An Economic Impact Assessment of Cooperation-88 Potato Variety in the Yunnan Province of China

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ACADEMIC ABSTRACT

Cooperation-88 (C88) is a late blight resistant potato variety that was formally released in China in 2001 and has become popular in China's Yunnan Province. The International Potato Center (CIP) and Yunnan Normal University collaborated to produce the variety, which is one of CIP's most successful varieties. C88 is popular due to its high quality and taste, and it is used commonly in China's expanding potato chip processing market. The purpose of this study is to examine adoption of C88 in the Yunnan Province, its value chain, and economic impacts.

The analysis indicates that C88 is still popular with 16.8% of the potato area in Yunnan devoted to this variety in late spring 2015. To examine factors affecting household decisions to adopt and the intensity of their adoption, village adoption, household adoption, and household intensity of adoption were assessed. A village's proximity to a metropolitan county was the most important factor explaining adoption and intensity of adoption. Households in villages closer to a metropolitan county disadopted at higher rates than those farther away.

To quantify the economic benefits of C88 adoption, an economic surplus analysis was conducted. Total surplus changes ranged from $2 to 3 billion indicating significant economic benefits to consumers and producers in Yunnan.

GENERAL AUDIENCE ABSTRACT

Cooperation-88 (C88) is a popular late blight resistant potato variety that was released to the Yunnan Province of China in 2001. Late blight is the disease responsible for the Great Potato Famine in Ireland. The International Potato Center (CIP) and Yunnan Normal University collaborated to produce the variety, and C88 is one of CIP's most successful varieties. C88 is popular due to its high quality and taste, and it is used commonly in China's potato chip processing market. The purpose of this study is to examine the number and types of people who adopted C88 in the Yunnan Province, provide an understanding of the process from farm to consumer, and to determine the economic impacts of the variety.

A major finding of the study is that C88 remains popular in Yunnan as of spring 2015. To study the households that grew C88 during the spring 2015 season, statistical analysis was conducted with the focus on what household traits influence the number of surveyed households who grow C88 in a village, whether a household grows C88, and the number of hectares under C88. A village's proximity to a metropolitan county was the most important factor explaining whether a household adopted the variety and the number of hectares. Households in villages closer to a metropolitan county stopped growing C88 at higher rates than those farther away.

To quantify economic benefits, a supply and demand analysis of potatoes in Yunnan was conducted, which indicated significant economic benefits to consumers and producers in Yunnan.

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Chapter 1: Introduction

1.1 Introduction

Since 1993, China has led the world in potato production and area planted. Potato production has grown in China due to on-going growth in demand which arose from rapid income growth and increased consumption of Western food. In 2015, the Chinese government began promoting potatoes as a potential new staple crop, because compared to traditional staple crops like rice and wheat, potatoes produce more food and more calories per unit of water (FAO, 2008). As a result, potatoes are becoming a regular part of the Chinese diet.

With the growing importance of potatoes, research developing and disseminating improved varieties suited for China has followed. Potato cultivar research in China began in the 1940s with the selection and introduction of foreign varieties, and since then has primarily focused on the development of late blight-resistant germplasm (Jansky, Jin, Xie, Xie, & Spooner, 2009). Late blight disease (*Phytophera infestans*) is an important biotic constraint (Li, et al., 2010). The disease is caused by spores living on plant tissue which can destroy a whole plant within days. Late blight spreads quickly in cool, wet environments, which is especially detrimental to potato production in the Southwest Yunnan province, where most production occurs in the highlands where rain is abundant (Li, et al., 2010; Jansky, Jin, Xie, Xie, & Spooner, 2009). Due to late blight's negative effect on Chinese potato production, the International Potato Center (CIP) and Yunnan Normal University (YNU) collaborated to identify a late blight-resistant germplasm.

In 1986, a CIP-supported Vietnamese graduate student, Dao Hui Chien, identified late blight resistant CIP clones in collaboration with Professor Wang Jun (formerly of YNU) and Professor Canhui Li (YNU). A CIP Scientist, Peter Schmiediche, bred the advanced clones and

maintained the germplasm at the CIP genebank (Robinson & Srinivasan, 2013). These efforts were key to the breeding success of a late blight and virus resistant cultivar, Cooperation-88 (C88).

During experimental trials, C88 out-yielded Mira, the variety C88 eventually would replace, by anywhere between 5 and 76% (Li, et al., 2010). C88 also had the lowest late blight infection rate (Crook, Li, Xie, & Forbes, 2013). In 1995, C88 passed all provincial trials, allowing the variety to be released into any province in China. C88 was officially named in 1996 and formally released in Yunnan Province in 2001. A formal release occurs after the provincial government of has approved the variety. Before 2001, C88 was provided to extension and local government for trial and demonstration purposes, but the distribution of the variety to farmers was considered illegal. Despite being illegal, C88 was distributed to farmers and adoption began in 1996.

Afterwards, four more provinces (Guangxi, Chongqing, Sichuan, and Guizhou) legally approved and diffused C88. By 2001, C88 was under production in up to 70,000 hectares (ha) in Yunnan (C. Li, personal communication, September 1, 2015), and land area under C88 continued to increase until it was the most widely grown variety in Yunnan in 2009 (Li, et al., 2010). Its success is attributed to its late blight resistance, high yield, high quality, and good taste. C88 proved so popular that by 2010, it covered 400,000 hectares, with most of the area in Yunnan, and had an estimated impact of US $350 million in China in 2010 (Robinson & Srinivasan, 2013).

1.2 Problem Statement

C88 is likely one of CIP's biggest varietal successes. Estimates of internal rates of return range from 39 to 57%, indicating a large return on investment for CIP's research (Robinson &

Srinivasan, 2013). While Robinson and Srinivasan's research indicates large benefits and returns, the analysis was not thorough enough to create conclusive statements about C88's impact. Through their research, CIP connected their late blight germplasm research to the creation and release of C88, but the study did not fully capture the known benefits of C88 adoption: cost-savings from late blight resistance, productivity gains from yield increases, and the ability to sell in the potato chip processing market. Additionally, the study provided an overview of adoption rates based on previous estimates from Li et al (2010) and provincial Chinese potato statistics, but did not provide a detailed understanding of C88 diffusion.

Although known for its late blight resistance and high yields, new research suggests that C88 may not be as late blight resistant as originally understood. If late blight resistance was in fact not the major contributor to C88's wide-spread adoption, then the original understanding of the causes of its diffusion may be incorrect. Additionally, information is lacking regarding who adopted the variety and the characteristics of these adopters, including farm size, socioeconomic status, and production practices. The authors utilized a logistic curve to project future adoption and did not account for disadoption. To account for the full impacts of C88, the dynamics of adoption from beginning to end must be understood.

One reason for widespread adoption of C88 in Yunnan is the variety's role in value chains, especially potato chip processing. C88 is the preferred variety in the potato chip industry due to its low water content, size, gravity, and yellow color. As household income has increased in China, demand for processed potatoes has also increased, and thus the demand for C88. Additionally, it is important for the processing industry to have a reliable year round supply of raw materials, and from January to July, C88 is one of the few varieties readily available,

because it can matures earlier than other varieties in the low altitude, sub-tropical regions during the winter (Li, et al., 2010).

This study analyzes the dynamics of C88 adoption to better understand who adopted and disadopted the variety and why and conducts a rigorous impact analysis to quantify the economic benefits of C88. Quantifying the economic benefits of C88 provides evidence not only on its importance to producers and consumers, but on the impacts of CIP's efforts to improve potato varieties. The results can be used to inform donors of the growing importance of potatoes in China, and the impacts of these varieties in an economy where potatoes are becoming an integral part of a person's diet.

1.3 Objectives

The primary purpose of this study is to perform an ex-post economic impact assessment of the C88 potato variety in Yunnan. Specific objectives are to:

1. Measure the extent of and understand the determinants of adoption of C88. This is accomplished by using household survey data, including socioeconomic characteristics of farmers and land under C88 in the surveyed areas.
2. Estimate the economic impacts of C88 diffusion on producers and consumers in Yunnan. Yield, cost, price, and adoption estimates from household and community surveys are used to calibrate an economic surplus model and determine the net benefits of C88 diffusion.

1.4 Organization of Thesis

This thesis is organized into six chapters. The second chapter synthesizes the history of potato production in China. The third chapter provides a conceptual framework for the study and information on data collection. The fourth chapter describes the methods used to analyze C88

adoption and its impact. The fifth chapter presents the results from the empirical and qualitative analyses. The sixth chapter summarizes the study and provides ideas for future research.

Chapter 2. Background of Agriculture and Potatoes in China

This chapter provides background and context for the study. The chapter begins with an early history of potato production and consumption in China, and then describes current production and consumption.

2.1 History of Potato in China from the 1600s to the 1980s

Historically, Chinese famers planted a limited number of staple crops, including rice and various grains. Potatoes were first introduced as early as the 1600s by either Dutch settlers in Taiwan or by Russian or Siberian traders (International Potato Center, 2009). Early potato production was minimal compared to other crops and was concentrated in the highlands due to potato's agronomic preference for cooler weather. The Chinese living in the highlands primarily grew potatoes for subsistence and did not have access to urban markets. Even if they had access to markets, Chinese consumers preferred the taste of rice and noodles to potatoes.

Further constraining the expansion of the potato crop was the low availability of land. Prior to the Communist takeover in 1949, 70 to 80% of the land was owned by 10% of the wealthy families, who rented the land to peasants for cultivation (Fan, Gulati, & Dalafi, 2007). As a result, agriculture was primarily for subsistence on very small holdings.

Between 1949 and 1961, Chinese farms underwent structural changes that pushed farms into larger collective units with government owned land and more land was made available to peasant farmers. The government undertook these changes in order to institute collective farming and to increase agricultural productivity. Despite these efforts, productivity decreased due to production constraints implemented by the government, such as allocating land for specified crops and a quota system for those crops. Declining productivity, compounded with a large drought and ineffective policy choices, resulted in approximately 30 million people dying from

starvation between 1959 and 1961, one of the largest documented mass starvations in world history (Fan, Gulati, & Dalafi, 2007).

