presented by Jason Holderieath,

a candidate for the degree of master of agricultural and applied economics,

and hereby certify that, in their opinion, it is worthy of acceptance.

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Professor Corinne Valdivia

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Professor Laura McCann

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Professor Carla Barbieri

.....Thanks, Mandi.

## ACKNOWLEDGEMENTS

I have had the pleasure of working with some truly great individuals. I would like to thank Dr. Corinne Valdivia for her guidance and support. I would also like to thank Mr. Marc Strid for the opportunity to teach in his classroom for two years. I would also like to thank Dr. Laura McCann for sharing advice and expertise. I would like to thank Dr. Larry Godsey for inspiring me to go to graduate school and for helping me to succeed once here. I would like to thank Dr. Carla Barbieri for serving on my committee and providing valuable feedback. Finally, I would like to thank Dr. Harvey James and the Department of Agricultural and Applied Economics for ensuring I had funding to complete my program.

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Jason Holderieath

Dr. Corinne Valdivia, Thesis Supervisor

ABSTRACT

Farm households in the developing world who choose to be self-sufficient, instead of producing for the market, lack the money necessary for purchasing what cannot be produced within the home. It has been noted that households located at a greater distance to market (or with higher transportation costs) are more self-sufficient than households closer to the market (or with lower transportation costs). One promising theory on why self-sufficiency increases faster than transportation costs is that the markets are volatile and information about those markets is costly for the distant farmers.

Landline phones are generally not available; the only way prior to the introduction of mobile phones to get information about markets was to transport a member of the household to the market or to deliver without information. Using ordinary least squares this thesis project found a significant link between mobile phone use and increased market participation at greater transportation costs using 2009 survey data from several communities of the Bolivian Altiplano. These findings can guide development efforts and enhance the understanding of the impact of reducing information costs.

## CHAPTER 1.

### A PROBLEM OF MARKET PARTICIPATION

Low market participation has been historically viewed as a problem for development. Some theorists view the end goal of economic development as a state of complete specialization and market integration. Others are concerned that without cash income from market participation, money is not available for households to purchase needed services such as healthcare and education. Market participation has been studied from several perspectives.

These perspectives range from neoclassical perspectives that prescribe specialization to risk based perspectives that show that households may choose to be self-sufficient as a market risk avoidance technique to perspectives showing that often multiple activities combined can have a synergy for environmental, personal, or social goals. Recent attempts at understanding peasant household behavior have acknowledged the benefits of partial integration to the market and sought to understand obstacles to a household's desired level of integration.

Another approach looks at the costs associated with selling and buying goods, known as transaction costs. Transaction costs have been defined as "the cost of carrying out market transactions" (Coase 1960, 15). Carrying out market transactions in developing countries can be quite difficult and this difficulty has resulted in costs. Households may have to send someone some distance to market to learn market conditions, incurring costs of information. The cost of information is fixed and

consequently exhibits increasing returns to scale like other fixed transaction costs (Key et al. 2000). Transportation to market is proportional, i.e., there is a cost associated with each unit sold; however those selling large amounts of goods likely transport goods more cheaply per unit than households selling small amounts. Once the product is at the market, households have a strong incentive to sell regardless of price, incurring costs of being at a position of little market power. Peasants incur an extension of market power costs in the cost of legal risk; potential buyers might renege on agreements and without feedback mechanisms or appropriate legal structures for recourse the peasant may suffer a loss. In countries without functioning risk protection markets the weather and pests can be a source of risk. Weather affects households in a community relatively equally (unless there are irrigation mechanisms) with good years resulting in market gluts and low prices and bad years resulting in shortages and high prices. Pests may affect single farms, resulting in poor production for a single household during a period of low prices in the community.

All of these difficulties result in costs whether or not the household has actually been subject to them in a given year; the household must plan for them and structure activities to ensure survival. Both purchases and sales result in transaction costs. Peasant household production and consumption decisions are simultaneous. The result often is that households diversify and are self-sufficient. By choosing to produce all of the needs of the household within, both buying and selling costs are avoided and food security is maintained at the cost of cash income for non-food needs. By examining the costs associated with market integration, solutions may be found that allow peasant households to supplement subsistence with some level of market integration.



Often the observed level of self-sufficiency or diversity of crops on a farm is associated with distance or the actual cost of transportation of goods to market for the household. Farms located at a greater distance or with higher transportation costs tend to be more self-sufficient. Transportation costs of goods to market alone do not account for the differences between near (low cost of transportation) and distant (high cost of transportation) households. Transaction costs are a promising explanation of the differences of market integration observed between low and high cost households. Recent literature indicates that mobile phone use in trading can reduce transaction costs, potentially allowing households to integrate at a higher level than previously possible.

If a technology such as mobile phones can be shown to decrease one type of transaction costs (information costs) and make higher transportation costs more bearable it would enhance the understanding of the interplay between transaction costs and transportation costs. Results that show that mobile phones have a positive impact will also have the practical use of guiding development efforts. Investment in modern marketing systems will allow price signals to be passed more efficiently. Better and cheaper market information will lead to changes in strategies and innovations compatible with endowments (Ruttan and Hayami 1998).

A historical comparison made by Abraham (2007) illustrates the importance of understanding the effect of mobile phones. The introduction of the telegraph in the nineteenth century United States is credited with much of subsequent growth of the previously unsettled West. The introduction of the telegraph took forty years and the paired investment of the railroad and new organizational structures to make its full impact on the United States. Like the telegraph of the United States, mobile phones have

the capacity to drastically reduce information costs in developing countries. In smallholder farming regions mobile phone use is growing rapidly. An example of this growth can be seen in Bolivia; this country has seen an increase from 9.19 mobile phone subscriptions per 100 inhabitants in 2001 to 66.14 in 2009 to 72.48 per 100 inhabitants in 2010 (ITU 2011). During the same period of time fixed line telecommunications did not grow nearly as rapidly with 6.19, 8.23, and 8.54 subscribers per 100 inhabitants, respectively (ITU 2011). Understanding market participation during this period of change will help us build toward an understanding of subsequent changes in market, social, and political organizations and the process of change.

### 1.1. THE INSTITUTIONAL ENVIRONMENT

Bolivia has been characterized by conquest and revolution. Since gaining independence from Spanish rule in 1825 there have been at least 200 coups and countercoups (CIA 2012). Democratic civilian government was reestablished in 1982. Evo Morales was elected President in 2005 and his party took control of the legislative branch in 2009 on the agenda of empowering poor and indigenous people (CIA 2012).

Risk Category	Year Ago	Current (06/08)	One Year Ahead		Five Years Ahead		Points Possible
			Worst Case	Best Case	Worst Case	Best Case	
Political	56.5	58.0	52.5	62.5	56.5	67.0	100 (PR)
Financial	40.0	43.5	38.5	44.5	32.0	44.0	50 (FR)
Economic	36.5	36.5	34.0	38.0	30.5	40.5	50 (ER)
Composite	66.5	69.0	62.5	72.5	59.5	75.8	100

Composite=0.5\*(Political Risk (PR) + Financial Risk (FR) + Economic Risk (ER))

Source: Adapted from PRS. Published: June 1, 2008. Published Bolivia, politics, international country risk guide (ICRG). The PRS Group. Accessed: 2/16/12.

The Political Risk Services (PRS) Group International Country Risk Guide is written primarily for international investors, however it is also a good indicator of the risk associated with domestic investments. During the 2007-2008 period leading up to the survey Bolivia was wrestling with big issues of autonomy for departments and land reform (PRS 2008). Recall votes for President Morales were scheduled for the August following the survey, amid controversy over setting the threshold for removal from office (PRS 2008).

In addition to nationalizing oil companies, Morales announced May 1, 2008 that he would take full state control of Entel, the countries largest telecommunications firm (PRS 2008). Transportation and mining were also likely targets for nationalization (PRS 2008). These nationalizations had an effect on the PRS ratings (expropriation of private investments are worth 10 of the 50 points possible for financial risks), however the investment in their farms by smallholder farmers of the survey region will not likely be directly threatened by any of these reforms.

Table 1 shows the scores of the PRS Country Risk ratings for June 1, 2008. Categories are out of the points possible listed in the rightmost column. A zero would indicate very high risk and one-hundred (in the case of Political or Composite) would indicate very low risk. As table 1 shows, Bolivia falls into low to moderate risk bands in spite of the instability of the government and nationalizations.

In addition to the instability of the nation, or possibly because of it, Bolivia is one of the poorest and least developed nations in South America (CIA 2012). The instability of leadership likely has lead to uncertainty in the direction of institutional change. As

North (1997, p. 6) claimed, “stability is a necessary condition for complex human interaction...”

The HDI is a composite index that considers three dimensions of development: health, education and living standards (UNDP 2011a). The United Nations considers HDI values of 0.614 to 0.741 for 2011 to indicate medium development (UNDP 2011b). Bolivia’s 2011 Human Development Index (HDI) value was 0.633 in comparison to the mean value for Latin America and the Caribbean of 0.731 (UNDP 2011b). Problems with inequality are apparent (CIA 2012). The 2011 inequality-adjusted HDI was 0.437, almost seventeen percent less than the unadjusted HDI (UNDP 2011b). HDI inequality adjustments of fifteen to twenty percent are common in this region, however Bolivia is the least developed country in South America once adjusted for inequality (UNDP 2011b).

Table 2. Bolivia country level characteristics of interest.	
Characteristic	Bolivia (CIA 2012)
Ethnic Groups	Quechua 30% Mestizo (mixed white and Amerindian ancestry) 30% Aymara 25% White 15%
Languages	Spanish (official) 60.7% Quechua (official) 21.2% Aymara (official) 14.6% Foreign languages 2.4%, other 1.2% (2001 census)
Religions	Roman Catholic 95%, Protestant (Evangelical Methodist) 5%
Median Age	22.5
Literacy	Definition: age 15 and over can read and write Total population: 86.7% Male: 93.1% Female: 80.7% (2001 census)

*Source:* Data from CIA. Published: 1/9/12. Published Bolivia. United States of America Central Intelligence Agency. Accessed: 1/9/12.

Table 2 summarizes cultural descriptive statistics of Bolivia as a whole. In contrast, the survey area is populated primarily by people who self-identify as Aymara. Following paragraphs will describe the tension that has developed between the Aymara and other groups within Bolivia as well as other relevant topics of interest for this study.

The Aymara have been subject to outside dominant groups throughout their history (Swanson and Lagace 2010). The Aymara seem to have developed subtle defenses to threats, as evidenced by the widespread phenomena of the Aymara speaking in a monotone when speaking to people who are the object of Aymara hostility (Hardman 1981). This standoffish response to those associated with the domineering Spanish influence led early ethnographers to unfairly critique the Aymara as unsociable (Hardman 1981).

It was not an uncommon belief among Spanish speakers of the lowlands that the highland Aymara were incapable of speaking Spanish (Saavedra 1971). Spanish speakers attempting to communicate in the Aymaran language often carry the inflections and characteristics of Spanish to their “patrón Aymara,” retaining the relationship of “patrón/peón” and all of the connotation of inequality embodied in this language (Saavedra 1971, 22).

The interaction between the Aymara and Spanish speakers in La Paz is strained by a lack of cultural commonality (Saavedra 1971). The Aymara perceive Spanish speakers as loud, overly confident in their speech, and impolite because of the stark contrast between the Spanish speaking culture of the lowlands and the Aymara culture (Saavedra 1971). For example, in Aymara culture strangers greet, but do not interact unless introduced by someone who knows both parties and conversation explicitly

reveals the source of the information through markers of personal and impersonal knowledge (Saavedra 1971; Hardman 1981).

Incorporated first into the Incan Empire and later subject to Spanish conquest and finally the Bolivian Republic, each incorporation was accompanied by institutional change to the conqueror's advantage (Buechler 1983; Swanson and Lagace 2010). The system of serfdom established by Incan domination made the area ready for incorporation into the Spanish feudal system (Saavedra 1971). Differences persist between communities dominated by Spanish haciendas and free communities (Swanson and Lagace 2010). These persistent differences illustrate the importance described by North (1990) of path dependency, i.e. historical institutions in determining current institutions.

Most Aymara practice agriculture for part or all of their livelihood along with migratory labor, craft work and marketing surplus crops (Hardman 1981; Swanson and Lagace 2010). "Like other twentieth-century peasant groups, the Aymara are increasingly linked to a cash economy and respond with shifts in their adaptive strategies and consumption demands" (Swanson and Lagace 2010). Prior to incorporation with the Incan Empire, trade was present between people of different climates and altitudes (Buechler 1983). Specialized terminologies for buying and selling were developed and used in the Aymara language.

The importance and nature of markets through time are subject to debate (Buechler 1983). During the period of domination by the Incan empire markets either diminished in importance or the Incan's changed marketing institutions for their own purposes, depending on the source (Buechler 1983). During the period of Spanish

domination markets either disappeared or were used by Spanish colonialists to meet their needs, again depending on the source (Buechler 1983).

During the period of Spanish domination, Aymara and other native peoples were relocated to communities dominated by a local headman and a Spaniard with a grant from a provincial governor and later into a hacienda system (Buechler 1983). Marketable surpluses were eliminated by forced tribute of labor, goods, and services (Buechler 1983). Following the successful revolution by the *Movimiento Nacionalista Revolucionario* land was redistributed to the peasants who had previously been tenants (Buechler 1983; Grootaert and Narayan 2004).

Aymara supernatural beliefs are still practiced even after the imposition of Spanish Catholicism and recent progress by protestant missionaries (Swanson and Lagace 2010). The Aymara supernatural beliefs manifest themselves in a belief in several nature spirits (Swanson and Lagace 2010). Participation in local institutions, including religious organizations, has varying importance across Bolivia, but social capital is in general important in determining household welfare (Grootaert and Narayan 2004).

This study will examine two regions within Bolivia. One of the two regions, Ancoraimes, is located in the northern highlands of La Paz to Lake Titicaca. The average temperature is 8°C (46°F) and annual rainfall is 480.9 mm. All of the locations were above 3800 meters in elevation (12467 ft.). The communities of Ancoraimes are between 96 km and 112 km (59.6 mi. to 69.6 mi.) from La Paz (Romero 2009a).

The other region, Umala, is located in the central highlands. The average temperature is 11°C (51.8°F) and receives 300-400mm of annual rainfall. The main

market in Umala is Patacamaya, which is located 92km from La Paz. Each of the locations is between 11km and 28km from Patacamaya (Romero 2009b).

Fixed line phone service is generally not available to peasant households. Mobile phone coverage is available in the Umala communities of San Jose and coverage can be found up to 60 km west-southwest from Patacamaya. Service is available from three companies, although TIGO is the most popular with producers. Coverage is available in the Ancoraimes communities of Chinchaya, Cohani, and Calahuancani but only the high parts of Chojnapata. Chojnapata does have a fixed landline available for use and times can be scheduled for people to talk over the landline. Again, TIGO is the carrier of choice along with two other carriers in the market (Yucra Sea 2012).

Service is expensive. A handset cost \$100 USD in 2008, but today costs only Bs. 280 (about \$40 2012 USD). Calls cost the same today as they did in 2008, at Bs. 1.80 (about \$0.25 2008/2012 USD). There are promotions that can reduce the cost significantly as well. The carriers used to round to the minute, but now bill to the second. Calls are billed when placed, so receiving a call is free (Yucra Sea 2012).

Despite centuries of domination by other cultures the Aymara have retained parts of their culture including language, farming practices to protect the soil, the use of biophysical indicators, and a spiritual link with nature (Gilles and Valdivia 2009). Each dominating culture left its mark on the institutions of Bolivia and those distinctive institutions continue to have influence long after official domination has ended. Bolivia's government has been unstable since independence was won from Spain and poverty and inequality persist. With the preceding brief overview of Bolivia and the survey area, the data analysis will be conducted with awareness that location, language, and social links



will affect the outcome. Landline adoption has remained quite low. While expensive, mobile coverage is for the most part available and adoption has been increasing rapidly.

## 1.2. THE HYPOTHESIS AND OBJECTIVES

The general objective of this research is to understand how technology impacts information costs, in turn mitigating the inverse relationship between transaction costs and market participation. This study will examine quantitative data from a household survey of peasant households located in two regions of the mountainous environment of the Bolivian Altiplano conducted in 2008-2009. Bolivia is by most measures the least developed country in South America. Market participation among peasant households of the Bolivian Andes is low.

The hypothesis for this thesis is: all else equal, it should be expected that households with higher transportation costs or at a greater distance should be able to increase the degree of agricultural market participation, expressed as a proportion of cash sales of farm goods to total income including subsistence product.

The specific goals are first, to understand the levels of participation of households in markets; second, to describe transportation costs and transaction costs; and third, to determine how mobile phones and other factors decrease transaction costs allowing for households located at a greater distance from the market to integrate.

### 1.3. OVERVIEW OF THE THESIS

The following chapter, the literature review, focuses on market participation, transaction costs, mobile phones, household preferences, and the interactions between these topics in order to inform development of the theoretical framework.

Implementation of the theoretical framework to quantitative measures will follow in the third chapter. Methods of analysis available for studies of this type are also reviewed in chapter 3. Chapter 4 presents the estimation of the model and discussion of the results.

Conclusions and a discussion of the limitations and suggestions for further research are presented in Chapter 5. The Appendices provide details on variables not included in the final estimation, estimation results of a model using a different dependent variable, and notable findings from data exploration.

## CHAPTER 2.

### LITERATURE REVIEW

In this chapter the literature is reviewed in order to inform a theoretical framework developed at the end of this chapter and the beginning of the next. This chapter begins with a review of market integration as it has been studied in economic history and then discusses household models. Following this, approaches that consider multiple motives of actions and transaction costs are explored as methods of analysis. Following these approaches, applied literature on the uses and effects of mobile phones are reviewed. Finally, important concepts from the literature for the conceptual framework are discussed in the conclusion of this chapter. Lessons for the conceptual framework are summarized at the end of each section.

#### 2.1. MARKET INTEGRATION IN ECONOMIC HISTORY

In the years following World War II much of the development economics community sought to fix self-sufficiency as the community believed it to be a problem (Staatz and Eicher 1998). Neoclassical theorists believed that self-sufficiency and the associated diversity of crops within a peasant household was a problem for development of a country as a whole, not just a problem for the farmer. Neoclassical theorists encouraged specialization and market integration (Staatz and Eicher 1998; McMichael 2008; Peet and Hartwick 2009). The models used by these theorists assumed that

markets would function and an economically efficient level of specialization and market integration could be reached (Staatz and Eicher 1998).

As shortcomings of the neoclassical approach became apparent additional approaches emerged. Douglass C. North, a pioneer in New Institutional Economics and an advocate for realistic development theory claimed, “Neoclassical theory is simply an inappropriate tool to analyze and prescribe policies that will induce development” (1994, 359).

North (1994) advocated a modification of neoclassical theory that he called a theory of economic dynamics. North (1994)’s modifications included institutions and transaction costs, dismantled the rationality assumption of neoclassical theory, and added the dimension of time. Regarding the rationality assumption North stated,

“It is necessary to dismantle the rationality assumption underlying economic theory in order to approach constructively the nature of human learning. History demonstrates that ideas, ideologies, myths, dogmas, and prejudices matter; and an understanding of the way they evolve is necessary for further progress in developing a framework to understand societal change. The rational choice framework assumes that individuals know what is in their self-interest and act accordingly. ...[Assuming that individuals act in this manner] is patently false in making choices under conditions of uncertainty—the conditions that have characterized the political and economic choices that shaped (and continue to shape) historical change.” (North 1994, 362)

Additional approaches have been explored in empirical and theoretical work including, but not limited to, the following four.

In the first approach, studies examined household responses to risk and uncertainty (e.g. Lipton 1968; Ellis 1993, Ch. 5; Morduch 1995; Valdivia et al. 1996; Zimmerman and Carter 2003; Isakson 2007) and developed compelling arguments to explain abstaining from complete reliance on markets and specialization in environments

characterized by missing markets for risk reducing financial instruments and incomplete information.

Second, an approach that critiqued the specialization of farms has come from a perspective of looking at the environmental and consumption benefits of diversification (e.g. Altieri and Merrick 1987; Swinton and Quiroz 2003; Valdivia 2004). This argument has looked at co-benefits of intercropping and self-sufficiency to explain levels of diversification viewed by neoclassical theorists as inefficient.

Third, farmers have also been modeled as expressing either social or personal preferences through their choices of land use (e.g. Steinberg 1999; Smale et al. 2001; Isakson 2007). The Conceptual Framework of this thesis draws from the tradition of farmer preferences.

Finally, a fourth approach is one of balancing transaction costs, i.e. costs related to transacting, and the gains from market integration or specialization (Omamo 1998). This approach will be examined in depth in following sections of this chapter, including a discussion and definition of transaction costs.

## 2.2. HOUSEHOLD MODELS

Household models, such as those described in Ellis (1993) have been used to analyze decisions when consumption, production, and market decisions are decided jointly. The characteristic of the household model depend on the types of input and output markets farmers relate to, as well as the resources of the household, such as land and labor. By using a household model that matches the constraints and opportunities of

a household, a researcher should be able to understand the tradeoffs required for a household to reach its goals within its set of constraints and opportunities.

For example, a household that is both consumer and producer, has no access to a labor market, and has access to more land could be represented by the Chayanov farm household model with the household's indifference curves trading off labor days and leisure days within the constraints of the household in order to meet food demand and to utilize available household labor (see Ellis 1993).

Another household model, the Low farm household model, describes how households allocate labor of different values. For example, if a member of the household can earn more off farm than their labor is worth on farm that member should be expected to work off farm. Members of the household who cannot earn more outside the farm are expected to work on the farm. This model provides insight into households striking the balance between keeping labor on the farm for production and selling it, either in off seasons or entirely by having members of the household migrate permanently (see Ellis, 1993).

Another specific example of a traditional economic model is the New Home Economics Model first proposed by Becker (1965). The model is concerned with maximizing the utility resulting from purchasing goods and producing goods for use within the home ( $Z$  goods) from labor and purchased inputs. The model admits that it is not the purchase of a factor or a product that produces utility, but the use of the items. The household maximizes utility subject to a production function, a money income constraint, and a time constraint. Ellis (1993) detailed the use of the model. The shortfalls of this model are that it only looks at income and time constraints in relation to factor

prices, home produced goods are only for home use, and it does not consider cultural, social, or personal preferences in decision-making.

Sadoulet and de Janvry (1995) provide a framework that could be used based on factor prices. The household maximizes welfare (in-kind or cash) based on its resource endowment and factor prices.

In the area of interest for this thesis a labor market exists, consumption, production, and market decisions are made simultaneously, and it should be expected that households could be represented by some variant of the farm household model. These models can help to visualize conceptually how a change such as adoption of mobile phones for trade could also change observable characteristics such as division of time and specialization of production.

### 2.3. MULTIPLE MOTIVES OF THE HOUSEHOLD

An alternative to neoclassical theory is needed to show the interaction of social factors and personal preferences as much as constraints of law and capital in livelihood choice (North 1994; Long 2001; Wilson 2008). Long (2001) presented a more complex picture, citing:

“Livelihood is never just a matter of finding or making shelter, transacting money, getting food to put on the family table or to exchange on the market place. It is equally a matter of ownership and circulation of information, the management of skills and relationships, and the affirmation of personal significance [involving issues of self-esteem] and group identity. The tasks of meeting obligations of security, identity and status, and organising time are as crucial to livelihood as bread and shelter.” (Wallman et al. 1982, 5)

Long (2001) contributes his own perspective in a framework of interacting levels of social action. The first level is the “lifeworld” to depict the “lived-in” and “taken-for-granted” world of the social actor. This is followed by a discussion of livelihood. “Livelihood best expresses the idea of individuals and groups striving to make a living, attempting to meet their various consumption and economic necessities, coping with uncertainties, responding to new opportunities, and choosing between different value positions” (Long 2001, 54). Long (2001) provided emphasis on the importance of identity, “identity vis-à-vis other persons,” and relationships with others in livelihood choices. Looking at livelihoods from this perspective requires one to consider social dimensions of livelihoods embedded in social institutions, norms, and culture (Long 2001). This framework parallels well within North’s framework of institutions based on the sum of individual values within a society.

The activities making up a household’s livelihood change over time as opportunities and constraints are encountered (Wilson 2008). Wilson (2008) is a conceptual paper that included a vision of sustainable development characterized by “a deepening of diversification activities” and weak integration “into the global capitalist market” (Wilson 2008, 368). Wilson (2008) provided a framework of transition paths from monoculture to diversification through time. In addition to resource levels, the starting point is important to determining available transitional pathways, indicating that transitional pathways are characterized by path dependency (Wilson 2008, 375). Farm level choice of a pathway is dependent on more than traditional economic concerns of profit maximization; cultural, social, and personal value concerns are key to the choice as well (Wilson 2008). Wilson (2008)’s concept of a pathway of transition over time



dependent on cultural, social, and personal values strongly parallels North (1994)'s call for an economic theory of change over time that emphasized path dependency and the relevance of institutions.

Shucksmith and Herrman (2002) were also concerned with the traditional agricultural economic model of a farmer as a businessman making decisions purely out of profit maximization in their study about changes that were likely to come to British agriculture after major changes in subsidy programs. They studied attitudes, socialization, and initial circumstances of farmers.

The unique contribution of Shucksmith and Herrmann (2002) is the way they operationalize farmer decisions in a way that takes account the identity, normative, cultural, and community dimensions of livelihood. Building on Bourdieu, Shucksmith and Herrmann (2002) develop a concept of “disposition-to-act” that shapes, in part, farm household actions:

“The actions of farmers and farm households may be viewed as the outcome of interplay between the individual’s own “disposition-to-act” (the product of socialisation and interaction), the farm household’s material resources (size of farm, capital, labour skills, cultural capital, position in the life-course, tenure) and external structures (relative prices, policy, labour market opportunities, social and cultural norms, etc.).” (Shucksmith and Herrmann 2002, 39)

The foundation for a conceptual framework based on multiple motives of livelihood has been provided by Long (2001) to establish the importance of noneconomic factors in livelihood choice. Wilson (2008) defined and characterized farms by their diversification or lack of diversification and the pathways to changes between types of enterprises. Shucksmith and Herrmann (2002) operationalized these concepts into a

tension that can be visualized. This tension will be explored in the next chapter as part of the theoretical framework of this thesis.

## 2.4. INSTITUTIONS AND TRANSACTION COSTS

Following the lead of literature on transaction costs and institutions, first a definition of institutions and transaction costs must be developed. Once transaction costs are defined, literature establishing a link between transaction costs and market participation will be surveyed.

Institutions “are the humanly devised constraints that shape human interaction” (North 1997a, 2). This interaction can be political, economic, or social (North 1991). Institutions can be either informal, such as social norms, or formal, such as laws and contracts (North 1990). As humanly devised constraints, institutions define the choice set of wealth maximizing opportunities available to individuals (North 1990, 67). Three of North (1997b)’s arguments are important for the development of this thesis: (1) Institutional structure and organizations of a political-economy are the primary source of economic growth, (2) Economic growth requires stable institutions and organizations that provide low cost transacting in impersonal political and economic markets and (3) Institutions and their evolution are a direct result of the belief systems of the society.

The perspective that bargaining power matters in creating institutions in a world of positive transaction costs is important to understand how societies develop their formal rules. “Institutions are not necessarily or even usually created to be socially efficient; rather they, or at least the formal rules, are created to serve the interests of those with the

bargaining power to create new rules” (North 1994, 360-361). Furthermore, developing to a state of low-cost transacting through political and economic institutions requires a credible commitment to property rights (North and Weingast 1989; North 1997a).

Historical studies have shown that the state is not the only source of transaction cost lowering institutional innovation, by lowering transaction costs, groups of traders who adhere to a common set of norms and have an effective feedback mechanism were able to succeed in trade in the absence of legal structures to support low cost transacting (Ellickson 1989; Greif 1989).

#### 2.4.1. TRANSACTION COSTS DEFINED

The most observable feature of the institutional framework, i.e. the matrix of institutions that govern an economic or political activity, are transaction costs (North 1990, 68). Many definitions of transaction costs have been used in empirical work, which makes it necessary to define explicitly the notion of transaction costs being used in empirical work to provide for proper interpretation of the work (McCann et al. 2005; Benham and Benham 2010). As one of the early theorists concerned with transaction costs, Coase (1960, 15), defined the concept later named transaction costs as “the cost of carrying out market transactions.” In his study of the cost of transacting on the New York Stock Exchange, Demsetz (1968, 35) stated “transaction cost may be defined as the cost of exchanging ownership titles.” McCann, et al. (2005, p. 530) provided a definition, primarily targeting environmental policy evaluation, “transaction costs are the resources

used to define, establish, maintain, and transfer property rights.” Examining organizational structure Williamson (1979) observes,

“Among the factors on which there appears to be developing a general consensus are: (1) opportunism is a central concept in the study of transaction costs; (2) opportunism is especially important for economic activity that involves transaction-specific investments in human and physical capital; (3) the efficient processing of information is an important and related concept; and (4) the assessment of transaction costs is a comparative institutional undertaking. Beyond these general propositions, a consensus on transaction costs is lacking.” (Williamson 1979, 234)

Transaction costs have different dimensions (North 1997a). Time acquiring information, information costs, or search costs are all dimensions of transaction costs (North 1990, 68). North (1990, p. 108) explained that “the costs of transacting arise because information is costly and asymmetrically held by the parties to exchange and also because any way that the actors develop institutions to structure human interaction results in some degree of imperfection in the markets.” Transaction costs can be monetary, e.g., “bribery... as well as losses due to imperfect monitoring and enforcement” do not necessarily have to be explicit monetary costs, e.g., “time acquiring information, queuing...” (North 1990, 68). Williamson (1979) was particularly concerned with opportunistic behavior and its effect on contracting relationships. Opportunistic behavior can result in explicit or implicit costs as parties adapt or respond to experiencing or anticipating such behavior. Information costs in the context of rural households in developing countries may include transporting a person through whatever means available to the market just to acquire information (Overå 2006). Determining market conditions prior to delivery of goods to be sold may not be possible (Jensen 2007).

The distinction between transaction costs and production costs is not always clear when examining data (McCann et al. 2005; Benham and Benham 2010). In an attempt to differentiate the transaction and production costs, the following paragraphs will discuss examples of transaction costs from work that has become prominent in the field.

Similar to the explanation of North (1990), Staal, et al. developed a list of elements that describe transaction costs in his study of dairy markets in East Africa,

“Transactions costs include, inter alia, the costs of searching for a partner with whom to exchange, screening potential trading partners to ascertain their trustworthiness, bargaining with potential trading partners (and, in some cases, officials who can hold up trade) to reach an agreement, transferring the product (this typically involves transportation, processing, packaging, and securing title, if necessary), monitoring the agreement to see that its conditions are fulfilled, and enforcing (or seeking damages for any violation of) the exchange agreement.” (Staal et al. 1996, 5)

Staal et al. (1996) is very specific, but also included costs (transportation and packaging), which are more often thought of as production costs. The transportation costs described by Staal et al. (1996) are the actual costs of transporting the good, not transportation costs as described by Overå (2006) to acquire information. Transportation costs (of the good) can serve as “a reasonable first approximations of farm-to-market transaction costs in smallholder farming regions” (Omamo 1998, 159). Distance to market is weakly associated with transaction costs (Renkow et al. 2004). Staal, et al. (1996, 26) study of dairy producers in east Africa concluded, among other conclusions, that “transactions costs increase with distance, most likely faster than transportation costs alone, due to the increased costs of information and risk of dairy product spoilage before a buyer is found.” The preceding discussion demonstrates that transportation costs and distance to market are relevant indicators of transaction costs. However, as transaction costs are the primary barrier to trade over time, not transportation costs, (North 1987) it

remains useful to maintain them as separate concepts, in other words, not include transportation costs of goods as a transaction cost.

#### 2.4.2. TRANSACTION COSTS AS A BARRIER TO TRADE

When costs of trade exceed benefits we expect to see self-sufficiency. Transaction costs that are sufficiently high can prevent rural households from participating in markets (North 1990, 67; Renkow et al. 2004; Alene et al. 2008) effectively eliminating the choice of trade from the set of opportunities available to the household (Key et al. 2000). This barrier illustrates North's point when he argues "The interaction of these [institutional] constraints shapes the potential wealth-maximizing opportunities of entrepreneurs (economic or political)" (North 1990, 73). For instance, Alene, et al. (2008) found that transaction costs, relative to price and other factors, have significant negative effects on market entry and intensity of smallholder marketed surplus and input use. Renkow, et al. (2004) found while studying smallholder maize producer market participation in Kenya that transaction costs are a significant deterrent to market participation.

The foundation of arguments for transaction cost based analysis of household market participation can best be summed up by the conclusion to North's 1981 book:

"The ongoing tension between the gains from specialization and the costs arising from specialization not only is the basic source of structure and change in economic history but is at the very heart of modern problems of political and economic performance." (North 1981, 209)

North's tension means that if transaction costs are at levels that outweigh the gains from trade, households will choose not to participate in markets, choosing instead

to diversify and be self-sufficient (Omamo 1998). Farmers choosing to produce the household's needs themselves avoid the transaction costs that come from selling their goods and then buying the goods they need. The tension between transaction costs and market participation has been studied in several ways. The following paragraphs examine several examples including many of the empirical studies referenced in the preceding discussion.

### 2.4.3. TRANSACTION COSTS IN SMALLHOLDER PRODUCTION IN DEVELOPING COUNTRIES

Key et al. (2000), developed a supply model with data from Mexican corn producers in order to understand supply response (or lack thereof) to price changes. Key et al. (2000) noted that heterogeneous market participation would have important implications for an estimation of price response. They divided transaction costs into proportional transactions costs (PTCs) and fixed transactions costs (FTCs). PTCs are transaction costs which occur in per unit sold increments and "include per-unit costs of accessing markets associated with transportation and imperfect information" (Key et al. 2000, 245). FTCs are costs which are associated with entry in the market, these costs are the same for any amount sold and may include: search costs, "negotiation or bargaining" (especially in cases of imperfect price information), and "screening, enforcement, and supervision" (Key et al. 2000, 245-246). Survey data collected by the Mexican government was used and cases with corn producers farming at least one hectare of land (in order to capture producers instead of those with garden plots) (Key et al. 2000). The result was a 382 household sample with 190 net sellers, 69 net buyers, and 123 were self-

sufficient in corn production (Key et al. 2000). Using production shifters and PTCs Key et al. (2000) estimated sellers' production and buyers demand equations (quantity of maize). Using production shifters and FTCs Key et al. (2000) estimated selling and buying thresholds for sellers and buyers. Both types of transaction costs were important in explaining the household corn supply behavior in response to price in Mexico (Key et al. 2000). "The existence of idiosyncratic transactions costs implies that some households will opt for self-sufficiency instead of market participation" (Key et al. 2000, 258). Key et al. (2000) concluded that policies to reduce transaction costs and efforts to improve marketing organizations would increase maize production in Mexico by encouraging market participation.

Staal et al. (1996) focused on the role of transaction costs in discouraging smallholder farmers from participating in the dairy markets of Kenya and Ethiopia. Differences in dairy marketing patterns were observed in order to estimate the effect of organizations on those marketing patterns. Milk's characteristics make it vulnerable to transaction costs; it is highly perishable, market outlets vary seasonally, it is bulky, and there is a lack of easily measured quality standards. Observing a level of transaction costs that is a barrier is difficult, because the transaction does not actually occur (Staal et al. 1996). Levels of prohibitive transaction costs can be observed by lack of commercialization (Staal et al. 1996). A survey asked 231 respondents about their dairy marketing activities for the previous year, with the most unreliable third dropped from analysis. Respondents were located in varying distances to urban centers. The respondents were then clustered as large and small groups. After comparisons were made between groups, Staal et al. (1996) found that transaction costs in east African dairy



are high. The size and proximity to an urban center influence marketing decisions.

Small producers receive lower prices and may incur higher transaction costs.

Organizations of collective action reduce transaction costs. Staal et al. (1996)

recommend a strong course of action studying the impact of collective action

organizations noting their apparent importance in reducing transaction costs.

Omamo (1998) was concerned with how individual household market failures were observed with high degrees of enterprise diversification due to North's tension. Omamo had observed this tension in Kenya and cited two other studies set in Africa that reinforced the nature of North's tension. Omamo (1998) considered a world absent of risk where a tension between the costs of transacting were either more or less than the use value of the good being grown. When the use value is greater than the amount the crop can be sold for less transaction costs, it is used within and the household strives to be self-sufficient with a diverse mix of enterprises. Omamo (1998) used a series of equations to demonstrate the balance of transaction costs and benefits such as net revenue through a simulation model.

Omamo (1998) explained:

“However, the current analysis suggests that diversification induced by failures in insurance markets for risk-averse farmers is but one manifestation of a more general phenomenon, captured [in an equation balancing total transaction costs and net enterprise revenue], in which market failure means that benefits to self-provision of any potentially tradable item outweigh the forgone gains of market dependence. Because specialisation and trade are inseparable, the transaction costs paid by a household both determine and reflect the diversification of its production portfolio.” (Omamo 1998, 154-155)

The tension between transaction costs and market participation can be observed farms located further from market centers tend to be more diverse (Omamo 1998). In fact,

transportation costs serve as an approximation of transaction costs in smallholder farming regions (Omamo 1998). Omamo (1998) concluded noting that on farm diversification is an optimal response to high transaction costs for rural households.

Renkow et al. (2004) used survey data with a sample of 324 Kenyan maize farmers. Renkow et al. (2004) built their model of joint household supply and demand for maize from de Janvry et al. (1991) and Key et al. (2000) to determine the ad valorem tax equivalent rate for fixed transaction costs (FTCs from Key et al. (2000)). A maximum likelihood estimator is used to estimate demand or cost functions. They assumed that all households face identical transaction costs on average, and FTCs are the same for net sellers and buyers with a mean of zero and a common variance. As control variables, mode of transportation, distance to market, and land ownership are used. Renkow et al. (2004) determined that an effective ad valorem tax rate was 15.5 percent. In other words a household must be able to produce at least at a value of 15.5 percent lower than market price in order to be incentivized to participate in the market. Interaction between distance and truck service was positive and statistically significant. Renkow et al. (2004) concluded that distance to market and mode of transport (animal or bicycle) are positively associated with the size of fixed transaction costs.

Alene et al. (2008) also examined the effect of transaction costs on smallholder market participation in maize supply and fertilizer demand markets of Kenya. This study used a survey of 802 maize producers across eight districts in western Kenya with a model also built off of Key et al. (2000) to estimate a static model of household maximization of utility of net revenue subject to a technology constraint. A series of probit models were used to determine adoption of marketing or fertilizer. Alene et al.

(2008) noted a significant obstacle for empirical analysis is that a level of transaction costs which are a barrier to trade are unobservable because no trade has taken place. The second significant obstacle noted is that transportation costs are difficult to observe when the household transports the goods itself.

Alene et al. (2008) simply resort to using what can be observed: distance and transaction cost mitigating technologies such as membership in marketing groups, communications assets, and ownership of transport. Transportation costs were scaled to a variable measuring distant and non-distant markets. Output prices varied considerably, both temporally and between households. The study found overall that transaction costs, relative to price and non-price factors, have significant negative effects on both market entry and intensity (Alene et al. 2008).

#### 2.4.4. LESSONS FROM LITERATURE ON TRANSACTION COSTS

Coase (1960, 15)'s, definition "the cost of carrying out market transactions" may be the most applicable definition for this thesis due to the informal nature of the markets in rural regions of developing countries, as well as this study's focus on barriers to transacting. The expected primary drivers of change in this study are information costs. Explicit definition is necessary for clear communication with often-different definitions being used in other studies. With the preceding definition and discussion in mind, possible elements of transaction cost to be considered include: costs related to acquiring information, costs related to finding trading partners, costs of forming agreements of sale, costs of enforcing sale agreements, and costs of maintaining a level of trust with trading

partners for ongoing trades. Transaction costs are associated with distance to market and transportation costs. It is clear that the nature of the good in part determines the level of transaction costs. The empirical studies discussed earlier worked with similar sizes of samples and had variables that can serve as examples for similar measures for this thesis. Finally, the empirical studies noted a measurement problem associated with transaction costs that are so high that trade does not occur; imperfect measures must suffice. Transportation costs are also noted as an imperfect measure, especially when the household transports its own goods.

## 2.5. MOBILE PHONES

This part of the thesis will discuss previous studies on mobile phones. First the established uses of mobile phones will be explored. Following uses will be a discussion on the effects of low market penetration. Then a discussion of the importance of social relationships and trust will lead to a discussion on mobile phones effect on the expressions of transaction costs such as price dispersion and transportation costs. Mobile phone use and market participation will then be discussed. Finally lessons for this thesis will be discussed. Much of the previous work on mobile phones was done with a theoretical framework based on transaction costs. Throughout this review I will link mobile phone studies to concepts from the review of transaction costs.

### 2.5.1. USES OF MOBILE PHONES IN SMALLHOLDER FARMING REGIONS

Mobile phones have had many uses attributed to them in development. Aker and Mbiti (2010) reviewed work of development practitioners and literature on mobile phones in development to develop a package of recommendations of possible uses of mobile phones in Africa. They believed that in addition to benefits to trading, mobile phones have the capacity to do other things such as banking for the unbanked through mobile payment systems, reinforcement of social ties, and literacy training reinforcement (Aker and Mbiti 2010).

Donner (2006) examined the link between mobile phones and building business relationships with a survey of micro-entrepreneurs conducted in Kigali, Rwanda during the month of December 2003. By completing interviews and examining call logs of 277 micro-entrepreneurs Donner (2006) was able to gain access to 2,700 discrete phone calls. A randomized pool of respondents was not available; respondents approached were in markets, shops, and or were roaming street vendors (Donner 2006). All respondents had mobile phones; 32 percent had landlines either at home or work (Donner 2006). Donner (2006) expected that early adopters of mobile phones would use their mobile for a higher proportion of business calls. Donner (2006) also expected that mobile phones would be used to change the users business network by adding new customers and suppliers while choosing to strengthen personal ties with people already known. After a quasi-likelihood regression model was employed to analyze the data gathered, newer users have a lower overall proportion of business calls than do early users (Donner 2006). Donner (2006) posed several explanations including differences in business success or intensity, or even

a change in use over time from new to older user. In this study, the highest proportion of new contacts was found in business-related call partners of micro-entrepreneurs who only own a mobile phone (Donner 2006). For personal networks, micro-entrepreneurs use mobile phones to strengthen ties (Donner 2006).

Abraham (2007) interviewed fishermen in India to determine how mobile phones affect the supply chain. He hypothesized that information technologies would play a role in correcting information asymmetries. Abraham (2007) employed a literature review and interviews with experts to prepare for focus groups and eventually interviews with 172 individuals from across the fishing industry throughout the Indian state of Kerala. Mobiles were found to be useful enough to the fishermen using them that 82 of the 172 fishermen would not stop using them if prices increased and even respondents who felt that mobiles were detrimental for business without further explanation now considered them indispensable (Abraham 2007). Many more respondents refused to answer, afraid that the interviewer was actually working for the telecommunications company and that rates would increase if respondents reported a willingness to pay more (Abraham 2007). Indicating an ability to mitigate the barrier of distance, respondents indicated an ability to carry out business outside of their immediate area following the introduction of mobile phones (Abraham 2007). Abraham (2007) claimed that the data showed an environment of reduced risk and uncertainty with the introduction of mobile phones; three quarters of respondents indicating considerably reduced business risk since beginning to use mobile phones. The survey results led Abraham (2007) to be cautiously optimistic about a possible productivity increase as a result of mobile phone use. Abraham (2007) identified broad requirements for communications technology to be successful in underdeveloped

markets: the innovation must be affordable, local knowledge is required to identify market opportunities, and information asymmetries in markets must be correctable through creative use of technology (Abraham 2007). Throughout, Abraham (2007) emphasized the role of information being transmitted through prices drawing on a tradition of Hayak (1945) and Stigler (1961), but does relate the capacity of mobile phones to reduce information costs to a reduction in transaction costs.

Using a case study method, Jagun et al. (2008) looked specifically at the impact of mobile phones on supply chains in the ceremonial cloth weaving sector of Nigeria. Sixteen semi-structured interviews with seven intermediaries, six weavers, and three buyers were conducted in person. Jagun et al. (2008) detail the different roles and risks and opportunities associated with each. Intermediaries have the capital and recognize the need for communications so in some cases they provide a phone for their weavers or they sell a phone to the weaver to be paid for out of future sales of garments (Jagun et al. 2008). They found that mobile phones were particularly valued as a “substitute for unproductive travel” (Jagun et al. 2008, 57). Evidence for the impact of mobile phones closing physical distances was seen in the broader geographical spread each of the different levels of participants were able to engage (Jagun et al. 2008). The study concluded that mobile phones reduce the impact of problems related to time and cost spent acquiring information and physical risk of travel; but that they did not eliminate those problems, nor do they address issues of class differentiations (Jagun et al. 2008). If sufficient trust is present between call participants, mobile phones can help speed the order process (Jagun et al. 2008). The structure of the market with intermediaries between buyers and weavers has limited the impact mobile phones have had on

correcting information asymmetry; intermediaries are in a position of considerable power over the weavers (Jagun et al. 2008). The authors noted that evidence for continuation of current wealth patterns was as, or more, abundant than evidence of mobile phones acting as a leveler of socioeconomic patterns (Jagun et al. 2008). The importance of the availability information over the technology was reinforced as well (Jagun et al. 2008).