After 1961, many policy adjustments occurred that wavered between relaxing and increasing government control. Major changes began in 1978 when production teams were dissolved and collective farming was replaced by the Household Responsibility System (HRS). Under the HRS, land was still owned by the communes, but farmers were allowed to make their own production decisions (Fan, Gulati, & Dalafi, 2007, p. 16). Farmers now had incentives to increase their productivity due to the ability to link their effort to their outcomes.

These increases in productivity in conjunction with the combining of agricultural institutions led to an increase in rural markets such that "by the mid-1980s, marketing activities were completely liberalized for non-staple products such as fruits and vegetables" (Fan, Gulati, & Dalafi, 2007, p. 16). Farmers could now connect to urban markets where consumers increasingly demanded a diversified diet. Liberalization following the introduction of the HRS led to a surge in potato production, since demand was now more driven by consumer preferences than ever before.

2.2 Current Conditions

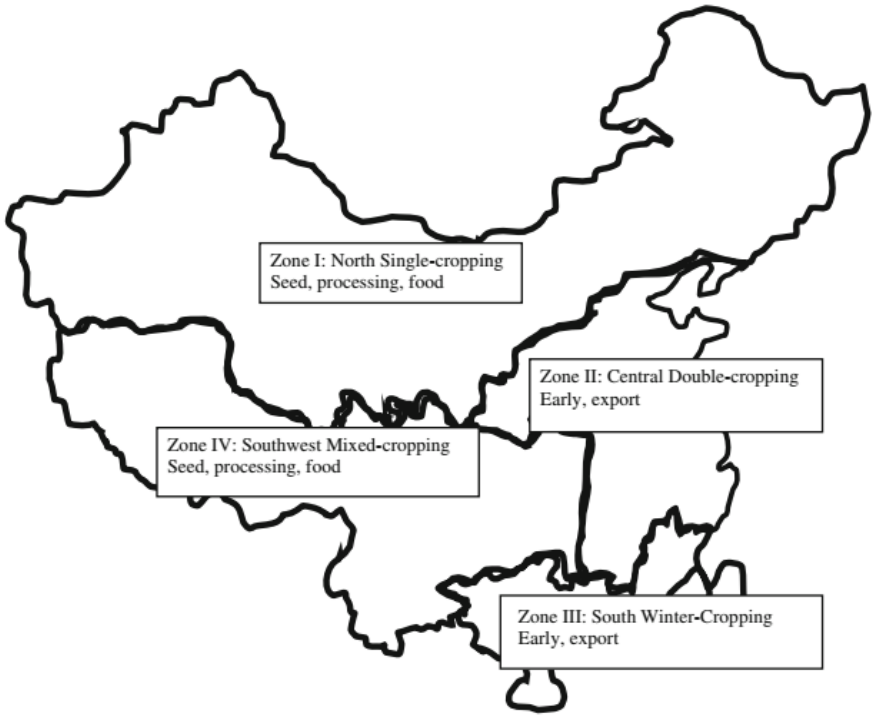
As markets became more liberalized, the ability to move potatoes across the country, especially from rural to urban areas, was crucial to the rise in potato consumption. Until recently, potatoes were not widely consumed due to prohibitive costs of transport. As a result, potatoes were not widely produced. It was not until the early 1960s when potato production began to increase as transportation costs fell. Potato production increased to such an extent that 70% of the worldwide growth in potato production between 1961 and 2007 is attributable to growth in China (Wang & Zhang, 2010). In 2013, China produced 96 million metric tons (mmt) of

potatoes, compared to the second largest producer, India, which produced less than half this amount (45 mmt). The United States, the third-largest producer, produced 20 mmt (FAOSTAT, n.d.).

This increase in potato production is tied to the introduction of the HRS system and ability of farmers to meet consumer demand. Consumers find potatoes a desirable vegetable, especially during the winter, because they can keep for a long period of time and can be cooked in different ways (Wang & Zhang, 2010). Further adding to the increased consumer demand for potatoes, the Chinese government has pushed for increased potato production in order to improve food security and nutrition uptake. Concurrent with the increase in demand, potato yields have steadily increased, resulting in growing profitability of potato production (Jansky, Jin, Xie, Xie, & Spooner, 2009).

Potato production in China is concentrated in four regions: north, central, southwest, and south, with the majority grown in the north and southwest (Figure 1). The southwest, where Yunnan is located, accounts for approximately 40% of China's potato production (Jansky, Jin, Xie, Xie, & Spooner, 2009). Yunnan has four growing seasons with the most land area under potato during the late spring (Table 1). Yunnan Province is well-suited for potatoes because of the cool late spring with adequate rainfall and high altitudes. While these factors are beneficial for potato production, they are also catalysts for the spread of late blight.

Figure 1. The four Chinese potato production zones and their attributes



Source: Jansky, Jin, Xie, Xie, & Spooner, 2009

Table 1. Estimates for land under potato in Yunnan by season in 2014

2014 Season data refers to	Total hectares under potato
Early spring	86,667
Late spring	400,000
Autumn	43,333
Winter	60,000
TOTAL	590,000

Source: SIAC Database 2.1, 2015.

2.2.1 Constraints to Potato Production

Potato producers in China face major constraints that may prevent them from meeting the increasing consumer demand, including poor seed quality, diseases, and limited access to new technologies. Clean potato seed and germplasm are essential to increased production because

without clean seed, diseases and viruses spread quickly. Most producers in China do not have access to clean seed, and, as a result, virus-free seed only accounts for 20% of total potato plantings (Jansky, Jin, Xie, Xie, & Spooner, 2009). Most farmers recycle saved seed from year to year, which perpetuates the spread of viruses and bacteria.

One of the most important diseases affecting Chinese potato production is late blight, a disease which easily spreads through land, air, and water. Late blight spores can remain in soil and tubers for multiple seasons, so access to clean seed is essential (Seaman, Loria, Fry, & Zitter, 2014). An infected tuber can cause great losses in the field, during transport, and in storage. Iit was estimated that 39% and 56% of potato area was afflicted by late blight in 1995 and 1996, respectively. Losses exceeded $95 and $170 million in the respective year (Kai-yun & Yi, 2001). These high losses highlight the need for late blight resistant potato varieties.

Late blight problems are compounded because many farmers in Yunnan work intensively on small plots without incorporating crop rotations (Jansky, Jin, Xie, Xie, & Spooner, 2009). This can cause late blight to persist. An additional challenge to farmers is the lack of equipment needed for planting, fertilizing, spraying and harvesting (Jansky, Jin, Xie, Xie, & Spooner, 2009). Without these technologies, farmers find it difficult to prevent the spread of diseases and may result in low productivity.

2.3 Consumption

The growth in potato production and consumption is attributed to three factors: 1) increased income, 2) the introduction of Western processed and fast food, and 3) trade liberalization within the country beginning in the 1980s. Since 1991, per capita income has consistently increased at annual rates ranging from 7 to 14%. As incomes have increased, Chinese diets have moved away from staple crops, such as rice, to traditionally more expensive

items, including meats, dairy products, fruits, and more favored vegetables, including potatoes. The growth in demand for potatoes comes primarily from urban consumers, whose incomes have increased the most (Scott & Suarez, 2012).

Increased potato consumption is also attributable to a change in taste for processed and Western food, which frequently uses potatoes. This taste change is directly tied to the growth in income, as the demand for processed and Western food has increased simultaneously with income. In 2013 alone, China's demand for processed potatoes increased by 12% from the previous year (Meador, Lei, & Orlowski, 2013). Farmers have altered their production to meet this increasing demand, which requires producing the high-quality potatoes needed for French fries and potato chip markets (Wang & Zhang, 2010).

The final cause of increased potato consumption is related to the increased domestic trade liberalization which began in the mid-1980s. Before then, farmers were unable to sell in urban markets. In many urban markets, potatoes were available for the first time in the late 1980's and early 1990's (Wang & Zhang, 2004). Not only trade within the country increased, but trade with other countries increased, allowing the introduction of Western foods. Market liberalization has led to the expansion of potato production, such that China is now a major exporter of potatoes in Asia because of its comparative advantage in labor and transportation (Wang & Zhang, 2010).

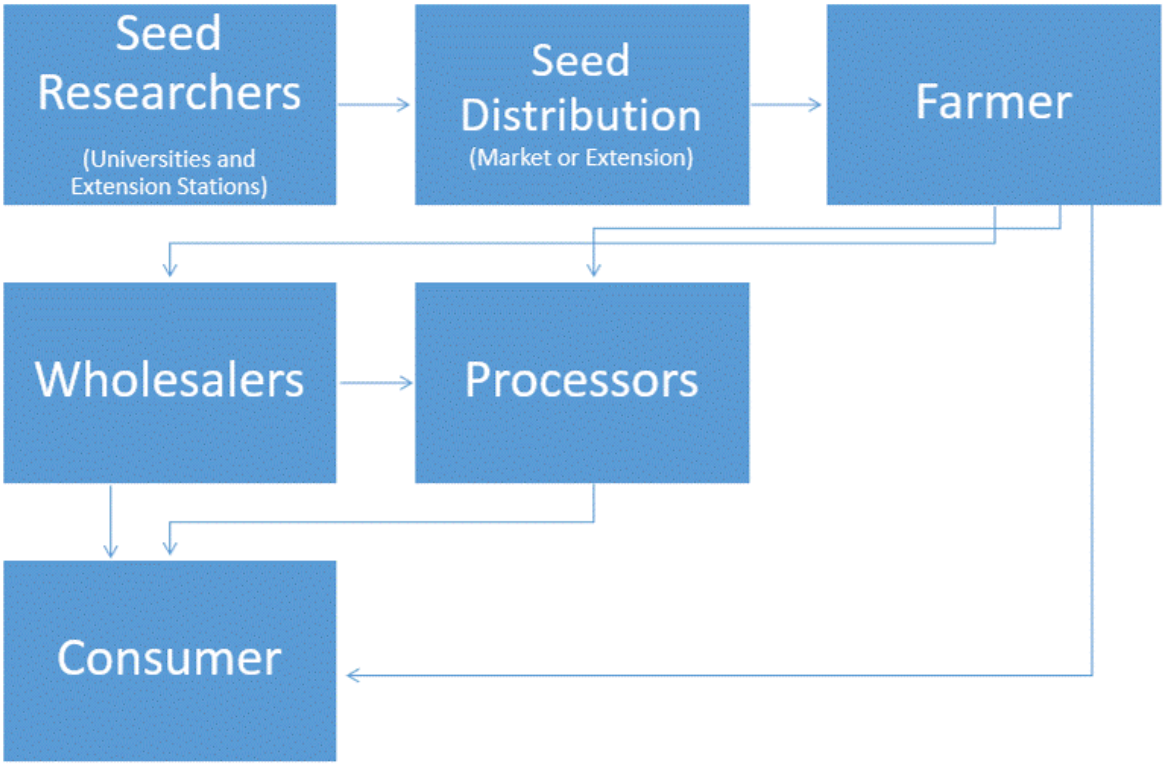
New potato varieties with high yields and disease resistance are necessary to ensure farmers can meet this surging demand for potato products in China. Most cultivars with disease resistance and high yield are bred for the fresh consumption market, but there is a lack of cultivars suitable for the processing industry (Jansky, Jin, Xie, Xie, & Spooner, 2009). As described above, C88 is suitable for both the processing and fresh consumption markets since it has the desired attributes for both markets.