Amaya Urquieta and Alwang (2012) combined qualitative and quantitative methods by using a survey of farm households of Tiraque, Bolivia to meet three objectives: first to determine if mobile phones affect market choice, second to determine if mobile phones are used to complement or replace existing networks, and third to examine the effects of changing market choices and networks on women. The survey was applied to 304 households and took place immediately after the 2007 potato harvest (Amaya Urquieta and Alwang 2012). By geo-referencing the data, households were chosen to control from locations with and without mobile phone coverage (Amaya Urquieta and Alwang 2012). This selection process combined with two-stage least squares estimation procedures were used to control for a potential endogeneity problem (Amaya Urquieta and Alwang 2012). GIS software was used to measure travel time and distance from households to markets (Amaya Urquieta and Alwang 2012). Amaya Urquieta and Alwang (2012)'s results indicate poor farmers are able to enhance market access through mobile phones as well as wealthier households. Amaya Urquieta and Alwang (2012) demonstrated the power of mobile phones to overcome a market power disadvantage of farmers; farmers bringing potatoes to market are reluctant to leave without selling them, giving the buyers an advantage in bargaining. With better information, farmers could choose delivery dates based on prices. Mobile phone



ownership was also found to increase the probability that a household participates in a distant market (Amaya Urquieta and Alwang 2012).

The physical risk associated with travel in developing countries should not be ignored. Bolivia's North Yungas Road (outside the survey area) is widely considered the most dangerous road in the world (Pentland 2008) and the U.S. State Department warns travelers that Bolivia is considered a medium to high crime country (US Dept. of State 2012) making a concern over personal safety for the peasant farmers of the survey a valid concern. These studies indicated that mobile phones are used as a substitute for traveling for information. This can lower the cost of information. The literature also indicated possible changes in power structures and networks. Lower cost information and changes in networks that facilitate better trading relationships will likely lead to reduced transaction costs and their expression such as price dispersion and abstaining from market participation.

### 2.5.2. MARKET PENETRATION

Low market participation has two problems for econometric studies. The first, addressed by Sampong et al. (2007), is that when there is a low number of respondents reporting the activity of interest (using mobile phones) it can be difficult to find significant results. Sampong et al. (2007) examined the income generating capacity of women in a district of Ghana. A survey of 91 randomly selected women was used to gather data to be analyzed (Sampong et al. 2007). The results of their regression suggest that mobile phone users have higher income generating capacity, even with the few (6)

mobile phone users in the survey (Sampong et al. 2007). In fact, the coefficient for mobile phone use was positive and significant to the one percent level in their estimation of the effect of modern information technologies on the income generating capacity of female food producers (Sampong et al. 2007).

The second, examined by Gruber and Koutroumpis (2010) and that Aker (2010) overcame, is that mobile phones may not actually have an effect until a certain number of trading pairs are using mobile phones. Gruber and Koutroumpis (2010) examined the link between mobile phone market penetration and the growth of economies. The authors used a 1995 study on the US Fax market (Economides and Himmelberg, *Critical Mass and Network Size With Application to the US Fax Market*) to describe the importance of the number of buyers and sellers using the technology in order for there to be a useful effect. Not surprisingly, they found a positive but small relationship for low penetration (low income) countries, and a positive and large for high penetration countries (Gruber and Koutroumpis 2010).

Aker (2010) analyzed two data sets consisting of primary and secondary sourced grain price data from 37 markets across Niger from 1999 to 2006 and a survey of traders and other market participants conducted in 35 markets across Niger between 2005 and 2007. The results of this study indicated that a critical mass of traders must have been using mobile phones for a price effect to exist (Aker 2010). Initially, the effect of mobile phones was not statistically significant; as more trading pairs acquired mobile phones price dispersion decreased (31% of market pairs in 2004/2005 for this data set) (Aker 2010).

Market penetration has two problems associated with it for econometric analysis. The first, indicated by Sampong et al. (2007), statistical significance could be illusive with low numbers of respondents (in a different situation with almost complete adoption a similar problem arises). Sampong et al. (2007)'s results show a significant coefficient on mobile phones, indicating that the difference between the groups must have been substantial to have such a low number of mobile phone users. The second, indicated by Gruber and Koutroumpis (2010) and Aker (2010), is that there has to be a certain level of market penetration in order for the telecommunications technology to have its expected results. For this thesis, it could be difficult to establish a link between market participation and mobile phones because a similarly low number of respondents (17 out of 318) are using mobile phones. Random sampling of the survey sample should ensure that market penetration is similar in the population of the surveyed communities (about five percent). The actual critical mass is likely context specific, meaning that it is impossible to know ex ante if a market penetration is great enough to show an effect.

### 2.5.3. SOCIAL RELATIONSHIPS AND TRUST

Trusting trading partners and building rapport over time is one way to lower transaction costs. As noted by Staal et al. (1996), Amaya Urquieta and Alwang (2012), and North (1990), there are costs associated with protecting oneself from opportunism. Reputation is an asset to be protected and reliable information about expected performance is expensive. Individuals possess unique advantages by possessing and being able to act on unique information, i.e., information held asymmetrically at a given

time (Hayek 1945). Costly information about people one works with can influence the structure of an organization (Alchian and Demsetz 1972). Costly information can also be reflected in general mistrust of a transaction (i.e. purchasing a used car) when one party knows more than the other about the transaction (Akerlof 1970). In the absence of effective legal structures personal networks (often based on reputation) can facilitate reduced cost trade (Ellickson 1989; Greif 1989).

Aker and Mbiti (2010) hypothesized that mobile phones will have the ability to better facilitate shocks through social capital and better ties with relationships across borders. They challenge researchers to understand the effects of mobile phones on social networks. The impact of mobile phones on social and business ties is an important concern. Aker and Mbiti (2010) independently reinforced Donner (2006)'s position that mobile phone use would strengthen ties.

Aker (2010) found that although an official system existed for market information since the 1990s, 89 percent of grain traders preferred personal and professional networks. Jagun et al. (2009) note the importance of trust between trading partners in determining the effectiveness of adopting mobile phones. These two results reinforce the importance of personal connections through the technology, as market participants prefer the information acquired through trusted network connections to an impersonal market reporting system.

Overå (2006) examined the interaction of telecommunication technology on the way traders in Ghana operate. The research objective was to determine if using telecommunication technologies can enhance trust between actors under conditions of uncertainty (Overå 2006, 1302). To conduct the study, informal conversations were held

with approximately 80 traders in fish, staples, vegetables and African textile prints (Overå 2006). The study found that for traders a mobile phone's most important function is searching for information (Overå 2006). Traders reduced transaction costs by adopting telecommunications technologies that substitute the need to transport people for the purpose of communication (Overå 2006). Overå (2006, 1303) concluded that through reduction of information asymmetries "adoption of new technology may enhance the development of trust between the actors in the market and facilitate transactions that might otherwise not take place or would take place at a higher cost." The technology is a lower cost tool for existing trust building activities of exchange through lower cost observation and feedback (Overå 2006). This study is one of a few that paid attention to the fact that traders must take into consideration many social, cultural, and moral concerns beyond profit maximization in order to continue trading with others; traders must prove over time that they are personally reliable (Overå 2006).

Amaya Urquieta and Alwang (2012)'s study of 304 farm households of Tiraque, Bolivia found that mobile phones were initially purchased to maintain contact with migrating family members and were subsequently used for marketing. Mobile phones for marketing purposes are used to communicate with long-standing contacts; the network of a household itself has not changed, only the tools of contact (Amaya Urquieta and Alwang 2012).

Mobile phones are primarily used to strengthen existing networks, but phones can also help bridge those gaps created by distance or the natural divide between different classes. This bridge could facilitate the function of the "outpost" who goes out and then brings knowledge back to the community as described by Oreszczyn, et al. (2010).

Community members outside of the community will not only be able to send remittances of money, but information. Therefore, indications of changes to networks or differences between networks between mobile phone users and non-users should be examined.

#### 2.5.4. EXPRESSIONS OF TRANSACTION COSTS

The presence of transaction costs can be observed in price dispersion, poor market coordination, and market participation. Varian (1980, 651) defines spatial price dispersion as “a situation where several stores contemporaneously offer an identical item at different prices.” Temporal price dispersion is a situation in which stores vary their prices over time (Varian 1980). Price dispersion often results from a lack of information. The cost of searching for buyers or sellers (a transaction cost) relative to the potential gains of an additional search is one source of price dispersion (Stigler 1961). In fact, Stigler (1961, 214) claimed, “price dispersion is a manifestation—and, indeed, it is the measure-of ignorance in the market.” Stigler (1961, 220) went on to say that “the maintenance of appreciable dispersion of prices arises chiefly out of the fact that knowledge becomes obsolete.”

Mobile phones have been shown to have the capacity to reduce search costs, in turn reducing the cost of information (Aker and Mbiti 2010). In fact, mobile phone coverage or mobile phone use has been found to reduce different measures or proxies of transaction costs (Donner 2006; Abraham 2007; Jensen 2007; Muto and Yamano 2009; Aker 2010; Islam and Grönlund 2010). For example, Jensen (2007) found better coordination of buyers and sellers and Aker (2010) found reduced price dispersion.

Aker (2010) found a 10 percent to 16 percent reduction in dispersion of agricultural prices across markets over the introduction period of cellular telephones in Niger, primarily through reduction in search costs. Aker (2010, p. 53) found mobile phones reduce the impact of distance on price dispersion, but distance still plays an important role in price dispersion. This would seem to indicate that mobile phones are important tools to reduce information costs, but distance still plays a key role, i.e. transporting the product is still expensive.

Abraham (2007) found that a strong majority of survey respondents reported that price dispersion over both time and space had decreased since the introduction of mobile phones. Again, this would indicate that mobile phones reduce transaction costs.

Jensen (2007) examined the effects of growing mobile phone use among fishermen and traders in southern India. Characteristics of interest in this market were: that fish are perishable, fishermen sell to marketers, the amount of fish caught varies from day to day, transportation on land is costly, and fish are caught and sold each day (Jensen 2007). Jensen (2007) was especially interested in price dispersion between different market centers and the role of information asymmetry in these price dispersions. The study was carried out with weekly surveys between September 3, 1996 and May 29, 2001. Prior to the introduction of mobile phones there were often excess buyers or sellers at a given market (Jensen 2007). The excess buyers and sellers would create an environment of price dispersion with markets characterized by excess buyers having higher prices and markets characterized by excess sellers having low prices and wasted fish (Jensen 2007). Excess fish were disposed of each day (Jensen 2007). After the introduction of the mobile phone system (which happens to cover about 25km out to sea)

fishermen began choosing markets by acquiring price information while at sea (Jensen 2007). After fishermen and marketers started using mobile phones Jensen (2007) found a persistent reduction in price dispersion between markets and a reduction of waste from unsold fish. The information provided through mobile phone use, not mobile phones in themselves, improved the south Indian fisheries markets. The source of the information was not the focus of the study.

Jagun et al. (2008) demonstrated the importance of the market and good characteristics. No price effects were found in Jagun et al. (2008); this should be expected given the specific and infrequent transactions of these ceremonial garments.

Muto and Yamano (2009, 1887) looked at panel data from Uganda from 2003 and 2005 investigate the effects of mobile phone expansion on market participation. They tracked community level ratios of net buyers and net sellers with a survey covering 856 households in 94 communities. From 2003 to 2005 mobile phone coverage expanded from 41 to 87 of the communities. Statistical models (depending on the link being examined) were used to determine a link between “(1) mobile phone network coverage at the community level, (2) the possession of mobile phones at the household level, (3) banana and maize market participation, (4) the proportions of sales to the total production of banana and maize, and (5) the 2005/2003 price ratio of banana and maize” (Muto and Yamano 2009, 1889). Market participation was measured by the ratio of households selling bananas (or maize) to producers of those crops in a community. The results indicated a large increase in households selling bananas more than 20 miles from district centers, but the authors admitted the causal link was uncertain (Muto and Yamano 2009, 1889, 1893). Maize is less perishable than bananas and no impact was found for maize



(Muto and Yamano 2009). Overall, the study found that mobile phone possession did not have an impact, but mobile phone coverage in rural areas does have a benefit for small landowners (Muto and Yamano 2009, 1893-1894).

In Amaya Urquieta and Alwang (2012), household ownership of mobile phones was found to be strongly significant in predicting increased urban potato marketing. Households are able to reduce the uncertainty of participating in distant urban markets and choose to market at those distant markets for substantially higher prices (Amaya Urquieta and Alwang 2012).

In this review, mobile phone use has been shown to decrease temporal and spatial price dispersion for goods that are compatible. Reduced price dispersion reflects lower information cost or a decrease in transaction costs. Mobile phones allow potential traders to address both the search cost and the knowledge obsolescence aspects of price dispersion through lower cost and faster communication. Not all goods will experience a reduction in transaction costs. The use of the mobile phones to reduce transaction costs is dependent on the information and the capacity to take advantage of what is learned. The literature indicated that market participation at long distances increases with mobile phone use. The difference between bananas, maize, fish, and ceremonial garments reinforces the importance of the good and the information in determining impact of mobile phones.

### 2.5.5. LESSONS FROM MOBILE PHONE LITERATURE

Jensen (2009) presented a general framework for understanding the impact of information and communications technologies on the functioning of agricultural markets. The framework appears to have potential, but is focused on welfare transfers through the supply chain. This would be an interesting approach, to a different question. The variety of problems and approaches observed in the related literature show there is a considerable interest in how mobile phones impact market activity and many ways to observe the interaction. Some common themes were found throughout the variety of literature. First, information is important. The actual driver of market change is the availability of lower cost information; the mobile phone is a tool used to acquire the needed information. Personal possession of a mobile phone may not be necessary to enjoy benefits of lower cost information, but mere possession of a mobile phone or coverage in the area is certainly not sufficient to encourage market participation or reduce transaction costs. Mobile phone possession may not be necessary to enjoy possible spill over effects of better functioning markets, but to be sure to be able to take advantage of the opportunity would necessitate access to the information mobile phones could act as a medium of access. Second, the characteristics of the goods being traded are still important; frequency of trades, transportability (both of the good and the transportation network), perishability, and degree of commoditization are important characteristics that will influence the effectiveness of mobile phones to induce market participation. Third, a critical mass of buyers and sellers using phones (which will likely depend on the location and goods) must be met in order for mobile phones to have an effect.

## 2.6. LESSONS FROM THE LITERATURE FOR THE CONCEPTUAL FRAMEWORK

Market participation of peasant farmers has been a topic of fascination for the history of development economics. Choice of degree of market integration is a choice of livelihood for the household. Neoclassical theorists developed household models that provided a base of knowledge to understand the tension of allocating scarce resources for a goal. The literature has challenged researchers to understand the impact of non-economic preferences in livelihood choices. Shucksmith and Herrmann (2002) developed a tension of internal resources, external structures and personal preferences, termed “disposition-to-act.” This tension can be used to incorporate the full spectrum of constraints on a household’s choice of livelihood and to explore peasant farmer market participation from a transaction cost perspective.

Low market participation and high price dispersion can be attributed to high transaction costs. Abstaining from markets in favor of self-sufficiency is a response to high transaction costs. Transaction costs can be mitigated by adoption of technology that allows for lower cost information. The literature reviewed shows that the lower cost information can reduce price dispersion and increase market participation.

The gap in the literature being filled by this study is two fold: (1) a relationship between mobile phones and market participation is estimated at the household level, and (2) non-economic factors influencing livelihood choices that are typically ignored are a major part of this analysis.

## CHAPTER 3.

### CONCEPTUAL MODEL, METHODS AND PROCEDURES

In this chapter a theoretical framework will be developed from the literature review. Following the conceptual framework will be a discussion of the methods available to the analysis and the data being used. After this, the variables are operationalized.

#### 3.1. CONCEPTUAL MODEL

If using mobile phones in trade decreases transaction costs, then holding personal preferences, household wealth characteristics, and risk preferences constant, mobile phone use should be associated with this hypothesis: it should be expected that households with higher transportation costs or at a greater distance should be able to increase the degree of market participation, expressed as cash sales of farm goods, of the output of their farms. In other words, controlling for other factors, mobile phones will have a positive effect on market participation for high cost or long distance households.

Figure 1 is a hypothetical representation of this hypothesis. On the vertical axis three categories of households are represented: low, intermediate, and high cost of transporting goods to market. On the horizontal axis a continuum of market integration is represented with low integration (high levels of self-sufficiency) on the left and high integration (low levels of self-sufficiency). Low cost households are no different between

the mobile phone group and non-users. There is a moderate increase in mid cost households, and large increase in high cost households. This is the expected relationship based on the literature reviewed.

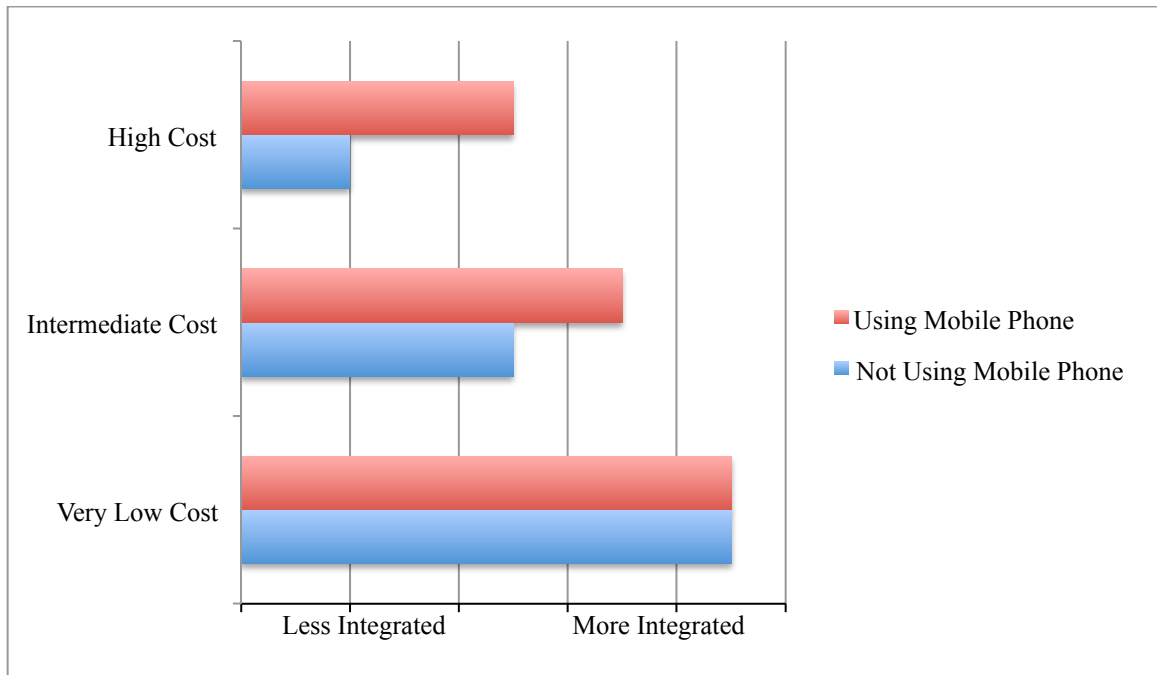


Figure 1. Representation of household market integration with and without mobile phone at high, intermediate and very low costs of transportation.

### 3.2. MODEL ESTIMATION METHODS

This section will address the benefits, assumptions, and limitations of the quantitative tools available for analysis. In this section, measures of central tendency will be compared, principal components analysis are then introduced, followed by an introduction of Tobit analysis, and then a discussion of linear regression. Following this section, the data used is described and variables are developed from the data to fit the theoretical framework presented in the previous section.

### 3.2.1. MEASURES OF CENTRAL TENDENCY

The single-sample  $z$ -test is a parametric test used for hypothesis testing using both mean and standard deviation to test for differences between the sample and population when the population variance is known and the sample distribution is normal (Jackson 2010). The single-sample  $t$ -test is a parametric test used to test for differences in the mean of a portion of a sample of the population and the full sample of the population, and does not require that the population be normally distributed or that the population standard deviation be known (Jackson 2010). However, the  $t$ -test does assume that data is interval or ratio and that the population distribution of values is symmetrical (Jackson 2010). The One-Sample Wilcoxon Signed Rank Test is the nonparametric equivalent of the single sample  $t$ -test (UCLA 2012). This tests for differences in the median value of the sub-sample and the median of the larger sample. As such, the  $t$ -test assumption regarding distribution does not apply and the only assumption of the One-Sample Wilcoxon Signed Rank Test is that the data is ordinal (UCLA 2012).

### 3.2.2. PRINCIPLE COMPONENTS ANALYSIS

Principal Components Analysis (either Principal Components Analysis [PCA] or Categorical Principal Components Analysis [CaPCA] depending on the nature of the variables, but collectively known as PCA) is used to observe the relative importance of the variables within the group of conceptual constructs. PCA is a technique used to reduce the number of variables into a smaller set of indices or components, which can be

included as continuous independent variables in regression models (Vyas and Kumaranayake 2006). PCA has been used to develop socioeconomic indicators (Vyas and Kumaranayake 2006) and to examine obstacles to agroforestry adoption (Valdivia et al. 2012).

### 3.2.3. TOBIT ANALYSIS

A Tobit model is “a model for a dependent variable that takes on the value zero with positive probability but is roughly continuously distributed over strictly positive values” (Wooldridge 2009, 847). Tobit analysis is a method of analyzing data with a hypothesized cluster of data at a limit, often zero (McDonald and Moffitt 1980). Wooldridge (2010, 667) refers to a distribution like this as a “corner solution outcome” and the model as a “corner solution model.” Tobit analysis would work with the corner solution outcome dependent variable (Wooldridge 2010). As the model is described later, the dependent variable would be between 0 and 1 because it is a proportion. Tobit analysis is not without problems. The notion of maximum likelihood, central to Tobit analysis, is less intuitive to interpret than conditional expectation of ordinary least squares (OLS).

### 3.2.4. ORDINARY LEAST SQUARES

Ordinary least squares (OLS) is “a method for estimating the parameters of a multiple linear regression model. The ordinary least squares estimates are obtained by

minimizing the sum of squared residuals” (Wooldridge 2009, 843). OLS finds a linear path through the independent variable space (with dimensions equal to the number of parameters in the model). Through a process of estimating the variance of each regressor and the covariance of each regressor  $(x_1, \dots, x_k)$  and the regressand  $(y)$ . OLS finds coefficients (known as  $\hat{\beta}$  when speaking of a sample and  $\beta$  when speaking of the population) expressed as equation 1 (using scalar notation where a bar indicates a sample average,  $\hat{\beta}_1$  is a slope coefficient, and  $\hat{\beta}_0$  indicates a y-intercept other than the origin).

The formulas for estimating  $\hat{\beta}_1$  and  $\hat{\beta}_0$  are:

$$\hat{\beta}_1 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2} \text{ and } \hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} \quad (1)$$

where  $x_i$  is the observed value of the first regressor for the  $i$ -th case,  $\bar{x}$  is the sample average of the first regressor,  $y_i$  is the observed value of the regressand for the  $i$ -th case and  $\bar{y}$  is the sample mean of the regressand.