Chapter 3: Concepts and Data Sources

This chapter begins with the conceptual framework of the study that describes the steps by which C88 research leads to economic value. The next section examines the methods used for sample design, data collection, and other data sources.

3.1 Conceptual Framework

Figure 2. Overview of the pathway for impacts for C88 research



To quantify C88's impacts on the Chinese economy, this study analyzes the complex network of stakeholder relationships, which can be modeled as a value chain (Figure 2). Each link in the value chain plays a role in moving C88 from research to the market, and understanding this chain provides additional information on C88's economic impacts. This study focuses on three major decisions: where C88 seed was distributed and why, factors that influence farmers to adopt C88 and their intensity of adoption, and how the value chain influences these

two adoption decisions. All of these decisions accumulate at the market-level where overall economic benefits can be measured. Unlike other countries where private entities are engaged in variety development and dissemination, the Chinese case is one of heavy involvement of the state. This involvement is a defining characteristic of the Chinese potato complex and must be understood in order to understand variety spread and its impacts

The first link in the chain is research and variety development. In China, new germplasm is developed and tested at agricultural research centers, which include universities and other research organizations. Research centers target traits or characteristics that farmers value; in the case of C88, the valued characteristic was late blight resistance. In addition to farmer preferences, researchers also consider traits desired by processors and final consumers.

Once a variety is ready for release, the research centers provide a plantlet or mini tubers of the new variety for a low price or for free to groups capable of seed multiplication. These groups include seed companies and some extension stations. Government extension agents and other officials build relationships with seed multipliers to determine if the variety is appropriate for their farmers. This determination may include running trials to evaluate the agronomic success of the variety. Assuming the variety is successful, the seed companies will then sell the seed either in the private market or to the government (local, county-level, or provincial).

County level officials and extension agents will identify suitable areas for the variety and will work with village leaders to determine if a variety is appropriate for the village. Many villages do not have access to clean seed, and extension agents and officials are the primary sources of information and seed. Households located in villages targeted by extension agents and/or county level officials for diffusion of C88 have the option to adopt C88. Those residing in

villages without access to C88 seed are unlikely to be aware of the new variety's existence and are less likely to adopt.

Once a variety is introduced to a village, households decide whether or not to adopt it. Within a village, the spread of knowledge and the decision to adopt a new variety is dependent on information, agricultural practices, and the uncertainty of production costs and yield of the new variety. Households adopt a new variety if the expected benefits, such as lower production costs and higher yields, are greater than the expected benefits obtained from the current variety and adequately compensate for risks associated with adoption.

If a household plans to sell, the next decision is where to sell their harvest and choices include local or regional markets or direct sales to a trader. If the household chooses to sell to a trader, the trader will then sell the harvest to a wholesaler or potato chip processing company. Another way to bring potatoes to market is that the company or wholesaler will send a representative to the village or hire a responsible village member, known as a businessman, to collect and transport the potatoes. The potatoes are then delivered to the destination market.

Potatoes in Yunnan can be sold in a variety of markets such as to potato starch producers, French fry processors, or chip processing, or markets catering to consumers of fresh potatoes. Most varieties are predominantly sold in one market, but C88 is unique in that it has two major markets: the potato chip and fresh consumption markets. Producers who adopt C88 benefit from a lower per-unit cost which is the result of the variety's high yield, and as more C88 is introduced into the market, consumers benefit from a lower market price. Overall, total welfare increases.

3.2 Data Sources and Methodology

This section provides background on the data used to measure the impacts described in the conceptual framework. Three types of data were collected: expert panel interviews, household and community surveys, and interviews with value chain participants. The information from the expert panel interviews provide adoption rates and land areas estimates of C88 in Yunnan. The surveys contain information that can be used to examine the village and household decisions about C88 adoption and intensity of adoption. The qualitative value chain interviews provide insight into the market linkages that create value at different stages of the C88 value chain.

3.2.1 Expert Panel Interviews

CIP and Michigan State University conducted expert panels in several provinces of China to determine the potato varietal adoption rates (SIAC 2.1, 2015). These one-day workshops were designed to gather detailed information on varietal diffusion and other characteristics of popular potato varieties in selected provinces. Participants included potato breeders, extension agents, and stakeholders in the potato value chain. A facilitator led a discussion where the participants were asked to name the most popular potato varieties in their province and to discuss the spread of these varieties. Once a consensus was reached, the panel compared the agreed upon values to historical data. If there were large discrepancies, then more discussion would occur (Maredia & Reyes, 2014).

The Yunnan panel was held on March 10, 2015. Table 2 displays the average, minimum, and maximum estimated adoption rates for C88 in 2014.

Table 2. C88 adoption rates by season in 2014 in Yunnan

Season	Most likely adoption rate (%)	Minimum adoption rate (%)	Maximum adoption rate (%)
Early spring	26.9	20	30
Late spring	16.8	10	25
Autumn	7.7	2	20
Winter	55.6	30	60

Source: SIAC Database 2.1, 2015.
Note: Adoption rates refer to the percentage of total potato area planted to the variety.

3.2.2 Surveys

The purpose of the household survey was to collect information on household and farm characteristics, adoption of potato varieties, potato production, and market participation among potato-producing households in Yunnan[1]. The survey had six modules. Module A described the location and time of the survey. Module B gathered information on household composition and characteristics. Module C asked respondents to detail their potato production from planting to selling in the market during the 2015 late spring season. Module D asked what factors influenced a household decision to adopt C88. Respondents were asked to rate the importance of different potato traits and then, how C88 performed according to these traits. Module E included questions on housing conditions, household assets, and farm assets.

The community survey was conducted in the same communities as the household survey. Its purpose was to validate data from the household survey, provide information on the dynamics of adoption at the village level, and obtain comparative production costs between C88 and the variety it replaced. Three to five village members knowledgeable about potato production were chosen to participate in the community interview, along with the village leader. Discussions were encouraged in order to reach a consensus about the requested information.

[1] The household survey instrument can be found in Appendix A.

The community survey included seven modules[2]. Module A asked about village location and survey participant characteristics. Module B gathered information on village-level attributes such as the number of households and the total area under potato. Module C asked participants to rank the top three most widely grown potato varieties and the timeline of C88 cultivation. Module D focused on potato production. The first part of the module asked questions about potato diseases and pests. The second part collected information on production costs of C88 compared to the variety it replaced or an alternative variety. A cost of production budget was formed by asking questions about labor, material inputs, and rented tools and machinery used for potato production for the replaced variety. A comparison to C88 was then made to determine if C88's production costs are greater than, less than, or the same as the alternative variety. Questions about production costs were incorporated into the community survey because the information is more difficult to obtain from individual farmers and would have extended the length of the household survey, increasing project costs. Module E gathered information about the markets where farmers sell potatoes and traders in the area. Module F asked about the existence of farmer organizations in the village and how many village members participate in each one.

3.2.2.1 Sample Design

To ensure representativeness of potato farmers in Yunnan province, a clustered random sampling procedure was used where each cluster was a village. The first step was to calculate the minimum sample size. The methods used for calculating the sample and cluster sizes were based on those reported in Walker and Adam (2011)[3].

[2] The community survey instrument can be found in Appendix B.
[3] A detailed calculation can be found in Appendix C.

With the goal to be 95% confident that the estimated adoption rate is within 4% of the true adoption rate, Equation 1 was used to determine the minimum sample size.

$$n \geq \frac{z_{0.95}^2 NP(1-P)}{(N-1)l^2 + z_{0.95}^2 P(1-P)} \qquad \textbf{(1)}$$

Where n is the minimum sample size, $z^2_{0.95}$ is the z value for the 95% confidence interval, N is the estimated total potato area in Yunnan, P is the estimated adoption rate of C88 in Yunnan, and l is the precision level of the sample or how closely the sample estimate is to the true population. Table 3 shows the values used in this study.

Table 3. Parameters and estimated result of minimum sample size

Parameter	Value
$z^2_{0.95}$	1.96
N	400,000
P	0.17
l	0.04
Minimum sample size	338
Final sample size	615
Final number of villages	41

The potato area in Yunnan for the late spring in 2014, N, is 400,000 ha (Hareau, et al., 2015; SIAC 2.1, 2015). P had a value of 16.8%, which is the estimated C88 adoption rate in late spring obtained from the expert panel (SIAC 2.1, 2015). The minimum sample size required to estimate the true adoption rate for C88 with a 95% confidence and a 4% precision level was 338 household surveys. The final sample size included 615 households located within 41 villages.

Once the minimum required number of households was determined, the next step was to select villages. Since village level data was not readily available, selection occurred form the largest to smallest geographic regions (county, town, village committee, and village). To select, probability proportionate to size (PPS) sampling was used to account for the potato area of each

unit in the population when selecting from each geographic unit. County potato area data were available, and as a result, the selected counties were determined prior to arriving in China.