OLS chooses the  $\hat{\beta}$  values in order to minimize the sum of squared residuals (what is left when regressors are multiplied by their respective coefficients and subtracted from the sample  $y$  values). Under the first through fifth assumption, known as the Gauss-Markov assumptions, the OLS estimators are the best linear unbiased estimators (BLUE). Put simply, the estimated value of  $\hat{\beta}$  is more and more likely to be close to the actual population  $\beta$  as the sample size approaches infinity.

The first assumption is that the model for the populations of interest is that the model for the population of interest can be represented in linear parameters (Wooldridge 2009). The second assumption is that the sample is randomly selected from the population (Wooldridge 2009).



The third assumption is that there is no perfect collinearity in the sample population. Assumption MLR3 assumes that there is no perfect collinearity in the sample or population. This assumption is crucial. Without it OLS cannot estimate  $\beta$ s for the model. The root reason for this is that in matrix form this assumption is that the covariate ( $x'x$ ) matrix is of rank  $k$ , where  $k$  is the number of parameters and  $x'x$  is a square matrix. The matrix notation formula for  $\beta$  is in equation 2. As can be seen in equation 2, the  $x'x$  matrix must be invertible. For the matrix to be invertible it must be of “rank  $k$ ” where the model has  $k$  parameters. If one of the regressors is exactly linearly dependent of another, for example a multiple of 2, the matrix will be of rank  $k-1$  and no unique solution to the equation will exist. If a  $x'x$  matrix is not of rank  $k$ , and if the software estimates fitted values, the  $\beta$ 's will not be reliable and should not be used.

The matrix form of the equation estimating  $\beta$  is:

$$\hat{\beta} = (x'x)^{-1}(x'y) \tag{2}$$

The fourth assumption is that the error term, known as  $u$  (of the population), has an expected value of zero, given any values of the independent variables (Wooldridge 2009). This conditional expectation form is more stringent than the fact that the error terms cannot be correlated with the  $x$  variables and that it must have a zero mean. It also means that given all of the  $x$ 's, the expected value of  $u$  is zero.

The fifth assumption is homoskedasticity. This means that the error term ( $u$  for the population,  $\hat{u}$  for the sample) has the same variance regardless of the values of any regressors (Wooldridge 2009). This assumption is not critical, as the estimators are still unbiased and consistent under heteroskedasticity (the  $u$  depends on the value of at least a regressor). The main consequence of heteroskedasticity is that it causes a larger sampling

variance, leading to invalid standard errors of the estimated values for  $\hat{\beta}_j$  [ $se(\hat{\beta}_j)$ ] (Hayes and Cai 2007). These invalid standard errors lead to invalid statistical inferences such as  $t$ -statistics and  $p$  values of the estimated values for  $\beta$  (Hayes and Cai 2007). Goodness of fit measures not dependent on the  $se(\hat{\beta}_j)$ s such as R- squared are still reliable, however F-statistics are no longer valid since the distribution is no longer “F-shaped” (Wooldridge 2009).

Heteroskedasticity can be observable visually, but in striving for rigorous analysis there are several tests of heteroskedasticity, each designed to test for a certain form of the many forms of heteroskedasticity (Hayes and Cai 2007). One of the more often mentioned tests for heteroskedasticity is the Breusch and Pagan test (Hayes and Cai 2007; Wooldridge 2009).

There are a number of ways to overcome heteroskedasticity present in a model. In order to use test statistics, one of at least two approaches can be used, the first of which is weighted least squares (WLS) (Hayes and Cai 2007; Wooldridge 2009). Using WLS requires knowledge of the form of the heteroskedasticity and a model of that form (Hayes and Cai 2007; Wooldridge 2009). The second approach is to use heteroskedasticity robust standard error estimators (Hayes and Cai 2007; Wooldridge 2009). Essentially, this changes the formula that finds standard errors and does not assume that they are constant. Robust standard errors are valid to use to conduct hypothesis tests (Hayes and Cai 2007; Wooldridge 2009). Hayes and Cai (2007) indicate that there is a building consensus that one of the methods of estimating heteroskedasticity robust standard errors (HC3) is so effective it should be used without regard to the apriori belief that heteroskedasticity is present. Since SPSS does not have this capability, Hayes and Cai (2007) also introduced

a macro that could be added to SPSS in order to estimate heteroskedasticity robust standard errors. Multiple restriction testing that would normally be conducted with an F test can be conducted with either a heteroskedasticity robust LM statistic test or asymptotically with a Wald test (Wooldridge 2009). The Hayes and Cai (2007) macro estimates a heteroskedasticity robust F statistic for the overall statistical significance of the model.

The sixth assumption is that the error,  $u$ , is independent of the explanatory variables and is normally distributed with a mean zero and constant variance (Wooldridge 2009). This assumption is necessary for finite sample inference, but can be dropped if the sample size is “large enough” (Wooldridge 2009). There is no exact prescription of large enough and some econometricians claim that  $n=30$  is satisfactory (Wooldridge 2009). The preferred method of checking the distribution for normality is the Shapiro-Wilk Test for Non-Normality (Shapiro et al. 1968; Royston 1982; Lehmann and Romano 2005; PsyStats 2012). As operationalized by SPSS, The Shapiro-Wilk Test for Non-Normality can be used for sample sizes from 3 to 2000, but in very small samples the test may not be able to detect non-normality and in very large sample sizes it may be overly sensitive to non-normality (Royston 1982; Park 2005; SPSS Inc. 2010; PsyStats 2012).

### 3.3. TESTS OF THE MODEL

This section of the text discusses the tests that can be used to evaluate the statistical model. The section begins with measures of goodness of fit, then to tests of

endogeneity, then tests to determine the appropriateness of missing value replacement techniques, and finally tests of multicollinearity.

### 3.3.1. GOODNESS OF FIT

McCloskey (2001) urges the student of economics to not be obsessed with statistical significance. More specifically McCloskey (2001) is urging economists to not confuse fit (what significance measures) with importance (the point of our models) and to instead be more concerned with the sizes of the coefficients.

One of the most commonly used goodness of fit tests is known as R-Squared. It measures fit of the model by comparing the sum of squared residuals with the total sum of squares (Wooldridge 2009). Once converted to a percentage, the R-Squared can be interpreted as the percentage of the sample variation in  $y$  that is explained by  $x$  (the vector form of all of the regressors of the model) (Wooldridge 2009). R-Squared values do not have to be above any particular value to be considered a good fit (Wooldridge 2009). Using R-Squared to measure goodness of fit has a problem in that it will always increase or stay the same as regressors are added, regardless of their explanatory power. Adjusted R-Squared imposes a penalty for adding independent variables, ensuring that explanatory power is actually increasing as variables are added or dropped (Wooldridge 2009).

### 3.3.2. ENDOGENEITY

Households choosing to purchase mobile phones are potentially more likely to choose higher levels of market integration (Amaya Urquieta and Alwang 2012). Muto and Yamano (2009) used a fixed effect instrumental variable model to specifically avoid this problem. The Muto and Yamano (2009) analysis also uses community level mobile phone coverage as part of its strategy. Amaya Urquieta and Alwang (2012) used a selection process of making sure that households with and without mobile phones were selected to control their perceived vulnerability to mobile phone use being endogenous.

### 3.3.3. MISSING VALUE REPLACEMENT

Little's Missing Completely at Random (MCAR) test is a method used to determine if missing values are missing completely at random (SPSS Inc. 2007). When the missing values are not missing completely at random only one method of imputation can be used and if the data is neither missing completely at random or missing at random then no method of imputation is appropriate (SPSS Inc. 2007). An example of data being neither is in a survey recording education and income, is if the probability that income is recorded varies by the value of income within each level of education (people with high incomes don't report them) (SPSS Inc. 2007).

### 3.3.4. MULTICOLLINEARITY

Multicollinearity is “a term that refers to correlation among the independent variables in a multiple regression model; it is usually invoked when some correlations are ‘large,’ but an actual magnitude is not well defined” (Wooldridge 2009, 842). Consequences of multicollinearity depend on the severity of the problem (Farrar and Glauber 1967). “In the limit, perfect linear dependence within an independent variable set leads to perfect singularity on the part of  $[(X'X)^{-1}]$  and a completely indeterminate set of parameter estimates  $[\hat{\beta}]$ ” (Farrar and Glauber 1967, 93). More moderately, explained variance is allocated arbitrarily between interdependent regressors leading to large variances, incorrect signs, and incorrect significance or insignificance determinations (Farrar and Glauber 1967). “Attempts to apply regression techniques to highly multicollinear independent variables generally result in parameter estimates that are markedly sensitive to changes in model specification and to sample coverage” (Farrar and Glauber 1967, 93-94). Farrar and Glauber (1967) indicate that multicollinearity is tolerable as long as it does not interfere with variables of interest. Variance Inflation Factor (VIF) is a diagnostic tool by which problematic levels of multicollinearity can be identified (O'Brien 2007; Wooldridge 2009). The idea of using a rule of thumb level to eliminate variables was challenged by O'Brien (2007). O'Brien (2007) established that VIF rules of thumb in themselves do not accurately provide a benchmark of a problem level of multicollinearity. The ideal solution would be to find a different, uncorrelated measure, and remove the multicollinearity while not exposing the model to potential omitted variable bias (Wooldridge 2009).

Comparing means of distances and transportation costs of different groups based on mobile phones and other household characteristics for statistical differences would achieve the goals of this study, but would be unable to prove causality. Ordinary least squares (OLS) should be able to make a more useful description of the relationships between the variables and establish causality.

### 3.4. DISCUSSION OF THE DATASET

The dataset being used is very close to ideal. It is from a 2009 survey of 318 households from two regions in the Bolivian Altiplano, Ancoraimes and Umala; where and 8 localities were selected, Chinchaya, Chojñapata, San Jose Llanga, San Juan Circa, Vinto Coopani, Kellhuiiri, Calahuancani, and Cohani. The questionnaire (based on an earlier survey taken in 2006) was developed over the period from September 2008 to May 2009 (Contreras 2009b). A pilot questionnaire was evaluated and improved on before training was conducted for interviewers, who were selected based upon their proficiency in Aymara, among other skills (Contreras 2009b). The survey was launched in June 2009, and interviews were completed during August 2009 (Contreras 2009a). The survey was taken on paper and data entry was reviewed for accuracy, selecting some at random for review (Contreras 2010). The surveyors report that missing data is rare, indicating that missing values are questions that did not apply or that were refused to be answered (Contreras 2010). Unfortunately, the reason for missing values was not coded during the data entry process. Quantities were converted to a standard measure (arropa, a measure of volume), since the units used by many households differed.

The questionnaire covers a great deal of activities that may be able to proxy for “disposition to act.” It also has many questions to capture transaction costs and livelihood outcomes. The weakness is that only has questions on trading with a mobile phone, but not coverage or ownership questions in 2009. A description of the survey area and how it fits into Bolivia can be found in chapter 1.

### 3.5. CONCEPTUAL AND EMPIRICAL FORMULATION

This section will discuss the conceptual formulation that builds on the literature to create a framework for the analysis to be conducted with and to understand the results in terms of the literature. As stated in equation 3, market participation is a function of disposition to act, external structures, and internal resources.

*market participation =*

*function of (disposition to act, external structures, internal resources) (3)*

Measures are developed in the section from the data to represent the conceptual framework. As variables were selected to represent each axis, care was taken to make sure that they were not correlated with other variables on that axis or mobile phone use. The process was the same for each axis of variables; first the axis was broken into conceptual groups, then Pearson correlation was performed followed by principal components analysis, and then uncorrelated groups of conceptually similar variables were regressed as independent variables on an early form of the dependent variable. The goal of this process was to find the most powerful, uncorrelated, combination of independent variables for each theoretical construct available in the data for the purpose of evaluating



market participation. Once groups of variables were chosen to represent internal, external and ability to act variables, the model was assembled and tested for multicollinearity and goodness of fit. The following paragraphs present the process in depth along each axis and the dependent variable, market participation.

### 3.5.1. THE DEPENDENT VARIABLE: MARKET PARTICIPATION

“The household portfolio is an expression of the choice set defined by access and control of resources, and the nature of assets possessed” (Valdivia 2004, 70). Previous studies have approached market participation in many ways. Key et al. (2000) used a binary variable to capture net buyers and net sellers. Alene et al. (2008) used a binary market participation variable for maize and fertilizer market entry. They also used the quantity of maize sold and fertilizer applied to measure intensity of market participation. Omamo (1998) was concerned about the diversity of activities on the farm, his deliberately simplified algebraic simulation model used a portfolio consisting of one cash and one staple crop. Holloway et al. (2000) used marketable surplus of milk. Finally, a review of household models by Ellis (1993) illustrates the diversity of maximization objectives measured in output or income. These studies identified various measures that captured market participation as a dependent variable.

In the case of Andean agriculture, where farmers produced for their own consumption and the market, the share of production for sales, of both crops and livestock, is measured in relationship to the total value of agricultural and other income generation activities of the household, such as off farm employment, extractive activities,

and remittances (Ellis 1998; Valdivia 2004). The dependent variable, a measure of market participation expressed as a portfolio ratio, is a ratio of products sold to the total value of production, including consumption, and the household's other sources of income.

A measure of agricultural market integration was created, as a ratio of products sold to the value of value of production, including that consumed by the household, and total cash income from all sources. To calculate market integration a series of variables were first developed. *Ag Sales* was defined as the sum of *Crops Sold*, *Ag Products Sold* such as milk and yogurt, and *Livestock Sold*, both alive and slaughtered.

$$Ag\ Sales = Crops\ Sold + Ag\ Products\ Sold, + Livestock\ Sold \quad (4)$$

Values based on market prices were assigned to goods produced and subsequently consumed within the household, in-kind income (*VSP*). For example, if a household consumed a share of the potatoes grown, it would be valued at the price available to the farmer. Staff responsible for data entry of the survey instrument also calculated this variable.

$$VSP = \sum(Valuation\ of\ Products\ Produced\ and\ Consumed) \quad (5)$$

*Extractive Sales* (ES) is the income generated from selling by-products such as manure, and the thola woody brush cleared from the land. Sales of these two products are summed.

$$ES = Manure\ sales + Thola\ Sales \quad (6)$$

*Government Payments* (GP) include *Bona Sol*, a payment from the Bolivian government to elderly individuals, and *Johnny Pinto*, a payment from the Bolivian government to support families with children.

$$GP = Bona Sol + Johnny Pinto \quad (7)$$

*Total Income* was calculated by summing all income sources described above along with an income source coded as other. *Other* was an open response category.

$$Total Income = Ag Sales + VSP + ES + GP + Labor Sales + Other \quad (8)$$

A dependent variable, *BsRatio*, was developed as the ratio of *Ag Sales* divided by *Total Income*.

$$BsRatio = \frac{Ag Sales}{Total Income} \quad (9)$$

As a ratio, all values fall between zero and one. Many of the households sell very little, or nothing, leading to a heavy distribution of the households at zero. Higher values indicate higher levels of integration. If one were to use a natural log to convert this asymmetric distribution to a normal distribution, taking the natural log of 0 will result in a missing value, dropping the case from the analysis and skewing the coefficients toward households that had already choose to trade. Estimating a ratio with ordinary least squares will also likely lead to heteroskedasticity in the model (Hayes and Cai 2007). As discussed previously, heteroskedasticity must be corrected before inference testing is valid.

An additional dependent variable, a measure of *Crop Sales* divided by the sum of *Ag Sales* and the value of subsistence products, was also created and analyzed. The second measure was dropped from further analysis when it became clear that it was a measure of the integration focusing only on crops instead of whole household portfolio of activities. The second measure's analysis is briefly presented in Appendix 2.

### 3.5.2. DISPOSITION TO ACT

Shucksmith and Herrmann (2002) develop the idea of “disposition-to-act” out of Bourdieu’s concept of habitus. The idea is that this disposition to act impacts the outcome of household actions. Disposition to act reflects a worldview, a lifetime of assimilating values and preferences (Shucksmith and Herrmann 2002). Shucksmith and Herrmann (2002)’s empirical study used results from qualitative interviews combined with quantitative survey data. Quantitative variables representing: “initial circumstances of the farm and household, the farmer’s socialisation, and the farmer’s attitudes” were used for their disposition to act (Shucksmith and Herrmann 2002).

Risk and uncertainty avoidance and mitigation, expression of risk preferences, has been shown to be an important determinant of household behavior in the region (Valdivia and Jetté 1996; Valdivia 2004). Climate, the environment, markets, and the political environment are all sources of uncertainty in the Andes (Valdivia 2004). The risk-averse peasant of Ellis (1993) trades off maximization of production for food security over time by minimizing input use. Depending on the perceived vulnerability of the risk-averse household natural hazards and market risks can both drive decision making in the absence of contingency markets (Ellis 1993). While external structures such as contingency markets and internal resources such as savings and access to credit can mitigate the effects of risk, the driver of decision-making remains the actor’s perceptions about risks. In the absence of any safety net, a risk-seeking household may continue to maximize inputs to maximize revenue and conversely, a risk-averse household may choose to abstain from those contingency markets in favor of lower, dependable,

production. Diversity of enterprises can be a risk and uncertainty preference adaptation strategy (Valdivia et al. 1996).

Table 3. Example survey questions valuated for use as disposition to act variables.	
For the wellbeing of your family, how much of a threat [does this risk] represent to your family: that prices are very low for the crops you sell in the market	<ol style="list-style-type: none"> <li>1. There is a threat or danger</li> <li>2. Is a minimal threat</li> <li>3. It is a moderate threat</li> <li>4. It's a very strong threat</li> <li>5. It is an extreme threat</li> </ol>
HEAD WOMAN [HEAD MAN]: How much control do you have when [this event] affects the wellbeing of your family: do you have any means of controlling pests for your crops	<ol style="list-style-type: none"> <li>1. You have no control</li> <li>2. More or less uncontrollable</li> <li>3. Not sure you can control</li> <li>4. You can control a bit</li> <li>5. Completely under your control</li> </ol>
HEAD FEMALE [HEAD MALE]: Feeling of dread of the possibility of receiving low prices on your crops in the market	<ol style="list-style-type: none"> <li>1. A common risk is not worried</li> <li>2. Not sure how you would feel</li> <li>3. Terribly afraid or afraid</li> </ol>

*Source:* SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALS Y PRÁCTICAS CICLO 2008-2009  
Translated by Dr. Corinne Valdivia. Brackets indicate questions were asked of separate audiences.

Table 3 contains example questions that reveal risk preferences of the household and individual members of the household. Operationalizing disposition to act was done by choosing a pair of questions clearly linked to the analysis and relatively high explanatory power based on principal components analysis were used to represent disposition to act: “For the wellbeing of your family, how much of a threat [does this risk] represent to your family: that prices are very low for the crops you sell in the market” and asking the head woman of the household, “How much control do you have when [this event] affects the wellbeing of your family: do you have any means of controlling pests for your crops”. These questions and their respective answers, ranging between 1 and 5, are displayed in table 3. Many other possible proxies for disposition to act could be imagined and several were attempted. Additional approaches not used in the final analysis are discussed in Appendix 1.

### 3.5.3. EXTERNAL STRUCTURES

External structures according to Shucksmith and Herrmann (2002, 39) include “relative prices, policy, labour market opportunities, social and cultural norms, etc.” These examples parallel North (1990)’s institutional framework of cultural and political, or informal and formal institutions. Transaction costs are the most observable feature of the institutional framework that belongs to this axis (external structures). Another factor that captures external structures is access and quality of transportation, through costs. In the following section significant findings in the literature related to external structures will be briefly discussed followed by what was able to be used in this study.

Table 4. Significant measures of external structures in previous studies.		
Variable	Sign (NS : Not Significant)	Study
Daily hours used in milk delivery (Pooled across seasons and Periurban)	-	Staal et al. (1996)
Time to the milk group (Marketable surplus Tobit model)	-	Holloway et al. (2000)
Sell to/buy from official source (Production Equations, Sellers Equation)	+	Key et al. (2000)
Crop Transport costs (pesos/MT) (Threshold Equations, Selling Threshold)	+	Key et al. (2000)
Sell to/buy from official source (Threshold Equations, Selling Threshold)	+	Key et al. (2000)
Sell to consumer/buy from grower (Threshold Equations, Selling threshold / buying threshold)	+/-	Key et al. (2000)
Truck x Distance	+	Renkow et al. (2004)
Distance to district center miles x mobile coverage (Banana Ratio of sales quantity to production, FE-IV)	+	Muto and Yamano (2009)
Mobile Phone Dummy (Dependent: effects of mobile on price dispersion)	- except when combined with road quality then +(NS)	Aker (2010)
Distance Dummy (>=375km) x mobile phone dummy (Dependent: effects of mobile on price dispersion)	-	Aker (2010)
Road Quality x mobile phone dummy (Dependent: effects of mobile on price dispersion)	-	Aker (2010)

Table 4 summarizes the relevant significant variables from previous studies that can be categorized as measures of external structures. Measures found insignificant were

omitted from table 4. Each of these studies were reviewed in depth in Chapter 2. The variables used centered around three themes: distance or cost of delivery, the nature of the buying and selling relationship, and noting particularly productive regions. These variables directly measure dimensions of transaction costs and as such were extremely desirable to include.

Key et al. (2000) found that the type of buyers and sellers were significant as noted in table 4. Selling to an official source had a positive and significant effect on both entry and intensity. Selling to consumers had a positive and significant effect on the selling threshold price and purchasing from growers had a negative and significant effect on the buying threshold price.

Market characteristics for the most important crop of the household were chosen to represent the relationship between buyer and seller, since farmers grow a large diversity of crops. The questionnaire recorded twenty crops that are asked about (no household grew all twenty), not including animal sales and household products such as milk and cheese. Two questions were chosen for their ability to describe the nature of the relationship between the buyer and seller. The variable, "First Product: Who do you usually sell to?" was recoded to be a binary variable with selling the first product to middlemen at the farm as a one and all other values as zero. The question was coded in such a way that only binary variables could be drawn from it. There was also considerable overlap between responses making understanding multiple binary variables difficult. The alternate values could have been: directly to consumers, middlemen at market, middlemen at location and consumers, both types of middlemen, consumers and middlemen at market, directly to consumers and either type of middlemen, and friends

and family. The second question describing the relationship between buyers and sellers asked how long the seller had known its buyer. As a continuous variable, it was used without recoding.

Staal et al. (1996) used a binary variable representing urban producers when estimating equations with data pooled across locations. The urban binary variable proved significant and positive in all equations it was included in (Staal et al. 1996). Alene et al. (2008) used a binary variable to note particularly productive region of their study in Kenya. This variable proved insignificant in their analysis (Alene et al. 2008).

A nominal variable representing the village the household is located in or near is used to capture location information; this variable was recoded as a series of dummy variables. The coding that caused the least multicollinear interference was a dummy variable that captured the productive regions of the survey area; San Jose, San Juan and Chinchaya were equal to one and all other values were equal to zero.