There was no reliable data on potato areas for administrative areas at levels lower than the county; therefore, the PPS selection for the lower levels was completed after arriving in China. To obtain this information, government officials and county extension agents were contacted to provide the potato area for the towns. Towns were selected at random using area weights, and the process was repeated for villages within selected towns. Once the village was reached, the village leader would provide a list of households. From this list, 15 households were selected at random, without weighing by potato area.

3.2.2.2 Data Collection

Two teams of two or three enumerators and one supervisor were formed. Enumerators were undergraduate seniors majoring in Biotechnology at YNU and were chosen by Dr. Canhui Li. Supervisors were staff or faculty at the Root and Tuber Crops Research Institute at YNU. In the field, supervisors conducted the community surveys, while the enumerators administered the household surveys.

Piloting took place from July 14th to 15th 2015, in Luquan, Kunming Prefecture. Ten household surveys and two community surveys were completed in Hao Da Hai village. The surveys were adjusted following the piloting experience based on recommendations of the enumerator teams.

After the questionnaires were finalized, enumerators and supervisors underwent a one-day training on survey enumeration. During training, the objectives of the project, the methodology, and the data collection techniques were covered. Since data to conduct the PPS

and random sampling was not always readily available before arriving in the field, the enumerators and supervisors were taught the procedure for PPS and random sampling[4].

Data collection occurred from late July to early September 2015. Forty-one villages were visited in 11 prefectures in Yunnan Province. In each village, the village leader would organize the meetings with the selected households. Enumerators would then conduct the survey with the household member who was most knowledgeable about potato production. Each household interview took approximately 20 to 30 minutes to complete. The community survey took about an hour to complete.

3.2.3 Value Chain Interviews

Interviewees were selected based on their occupation and their organization's role in C88's value chain. Participant occupations included extension officers at the county and province-level, seed company owners, a chip processing company CEO, a chip processing company manager, and a starch company CEO. Each person was asked questions specific to their position in their organization. Fifteen interviews were conducted during August and early September 2015[5].

The interviews were primarily qualitative with some estimates on procurement and market prices. These interviews are used to add a deeper understanding on the adoption of C88 with a specific focus on seed markets.

[4] An example of the procedure can be found in Appendix D.
[5] Appendix E has all transcribed interviews.

Chapter 4. Empirical Models

This chapter begins with the modeling approaches used to explain awareness and adoption decisions, followed by a description of the methodology used to quantify the benefits of C88 adoption.

4.1 Adoption

4.1.1 Village Adoption Model

Extension agents and county level officials' decision on where C88 is promoted obviously affects adoption and diffusion. To model this decision and its effect on adoption, a two-stage approach is used. In the first stage, a village level model is estimated to identify village characteristics that affect the extent of household awareness about C88. Fifteen households were interviewed in each village; therefore, awareness is defined as the number of respondents to the household survey within the village who have heard of C88. The second stage aims to explain the household decision to adopt C88 and its intensity. The adoption models include only households who live in villages where at least one respondent has heard of C88, since adoption can only occur if there is awareness.

To determine factors that influence the number of respondents who have heard of C88, the following model is estimated (Equation 2):

$$\boldsymbol{E_j = \alpha V_j + \varepsilon_j} \qquad \textbf{(2)}$$

- E_j is the number of respondents to the household survey (out of 15) who have heard of C88 in the j^{th} village
- V_j is a vector of village characteristics: existence of farm organization, number of households, potato land area, problems with disease, elevation, region, distance to metropolitan county, and cost of agricultural day labor

- ε_j is a normally distributed error term with zero mean and constant variance σ^2
- α is a vector of coefficients to be estimated.

A Tobit model is used because the dependent variable is continuous and non-negative. A Tobit estimates linear relationships between variables when the dependent variable is censored from the left or right (UCLA: Statistical Consulting Group, n.d.). Censoring prevents the dependent variables from taking on values that are below or above the threshold. This model is censored from below at zero since in some villages, no respondents have heard of C88.

Village characteristics (Vector V)

Table 4 provides definitions and descriptive statistics of the variables included in the V_j vector.

Table 4. Definition and descriptive statistics of the sample for the dependent and independent variables in village level Tobit model

	Variable	Definition		Mean[1]	Standard Deviation	Min	Max
Dependent Variable	Heard	Number of respondents to the household survey who have heard of C88 (out of 15 respondents per village).		7.68	6.83	0	15
Vector V Variables	Farm organization	A binary variable equal to 1 when there is at least one farm organization and zero otherwise.		0.19	0.40	0	1
	Number of households	Number of households.		111.34	104.45	22	499
	Potato area	Total potato area (hectares).		26.22	53.33	1	333.33
	Disease	= 1 if disease has significantly affected harvest in the village in the last 5 years		0.49	0.51	0	1
	Elevation	The elevation of the village in meters.		1935.17	596.92	493	3139
	Region	Frequency of each	1= Kunming, Chuxiong, and Qujing	31.71%			
			2= Zhaotong	43.90%			
			3= Honghe and Wenshan	7.32%			
			4= Lijiang, Dali, Nujiang, and Baoshan.	17.07%			
	Located in metropolitan county	Frequency of each	0= Located in metropolitan county.	19.51%			
			1= Located in county bordering metropolitan county.	34.15%			
			2= Located in a county two counties away.	46.34%			
	Labor	Wage rate for one day of agricultural work in the village in Yuan.		94.83	25.56	50	160

Source: Household & community data sets, 2015.
[1]There are 41 observations since 41 villages were interviewed.

Access to information is among the most important factors in the dissemination of C88. Farm organizations can provide households with trusted information regarding potato varieties and likely receive their information from extension agents. In Yunnan, the farm organizations conduct demonstration trials to assess a variety's performance. If deemed appropriate, the farm organization may sell or disseminate seed (Director Du, personal communication, August 16, 2015; Director Ma, personal communication, August 16, 2015; Deputy Director of Exension, personal communication, August 8, 2015). If a farm organization is located within a village, more respondents to the household survey within that village are expected to have heard of C88.

The number of households in a village can increase the likelihood that a household will be exposed to C88. Individuals are more likely to adopt a variety from subjective evaluation from peers than scientific evidence (Rogers, 2003). More households within a village may increase the likelihood that agricultural extension agents visit the village and provide services. Average village size for those visited by an extension agent is 120 households compared to 100 households for villages that did not receive the visit of an agricultural extension agent (Household & community data sets, 2015).

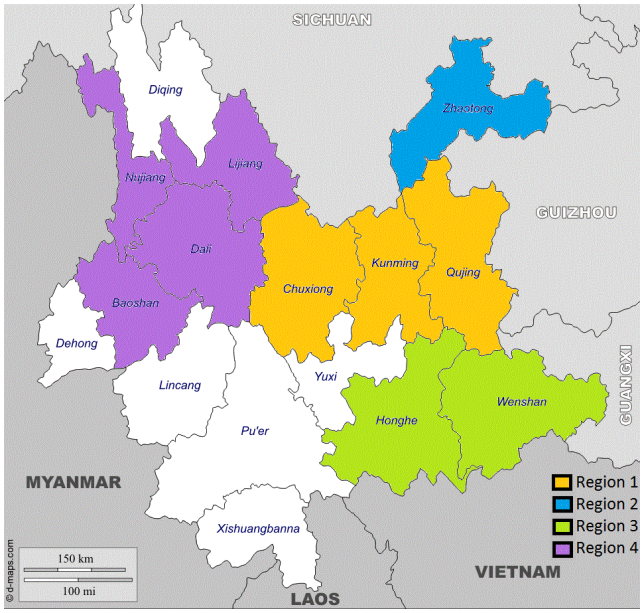
In Yunnan, agricultural extension agents work primarily with commercial farmers who cultivate large land areas (Li Bin, personal communication, August 13, 2015; Director Liu, personal commuication, August 14, 2015). Assuming extension agents visit villages and not individual households, villages with more potato area and high concentrations of commercial farms will be more likely to be visited by extension agent and thus, have a greater number of respondents to the household survey who are aware of C88.

C88 is known to be late blight resistant, and if a village has experienced large late blight losses, extension and the local government may provide C88 seed. Elevation affects the

distribution of potato production by season and also the incidence of late blight. In Yunnan, farmers located at higher elevations are more likely to grow potato in the late spring, when late blight is most prevalent. Households in low and medium elevation areas are more likely to grow potato in the autumn and winter, which are the seasons least affected by late blight. Villages where disease has affected production would be places where diffusion of C88 is most likely to be beneficial. Therefore, we expect a greater awareness about C88 in villages located at higher elevation, where disease problems are expected.

Within a prefecture, counties can have different growing seasons for potatoes which highlights the complexity of the agronomic conditions of Yunnan. To control for differences in agro-ecological conditions among regions and prefectures were grouped into four regions (Figure 3). The grouping is based on CIP scientist's knowledge of these conditions. Additionally, the regions control for remoteness and distance to market. Out of the surveyed prefectures, the three most populated cities are Kunming, Baoshan, and Qujing. All three cities are located in Region 1 (Central) or 4 (West). Region 2 and 3 are more remote since they are farther from highly populated cities.

Figure 3. The four regions of Yunnan used for the regional variable in the adoption analysis



Source: Map is from D-maps.com. White colored prefectures had no interviewed villages.

Two variables are used to capture proximity to cities, which should have a positive impact on awareness of C88: whether a village is located in the prefecture's metropolitan county and the village agricultural wage rate. Each prefecture has a capital city and several counties. The county where the capital city is located in is referred to as the metropolitan county. If a village is located within the metropolitan county, it is expected that households would have better access to information and markets. On average, 63% of households in the metropolitan county have received extension visits compared to 57% of those living in counties bordering the metropolitan county, and 47% of those farther away (Household & community data sets, 2015).

Since C88 is highly demanded in the chip processing industry, C88 producing households are likely to be better connected with chip processors compared to households who produce other varieties. The two interviewed chip processors were located in metropolitan areas, and since potatoes are a heavy crop, processors would likely want to buy locally to minimize transportation costs. Additionally, 97% of C88 producing households sell their harvest compared to 46% of

non-adopters (Household data set, 2015). Therefore, it is assumed that farmers in villages located within the metropolitan county are more likely to have heard of C88.