There are several ways to in which distance or cost of delivery has been captured. This idea has also been interacted with different variables of interest. Staal et al. (1996, 23) used “daily hours used in milk delivery” as a “[determinant] of producer prices of fresh milk in the Addis Ababa Milkshed, 1992-1993.” “Daily hours used in milk delivery” (implying cost of delivery) was only significant in the equation estimating periurban outlets pooled across seasons. Holloway et al. (2000) used a Tobit-equation with the explanatory variable time to the milk group was used to estimate marketable surplus. Reminiscent of Staal et al. (1996), as more time is spent marketing the household will have less marketable surplus the household will have more marketable surplus



(Holloway et al. 2000). Key et al. (2000) found transportation costs had a significant and positive effect on the selling threshold, as an entry decision.

Renkow et al. (2004) found that the interaction between truck ownership and distance was positive and significant when estimating a maximum likelihood estimating transaction costs. The truck ownership dummy was also significant, though it was negative.

Muto and Yamano (2009) found that when mobile phone coverage is interacted with miles to district center it has a positive and significant effect on the ratio of sales quantity to production of bananas. Possession of a mobile phone and community mobile coverage were not significant in themselves in this model. Only when interacted with distance to the district center is mobile phone use significant.

Aker (2010) found that the mobile phone dummy was significant and negative when estimating its effect on price dispersion for all equations except when a variable for road quality x mobile phone dummy was introduced. In that model, the interaction term was significant and negative, but the mobile phone dummy itself was insignificant. When the distance dummy and mobile phone were interacted in a separate equation the result was negative and significant and the mobile phone dummy was significant and negative.

Much of the preliminary discussion of this topic revolved around distance to market. It became clear that distance was not going to be a good indicator. As one would expect, statistically significant price dispersion between locations was apparent in many, but not all, of the first crops, and most, but not all, communities had wide spectrums of price between households that were not normally distributed indicating price dispersion

within the community. Transportation costs appeared to have a wide dispersion of transportation costs (measured as described in the following paragraph) between households in the same community. Once again, the distribution of transportation costs was wide and not normally distributed within the communities.

Transportation costs presented a similar problem to market characteristics. Transportation costs were reported for each crop and each category of animals, but not animal products. However, transportation costs have the advantage of being a nearly continuous variable (there are no negative values and there is a maximum recorded value), allowing for a meaningful mean and sum. The relative importance of agricultural products marketed was only recorded for crops and mobile phone use was only recorded for crops leading to selection of transportation cost measurements that only encompass crop transportation.

The measure used was the transportation costs of the most important crop of the household (first crop). First crop transportation was the most conceptually consistent measure of transportation costs developed with the earlier emphasis on market participation characteristics of the most important crop. Transportation costs were measured as Bolivianos spent on transport to Bolivianos earned (marketed crops only) for each crop. Adding a quadratic term to models that might have a point of diminishing or increasing returns is one technique to improve fit (Wooldridge 2009). This measure of transportation costs is distributed very tightly just above zero. The mean is .005 and with quartiles defined as very low cost ( $<.0026$ ), low cost ( $.0026 < x < .0060$ ), high cost ( $.0060 < x < .0133$ ) and very high cost ( $>.0133$ ).

Migration is a more complicated topic. Shucksmith and Herrmann (2002) categorized “labour market opportunities” as an external structure. Clearly, migration would not exist without the market structures for the households to respond to, and migration could be considered a proxy of market structures. However, in developing countries migration is a method of gaining cash income for the household through remittances or earnings. For a peasant household, the gain in cash is offset by the loss of labor available for the farm. The individual sent out is also a link to the outside world for information. Migrating family members provide information and income, but also remove capable hands from production within the home. Off-season migration could complicate this measure, allowing labor to be available for key seasons, and income in off-seasons.

Isakson (2007) used migrant labor as an independent variable in their analysis of factors influencing the diversity of farms and found it to be insignificant. Low (Ellis 1993) developed a model to understand the tradeoff between keeping labor on the farm or sending it out as either wage labor or migration, where there are different opportunity costs for men and women. Off farm income as measured by Alene et al. (2008) was significant and negative in their maize participation model; this reflects the tension between cash income and farm production. This thesis project measures migration by counting the days of all household members working off the farm and dividing these by the number of members expressed in adult equivalents as measured by Valdivia and Jetté (1996). Missing values were recoded as zero because the structure of the questionnaire suggests a missing value for this question is a zero than an omitted mean, median or even

a fitted value. Measuring migration this way captures the level of tension between the available labor and the labor sent out as migrants.

#### 3.5.4. INTERNAL RESOURCES

Along the internal resources axis Shucksmith and Herrmann (2002, 39) identified “size of farm, capital, labour skills, cultural capital, position in the life-course, [and] tenure.” Assets that Alene et al. (2008, 321) referred to as variables that “mitigate transaction costs” correspond with this axis. This list can be simplified to a list of the five capitals as described by Bebbington (1999): natural capital, human capital, cultural capital, social capital, and produced capital. These capitals are not only means to livelihood, they give meaning and give the capability to engage in that livelihood (Bebbington 1999). The capitals or assets that the decision maker can access or control are means to achieve objectives. In the following section significant findings in the literature related to internal resources will be briefly discussed followed by what was used in this study.

#### 3.5.5. NATURAL CAPITAL

Starting with natural capital, this capital is access to natural assets that can be used to increase well-being, give meaning, and build capabilities. Total land holdings have been used in market participation analysis (Staal et al. 1996; Renkow et al. 2004). Isakson (2007) used arable landholdings as a distinction between total land and

productive land and found it to be positive and significant in all of his estimations of factors influencing crop diversity. Alene et al. (2008) found that land (in Ha.) per capita was significant and positive in their market participation estimation (market entry) and Staal et al. (1996) found that the rental value of land was significant and positive in all their regressions estimating producer prices of fresh milk. Renkow et al. (2004) found farm size to be significant and positive in both the supply and demand equations of their analysis. Key et al. (2000) included crop and pasture land (in Ha.) in their regressions, but it was not significant. A scale variable capturing the answer to “How much land do you have?” is used to capture natural capital.

### 3.5.6. PRODUCED CAPITAL

Produced capital is a measure of access to assets that as the name implies are material wealth (Bebbington 1999); they can be a technology that help mitigate a cost or allow a productive activity. Alene et al. (2008, 321)’s examples were “...ownership of transport and communication assets...”

Specifically, Alene et al. (2008) found ownership of radio or telephone and ownership of pack animals insignificant in their maize market participation estimations and ownership of transport equipment such as bicycles, motorcycles and pack animals significant and positive in the same estimates. Key et al. (2000) found ownership of a pickup significant and negative in the seller production equation, but insignificant in the buyers production equation. They also found ownership of a pickup truck to be negative and significant in their selling threshold equations and insignificant in their buying

threshold equations (Key et al. 2000). Renkow et al. (2004) found dummy variables for truck ownership and bicycle and animal ownership were significant and negative. When interacted with distance only the truck dummy was significant and positive. Muto and Yamano (2009) while estimating the probability of selling bananas and the ratio of sales to production found that mobile phone possession was significant and positive in some of their estimations and community mobile phone coverage was significant and positive when the interaction term between phone coverage and distance was omitted. The distance to the district center was significant and positive when interacted with mobile phone coverage (Muto and Yamano 2009). Aker (2010) found that mobile phone coverage was significant and negative in all equations except when an interaction term between coverage and road quality was introduced. Aker (2010) also found that mobile phone coverage interacted with a dummy variable indicating long distance was significant and negative in her estimation of the effect of mobile phone on price dispersion.

A question in the survey asked if the household used a mobile phone to market each the crops grown. A binary variable capturing if a mobile phone is used in any crop was created. An interaction variable between mobile phone use and the transportation cost variable was created as described in Wooldridge (2009). Mobile phone use (a binary variable) was multiplied by the transportation cost.

### 3.5.7. HUMAN CAPITAL

Human capital is an investment in people such as education, labor, and skill that can increase well-being, give meaning and build capability (Bebbington 1999). The primary ways of measuring human capital are centered on: gender, lifecycle indicators, capturing the amount of labor available to the household, possession of indigenous or modern knowledge, and education.

Age can be used as a life cycle indicator (Valdivia and Jetté 1996). Alene et al. (2008) found age of the head of household to be significant and negative in their maize market participation model. Key et al. (2000) captured age in a fairly unique way; their analysis used a binary variable if the head of the household was over 55 and found it to be insignificant in all equations. Holloway et al. (2000) used farm experience (years) of the head of household, but found it to be insignificant in their marketable surplus estimation. This study follows the Key et al. (2000) lead and uses a binary variable capturing if the head of household is over 55.

Renkow et al. (2004) found household size to be positive and significant in their demand equation. Adult Equivalent Units are a measure of labor available to the household (Valdivia and Jetté 1996). Alternatively, other methods that could have been used include: Alene et al. (2008) counted adults in the household and found this measure to be positive and significant both in their maize market participation and maize market entry models. Omamo (1998) measured “labour” in “adult equivalents/month,” which would capture the amount of labor available to the household after migration (important in areas with significant off-season migration). This thesis uses adult equivalent units as

a denominator in other measures such as the migration variable, but does not directly use household size as a regressor. The method for calculating Adult Equivalent Units (AEU) is from Valdivia and Jetté (1996). This method was chosen because it has been established with data from the same area as the current data was from. Members age 15 and older are counted as a single adult equivalent unit. Based on the member's availability (due to schooling) and ability (older family members can carry out more difficult and valuable tasks) reduced values are assigned for younger family members. Those aged 9 to 14 are assigned a value of 0.6, members between 6 and 8 a value of 0.3, and those aged between 4 and 5 are assigned a value of 0.1 (Valdivia and Jetté 1996).

In market participation studies, such as Renkow et al. (2004), education is used as an independent variable, but found to be insignificant. Previous studies using this data used education of the head of household (Jensen 2010) finding it to be insignificant when estimating total income controlled for location. Holloway et al. (2000) used formal schooling in years of the head of household as a regressor in their Tobit model and found that it was positive and significant. Alene et al. (2008) used a binary measure of the educational status of the head of household: one for six or more years of schooling, zero otherwise and found that it was not significant.

The survey data measured education by two variables. The first, used in this analysis, is a measure of level of education attained. It does not differentiate intermediate levels of education or count partial attendance. For example "some college" as reflected in surveys designed for the United States such as Valdivia (2006) will be reflected as completion of the previous level. Table 5 shows the different levels of education, their English equivalents, and the numerical code used in later calculations.



Thinking of human capital as an asset to be drawn on, education for the household was measured by adding the levels of education accomplished and dividing that by the adult equivalents of the household. Education divided by AEU had a coding problem of how to handle “otros cursos” (other courses) that resulted in incorrectly high ordinal values. It is not clear where “otros cursos” should be coded as an ordinal response. As such, this measure of education was also dropped. A binary variable indicating greater than or equal to primary school was created for use in this analysis.

The idea that a household is more likely to produce for the market if by endowment or by skill is able to produce more with less is very intuitive. It is expected

Table 5. Education levels translated into English and numerical code and member one distribution of education attained.

Ed. Level (Spanish)	Ed. Level (English)	Code	Percent (Frequency) of Member 1
Ninguno	None	0	11.9% (38)
Preescolar	Preschool	1	1.6% (5)
Primaria	Elementary	2	63.2% (201)
Secundaria	Secondary	3	21.4% (68)
Normal	Teaching College	4	.6% (2)
Técnico de instituto	Technical Institute	5	(0)
Universitario	University	6	(0)
Otros cursos	Other Training	7	.3% (1)
System Missing			.9% (3)

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

that households that are better able to maximize equation 10 (a multiple product optimization problem with cost function  $C$ ) will produce for the market.

$$\max_{Q_1, \dots, Q_n} \pi(Q_1, \dots, Q_n) = (P_1 * Q_1) + \dots + (P_n * Q_n) - C(Q_1, \dots, Q_n) \quad (10)$$

As intuitive as this idea is, it proves very difficult to develop a meaningful measure of competitive advantage from this data. Among the challenges, the only input price available in the survey dataset is for labor. Beyond labor it must be assumed that input prices are the same for all farmers. This might be realistic for fertilizer since

fertilizer prices are fixed by the Bolivian government (USDA/FAO 2012). Since price dispersion is likely on other inputs, as evidence discussed in the transportation cost discussion shows product price dispersion, this assumption would reduce how meaningful a measure derived through this process would be.

The difference between mean of the predictions of the equation developed and the mean of the actual production for potatoes was not statistically significant. Initially it was planned to compare the actual production with the production predicted from the equation developed as described earlier in this paragraph, but these difficulties encouraged adoption of a simpler measure.

The measure chosen to represent both management ability (a human capital) and the quality of land (a natural capital) is the yield for the most important crop for marketing grown by the household measured in Bolivianos of crops produced (regardless of destination use) per hectare. Measuring yield fails to account for the inputs required to achieve those yields, but some level of differentiation between producers will be evident in the yields.

### 3.5.8. CULTURAL CAPITAL

Cultural capital is the concept that cultural practices are valuable for building capacity, improving well-being, and giving meaning or context (Bebbington 1999). Bebbington (1999) specifically mentions that part of livelihood in the Andes, part of residence there, is maintenance of cultural practices valued because they are meaningful. Beyond their meaningfulness is the fact that the practices are empowering, enabling, and

foster identity maintenance (Bebbington 1999). Cultural capital would be a potential source of disposition to act, as created by Shucksmith and Herrmann (2002), as the cultural practices are internalized as values and identity maintenance is conducted. No measure of cultural capital was developed for this thesis.

### 3.5.9. SOCIAL CAPITAL

Social capital is a highly controversial topic (Bebbington 1999, 2002). In its simplest form, social capital is the idea that people are able to leverage relationships and improve their well-being, give meaning, and improve capacity (Bebbington 1999). Social relationships and norms (elements of social capital) have been shown to create conditions for economic prosperity without organizational (government or formal associations) structures that would otherwise provide the feedback necessary for long-term trade relations (Greif 1989). Narayan and Prichett (1999, 872) referred to social capital as “the quantity and quality of associational life and the related social norms.” The ability to act through collective action is an important part of social capital (Bebbington 1999). Non-market institutions that act as a means to resources are a form of social capital (Valdivia 2004). Access to credit through social and family ties has been traditional method of enduring adverse risk events (Ellis 1993). Demonstrating the value of social capital to market participation in risky environments, Narayan and Prichett (1999, 873) stated, “Social links among parties may increase their ability to participate in economic transactions that involve some uncertainty about compliance, such as credit.” This concept has been measured through membership in agricultural organizations or

marketing groups (Key et al. 2000; Alene et al. 2008). Alene et al. (2008) found it significant in their maize marketed supply equation (intensity of participation) but not in their maize marketed participation (entry) models. Key et al. (2000) finding membership in agricultural associations (but not transport associations) significant in their sellers' production equation. Key et al. (2000) did not find access to common property pasture significant and membership in agricultural organizations was not significant in their threshold equations. Narayan and Prichett (1999) used membership in political, religious, occupational, and other groups as well as data on community homogeneity of these groups was to create a social capital composite variable.

Table 6. Survey responses describing participation in the marketing of various household products.		
Example Crops	Example Question for Crops	Possible Answers
Milk, Cheese, Chun, Yogurt, Tunta, Caya, Pito,	MILK: Who does the marketing of this product?	1. Mostly the men 2. Mostly the women 3. Both the men and women equally 4. With other families 5. In a group 6. Through a partnership
Potatoes, Oats, Beans, Peas, Quinoa, Barley Grain, Barley Hay, Onion, Alfalfa, Wheat, Isan, Oca, Papalis, Nabo, Lupine, Kanahua, Carrot, K'ara grain, Oats Hay, Wheat Hay	Potato: What types of arrangements do you make to sell your product?	1. None 2. Associations or institutions 3. Agree to price before going to market

*Source:* SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALAS Y PRÁCTICAS CICLO 2008-2009

Table 6 shows the questions that could be used to determine cooperative activity. For products such as milk and cheese cooperative marketing could be answer six and for crops such as potatoes and oats the answer required was “associations or institutions” to count as marketing through collective action. The acceptable answers were recoded into binary variables for each crop, 1 being marketing through collective action and 0 being otherwise. Those binary variables were summed and then the summed variable was

recoded into a binary variable to indicate if the household participates in marketing through collective action for any crop, 1 being yes and 0 being no.

Key et al. (2000, 253) stated, "...ignoring the heterogeneity of household behavior on the labor and credit markets as we do creates noise in our classification that could well blur the results we are estimating. Notably, labor self-sufficiency and credit constraints lower the supply response on other markets." This thesis has already covered labor markets through migration. Addressing credit was done with a similar approach as Key et al. (2000). This survey data measured whether the household had used credit in the past year. "Who did you get the loan from?" was a follow-up question asking if the household had borrowed any money. If the household had borrowed any money it would indicate if the loan was from "Bank, NGO, FFP" or "Friends or family." Additional binary variables were recoded to indicate use of formal credit from the "Bank, NGO, FFP" and use of informal credit from "friends or family." The availability of information on credit acquired through friends and family is an opportunity to examine the relative importance of credit from personal sources and formal sources. The two sources of credit were pooled into a single binary variable to indicate if the household had accessed credit from either of these sources in the past year.

### 3.6. VARIABLE SUMMARIES

This section presents descriptive statistics of the variables used in the model. Table 7 provides descriptive statistics for each of the variables. As noted below the "average" respondent sells just over half of the value created by the household, considers

low crop prices a moderate to strong threat, feels that crop pests are mostly uncontrollable, produces Bs. 6819.86 per hectare on 6.21 hectares, spends 15.07 days migrating, does not use a mobile phone in trade, and has known its buyer for 1.81 years. The average household has very high costs of transportation, interestingly only six households are over the mean.

Table 7. Descriptive statistics for dependent and independent variables.

	N: Valid (Missing)	Minimum- Maximum	Mean	Median	Mode	Std. Deviation
BSRATIO (See 3.5.1, Dependent)	318 (0)	0-1	0.56	0.6561	0	0.33
CONCERN (1-5)	318 (0)	0-5	3.5	4	4	1.13
CONTROL (1-5)	318 (0)	0-5	2.17	2	4	1.49
YIELD (Bs./Ha.)	318 (0)	0-232,685	6819.86	1666.67	0	21316.16
LAND (Ha.)	318 (0)	0-40	6.21	4	4	6.61
MIGRATION (Days/AEU)	318 (0)	0-182.2	15.07	0	0	27.9
MOBILE (Used Yes/No)	238 (80)	0-1	0.07	0	0	0.26
TRANSPORT (Bs. Spent/Bs. Earned)	161 (157)	0-0.51	0.02	.006	0	0.07
TRANSPORT <sup>2</sup>	161 (157)	0-0.26	0.005	0	0	0.03
INTERACTION	234 (84)	0-0.35	0.003	0	0	0.03
KNOWN (Years)	242 (76)	0-25	1.81	0	0	3.85
HH55 (Yes/No)	316 (2)	0-1	0.07	0	0	0.05
HHED>PRIMARY (Yes/No)	315 (3)	0-1	0.86	1	1	0.34
CREDIT (Yes/No)	318 (0)	0-1	0.11	0	0	0.32
COOP (Yes/No)	318 (0)	0-1	0.04	0	0	0.21
LOCATION (Yes/No)	318 (0)	0-1	0.59	1	1	0.49
MIDDLEMEN (Yes/No)	242 (76)	0-1	0.4	0	0	0.49

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

### 3.7. THE MODEL

Table 7 displays the descriptive statistics of each of the measures in the model. This model captures all of the dimensions necessary to learn about drivers of livelihood change. Disposition to act has been captured by *CONCERN* and *CONTROL*. External structures has been captured by *MIGRATION*, *TRANSPORT*, *TRANSPORT*<sup>2</sup>, *KNOWN*, *LOCATION*, and *MIDDLEMEN*. Internal resources have been captured by *YIELD*, *LAND*, *MOBILE*, *HH55*, *HHED>PRIMARY*, *CREDIT*, and *COOP*. The interaction

between *MOBILE* and *TRANSPORT* is captured in an interaction variable. Equation 11 shows the ideal model and equation 12 shows the operationalized model. Equation 11 is borrowing matrix notation to minimize the number of terms represented by using bold to represent a set of coefficients and variables, however the true matrix form of the equation would be what is represented after the comma in equation 11. The expected signs of the coefficients in equation 12 are the signs noted in equation 12. Migration is presented at the bottom of the internal resources row in order to convey the fact that it can also represent an external market. The next chapter will discuss results of the final model, its implications, limitations, and suggestions for future research.

$$BSRATIO = \beta_0 + \beta_w \mathbf{DISPOSITION TO ACT} + \beta_x \mathbf{EXTERNAL STRUCTURES} + \beta_z \mathbf{INTERNAL RESOURCES} + \beta_{mxt} mxt, y = \mathbf{x}\beta \quad (11)$$

$$\begin{aligned} BSRATIO &= \beta_0 + \beta_{w1} CONCERN + \beta_{w2} CONTROL - \beta_{x3} MIGRATION - \beta_{x4} TRANSPORT + \\ &\beta_{x5} TRANSPORT^2 + \beta_{x6} KNOWN + \beta_{x7} LOCATION + \beta_{x8} MIDDLEMEN + \\ &\beta_{z9} YIELD, + \beta_{z10} LAND + \beta_{z11} MOBILE + \beta_{z12} HH55 + \beta_{z13} HHED > PRIMARY + \\ &\beta_{z14} CREDIT + \beta_{z15} COOP + \beta_{x4z11} MOBILExTRANSPORT \quad (12) \end{aligned}$$

## CHAPTER 4.

### MODEL ESTIMATION, RESULTS AND DISCUSSION

This chapter details the findings of this study. First, differences between the market participation of phone users and non-users will be tested. Descriptive statistics of the model restricted to cases in the regression are then presented. The assumptions of linear regression are then tested and the model is evaluated. Discussion of significance, sign, and magnitude of the regression results will end this chapter.

#### 4.1. DEPENDENT VARIABLE TEST OF DIFFERENCES

A single-sample two-tailed  $t$ -test of the dependent variable indicates that the relationship between mobile phones and market participation is not significant. A single sample was used because mobile phone users are a part of the larger population obtained through the sample. The data values are ratios, however the population distribution, based on the sample properties, is not symmetrical. The One-Sample Wilcoxon Signed Rank Test also failed to show any statistical difference, this time with the mobile phone using group's median and the sample median, between the mobile phone users and the larger sample. It could be that the influence of mobile phones is subtler than median or mean values and the analysis will continue to ordinary least squares.



## 4.2. VARIABLES

Chapter 3 described the process of selecting measures and presented the model. As noted in table 7, many important variables have several missing cases. Each of those missing cases were dropped through the list-wise deletion process leaving a sample with N=160. These cases and the impact of this development will be discussed later in this chapter. Dropping those cases resulted in changes in the descriptive statistics. Table 8 presents the descriptive statistics for the sample restricted to cases included in the regression results.

Table 8. Descriptive statistics for dependent and independent variables restricted to cases used in model.

	N: Valid (Missing)	Minimum - Maximum	Mean	Median	Mode	Std. Deviation
BSRATIO (See 3.5.1, Dependent)	160 (0)	0.02-0.99	0.65	0.73	0.02	0.27
CONCERN (1-5)	160 (0)	1-5	3.86	4	4	0.87
CONTROL (1-5)	160 (0)	0-5	2.19	2	1	1.45
YIELD (Bs./Ha.)	160 (0)	0-232,685	11,436.55	3553.33	1666.67	28482.48
LAND (Ha.)	160 (0)	0.07-40	6.62	4.2	1.5	6.78
MIGRATION (Days/AEU)	160 (0)	0-120.33	15.29	0	0	26.37
MOBILE (Used Yes/No)	160 (0)	0-1	0.075	0	0	0.26
TRANSPORT (Bs. Spent/Bs. Earned)	160 (0)	0-0.51	0.02	.006	0	0.07
TRANSPORT <sup>2</sup>	160 (0)	0-0.26	0.005	0	0	0.03
INTERACTION	160 (0)	0-0.35	0.004	0	0	0.03
KNOWN (Years)	160 (0)	0-25	2.61	0	0	4.46
HH55 (Yes/No)	160 (0)	0-1	0.4	0	0	0.5
HHED>PRIMARY (Yes/No)	160 (0)	0-1	0.92	1	1	0.27
CREDIT (Yes/No)	160 (0)	0-1	0.15	0	0	0.36
COOP (Participated Yes/No)	160 (0)	0-1	0.06	0	0	0.23
LOCATION (Yes/No)	160 (0)	0-1	0.78	1	1	0.42
MIDDLEMEN (Yes/No)	160 (0)	0-1	0.56	1	1	0.5

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

Table 8 contains the minimum, maximum, mean, median, mode and standard deviation of each of the variables in the final model. The cases used for calculating these statistics have been restricted to cases included in the final regression. The impact of

reducing the sample size through listwise exclusion can be seen in the changes between the descriptive statistics of the entire sample and the reduced sample depicted in this chapter. As noted in table 8, the dependent variable through the process of listwise exclusion of cases has a minimum value of .02 while the minimum of the whole sample was .00. The change in sample size will be discussed later in this chapter.

### 4.3. ASSUMPTIONS OF LINEAR REGRESSION APPLIED

Once the process finding variables to fit theoretical constructs was complete a model was ready to be tested for compliance with the assumptions of Multiple Linear Regression. The model is expected to be linear in form. Households were chosen randomly. Great care was taken to avoid multicollinearity. When  $\hat{u}$  was used as a regressand on the regressors of the model this resulted in an R-squared of zero and insignificant coefficients of zero, indicating an expectation of  $\hat{u} = 0$  when given all the regressors (satisfying MLR4). The Breusch and Pagan test (Hayes and Cai 2007; Wooldridge 2009) when conducted on this model found statistically significant heteroskedasticity. The Hayes and Cai (2007) macro was used for all estimations needing robust standard errors. Heteroskedasticity robust LM statistics are used in place of F tests for joint hypothesis testing. In checking for MLR6, the distribution of  $\hat{u}$  using the Shapiro-Wilk Statistic rejected the null hypothesis that the distribution is normally distributed. This sample is much larger than thirty, so it likely is 'large enough' for asymptotic inference, if not for finite sample inference. This combined with the

precautions taken with estimating heteroskedasticity robust  $se(\hat{\beta}_j)$  estimates allows the analysis to continue with valid inference testing.

#### 4.3.1. MISSING VALUES

The drop in N from 318 to 160 may be a point of concern. As *Transport* is represented in equation 13, reported sales of zero result in an undefined value that causes the case to be dropped from analysis.

$$TRANSPORT = \frac{(Bs.Spent Transporting The Most Important Crop for Marketing+Yearly Trips)}{Bs.Earned For Selling The Most Important Crop for Marketing.} \quad (13)$$

When the frequencies of the variables in the final model were analyzed with a filter leaving only cases that were missing ( $\hat{u}$ =missing), 157 of the missing cases were from the transportation cost variables, and one case was excluded because mobile phone use was missing. Five of the seventeen (29 percent) mobile phone users were excluded.

Table 9. Comparison between valid percent of complete sample and valid percent of cases excluded by community.

	Valid Percent of Complete Sample	Valid Percent of Cases Excluded
Chinchaya	25.2	14.0
Chojñapata	8.8	10.8
San Jose Llanga	25.2	10.8
San Juan Circa	8.5	15.3
Vinto Coopani	8.5	15.9
Kellhuiri	7.9	14.6
Calahuancani	6.3	7.0
Cohani	9.5	11.5

*Source:* SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

Responses of zero in first crop earnings are responsible for 81 cases being dropped. Logically, if the crop is the most important for marketing purposes and earnings of zero are being reported the crop is either: being bartered and not the type of market

integration of interest in this analysis, not sold at the time of being interviewed, or the household was refusing to answer a sensitive question.

Households from Umala made up 56.7 percent of missing cases while Ancoraimes made up 43.3 percent while respectively making up 50.2 percent and 49.8 percent of the complete sample. Table 9 shows the comparisons between percent of missing cases and percent of the sample for each community. The proportions of cases excluded are substantially different for all communities except Calahuancani indicating that the communities with high market integration are better represented in this model than communities with low market integration.

Table 10 shows the descriptive statistics for households missing in the analysis. As indicated in table 10, the descriptive statistics for the group of households excluded from the analysis differs in a statistically significant manner from the descriptive statistics of the entire sample. However, MOBILE is not statistically different.

Of the households declaring a first crop (241), 168 declare potatoes, of which 77 declare Bs. 0 in sales (not missing), all 10 pea sellers report sales above 0, 1 of 1 barley hay sellers reported 0 sales, 2 of 60 onion sellers reported 0 sales, and 1 of 1 alfalfa sellers reported 0 sales. This results in the N=160 that we observe in the final regression analysis. It isn't the missing values that reduce the N all the way to 160, it is the zeros that are actually (and were originally) coded.

Table 10. Descriptive statistics for dependent and independent variables restricted to cases missing in model.

Variable	N: Valid (Missing)	Mean	Median	Mode	Std. Deviation	Minimum	Maximum
BSRATIO (See 3.5.1, Dependent) <sup>A</sup>	158(0)	0.48**	0.5573	0	0.36	0	1
CONCERN (1-5) <sup>A</sup>	158(0)	3.15***	3	4	1.24	0	5
CONTROL (1-5) <sup>A</sup>	158(0)	2.15	2	4	1.52	0	5
YIELD (Bs./Ha.) <sup>A</sup>	158(0)	2144.73***	0	0	7220.53	0	66666.67
LAND (Ha.) <sup>A</sup>	158(0)	5.80	4	1	6.44	0	30
MIGRATION (Days/AEU) <sup>A</sup>	158(0)	14.85	0	0	29.46	0	182.2
MOBILE (Used Yes/No) <sup>A</sup>	78(80)	0.06	0	0	0.25	0	1
TRANSPORT (Bs. Spent/Bs. Earned)	1(157)	0	0	0		0	0
TRANSPORT <sup>2</sup>	1(157)	0	0	0		0	0
INTERACTION	74(84)	0	0	0	0	0	0
KNOWN (Years) <sup>A</sup>	82(76)	0.24***	0	0	1.16	0	7
HH55 (Yes/No) <sup>A</sup>	156(2)	0.53**	1	1	0.50	0	1
HHED>Primary ((Yes/No) <sup>A</sup>	155(3)	0.81**	1	1	0.40	0	1
CREDIT (Yes/No) <sup>A</sup>	158(0)	0.08*	0	0	0.27	0	1
COOP (Participated Yes/No) <sup>A</sup>	158(0)	0.03	0	0	0.18	0	1
LOCATION (Yes/No) <sup>A</sup>	158(0)	0.40***	0	0	0.50	0	1
MIDDLEMEN (Yes/No) <sup>A</sup>	82(76)	0.10***	0	0	0.30	0	1

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALAS Y PRÁCTICAS CICLO 2008-2009

<sup>A</sup>: Mean tested against whole sample using a one-sample *t*-test.

\*, \*\*, \*\*\* Difference between missing cases and the complete sample significant to the 0.10, 0.05, and 0.001 levels, respectively.

Missing value analysis (Little's MCAR test) revealed that the missing values may not be missing completely at random (MCAR), complicating replacement. Based on missing value analysis, the pattern of missing variables does not seem to differ substantially between mobile phone users and those who do not use mobile phones. Also based in missing value analysis it appears that households that are less integrated in the market fail to report transportation costs (in this case the variable components which make up transportation costs) more often than more integrated households. This pattern

along with the results of Little's MCAR test indicate that the missing values are not missing completely at random or missing at random and cannot be replaced (SPSS Inc. 2007).

The methods of imputing missing values to transportation cost variables were not exercised in final analysis because of concern over artificially inflating the N with values that would not actually improve the analysis. The missing values are missing for a reason, either for refusal to answer (possibly answering 0 as a refusal to answer), crops were unsold at that time, or because the question did not apply to the respondent. Imputing a missing value on a respondent not answering because a question did not apply, crops had not been sold yet or for refusing to answer a sensitive question could only skew the analysis. The end result of not replacing values to boost N, and the fact that once all missing values have been accounted for no dependent values of 0 are found in the analysis indicates that the proper interpretation of the results later in this chapter should be that once a household enters the market, then the results hold. Entry from an entirely subsistence livelihood has not been analyzed, only movement from one level of partial integration to another.

Little's MCAR test was not conducted to test the migration per AEU variable because a meaningful null hypothesis could not be formulated. Little's MCAR test tests (the null) to see if a sample's missing values are completely at random and if rejected, the alternate is that the missing values are not missing completely at random. Logically, if missing values are actually zeros because the question did not apply Little's MCAR test will flag that as not missing completely at random, which is what is expected. However, the test would not differentiate between the zeros as missing values and a refusal of, say,

70 percent survey respondents who migrate 180 days or more to answer. This lack of differentiation makes the test not very informative for the migration variable.

#### 4.3.2. ENDOGENEITY

Econometrically,  $\hat{u}$  was uncorrelated with all regressors and the regressand and when  $\hat{u}$  is used as a regressand each regressor has an insignificant coefficient of zero. This fact should satisfy concerns of endogeneity. The next two points are practical, data related reasons why the proposed endogeneity is not a problem. As indicated by figure 2, it is not immediately clear if mobile phone users in this sample are more market integrated based simply on the distribution of levels of integration split by mobile phone use. If anything, it appears on visual examination that mobile phone users are closer to normal distribution (with a peak in the center of the distribution and thin tails) in their choice of market participation level than those who do not use phones.

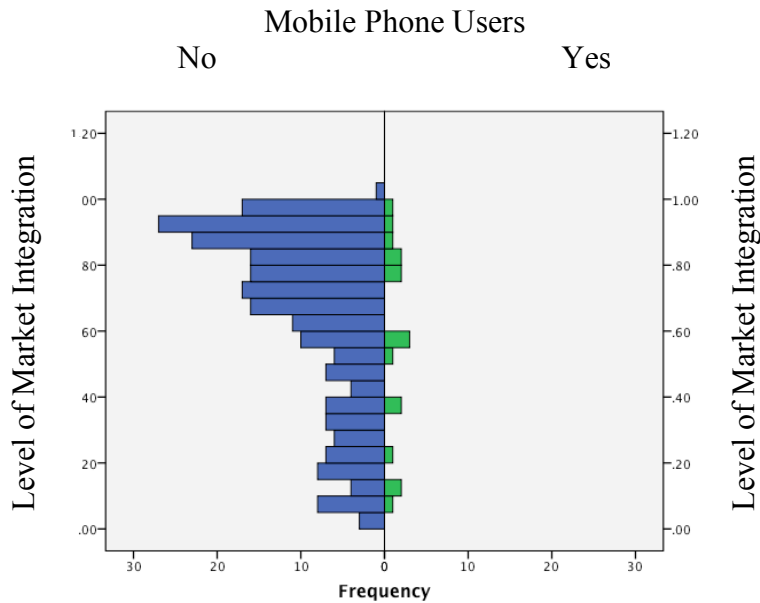


Figure 2. Histogram showing the distribution of market integration levels of mobile phone users (right) and non-users (left).  
 Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

The second point is that higher levels of market integration are correlated at a significance level of .01 to the sum of income and the value of self produced goods consumed. However, as shown in figure 3, the improvements in income and consumption indicated by the linear relationship between the sum of cash income and self produced goods consumed and the level of market integration of a household is not achieved by many at the higher end of the integration spectrum.

Figure 3 is the representation of actual household data and shows the relationship between the dependent variable of the analysis and the absolute value of household income. On the vertical axis is the sum of cash income and the value of self produced goods consumed and on the horizontal axis, the ratio of agricultural goods sold to the sum of total cash income and value of self produced goods consumed. A flat horizontal line indicating the median sum of household income and consumption (as defined



immediately prior) shows the absolute income value for the middle household of the sample and a line with a positive slope indicating a positive linear relationship between the two axis derived through linear regression are plotted as well.

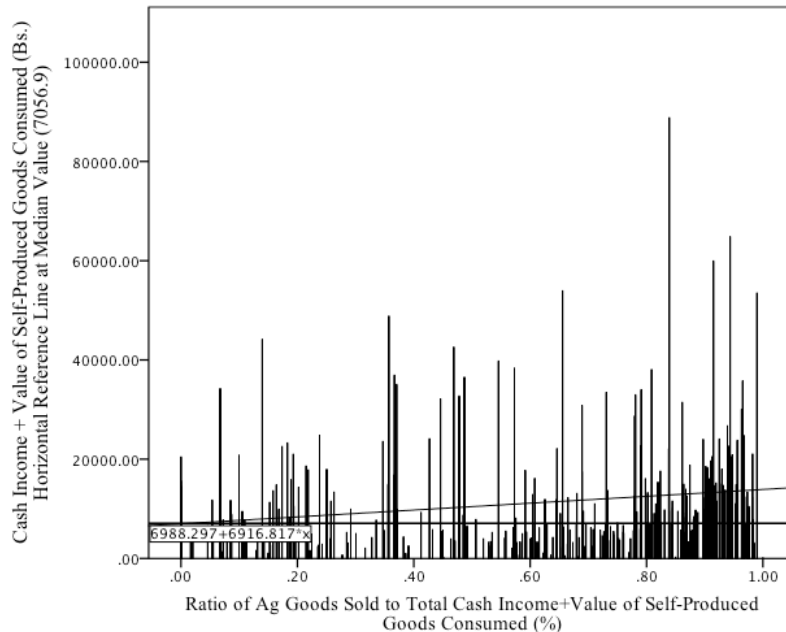


Figure 3. Relationship between the sum of household cash income and consumption with the ratio of agricultural goods sold to the sum of household cash income and consumption  
*Source:* SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

#### 4.4. RESULTS AND DISCUSSION

Confirmation of the hypotheses will be seen if the estimated coefficient on the interaction term between mobile phones and transportation costs is positive and significant. The conceptual model has been updated to reflect the econometric analysis of this data set in equation 14. Each of the coefficients and its significance will be discussed in depth in this part of the text.

$$\begin{aligned} \text{BSRATIO} = & 0.5 + 0.033 * \text{CONCERN} + 0.011 * \text{CONTROL} + 7.64\text{E-}07 * \text{YIELD} + 0.005 * \text{LAND} - \\ & 0.005 * \text{MIGRATION} - 0.1657 * \text{MOBILE} - 2.641 * \text{TRANSPORT} + 5.217 * \text{TRANSPORT}^2 \\ & + 0.905 * \text{INTERACTION} + 3.177\text{E-}5 * \text{KNOWN} + 0.048 * \text{HH55} - 0.093 * \\ & \text{HHED} > \text{PRIMARY} + 0.03 * \text{CREDIT} + 0.007 * \text{COOP} + 0.163 * \text{LOCATION} + 0.024 * \text{MIDDLEMEN} \quad (14) \end{aligned}$$

Table 11. Results for Farm Sales as a Percentage of Household Income.

Dependent: BSRATIO (y)	Defended Model		Corrected Model		
	Coefficient (SE)	VIF	Coefficient (SE)	VIF	
(Constant)	0.5313 (0.1100)***		0.500 (0.1166)***		
CONCERN	0.0428 (0.0255)*	1.1490	0.033 (0.0255)	1.150	
CONTROL	0.0165 (0.0122)	1.0510	0.011 (0.0120)	1.096	
YIELD (Bs/Ha)	9.270E-07 (0.00)*	1.1440	7.643E-7 (0.00)	1.191	
LAND (Ha)	0.0066 (0.0021)***	1.0830	0.0053 (0.0022)**	1.205	
MIGRATION (Days/AEU)	-0.0056 (0.0008)***	1.0670	-0.0052 (0.0009)***	1.092	
MOBILE (Used Y/N)	-0.1536 (0.0794)*	1.3240	-0.166 (0.0860)*	1.403	
TRANSPORT (Bs. Spent/Bs. Earned)	-3.3019 (0.7363)***	12.4990	-2.641 (0.9510)**	14.053	
TRANSPORT <sup>2</sup>	6.4620 (1.5499)***	10.9910	5.217 (2.0263)**	12.107	
INTERACTION (MOBILExTRANSPORT)	0.6949 (0.3611)*	1.6840	0.905 (0.4545)**	1.770	
KNOWN (Years)			-3.177E-5 (0.0040)	1.147	
HH55 (Y/N)			0.048 (0.0356)	1.242	
HHED>PRIMARY (Y/N)			-0.093 (0.0564)	1.124	
CREDIT (Y/N)			0.030 (0.0663)	1.156	
COOP (Y/N)			0.007 (0.0663)	1.098	
LOCATION (1/0)			0.163 (0.0507)**	1.318	
MIDDLEMEN (Y/N)			0.024 (0.0350)	1.112	
N (1/2)	160/160	R-Square (1/2)	.4804/.5485	F (1/2)	133.10/40.2186
K (1/2)	9/16	Adj. R Square (1/2)	.449/.498	F Sig. (1/2)	0.00/0.00

Critical Values: \*\*\*.01 Significance Level, \*\*.05 Significance Level, \*.1 Significance Level  
Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

Table 11 displays the heteroskedasticity consistent regression results. Standard errors, *t*-values, *F*-values, and *p*-values have all been calculated to be robust to the effects of heteroskedasticity. *LOCATION*, *TRANSPORT* and *TRANSPORT*<sup>2</sup> were not established as jointly significant using a heteroskedasticity robust LM test procedure (LM=6.224, .10 *X*<sup>2</sup>=6.25). Excluding *TRANSPORT* and *TRANSPORT*<sup>2</sup> alone was not significant with an LM=3.587 (.10 *X*<sup>2</sup>=4.61) with *LOCATION* remaining in the analysis. Dropping

*LOCATION* from each of the models used in the heteroskedasticity robust LM test for *TRANSPORT* and *TRANSPORT*<sup>2</sup>, but not including it as part of the yields the same LM=6.224 (.05  $X^2=5.99$ ) as *LOCATION*, *TRANSPORT* and *TRANSPORT*<sup>2</sup>. This suggests, intuitively, that some of the same information is contained in *LOCATION* as each of the *TRANSPORT* variables. However, *LOCATION* contains information on differentiation between how well markets function in those communities that is not contained in *TRANSPORT*.

#### 4.4.1. DISPOSITION TO ACT

$$BSRATIO = \beta_0 + \beta_{w1}CONCERN + \beta_{w2}CONTROL \dots \quad (15)$$

Neither *CONCERN* nor *CONTROL* was significant. This does not suggest that Disposition to Act is unimportant, but in this model it did not prove statistically significant.

#### 4.4.2. EXTERNAL STRUCTURES

$$BSRATIO = \dots - \beta_{x3}MIGRATION - \beta_{x4}TRANSPORT + \beta_{x5}TRANSPORT^2 + \beta_{x6}KNOWN + \beta_{x7}LOCATION + \beta_{x8}MIDDLEMEN + \dots + \beta_{x4z11}MOBILExTRANSPORT \quad (16)$$

Migration is a measure of household resources, both as income and as a constraint for labor in agriculture. Migration is a type of market integration. With a coefficient of -0.0052, migration was significant. A single day per adult equivalent unit of the household increase in migration would lead to a decrease of 0.52% in household portfolio sold.

This suggests confirmation of models presented in Ellis (1993) that represent a tension between labor on the farm and labor for off-farm income.

*TRANSPORT* and *TRANSPORT*<sup>2</sup> were each significant individually.

*TRANSPORT* and *TRANSPORT*<sup>2</sup> are multicollinear by design (Wooldridge 2009) so one should expect a high VIF for those two variables; there is no reason to suspect that coefficients are inaccurate in this case. Jointly they were significant when *LOCATION* is dropped from the analysis. This suggests that *TRANSPORT* variables and *LOCATION* represent much of the same information. The significance of *TRANSPORT* confirms Staal et al. (1996), Holloway et al. (2000), Key et al. (2000) and Aker (2010) in their respective measures of the cost of transporting goods. The signs of *TRANSPORT* and *TRANSPORT*<sup>2</sup> will be discussed jointly with *INTERACTION* and *MOBILE* later in the chapter. *LOCATION* was individually significant and positive, as expected. These results confirm the findings of Staal et al. (1996) when they included the binary urban variable.

*KNOWN* was not significant. However, an interesting tangent is seen in table 12; mobile phone users have a statistically longer lasting relationship with their buyers of their most important crop than non-users. It appears to confirm Donner (2006)'s assertion that entrepreneurs use mobile phones to strengthen ties. It does not appear that mobile phone users are shopping for the best price, as much as they are reducing the cost of information with existing business ties.

Table 12. Relationship between mobile phones and relationship with buyer.  
How long have you known the buyer of your most important crop? (in years)

Use Mobile	N	Mean	Std. Deviation	Std. Error Mean
No	178	2.1124*	4.13457	.30990
Yes	15	4.0667*	4.58984	1.18509

\*Difference significant to the .10 level.

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

*MIDDLEMEN* was not significant. This was a challenging variable to construct from the data, suggesting that possibly if a measure closer to those used by Key et al. (2000) was available it might be significant.

As Amaya Urquieta and Alwang (2012) show, it is possible that market choice will change with the use of mobile phones. It was not clear how to incorporate a measure of market choice change in the model, however an exploration of the data with *z*-scores through a series of groupings is described in appendix 6. The result of this cursory analysis was that there is a difference for some crops in some places. For the most part, the market choice was not statistically different.

#### 4.4.3. INTERNAL RESOURCES

$$\begin{aligned} &BSRATIO \\ &= \dots + \beta_{z9}YIELD + \beta_{z10}LAND + \beta_{z11}MOBILE + \beta_{z12}HH55 + \beta_{z13}HHED > \\ &PRIMARY + \beta_{z14}CREDIT + \beta_{z15}COOP + \beta_{x4z11}MOBILE \times TRANSPORT \end{aligned} \quad (17)$$

The first measure of the household's Internal Resources is the variable measuring the mean yield, in Bolivianos per hectare for the household's crops, regardless of destination, including home consumption. *YIELD* is not significant.