The cost of labor is also correlated with proximity to a city. Villages located closer to cities have higher wage rates because there is more off-farm labor demand in such areas. Zhao (1999) studied the effect of rural (farm and non-farm) incomes versus migratory incomes in China, and found that urban migrants earn 3,509.3 Yuan more per year than rural farm workers Therefore, villages closer to cities have higher wage rates.

4.1.2 Household Adoption Models

Two measures of adoption are considered: a binary and a continuous outcome. The binary outcome is a simple yes or no if a farmer grew C88 during the late spring season in 2015. The continuous outcome measures the intensity of adoption. Different indicators have been proposed to measure the intensity of adoption, such as quantity of seed planted, land area, and percent of land area under the new technology (Fernandez-Cornejo, Daberkow, & McBride, 2001; Lin, 1991; Estudillo & Otsuka, 2006; Nkonya, Schroeder, & Norman, 1997). In this study, land area under C88 is selected as measure of the intensity of adoption since there is more confidence in these estimates compared to amount of seed used. During the survey interviews, several farmers provided land title documents when asked about the size of their plots. The amount of seed used in each plot required recall and more likely to suffer from measurement error.

A continuous measure of adoption can provide more information than a binary one since it measures adoption on a scale. Moreover, having two adoption models allow us to compare results and determine if some variables influence the decision to adopt and intensity of adoption in different ways. We first hypothesize the same factors to influence both measures of adoption since there is no evidence to believe otherwise. We also expect the determinants of adoption to impact the two measures, adoption and intensity, in the same direction.

For this research, the adoption decision and the intensity of adoption are estimated using a probit and Tobit model, respectively. These models are estimated conditional on awareness about C88 in the village. One of the most commonly used models to study the binary adoption decision is the probit which analyzes the association between explanatory variables and the probability a household adopts C88 (Feder, Just, & Zilberman, 1985). In previous studies, Alene,

Poonyth, & Hassan (2000) and Fufa & Hassan (2006) used Tobit models to examine adoption over continuous values while accounting for those who do not adopt. By modelling both decisions, this study can confirm whether factors impact these measures of adoption differently and further validate the findings.

Empirical Household Adoption Model

We use two models, probit (3) and Tobit (4), to analyze the determinants of adoption and intensity of C88 adoption:

$$\boldsymbol{D_{ij} = f\left(H_{ij}, F_{ij},\ I_{ij,} V_{j,}\ \gamma_{ij}\ if\ E_j \geq 1\right)} \quad \textbf{(3)}$$

$$Where\ D_{ij} = \begin{cases} D_{ij} = 1\ if\ the\ ith\ household\ currently\ grows\ C88 \\ D_{ij} = 0\ if\ the\ ith\ household\ does\ not\ currently\ grow\ C88 \end{cases}$$

$$\boldsymbol{A_{ij} = bH_{ij} + cF_{ij} + dI_{ij} + \alpha V_j + \varepsilon_{ij}\ \ if\ E_j \geq 1} \quad \textbf{(4)}$$

- D is the i^{th} household in the j^{th} village's decision to adopt C88 in late spring 2015
- A_{ij} is the area under C88
- H_{ij} is a vector of household characteristics: age, education level and primary occupation of the household head, total number of household members, and dependency ratio
- F_{ij} is a vector of farm characteristics: land owned, agricultural equipment, and livestock
- I_{ij} is a vector of a farmer's valuation of two attributes in potato varieties: price received and late blight resistance
- V_j is a vector of village characteristics: farm organization, number of households, potato area, problems with disease, elevation, distance to metropolitan county, region, and cost of labor
- ε_{ij} and γ_{ij} are an idiosyncratic errors where ε_{ij} ~N(0, σ^2)
- E_j the number of respondents to the household survey (out of 15) who have heard of C88

- b, c, d, and α are all vectors of coefficients to be estimated.

Table 5 delineates the definition and descriptive statistics of the sample for the variables included the adoption models.

Table 5. Definition and descriptive statistics for the dependent and independent variables in household probit and Tobit models

	Variable	Definition		Mean[1]	Standard Deviation	Min	Max
Dependent Variables	C88 area	Area under C88 (ha).		0.12	0.38	0	3.33
	Adopt	1 if a household currently grows C88; 0 if not.		0.23	0.42	0	1
Vector H Variables	Age of head of household	Age in years		49.45	10.85	21	87
	Education of head of household	Frequency of each	1=None	14.94%			
			2= Primary	50.65%			
			3= Secondary	34.42%			
	Primary occupation is farming	=1 if the primary occupation of the household head is farming.		0.89	0.31	0	1
	Household size	The number of household members.		4.26	1.49	1	12
	Dependency ratio	Number of household members who are 15 years and younger divided by the number of total household members.		0.18	0.19	0	0.67
Vector F Variables	Farm size	Total area a household farms (ha).		0.75	2.36	0.01	47
	Agricultural equipment wealth	A household's perceived wealth of their agricultural equipment (Yuan).		1576.57	3284.95	9	43870
	Livestock wealth	A household's livestock index.		1.84	3.47	0	75.4
Vector I Variables	Importance of late blight resistance	Importance of late blight resistance in a variety to a farmer: 1 (don't care) to 3 (very important).		1.91	0.71	1	3

	Variable	Definition		Mean[1]	Standard Deviation	Min	Max
	Importance of price received	Importance of price received for a variety to a farmer: 1 (don't care) to 3 (very important).		2.04	0.82	1	3
Vector V Variables	Farm organization in village	=1 if there is farm organization in the village.		0.19	0.40	0	1
	Number of households	Number of households in the village.		111.74	103.34	22	499
	Village potato area	Total village potato area (ha).		26.37	52.77	1	333.33
	Disease	=1 if disease has significantly affected harvest in the village in the last 5 years.		0.49	0.50	0	1
	Elevation	Village elevation (meters).		1936.98	589.05	493	3139
	Region	Frequency of each	1= Kunming, Chuxiong, and Qujing	31.82%			
			2= Zhaotong	43.83%			
			3= Honghe and Wenshan	7.31%			
			4= Lijiang, Dali, Nujiang, and Baoshan.	17.05%			
	Located in metropolitan county	Frequency of each	0= Located in metropolitan county.	19.64%			
			1= Located in county bordering metropolitan county.	34.09%			
			2= Located in a county two counties away.	46.27%			
	Labor	Wage rate for one day of agricultural work in the village (Yuan).		94.81	25.27	50	160

[1]All variables have 616 observations.

Household Characteristics (Vector H)

Farmer characteristics, such as age, education, and occupation, are expected to influence adoption decisions about C88. Information is crucial to the adoption of new technologies and certain characteristics, such as age, education, and occupation, pre-dispose a farmer to seek information or not. Age may represent farming experience which indicates a better knowledge of agricultural practices (Feder, Just, & Zilberman, 1985). Older farmers will therefore be more likely to adopt new agricultural technologies. Better educated farmers tend to adopt earlier, because they can process information better and faster (Feder, Just, & Zilberman, 1985; Huque, Rashid, & Rahman, 1996; Kabunga, Dubois, & Qaim 2012). C88 seed distribution was targeted at commercial farmers, who are more than likely to farm as their primary occupation, rather than secondary, and will likely dedicate more time seeking out information and learning about new technologies. Farmers who are better educated, older, or farm full-time should be more likely to adoption C88 and intensify its cultivation.

Household composition is also expected to influence the adoption decision process. China has a strong tradition of multi-generational households, which includes adults caring for their elderly parents, as well as caring for their own children. This means that a larger household might not directly translate into greater farm labor availability if working age household members spend less time farming because of time spend caring for other household members. Thus, this study controls for household composition from two point-of-views: the number of household members and the dependency ratio, which is measured as the percent of household members under 15 years old.

Farm Characteristics (Vector F)

Physical capital, in the form of land, agricultural equipment, and livestock ownership, can influence adoption. As noted in the value chain interviews, extension agents targeted mostly

wealthier and commercial farmers. Government resources can be optimized by targeting commercial farmers as they are more likely located in accessible areas, and effectively utilize information provided by extension agents, and they produce larger quantity, which is crucial given that food insecurity is a major issue in China. Additionally, extension agents may target the wealthier farmers in hopes for faster adoption and that the information will be passed on to poorer farmers (Gautum, 2000). Therefore, wealth, measured using a livestock index[6], the value of agricultural equipment, and farmland, is expected to have a positive impact on the decision to adopt C88 and intensify its production.

Valuation of Traits (Vector I)

A farmer's valuation of certain varietal traits are important determinants of adoption. In the household survey, farmers were asked how important a list of traits were to them when considering new potatoes varieties. Farmers would choose the rating that best represents their valuation on a scale from 1 (don't care/not important) to 3 (very important). The list of traits were broken down into three groups: production, processing and marketing, and consumption. Two traits were chosen for the analysis, the price received (market price) and late blight resistance.

Farmers who consider the price received to be an important variety attribute are more likely to sell in the market, and thus adopt C88. This is because C88 is connected to a higher quality value-chain which leads to higher prices (Li, et al., 2010). Moreover, C88 was targeted towards commercial farmers, who are more likely to be market-oriented. Our data reveal that C88

[6] The livestock index is calculated using livestock units from Chilonda & Otte (2006). The two assumptions made regarding the index was that rabbits and geese can use the same unit as a chicken. Upon reviewing other studies, rabbits had similar or the same unit as chickens and geese are a form of poultry. Household animals, such as dogs and cats, were not included in the index.

receives a price of $390 per ton compared to $351 per ton for the other varieties combined (Household & community data sets, 2015).

Similarly, farmers who consider late blight resistance an important trait are more likely to live in areas where late blight is an issue, and thus seeking late blight resistant varieties such as C88. Late blight greatly affects potato production in China, and C88 was bred with the intent to be late blight resistant. In this case, the relationship between a farmer's value on late blight resistance and adoption is expected to be positive.

Village Characteristics (Vector V)

The vector V includes the same village characteristics as those included in the village model. These variables are expected to impact the adoption decisions in the same direction as they impact awareness about C88.