The next measure of household resources, *LAND*, was significant and as expected positive. The coefficient is 0.0053, indicating a one-hectare increase in land holdings leads to a 0.53% increase in household portfolio sold. Households with larger landholdings are more integrated, and *vice versa*.

Mobile phone use was negative and statistically significant. The sign was surprising but will be discussed in section 4.4.4. The significance of this measure

confirms Alene et al. (2008), Muto and Yamano (2009) and Aker (2010) who indicated that when mobile phones are interacted with distance or transportation costs lowered the cost of information across their respective barrier.

*HH55* was not significant, as it was not significant in Key et al. (2000).

Education was not significant, confirming previous analysis of this data by Jensen (2010) and other analysis by Renkow et al.(2004) and Alene et al. (2008). *CREDIT* was not significant in this thesis; Key et al. (2000) found their measure of credit significant. However, Key et al. (2000) were trying to correct for noise in credit and labor markets and this thesis was simply trying to examine the importance of using credit. The different aims could be why there was a difference in significance. *COOP* was not significant and this was also surprising. This was especially surprising because it was significant in the intensity of participation model, but not the entry model presented by Alene et al. (2008) and this model is an intensity model.

Gender was not included as a regressor in the model. However, the idea of market women or “cholas” and her husband or “indios” (not the market women and market man) emphasized by Hardman (1981) seems to be confirmed by the survey data. To the question “who in the household generally sells the product” the answer “mainly women” made up the highest percentage of non-zero valid responses for each of the crops except barley hay and lupine. Women also made up the majority of those marketing products such as milk and cheese. Livestock sales were less clearly dominated by women; native and improved sheep sales were nearly split between genders. Cattle and llama sales were clearly dominated by men.

As an interesting digression, the domination of cattle by men is interesting because the concerns of men and the control of men regarding low cattle prices was relatively unimportant to the concerns and control women had when using principal components analysis to determine the relative importance of those variables. The significance of the concern of women is likely due to the frequency of domestic spending (food and school supplies) from proceeds of cattle and llama sales.

#### 4.4.4. DISCUSSION: TRANSPORTATION COSTS AND MOBILE PHONES

Table 13 shows some household characteristics of households with transportation costs equal to or greater than .20 Bs./Bs. These households are the six highest transportation cost households. These households are headed by men slightly younger than the mean age of the sample (4 of 6 are in the second to bottom quartile), are on small plots of land (3 of 6 are in the bottom quartile and one is in second and third respectively), have large homes (4 of 6 are in the top 2 quartiles of household size) and sell agricultural goods (all but one are in the bottom quartile of agricultural sales). Aside from their perspective on the threat of low prices and their lack of control over pests it is hard to find commonality between all six cases. Means of the sample included in the regression have been provided for comparison for continuous and ratio variables. Cases 4 and 5 have very high rates of *MIGRATION* considering that each household has 12 and 10 members, respectively. However, cases 1 and 3 are below the sample mean. Case 4 almost produces (*YIELD*) at the sample average with high levels of migration. Cases 2 and 4 use a mobile phone in trade and have high levels of migration, which seems to

support the assertion made by Amaya Urquieta and Alwang (2012) that mobile phones are purchased initially to maintain contact with migrating family members and then used in trade.

Table 13. High transportation cost households included in final regression.

Case Number	Sample Mean of cases included in regression	1	2	3	4	5	6
TRANSPORT	0.005	0.2	0.21	0.24	0.35	0.42	0.51
Location		Chinchaya	Cohani	Cohani	Chojñapata	Cohani	Chinchaya
Member 1 Gender		M	M	M	M	M	F
Member 1 Age	51	84	45	35	49	46	48
Member 1 Education		Elementary	Secondary	Secondary	Secondary	Elementary	Elementary
CONCERN		Moderate Threat	Moderate Threat	Moderate Threat	Moderate Threat	Moderate Threat	Moderate Threat
CONTROL		No Control	No Control	know how to control	know how to control	know how to control	No Control
YIELD	11436.55	15000.00	5055.56	14444.44	10241.67	0	1510.20
LAND	6.6	3	0.4	0.3	5	2.2	1.9
MIGRATION	15.29	12.20	25.92	11.96	38.47	34.71	0
MOBILE		N	Y	N	Y	N	N
KNOWN	2.61	0	5	0	8	0	0
CREDIT		N	N	Y	N	Y	N
COOP		N	N	N	N	N	N
LOCATION		Y	N	N	N	N	Y
MIDDLEMEN		Y	Y	Y	Y	N	Y
VSP	789	350	404	162	3779	1589	111
HH Members	5	3	7	6	12	10	3
BSratio	0.65	0.19	0.13	0.22	0.24	0.3	0.68
Ag Sold	693	720	560	1090	5910	1500	237

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

As mentioned in the two previous sections, results for *TRANSPORT*, *TRANSPORT*<sup>2</sup>, *MOBILE*, and *INTERACTION* need to be evaluated together. As evident in table 11, mobile phone use (a shift in intercept) is significant and negative. This was puzzling until graphed in figure 4. The interaction term (a shift in slope) is significant, positive, and larger than mobile phone use in itself. Transportation and its square are jointly significant. The positive coefficient on the quadratic term is an indicator that the



equation is convex shaped. The convex shape of this line implies there is at least a neighborhood minimum and possibly a global minimum for the function. In practical terms, as figure 4 shows, after reaching a minimum point as one moves rightward the function is increasing. The significant interaction term confirms Aker (2010) and Muto and Yamano (2009).

On the vertical axis figure 4 shows the ratio of agricultural goods sold to the total family income plus the value of subsistence products, as described in Chapter 4. The horizontal axis of figure 4 shows the transportation cost of the first crop. The dashed and solid lines are approximations of the partial effects of mobile phone use and transportation costs on market integration.

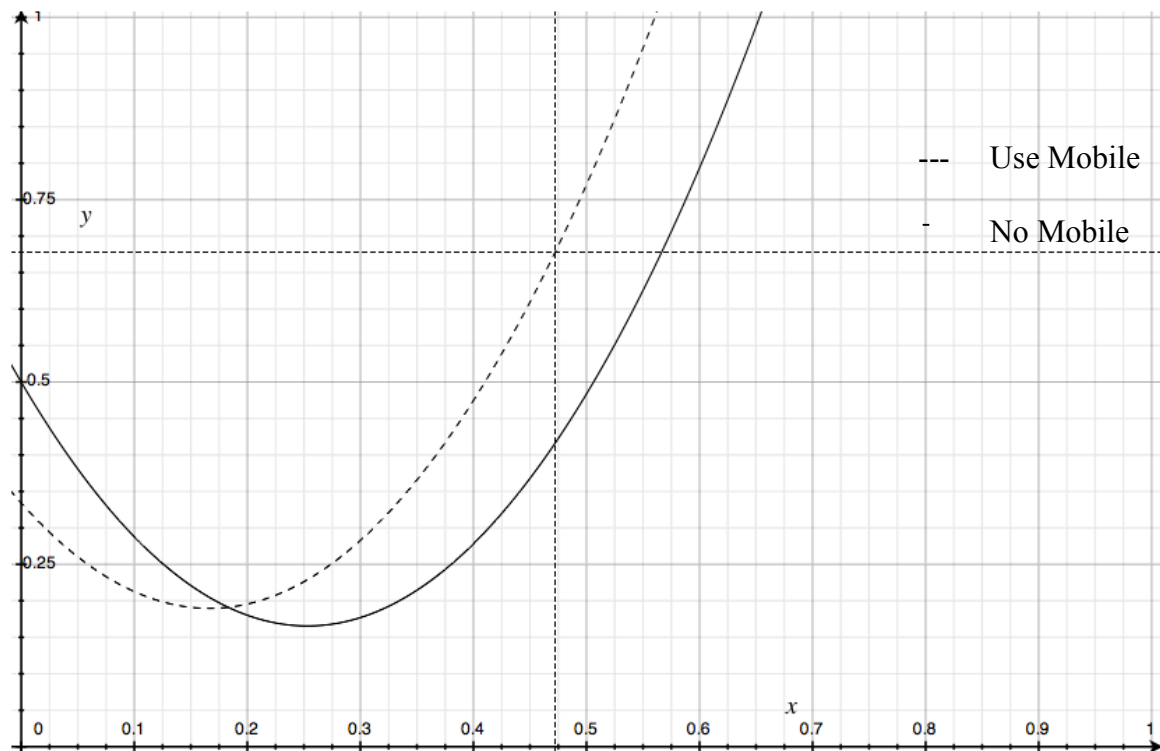


Figure 4. The expected impact of transportation costs.  
 Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

$$y=0.4997-0.1657 [1]+0.9053 [1]*TRANSPORT-2.6408*TRANSPORT+5.2173*TRANSPORT^2 \quad (18)$$

$$y=0.4997-0.1657 [0]+0.9053 [0]*TRANSPORT-2.6408*TRANSPORT+5.2173*TRANSPORT^2 \quad (19)$$

Equations 18 and 19 are equation 14 reduced to only the terms of interest and the y-intercept, holding all else equal, where x (transportation cost) is represented on the horizontal axis of figure 4. Equation 18 is the estimated level of integration depending on the constraint of transportation cost for a household using a mobile phone in trade (dashed line in figure 4). Equation 19 is the estimated level of integration depending on the constraint of transportation cost for a household not using mobile phones in trade (solid line in figure 4).

Mobile phones have a statistically significant lessening effect on market integration at low transportation costs and then an increasing effect on market integration at high transportation costs. At some point, approximately  $TRANSPORT=0.18$ , the two curves intersect. At this point mobile phones become useful for high transportation cost households and less useful for low transportation cost homes. To understand the effect of mobile phones and transportation costs partial derivatives are used to find the partial effects. The partial effect of mobile phones is represented in equation 20. The effect of mobile phones relies on transportation costs. Similarly, the effect of transportation costs, represented in equation 21, depends on mobile phone use.

$$\frac{\partial y}{\partial MOBILE} = -0.1657 + 0.9053 * TRANSPORT \quad (20)$$

$$\frac{\partial y}{\partial TRANSPORT} = 0.9053 * MOBILE - 2.6408 + 10.4346 * TRANSPORT \quad (21)$$

This research confirms much of the literature reviewed. Much like Muto and Yamano (2009) the regression results indicate that mobile phones can help overcome

very high transportation costs (longer distance in the case of Muto and Yamano (2009)) achieve higher levels of market integration. The longer relationships mobile phone users have with their buyers confirms Donner (2006) and Overå (2006) that the mobile phone users are using mobile phones to build relationships and continue to do business with those buyers by lowering transaction costs. The next chapter will discuss the conclusions, limitations and recommendations from this study.

## CHAPTER 5.

### CONCLUSIONS

Low market participation has been viewed as a problem in the past and high transaction costs have been found to be a contributing factor to low market participation. Mobile phones are expected to lower transaction costs by lowering the cost of information to allow greater market participation. This thesis examined the relationship between market integration, mobile phone use, transportation costs, and a series of control variables. A three-construct framework of analysis was developed that included disposition to act, the internal resources of the household and the external structures affecting the household. Once developed, the model was stable and deemed reliable after several tests.

A statistically significant link between mobile phone use and transportation costs has been established. The hypothesis that higher transportation cost households will be able to participate to a higher degree in the market has been confirmed. It was surprising that the *MOBILE* variable was negative. As a transaction cost reducing technology, it seems logical that *MOBILE* would be positive and significant for all levels of *TRANSPORT*. However, the results indicate that mobile phone use only has a positive effect on the integration of high cost of transportation households. Testing for differences between groups confirms that mobile phone users are focusing on building stronger, rather than bigger networks. Networks are likely expanding as well, but the focus appears to be on strengthening.

### 5.1.1. LIMITATIONS

This research has several limitations. As a fitted line, holding all other factors constant it is important to not interpret these lines as containing the only possibilities available to the households. Graphing all the variables and their respective coefficients would require 18 dimensions, and this not possible. Even a three dimensional representation would fall short of representing all possible levels of diversification, much less paths of transition. It is also important to remember that this line is a fitted representation, designed to minimize the sum of squared residuals of the sample model. An extension of this critique is that the survey is a single point in time; multiple points in time would help understand transition paths. The second major limitation is the importance of locality. The model represents a diverse set of landscapes and shows that context matters and has to be included as a variable in the analysis of regions that are very diverse.

The third major limitation is the reduction in the sample due to the transportation cost variable. A meaningful transportation cost without imputing values (since it appears that the missing values may have been missing systematically or at least not at random) would be an excellent follow up.

The fourth is more of a caveat to the interpretation of this research, the missing values of the dependent variable appeared to be systematic on the low end, in particular zero. This model is not intended to be used to find the expected value of household market participation given the regressors, it is intended to test in a statistically rigorous way if there is a relationship between mobile phone use and transportation cost. That

relationship has been found. The lack of zero trade households in the analyzed portion of the sample indicates that this model is only valid for examining an increase in market participation, not market entry.

### 5.1.2. RECOMMENDATIONS

Further research should add the time dimension. Reports received in March 2012 (after data analysis was complete) have indicated nearly ubiquitous ownership of mobile phones among farm families (Yucra Sea 2012). The report stated exactly what the data analysis indicated, households are using mobile phones to make price inquiries, schedule deliveries, and to make price agreements before delivery (Yucra Sea 2012). In other words, the households are using mobile phones to lower their transaction costs. The growth from under twenty households using mobile phones to market to a nearly ubiquitous presence, especially given the limited resources, indicates that the mobile phones are of economic benefit.

Adding the time dimension would allow a study to address the price dispersion observed both within and between communities. Jensen (2007) and Aker (2010) were both concerned with changes in price dispersion that this study could not address because of the single observation.

Following the households through time would provide the opportunity to understand enterprise transition paths, instead of inferring the path by observing static points. Understanding the opportunities provided by mobile phones during the expansion of their use and how the paths of change flow (or don't flow if transition paths are

nonlinear) would be working toward answering North (1994)'s call for a theory of economic dynamics. If mobile phones truly are a telegraph moment as Abraham 2007 proposed, we should be ready to watch for changes and understand why prosperity follows in some places but not others.

Including household location and analyzing market of choice with this data has the potential of enriching the data as well. Mobile phone coverage maps should be acquired and overlaid the map of households. Distance has the problem of price dispersion at a given location, but including distance has the potential overcome the market entry problem.

## APPENDIX 1.

### BACKGROUND AND ADDITIONAL INFORMATION ON THE MODEL.

This appendix provides additional information about the model omitted from the body of the thesis for ease of reading. This appendix begins by examining the order of importance between crops in the two regions. This appendix ends by detailing other ways that conceptual constructs of this thesis could have been measured, but were not.

#### 1.1. ORDER OF CROPS

As discussed in the body of this thesis, the order of crops (in particular the most important) was used as a method of simplifying the household portfolio. It is interesting to see what crops are popular in different locations and if common trends or divergent choices can be observed in the choice of first, second and third crops.

In Ancoraimes (figure 5) there are three crops that have observations for most important. Many observations then choose potato and then there are many different choices. An interesting aside is that none of these households that chose barley grain or barley hay chose the other as important. This could suggest that these households are either using the other product, either hay or grain or they do not consider it important.

Figure 6 is a visualization of the choices of households in Umala regarding their first crop, second crop, and third crop. Umala is more focused on Potatoes than



Ancoraimés is. In fact, the only crop listed first is potato. One household did market both barley grain and barley hay.

These visualizations depict the crops that are valued in these regions. Many of the variables to follow will use the first crop notation to be sure that the measurement is the most important for the household's marketing. These visualizations emphasize the difference in the diversity of opportunities in the two regions.

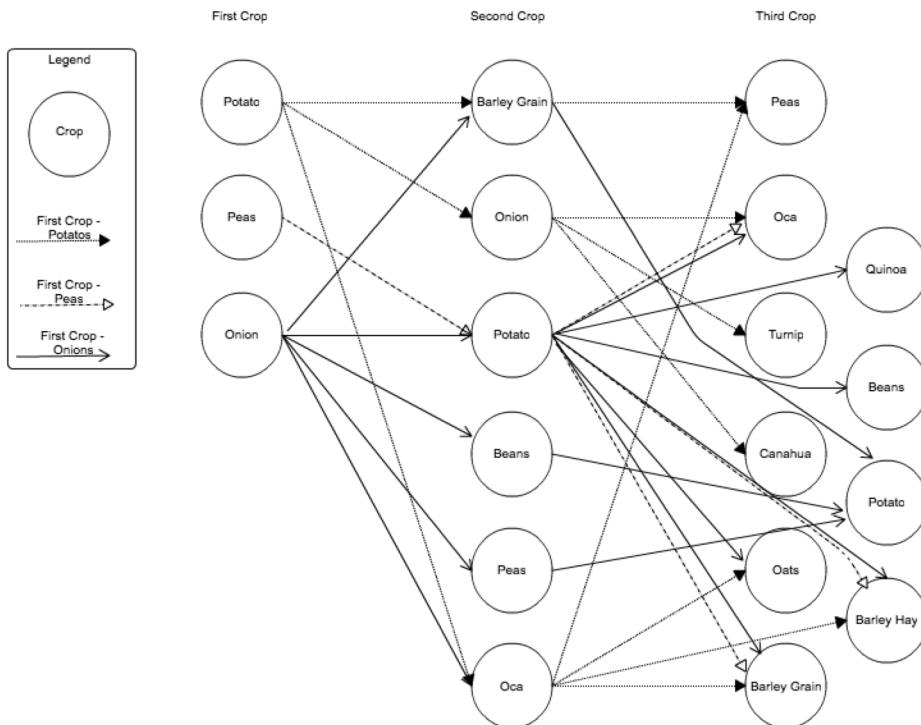


Figure 5 Visualization of Ancoraimes Cross Tabulation Of First Crop-Second Crop-Third Crop. Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

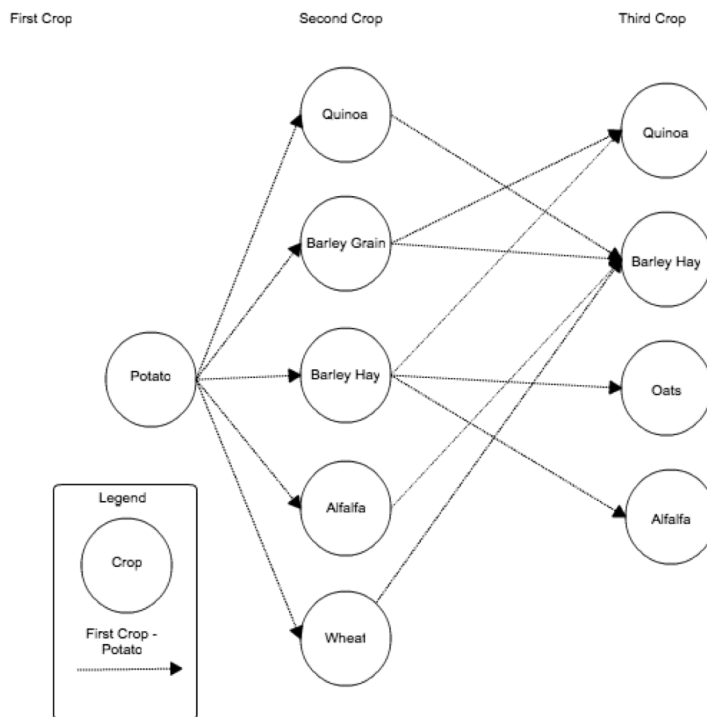


Figure 6. Visualization of Umala Cross Tabulation Of First Crop-Second Crop-Third Crop. Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

## 1.2. ADDITIONAL FINDINGS FROM THE LITERATURE

Alene et al (2008) was highly informative in the development of this thesis. This section provides additional information on the findings of Alene et al. (2008). In measuring market participation: gender (-, male=1), age (-), extension access (+), credit access (+), land per capita (+), adults in the household (+), off-farm income (-), distant fertilizer market (-), and ownership of transport equipment (+) were all significant. These would indicate an association with FTCs. In measuring the amount sold, only extension access (+), number of adults in the household (+), livestock ownership in tropical livestock units (+), district level modern variety use (+), price of maize (+), distant maize market (-), distant fertilizer market (-), and a member of a marketing group (+) were significant. These indicated an association with PTCs (Alene et al 2008).

In measuring fertilizer demand, transaction costs, input prices, output prices, and factors of production are expected to affect demand. Livestock ownership, access to credit, and off farm employment were also expected to be significant. Adoption of fertilizer was significantly affected by age of the head of household (-), extension access (+), off-farm incomes (+), price of maize (+), distance to fertilizer market (-), transport equipment (+), and if the household was in a location of high production (+). Fertilizer demand was significantly affected by head of household gender (-, male=1), access to extension (+), land per capita (-), tropical livestock units of animals owned (+), off-farm incomes (+), district level adoption of modern varieties (+), price of maize (+), member of a marketing group (+), and ownership of pack animals (+) (Alene et al 2008).

### 1.3. TRANSACTION COST VARIABLES AND CORRELATIONS

As discussed in the body of the thesis, when developing measures to capture external structures, in particular dimensions of transaction costs, a possible problem of multicollinearity became apparent. This section contains the referred to correlation table.

Table 14. Correlations Between Market Characteristics and Mobile Phone Use

		Mobile	Frequency	Find Prices?	Arrangements	Pay Cash?	Who?	How Long?
Pearson Correlation = PC Sig. (2-tailed) = Sig. N=N								
Use Mobile	PC	1						
	Sig.							
	N	238						
FIRST PRODUCT: FREQUENCY OF SALE	PC	.020	1					
	Sig.	.783						
	N	193	242					
FIRST PRODUCT: HOW DO YOU FIND OUT ABOUT PRICES?	PC	.110	.368**	1				
	Sig.	.129	.000					
	N	193	242	242				
FIRST PRODUCT: WHAT TYPES OF ARRANGEMENTS...?	PC	.203**	.602**	.465**	1			
	Sig.	.005	.000	.000				
	N	193	242	242	242			
FIRST PRODUCT: BUYERS PAY CASH?	PC	-.023	.754**	.511**	.793**	1		
	Sig.	.752	.000	.000	.000			
	N	193	242	242	242	242		
FIRST PRODUCT: WHO DO YOU USUALLY SELL TO?	PC	-.087	.474**	.211**	.409**	.561**	1	
	Sig.	.231	.000	.001	.000	.000		
	N	193	242	242	242	242	242	
FIRST PRODUCT: HOW LONG HAVE YOU KNOWN YOUR BUYER	PC	.125	.261**	.121	.472**	.300**	.075	1
	Sig.	.083	.000	.060	.000	.000	.243	
	N	193	242	242	242	242	242	242

\*\* Correlation is significant at the 0.01 level (2-tailed).