4.2 Economic Surplus Analysis

How benefits are measured is dependent upon whether the economy is considered closed or open. A closed economy would indicate that producers in Yunnan do not trade their potatoes, while an open economy accounts for trade. If trade is assumed in the model but the amount of potatoes produced and traded is small, farmers are essentially price takers. This study assesses economic benefits of C88 under both closed and small-open economy assumptions in Yunnan.

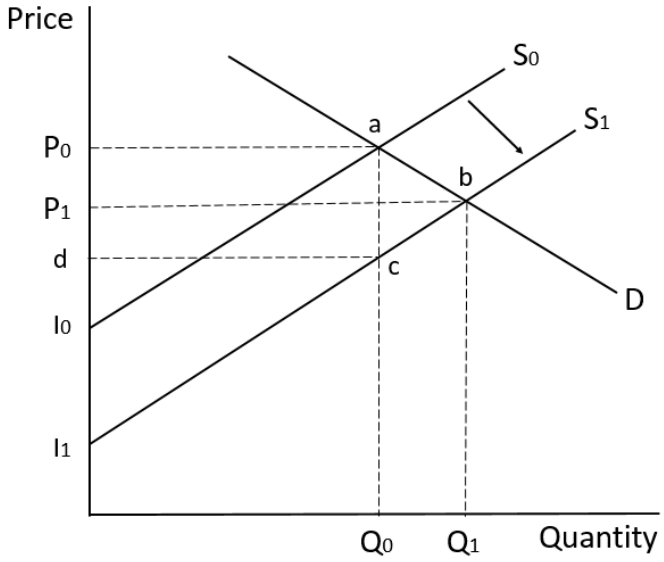
Closed Economy

As more farmers in Yunnan adopt C88, more potatoes are produced, inducing a rightward shift in the market supply (Figure 4). This shift occurs because the per-unit cost of potato production is lower for adopters due to C88's higher yields. As more farmers adopt, increasing amounts are produced at this lower per-unit cost. As the market supply shifts outward against a downward sloping demand curve, prices will fall (P_0 to P_1) and equilibrium quantities will

increase (Q_0 to Q_1). These changes are associated with changes in consumer and producer surplus.

Consumer surplus reflects welfare benefits to consumers of potatoes, and is the difference between the price consumers are willing to pay and what they actually pay. Producer surplus reflects benefits to producers, and is the difference between the lowest price a producer would accept and the equilibrium price. Graphically this is the area above the supply curve and below the equilibrium price. The change in consumer and producer surplus is represented by the area P_0abP_1 and $P_1bI_1 – P_0aI_0$, respectively. (Figure 4).

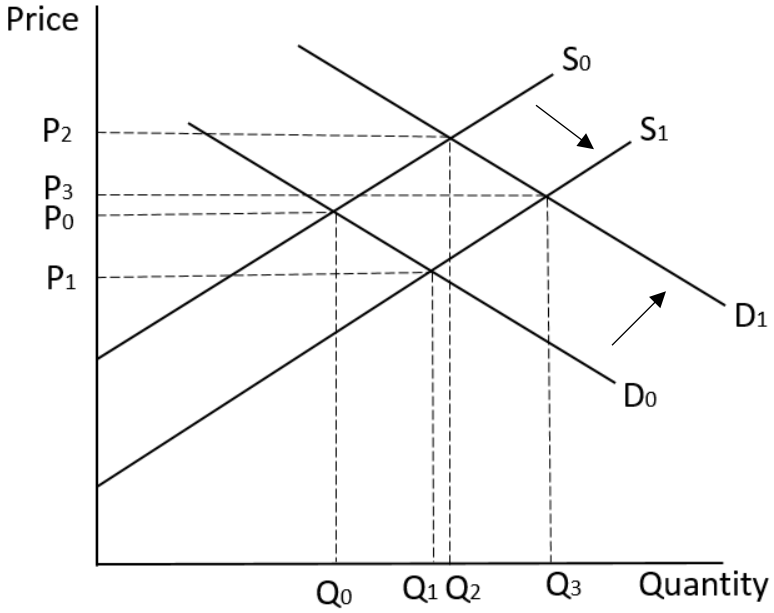
Figure 4. Graphical representation of the supply curve shift due to C88 adoption in a closed economy in a single year



The demand curve for potatoes will also shift rightward over time due to growing per capita income and expanding population. As the demand shifts, a new equilibrium price and quantity is established. If there was only an outward shift of the demand curve, the equilibrium price would shift from P_0 to P_2 and equilibrium quantity from Q_0 to Q_2 (Figure 5). If there was only an outward shift of the supply, the equilibrium price would shift from P_0 to P_1 and equilibrium quantity from Q_0 to Q_1. Since there is an outward supply and demand curve shift, the

equilibrium price and quantity will move from P_0 to P_3 and Q_0 to Q_3. These shifts imply changes to consumer and producer surplus.

Figure 5. Graphical representation of simultaneous shifts in supply and demand in the Yunnan potato market in a single year

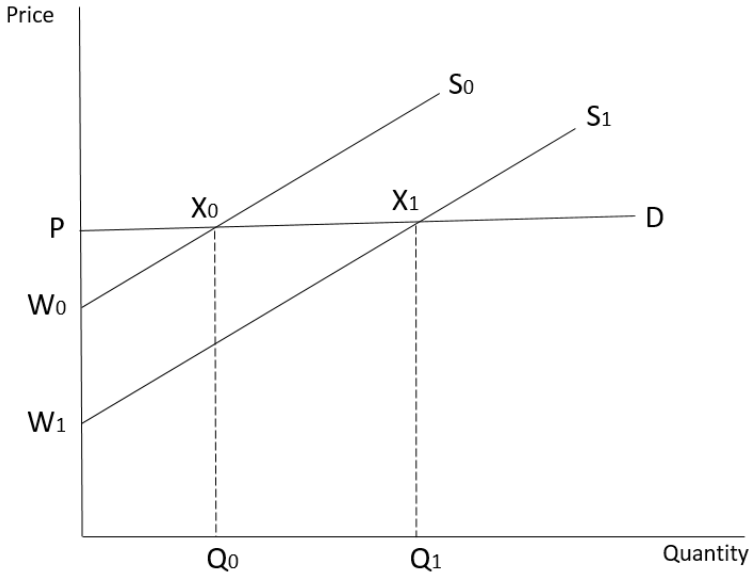


Open economy

Li et al (2010) note that C88 is sold in surrounding countries and provinces. However, detailed data on exported C88 is currently unavailable. It is important to determine the benefits in the instance that C88 farmers do export. To account for exports, a small open economy is assumed. According to Alston et al (1995), in most cases it is appropriate to assume a small open economy since it is unlikely a country, or in this case Yunnan, will have enough market power over the long run to influence the national price of potatoes.

Similar to the closed economy example, the market supply will shift outwards as more farmers adopt C88. In this scenario however, it is against a perfectly elastic demand curve which causes quantity to increase to Q_1 and does not affect price (Figure 6). Unlike the closed economy case, all surplus accrues to producers and the change in surplus is the area $W_0X_0X_1W_1$.

Figure 6. Graphical representation of supply curve shift due to C88 adoption in a small open economy in a single year



4.2.1 Measuring C88 Benefits

Closed Economy

To quantify the total surplus changes in a closed economy context, a two-step process is necessary. First, the equilibrium price and quantity with the demand curve shift and without the supply curve shift are determined. The annual proportionate change in demand for potatoes can be measured by V, which is obtained from Equation 5.

$$V = \Delta POP + S * \Delta \mathrm{I} \quad \textbf{(5)}$$

Where ΔPop is the proportionate change in population[7], S is the income elasticity of demand for potatoes, and ΔI is the proportionate change in per capita income[8].

Once the magnitude of the demand shift is determined, the equilibrium price and quantity resulting from the shift can be determined. The equilibrium price for a shift in demand would be:

[7] $\Delta Pop = (Pop_i - Pop_{i-1})/Pop_{i-1}$ where i denotes time.
[8] $\Delta I = (I_i - I_{i-1})/I_{i-1}$ where i denotes time.

$$P_1 = P_0\left(1 + \frac{v}{n+\varepsilon}\right) \quad \textbf{(6)}$$

Where P_1 is the new equilibrium price, P_0 is the base equilibrium price, V is the proportionate shift in demand, n is the price elasticity of demand, and ε is the price elasticity of supply (Norton, Ganoza, & Pomareda, 1987). In this example, 2015 is used as the base, and we are interested in solving for prices and quantities moving backwards in time from 2015. Subscripting the price in (6) using a base of zero (representing 2015), Equation 6 can be rearranged to obtain Equation 7 where P_0 is 2015 and P_{-1} is 2014.

$$P_{-1} = \frac{P_0}{(1+\frac{v}{n+\varepsilon})} \quad \textbf{(7)}$$

From Norton et al (1987), the equilibrium quantity resulting from the outward shift of the demand curve would be:

$$Q_1 = Q_0(1 + v - \frac{v}{n+\varepsilon}) \quad \textbf{(8)}$$

Where Q_1 is the new equilibrium quantity and Q_0 is the base quantity.

Similar to the price equation, Equation 8 was rearranged to account for the backwards shift in the supply curve to obtain Equation 9:

$$Q_{-1} = \frac{Q_0}{(1+v-vn/(n+\varepsilon))} \quad \textbf{(9)}$$

The second step in the process is to account for the inward supply curve shift. The shift can be expressed as a proportion of price, known as the K-shift. K is determined by Equation 10.

$$\text{K} = \left(\frac{\boldsymbol{Y}}{\boldsymbol{\varepsilon}}\right) - \left(\frac{\boldsymbol{C}}{\boldsymbol{1+Y}}\right) A \quad \textbf{(10)}$$

where Y is the proportionate yield increase per hectare after adoption of the new technology, C is the proportionate change in variable input cost per hectare, and A is the proportion of total Yunnan potato land under C88 (adoption rate) (Alston, Norton, & Pardey, 1995).

The relative reduction in the price due to the supply shift is denoted Z:

$$Z = K\varepsilon/(\varepsilon + n) \quad \textbf{(11)}$$

Total economic benefits are measured by determining the net change of the consumer and producer surplus in each market:

$$\Delta TS = \Delta CS + \Delta PS = P_0 Q_0 K\,(1 + 0.5Zn) \quad \textbf{(12)}$$

where ΔTS, ΔCS and ΔPS are changes in total, consumer, and producer surplus, P_0 is the initial equilibrium price, and Q_0 is the initial equilibrium quantity (Alston, Norton, & Pardey, 1995).