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

#### 1.4. ALTERNATE MEASURES OF DISPOSITION TO ACT

This section of the appendix details alternate measures to the ones chosen to measure disposition to act. Most of these measures had a statistical problem such as multicollinearity, but some were needlessly complicated.

The survey asked eighty-three questions about different members of the household's perception of dread, risk, and uncertainty or fear and strategies. An attempt was made to use these questions to form an index variable for disposition to act reminiscent of Vyas and Kumaranayake (2006)'s socioeconomic status indices.

Incidentally, this complicated approach did not work well. Using principal components analysis, the information contained in questions on concern, risk, uncertainty, control, and climate and weather information preferences was condensed to two groups totaling twenty-five uncorrelated variables. Of those, the first two of each were used. The coefficients are difficult to interpret; however this is not the focus of the study and this may be tolerated for a good fit in the final analysis. However, once reduced to a manageable four-variable index most of the explanatory value had been lost and they were not significant as regressors against the study dependent variable.

The index values were evaluated with a series of dummy variables developed in the spirit of Valdivia and Jetté (1996) to capture if the household has native or improved cattle or sheep. Valdivia and Jetté (1996) and Valdivia (2004) both used number of

improved sheep and cattle to capture technology adoption and number of criollo cattle and sheep as an indicator of indigenous knowledge.

The number of improved or native cattle and sheep was also evaluated as a variable. The number of improved cattle was clearly most important with a loading of 1.432 (the next highest loading was Improved Sheep at .835). This information combined with correlation analysis revealed that none of the four dummy variables could be in a single equation without risking multicollinearity and that the number of Native Cattle and Native Sheep were correlated lead to selection of a combination of Number of Improved Cattle, Number of Improved Sheep, Number of Native Sheep as the combination to be evaluated. Number of Improved Cattle was correlated with all four dummy variables, eliminating their use. These measures also proved somewhat problematic early on and were eliminated.

## 1.5. ALTERNATE MEASURES OF EXTERNAL STRUCTURES

In addition to the transportation of the most important crop, there were alternate ways of measuring the cost of transportation the household is subject to. One method, the mean of transportation costs for each crop, was used but also had problems with missing values (n=186 in this model) and the mean failed to differentiate the households by what the household considered important. It is possible that a weighted average might be an appropriate way to approach this in future analysis. Another way of measuring is to sum the transportation costs of the household. However, this was worse than mean. If a

household participated in more markets, it would have a higher transportation cost value, regardless of how efficiently the household could transport its goods.

## 1.6. ALTERNATE MEASURES OF INTERNAL RESOURCES

This section of the appendix details additional measures of internal resources. In particular measures of natural capital (irrigated land), produced capital (livestock owned) and human capital (language skill) are explored.

Irrigated land can capture some information about the quality of the land and the intensity of its use. Two variables were created to capture the irrigated land value. First, the answer to the question “How much land is irrigated?” was captured in a variable. Second, a variable was created that divided irrigated land by total land to capture the proportion of irrigated land. Two cases had to be excluded from the variable capturing the proportion to avoid attempting to divide by zero because the houses were recorded as not owning any land. Simply measuring the amount of land owned and leaving quality to the mean yield variable ended up being the best approach based on stability of the model and statistical significance.

Livestock owned is an asset, sometimes used as a savings account (Valdivia 2004); as a savings account livestock should be thought of as produced capital. Alene et al. (2008) used a livestock variable measured in tropical livestock units and Key et al. (2000) use an index of livestock assets to capture this information. The number of each type of animal owned by the household was multiplied by the mean price between the high and low price available for the household, capturing the value to the household of its

livestock. Measuring the value to the specific household is particularly important for this study because the premise of mobile phones increasing market participation is that information is not readily available, and when information is not readily available (not to mention disparate bargaining power relationships) geographic and temporal price dispersion is to be expected. This measure captures the value of the animals the household owns to that household. However, this measure was theoretically difficult to separate from the dependent variable and seemed to have an endogeneity problem, though one was never detected as the model was ran.

A method for dealing with the diversity of languages spoken in Bolivia was not found in the literature. It stands to reason though, that if three languages are spoken in the country: Spanish, Aymara, and Quechua; households who can speak and understand more of those languages will be at an advantage in the market place. The first variable used the questions in table 15 to capture the diversity of language skills possessed by the head of the household. The second variable used those same questions, summed the household responses and then divided by the adult equivalent units of the household. This variable captures the language skill of the household for the instance that the head of the household is not the individual who does most of the marketing.

In the process for creating the sum variables for head of household and the household the variable was recoded so that speak and understand was represented by two and understands but does not speak is represented by one. This was done so that the intuition of a progression between no skill and operational skill can be used and so that a sum is a meaningful number, with higher skills represented by higher numbers. This



measure proved insignificant, as would have been expected based on Hardmann (1981).

It also seemed to make the model unstable and was eliminated from analysis.

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Table 15. Language Proficiency Questions

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Question	Response
p5a.1: Do you speak, understand ...? Spanish [or Aymara, or Quechua ]	0. None. 1. Speak and Understand 2. Understands, but does not speak

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*Source:* SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

## APPENDIX 2.

### EARLY VERSION OF MODEL WITH ALTERNATE DEPENDENT VARIABLE.

Another attempt at estimating a relationship between mobile phone use and agricultural integration to the market was made with a different dependent variable; this appendix provides an introduction to the alternate model. The dependent variable in these calculations was crop sales divided by the sum of agricultural sales and the value of subsistence products. This dependent variable was known as BSratio5. Crop Sales were of interest because the independent variables of interest were crop transportation and use of a mobile phone to market crops (due to data limitations).

$$BSratio5 = \frac{Crops\ Sales}{Ag\ Sales + VSP} \quad (22)$$

Independent variables were nearly the same as previous analysis discussed in the body of this thesis, but the results were radically different. Table 16 shows the results of the heteroskedasticity consistent regression results using the dependent variable described in equation 22. The results were an equation that had few significant regressors, had a non-normal distribution of  $\hat{u}$  and only predicted 14% of the variation in BSratio5. When these problems were ignored and the variables of interest in the equation plotted the relationship was exactly the opposite as the results discussed in the body of the thesis. High transportation cost households using mobile phones were less integrated than their non-phone using counterparts. Low transportation cost households using mobile phones were more highly integrated than their non-phone using counterparts. In the end it was

clear that this relationship would require a completely different set of parameters and possibly a different form. The problem could be that other forms of ag sales were included in the denominator, or it could be a problem of needing phone use data on those other forms of ag sales. With these problems and the greater interest being in household portfolios this line of analysis was discontinued.

Table 16. Heteroskedasticity consistent regression results for crop sales as a percentage of farm income.

BSRatio5 ( $y$ )		Heteroskedasticity-Consistent Regression Results			Collinearity Statistics	
		Coefficient (SE)	t	P> t	Tolerance	VIF
(Constant)		0.3142 (0.1122)	2.8013	0.0058		
CONCERN ( $w_1$ )		0.0080 (0.0244)	.3286	0.7429	0.8705	1.1487
CONTROL ( $w_2$ )		0.0499 (0.0147)	3.4012	0.0009	0.9511	1.0514
YIELD (Bs/Ha) ( $x_3$ )		1.026E-06 (0.0000)	2.1641	0.0320	0.8739	1.1443
LAND (Ha) ( $x_4$ )		-0.0059 (0.0033)	-1.7889	0.0756	0.9234	1.0830
MIGRATION ( $x_5$ )		0.0008 (0.0008)	.9488	0.3443	0.9369	1.0673
MOBILE ( $z_6$ )		0.1985 (0.0836)	2.3744	0.0188	0.7555	1.3235
TRANSPORT ( $z_7$ )		-0.1445 (1.1279)	-0.1281	0.8983	0.5938	1.6842
TRANSPORT <sup>2</sup> ( $z_7^2$ )		1.3761 (2.5847)	0.5324	0.5952	0.0800	12.4988
INTERACTION ( $z_6z_7$ )		-1.5012 (1.3484)	-1.1133	0.2674	0.0910	10.9905
N	160	R-Square	.1889	$\hat{u}$ Shapiro-Wilk Statistic	.954	
k	9	Adj. R Square	.140	$\hat{u}$ Shapiro-Wilk Sig.	.000	
F	4.2772	F Sig.	.0001	Residual ( $\hat{u}$ ) Mean	0	

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

APPENDIX 3.

MAP OF THE SURVEY AREA.

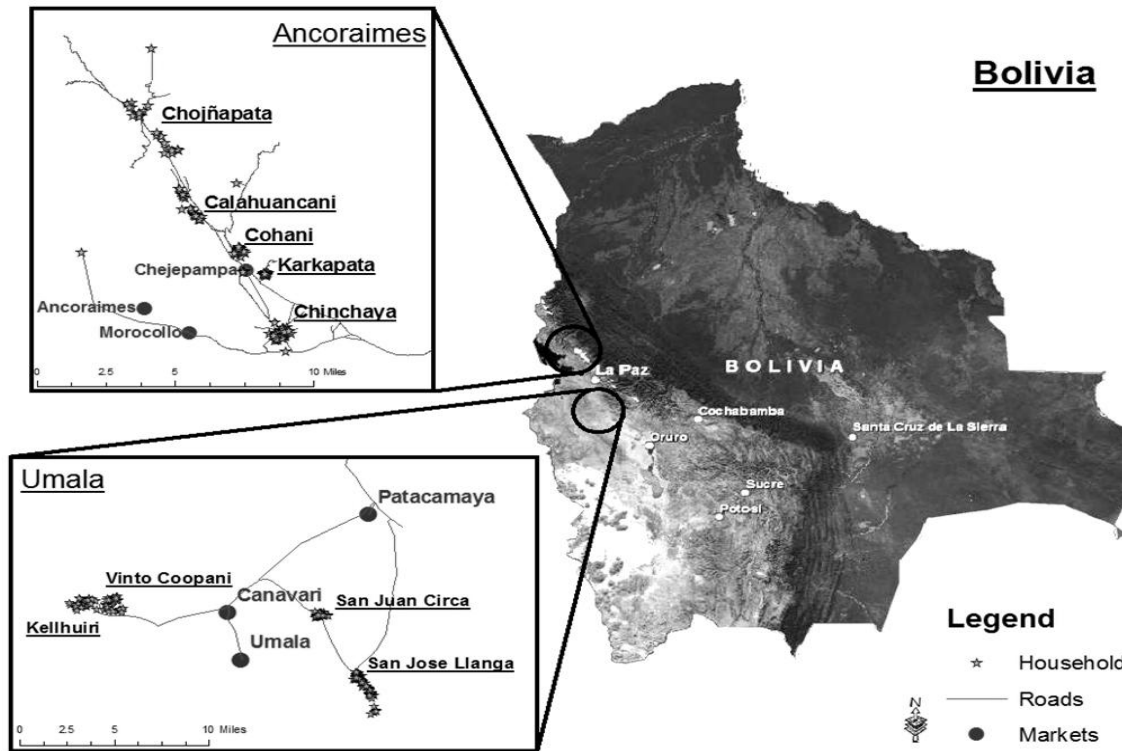


Figure 7. Map of the survey area.  
Source: Jensen (2010, p. 19)

## APPENDIX 4.

### MOBILE PHONE PENETRATION DURING STUDY YEARS.

As discussed in the body of the thesis, the literature indicates that a number of mobile phones are required to observe an effect. While each goal and institutional environment is different, Bolivia has certainly exceeded the market participation of any of the studies reviewed.

Table 17. Mobile phone penetration rates during study years of major studies.

Study	Country	Year(s)	Mobiles per 100*
Abraham, 2007	India	2007?	19.89
Aker, 2010	Niger	2005-2007	2.49//6.45
Donner, 2006	Rwanda	2003	1.48
Islam and Grönlund, 2010	Bangladesh	2009	35.66
Jagun, et al., 2008	Nigeria	2008?	41.81
Jensen, 2007	India	1996-2001	.03//.61
Muto and Yamano, 2009	Uganda	2003/2005	2.91/4.62
Overå, 2006	Ghana	2001/2003	1.24//3.86
Bolivia	Bolivia	2009	66.14

\*In study years

Source: ITU (2011)

## APPENDIX 5.

### FREQUENCY TABLES OF RESPONSES REGARDING MOBILE PHONE USE.

Table 18. Mobile phone use by crop.

Potato: Use the phone to negotiate the sale of their products?		Frequency	Percent
Valid	0 or No	311	97.8
	Yes	6	1.9
	Total	317	99.7
Missing	System	1	.3
Total		318	100.0

Peas: Do you use the phone to negotiate the sale price of their products?		Frequency	Percent
Valid	0 or No	48	15.1
	Yes	1	.3
	Total	49	15.4
Missing	System	269	84.6
Total		318	100.0

ONION: Use the phone to negotiate the sale price of their products?		Frequency	Percent
Valid	0 or No	67	30.0
	Yes	11	3.5
	Total	78	24.5
Missing	System	240	75.5
Total		318	100.0

Use Phone in Any Crop		Frequency	Percent
Valid	No	221	69.5
	Yes	17*	5.0
	Total	238	74.8
Missing	System	80	25.2
Total		318	100.0

\*One household uses mobiles for 2 crops

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALS Y PRÁCTICAS CICLO 2008-2009

Table 19. Mobile phone by location.

		Frequency	Percent
Valid	Ancoraimes	13	76.5
	Umala	4	23.5
	Total	17	100.0

	Location code	Frequency	Percent
Valid	Chinchaya	11	64.7
	Chojñapata	1	5.9
	San Jose Llanga	4	23.5
	Cohani	1	5.9
	Total	17	100.0

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALS Y PRÁCTICAS CICLO 2008-2009

APPENDIX 6.

WHERE DO YOU MARKET YOUR FIRST CROP, WHY, DO YOU USE A MOBILE PHONE?

Table 20. Preferred location of sale, separated by location and mobile phone use for households that consider potato to be their most important crop.						
First Product:	Location code			Use Mobile		Total
				No	Yes	
POTATO	Chinchaya	POTATO: Where do you sell? Answer 1	0	9 <sub>a</sub>	2 <sub>a</sub>	11
		Total		9	2	11
	Chojñapata	POTATO: Where do you sell? Answer 1	0	1 <sub>a</sub>	0 <sub>a</sub>	1
			3	2 <sub>a</sub>	0 <sub>a</sub>	2
			6	4 <sub>a</sub>	0 <sub>a</sub>	4
			7	4 <sub>a</sub>	1 <sub>a</sub>	5
	Total		11	1	12	
	San Jose Llanga	POTATO: Where do you sell? Answer 1	1	63 <sub>a</sub>	4 <sub>a</sub>	67
			2	1 <sub>a</sub>	0 <sub>a</sub>	1
			Total		64	4
	San Juan Circa	POTATO: Where do you sell? Answer 1	1	9		9
			Total		9	
	Vinto Coopani	POTATO: Where do you sell? Answer 1	1	3		3
			Total		3	
	Kellhuiri	POTATO: Where do you sell? Answer 1	1	1		1
			10	1		1
			Total		2	
	Calahuancani	POTATO: Where do you sell? Answer 1	3	2		2
			6	1		1
			7	6		6
			Total		9	
	Cohani	POTATO: Where do you sell? Answer 1	0	5		5
			6	1		1
			Total		6	
	Total	POTATO: Where do you sell? Answer 1	0	15 <sub>a</sub>	2 <sub>a</sub>	17
			1	76 <sub>a</sub>	4 <sub>a</sub>	80
			2	1 <sub>a</sub>	0 <sub>a</sub>	1
3			4 <sub>a</sub>	0 <sub>a</sub>	4	
6			6 <sub>a</sub>	0 <sub>a</sub>	6	
7			10 <sub>a</sub>	1 <sub>a</sub>	11	
10			1 <sub>a</sub>	0 <sub>a</sub>	1	
Total		113	7	120		

Each subscript letter denotes a subset of Use Mobile -1 otherwise 0 categories whose column proportions do not differ significantly from each other at the .05 level.  
 Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALS Y PRÁCTICAS CICLO 2008-2009



Table 21. Why the preferred location is preferred, separated by location and mobile phone use for households that consider potato to be their most important crop.

First Product:	Location code			Use Mobile		Total
				No	Yes	
POTATO	Chinchaya	POTATO: Why do you prefer this market? Answer 1	0	9 <sub>a</sub>	2 <sub>a</sub>	11
		Total		9	2	11
POTATO	Chojñapata	POTATO: Why do you prefer this market? Answer 1	0	1 <sub>a</sub>	0 <sub>a</sub>	1
		It is close		3 <sub>a</sub>	1 <sub>a</sub>	4
		They pay more		5 <sub>a</sub>	0 <sub>a</sub>	5
		I can buy other things		1 <sub>a</sub>	0 <sub>a</sub>	1
		There are many buyers		1 <sub>a</sub>	0 <sub>a</sub>	1
Total		11	1	12		
POTATO	San Jose Llanga	POTATO: Why do you prefer this market? Answer 1	It is close	55 <sub>a</sub>	2 <sub>a</sub>	57
			They pay more	1 <sub>a</sub>	0 <sub>a</sub>	1
			There are many buyers	2 <sub>a</sub>	0 <sub>a</sub>	2
			Es la única feria	6 <sub>a</sub>	2 <sub>b</sub>	8
Total		64	4	68		
POTATO	San Juan Circa	POTATO: Why do you prefer this market? Answer 1	It is close	6		6
			It is the only market	3		3
		Total		9		9
POTATO	Vinto Coopani	POTATO: Why do you prefer this market? Answer 1	It is close	2		2
			It is the only market	1		1
		Total		3		3
POTATO	Kellhuiri	POTATO: Why do you prefer this market? Answer 1	It is close	1		1
			I know buyers	1		1
		Total		2		2
POTATO	Calahuancani	POTATO: Why do you prefer this market? Answer 1	It is close	4		4
			They pay more	1		1
			I know buyers	2		2
			There are many buyers	2		2
Total		9		9		
POTATO	Cohani	POTATO: Why do you prefer this market? Answer 1	0	5		5
			They pay more	1		1
		Total		6		6
POTATO	Total	POTATO: Why do you prefer this market? Answer 1	0	15 <sub>a</sub>	2 <sub>a</sub>	17
		It is close		71 <sub>a</sub>	3 <sub>a</sub>	74
		They pay more		8 <sub>a</sub>	0 <sub>a</sub>	8
		I know buyers		3 <sub>a</sub>	0 <sub>a</sub>	3
		I can buy other things		1 <sub>a</sub>	0 <sub>a</sub>	1
		There are many buyers		5 <sub>a</sub>	0 <sub>a</sub>	5
		It is the only market		10 <sub>a</sub>	2 <sub>a</sub>	12
Total		113	7	120		

Each subscript letter denotes a subset of Use Mobile -1 otherwise 0 categories whose column proportions do not differ significantly from each other at the .05 level.

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALES Y PRÁCTICAS CICLO 2008-2009

Table 22. Preferred location and why the preferred location is preferred separated by location and mobile phone use for households that consider peas to be their most important crop.

First Product:	Location code			Use Mobile - 1 otherwise 0		Total
				.00	1.00	
Peas	Cohani	PEAS: Where do you sell? Answer	6	3 <sub>a</sub>	1 <sub>a</sub>	4
		1	7	6 <sub>a</sub>	0 <sub>a</sub>	6
		Total		9	1	10

Each subscript letter denotes a subset of Use Mobile -1 otherwise 0 categories whose column proportions do not differ significantly from each other at the .05 level.

First Product:	Location code			Use Mobile - 1 otherwise 0		Total
				.00	1.00	
Peas	Cohani	Peas: Why do you prefer this market? Answer 1	It is close	5 <sub>a</sub>	0 <sub>a</sub>	5
			They pay more	3 <sub>a</sub>	1 <sub>a</sub>	4
			I have little production	1 <sub>a</sub>	0 <sub>a</sub>	1
		Total	9	1	10	

Each subscript letter denotes a subset of Use Mobile -1 otherwise 0 categories whose column proportions do not differ significantly from each other at the .05 level.

Table 23. Preferred location and why the preferred location is preferred separated by location and mobile phone use for households that consider onion to be their most important crop.

First Product:	Location code			Use Mobile - 1 otherwise 0		Total
				.00	1.00	
Onion	Chinchaya	ONION: Where do you sell? Answer 1	3	41 <sub>a</sub>	6 <sub>a</sub>	47
			4	1 <sub>a</sub>	0 <sub>a</sub>	1
			5	1 <sub>a</sub>	0 <sub>a</sub>	1
			6	7 <sub>a</sub>	1 <sub>a</sub>	8
			9	1 <sub>a</sub>	0 <sub>a</sub>	1
	Total			51	7	58
	Chojñapata	ONION: Where do you sell? Answer 1	0	1		1
			Total			1
	Total	ONION: Where do you sell? Answer 1	0	1 <sub>a</sub>	0 <sub>a</sub>	1
			3	41 <sub>a</sub>	6 <sub>a</sub>	47
			4	1 <sub>a</sub>	0 <sub>a</sub>	1
			5	1 <sub>a</sub>	0 <sub>a</sub>	1
			6	7 <sub>a</sub>	1 <sub>a</sub>	8
			9	1 <sub>a</sub>	0 <sub>a</sub>	1
Total			52	7	59	

Each subscript letter denotes a subset of Use Mobile -1 otherwise 0 categories whose column proportions do not differ significantly from each other at the .05 level.

First Product:	Location code			Use Mobile -1 otherwise 0		Total
				.00	1.00	
Onion	Chinchaya	ONION: Why do you prefer this market? Answer 1	It is close	3 <sub>a</sub>	0 <sub>a</sub>	3
			They pay more	19 <sub>a</sub>	4 <sub>a</sub>	23
			I know buyers	0 <sub>a</sub>	1 <sub>b</sub>	1
			There are booths	5 <sub>a</sub>	1 <sub>a</sub>	6
			There are many buyers	23 <sub>a</sub>	1 <sub>a</sub>	24
			It is the only market	1 <sub>a</sub>	0 <sub>a</sub>	1
	Total			51	7	58
	Chojñapata	ONION: Why do you prefer this market? Answer 1	0	1		1
			Total			1
	Total	ONION: Why do you prefer this market? Answer 1	0	1 <sub>a</sub>	0 <sub>a</sub>	1
			It is close	3 <sub>a</sub>	0 <sub>a</sub>	3
			They pay more	19 <sub>a</sub>	4 <sub>a</sub>	23
			I know buyers	0 <sub>a</sub>	1 <sub>b</sub>	1
			There are booths	5 <sub>a</sub>	1 <sub>a</sub>	6
There are many buyers			23 <sub>a</sub>	1 <sub>a</sub>	24	
It is the only market			1 <sub>a</sub>	0 <sub>a</sub>	1	
Total			52	7	59	

Each subscript letter denotes a subset of Use Mobile -1 otherwise 0 categories whose column proportions do not differ significantly from each other at the .05 level.

Source: SANREM CRSP (2009) INFORME FINAL ENCUESTA DE ESTRATEGIAS DE VIDA, CAPITALS Y PRÁCTICAS CICLO 2008-2009

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