Changes in consumer and producer surplus are:

$$\Delta CS = P_0 Q_0 Z\,(1 + 0.5Zn) \quad \textbf{(13)}$$

$$\Delta PS = P_0 Q_0 (K - Z)(1 + 0.5Zn) \quad \textbf{(14)}$$

These changes are computed moving backwards in time from the base (2015).

Small open economy

Compared to the closed economy, surplus changes in the small open economy are relatively easier to calculate. Unlike the closed economy, the base price and quantity do not need to be recalculated for each year. The largest difference is the measurement of benefits since the demand curve is perfectly elastic and there are no gains to consumers. K (Equation 10) is the same in the closed and open economy models. Change in total surplus can be obtained from Equation 15:

$$\Delta TS = \Delta PS = P_C Q_0 K(1 + 0.5K\varepsilon) \quad \textbf{(15)}$$

Where P_C is the price for potatoes in Yunnan and Q_0 is the initial quantity of potatoes in Yunnan in 2015.

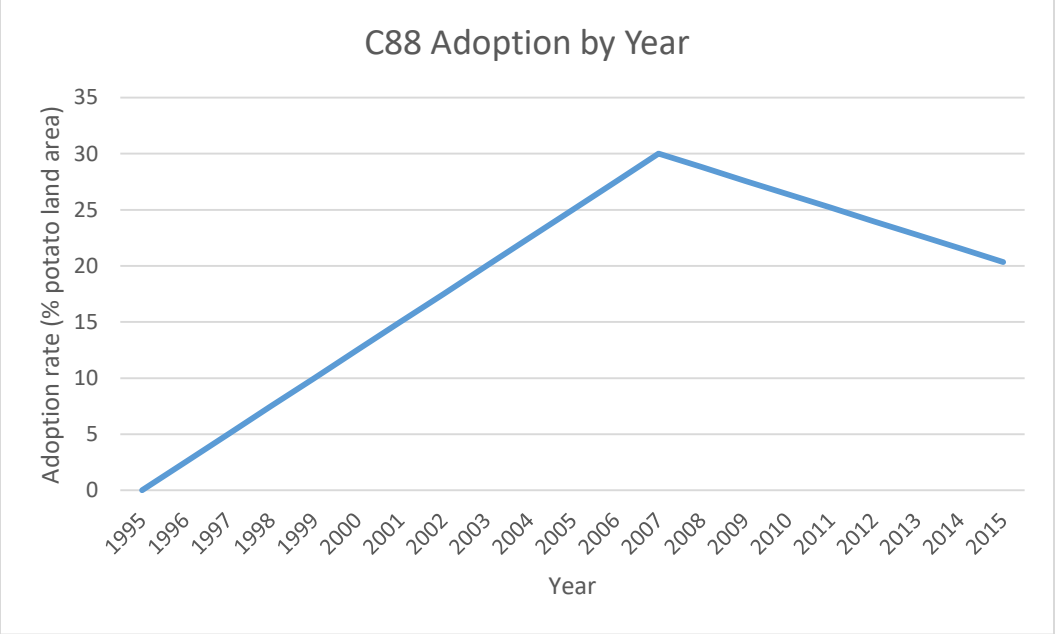
4.2.2 Parameters

The parameters used to estimate the surplus changes in the closed and small open economy are described below. Unless stated otherwise, the parameters are used in both analyses.

Adoption Rate

The C88 adoption rate in Yunnan from 1996 to 2015 is based on the land area adoption rates and area estimates from the SIAC 2.1 database (2015). The peak year of C88 adoption in Yunnan was in 2007 at 30% of the total area under potato in the province and has decreased since then (SIAC 2.1, 2015). With evidence of disadoption from the household-level data and the SIAC 2.1 database, a linear interpolation of the adoption profile begins with zero percent in 1995, peaks at 30% in 2007, and falls to 22% in 2014 (Figure 7).

Figure 7. C88 adoption by land area from 1996 to 2015 in the Yunnan Province



Source: SIAC 2.1 database, 2015 & household dataset, 2015.

Price

The price of potatoes was identified in the community survey. The current community prices, base year 2015, were weighted by the quantity produced for each variety at the village level and then weighted at the provincial level. The per-ton prices are divided by the Purchasing Power Parity (PPP) exchange rate of 3.56 Yuan to the US Dollar (OECD, 2016). The weighted average price for all potato varieties in Yunnan was $375 per ton.

Prices in the small open economy and closed economy models are determined differently. The assumption in the small open economy is that Yunnan does not greatly affect the price of potatoes and therefore are price takers. In the closed economy model, price is determined within the market when quantity supplied meets quantity demanded.

In the small open economy model, the prices had to be adjusted to reflect the variation in the exogenously determined price from year to year while keeping them in 2015 prices. To do so, the nominal price for potatoes in Yuan per ton and GDP deflator for China from 1995 to 2016 were obtained from FAOSTAT and the World Bank, respectively. The GDP deflator was in a base year of 2000 and was adjusted to 2015 by dividing each year by the 2015 value. Once the prices were deflated, the proportionate price change from one year to the next was calculated. FAOSTAT only had prices for potatoes in China for 1996 to 2013. The proportionate changes for 2013 to 2014 and 2014 to 2015 were assumed to be the same as that from 2012-2013. Using the calculated proportionate changes and the price from the community surveys, the real prices in constant 2015 dollars was projected backward from 2014 to 1996.

Elasticity of Supply and Demand

The demand elasticity for fresh potatoes, -0.65, is taken from Ahmadi-Esfahani and Stanmore (1997), which was estimated using the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980). Ahmadi-Esfahani and Stanmore used data from the Dazhongsi wholesale market in Beijing.

The elasticity of supply is assumed to equal one since estimates of the potato supply elasticity for China are not available in the literature. Alston et al (1995) suggest using an elasticity of one when in doubt for annual crops to minimize bias that might result from the assumption of a linear supply curve.

Quantity Produced and Land Area

The estimate of land area under potato in Yunnan used in the study was obtained from the SIAC 2.1 database (2014). To project the 2015 and 1996-2013 area, the percentage change in potato area from 2015 to 1996 in Yunnan is assumed to be the same as the percentage change for all China. The latter was computed using data on area under potato production in China between 1996 and 2015 obtained from FAOSTAT. Using the area estimates from the SIAC 2.1 database, an annual growth rate of 2% was applied to project the area under potato in Yunnan backwards from 1996-2013 and forwards to 2015.

Utilizing the household harvest and plot area estimates, yields were calculated by plot; the potato yield on non-C88 land was computed as a quantity weighted average from the household data. The weighted average yield for all potato varieties in Yunnan, C88, and all varieties excluding C88 were 21, 24, and 19 tons per hectare, respectively.

To obtain the quantity in 2015, the yield for all potato varieties in Yunnan was multiplied by the area estimate in 2015. Since there is no reliable data on what proportion of production goes to which market, the quantity estimates include all potatoes produced. Production sold as feed and seed, for example, would be worth less than marketable potatoes. Therefore, our models assume a single price for all potatoes produced and sold in the market which would overstate benefits.

Exogenous Demand Shift

The data used to estimate V in the closed economy model were for all of China, and are assumed to represent Yunnan as well. The estimates for the proportionate changes in per capita income and population from 1996 to 2015 were obtained from the World Bank. The income elasticity of demand is 0.58 (Ahmadi-Esfahani & Stanmore, 1997). Using Equation 5, V is calculated from 1996 to 2015 (Table 6).

Table 6. Estimation of the proportionate change in demand for potatoes in Yunnan, V

Year	Proportionate change in population[1]	Proportionate change in income[1,2]	V
1995-1996	0.010	0.088	0.06
1996-1997	0.010	0.081	0.06
1997-1998	0.010	0.068	0.05
1998-1999	0.009	0.067	0.05
1999-2000	0.008	0.076	0.05
2000-2001	0.007	0.075	0.05
2001-2002	0.007	0.084	0.06
2002-2003	0.006	0.093	0.06
2003-2004	0.006	0.094	0.06
2004-2005	0.006	0.107	0.07
2005-2006	0.006	0.121	0.08
2006-2007	0.005	0.136	0.08
2007-2008	0.005	0.091	0.06
2008-2009	0.005	0.087	0.06
2009-2010	0.005	0.101	0.06
2010-2011	0.005	0.090	0.06
2011-2012	0.005	0.072	0.05
2012-2013	0.005	0.072	0.05
2013-2014	0.005	0.067	0.04
2014-2015	0.005	0.064	0.04

[1] *Source*: World Bank Indicators, 2015.
[2] The annual growth in GDP per capita is used for the proportionate change in per capita income.

Time Value of Money

In both models, it is important to account for the time value of money as benefits in earlier years of the technology are worth more than those in 2015. In ex-ante studies, future values are projected and are discounted to reflect present year values. Since the study is ex-post, the present value of the benefits before 2015 are calculated to reflect what the value of those benefits are in 2015 (Equation 16).

$$\boldsymbol{PV = CV * (1 + r)^n} \quad \textbf{(16)}$$

Where PV is the present value, CV is the current value, r is the discount rate, and n is the period. In this case, period 0 is 2015 where FV = PV. Typically, a discount rate of 3-5% is used (Alston, Norton, & Pardey, 1995), and in this study, three percent is used to remain conservative.

Chapter 5: Results and Discussion

Section 5.1 provides an overview of the adoption of C88 from 1996 to 2015. Section 5.2 presents estimation results from the village model which examines which factors affect the number of farmers in a village who have heard of C88. Section 5.3 presents estimation results from the household models which examine the determinants of adoption and intensity of C88 adoption. Additional models are estimated to examine the factors associated with disadoption. Finally, Section 5.4 describes the results from the economic surplus analysis.

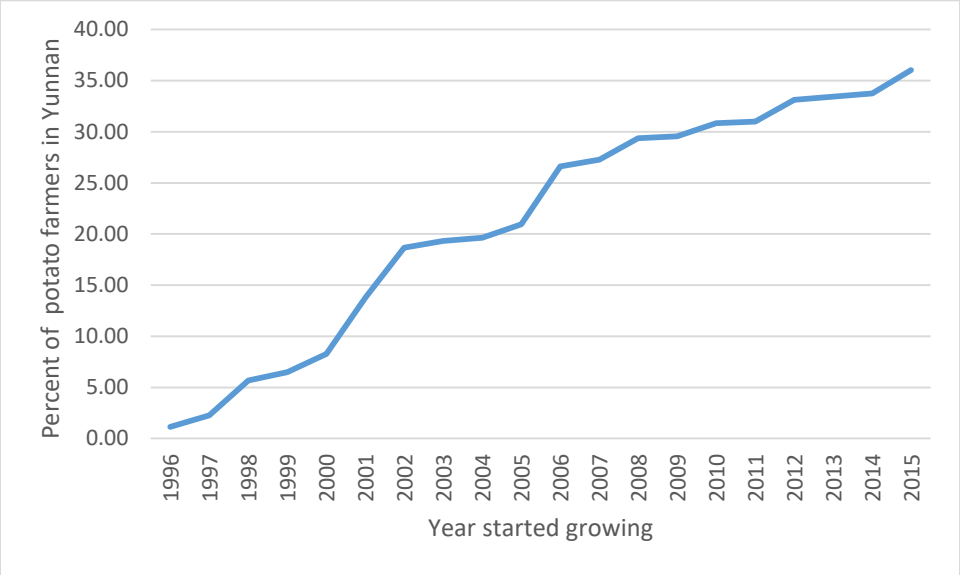
5.1 Overview of C88 Adoption

In the late spring of 2015, 71% of villages have at least one respondent to the household survey who has heard of C88. Twenty-three percent of potato farming households in Yunnan grew C88. This percentage jumped to 33 percent when considering only househholds who live in villages where awareness about C88 exists.

Over the twenty-year history of C88, 51% of all potato farming households have heard of C88, and 45% have ever grown C88. The percentage among those who have heard of C88 and have chosen to grow C88 is high at 87%. If a household has heard of C88, the likelihood that it will adopt is very high. One of the notable differences between adopters and non-adopters is land holdings. Adopters and non-adopters own 1.56 and 0.51 ha, respectively. On average, adopters have 0.75 ha under potatoes and 0.53 ha under C88 while non-adopters only have 0.22 ha under potatoes.

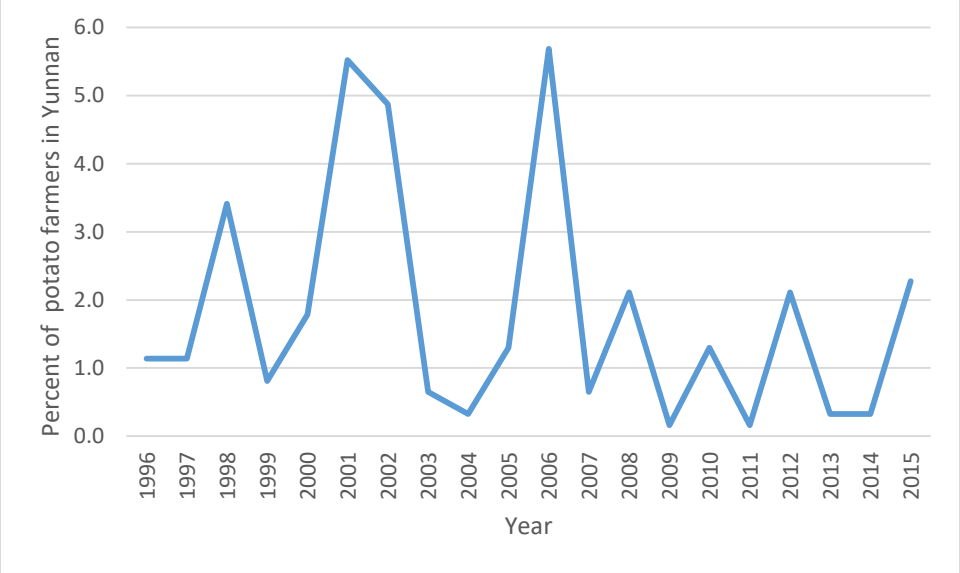
Between the introduction of C88 in 1996 and 2015, the cumulative percent of farmers who have ever grown C88 in Yunnan was 36% (Figure 8). The largest percentage gain of potato farmers in Yunnan who adopted occurred in 2001, when C88 was officially released, and in 2006 (Figure 9). Based on the household survey data and the information shown in Figure 8, a small number of farmers adopted C88 from 2003 to 2005.

Figure 8. Percent of potato farmers in Yunnan who have ever grown C88 by year from 1996 to 2015



Source: Household data set, 2015.

Figure 9. Percent of potato farmers in Yunnan by the year they began growing C88 from 1996 to 2015



Source: Household data set, 2015.

Since 2007, the number of first time growers of C88 has decreased. The estimated adoption peak was in 2007 when the variety covered approximately 30% of the potato land area (SIAC 2.1, 2015). According to the household data set, 16.2% of the potato land area in Yunnan was cultivated to C88 in the late spring season for 2015. The Expert Panel (SIAC 2.1, 2015)

estimates 16.8% of the potato land area in the 2014 late spring season was under C88, which mirrors the findings of this study.

5.2 Village Model

Since C88 cannot be adopted without being first introduced to the village, the factors that influence the number of respondents to the household survey in a village (maximum 15) who have heard of C88 can provide insight into why some villages were exposed, unofficially and officially, over others. The village level model includes 41 observations; the number of villages in this study. Variables found to influence awareness about C88 are: number of households in the village, living in Zhaotong, and whether disease has had a great effect on production in the last five years. The results are found in Table 7.

Table 7. Estimate results from the village level Tobit model: determinants of farmer exposure to C88

Observations	41	
R^2	0.26	
Dependent Variable	Number of surveyed farmers who have heard of C88	
Independent Variables	**Marginal effect (s.e.)**	**P-value**
Region (base is Central)		
Zhaotong	-12.32 (2.44)	0.000
South	0.13 (3.50)	0.970
West	-2.03 (2.70)	0.453
Elevation (1000)	2.08 (2.04)	0.307
Located in metropolitan county (base is being located in the metropolitan county)		
Borders county	-1.55 (2.41)	0.519
Two counties away	-1.19 (2.03)	0.558
Village farm organization (base no organization)	-0.37 (2.05)	0.855
Number of households	-0.022 (0.007)	0.003
Village potato area (ha)	0.019 (0.161)	0.225
Disease (base no problem)	-3.47 (1.79)	0.054
Cost of labor (Yuan)	-0.057 (0.035)	0.103

Note: Standard errors are shown in parentheses. The marginal effects are the average marginal effect.
Source: Household & community data sets, 2015.

The number of households in a village has a negative association with the number of respondents to the household survey in a village who have heard of C88. On average, an additional household in a village decreases the number of respondents that have heard of C88 by 0.022. While the coefficient was predicted to be positive, the negative coefficient may be a result of population density and that more households indicate less land per farmer.

The marginal effect of living in Zhoatong is -12.32, indicating that villages located in Zhaotong have 12 fewer households (out of 15) who have heard of C88, compared to villages in the Central region. While land area under potato is large in Zhaotong, very little potato area is under C88. An explanation for the low exposure in Zhaotong is that households in the region intercrop potatoes with maize. C88 grows horizontally and matures later in the season, which does not integrate well in mixed cropped systems. The interview with the extension agent in Zhaotong confirmed these findings and provided further explanation. The agent indicated that although C88 has not been widely disseminated in the region, interest is strong among farmers and the extension offices are working to multiply and disseminate C88 seed to interested farmers.

Finally, whether a village has experienced disease problems that greatly affected their production in the last five years is negatively correlated to the number of surveyed potato households who have heard of C88. Compared to villages where disease is not a problem, villages with disease problems have three fewer respondents to the household survey, out of 15, who have heard of C88. Based on the community surveys, many villages do not use pesticides and approximately 51% of the villages did not believe disease is an issue. The variable has a bit of subjectivity based on farmers' education regarding disease and management.

5.3 Household Models

The adoption and intensity of adoption models, being conditional on village awareness about C88, include 436 observations and standard errors are clustered at the village-level[9]. The marginal effects for both models are shown in Table 8. Livestock index, village potato area, household size, and region and proximity to a metropolitan county are key determinants of these adoption decisions and discussed further.

Table 8. Estimation results from the household probit and Tobit models: determinants of adoption and intensity of adoption

	Probit		**Tobit**	
Observations	436		436	
R^2	0.43		0.53	
Dependent Variable	Currently grow C88 (0= no, 1= yes)		Intensity of C88 adoption (area under C88)	
Independent Variables	**Marginal Effect (s.e.)**	**P-value**	**Marginal Effect (s.e.)**	**P-value**
Age of head of household	-0.0019 (0.0023)	0.428	-0.0054 (0.0038)	0.159
Primary occupation is farming (base is not primary occupation)	0.093 (0.080)	0.245	0.15 (0.13)	0.278
Education (base is no education)				
Primary	0.019 (0.040)	0.636	0.064 (0.072)	0.378
Secondary or higher	0.032 (0.044)	0.455	0.069 (0.072)	0.336
Household size	0.038 (0.018)	0.031	0.083 (0.032)	0.009
Dependency ratio	-0.24 (0.12)	0.050	-0.48 (0.21)	0.019
Total farm size (ha)	0.020 (0.016)	0.193	0.090 (0.0090)	0.000
Agricultural equipment wealth (Yuan, scaled by 100)	-0.00022 (0.00048)	0.640	-0.00069 (0.00072)	0.343
Livestock wealth (index)	0.031 (0.012)	0.009	0.031 (0.019)	0.105

[9] Due to the use of village-level variables, errors for observations within a cluster are likely to be correlated, while individuals across clusters are unlikely to have correlated standard errors (Cameron & Miller, 2015).

	Probit		Tobit	
Importance of late blight resistance (base is not important)				
Somewhat important	0.028 (0.048)	0.559	0.00070 (0.059)	0.990
Very important	0.0013 (0.044)	0.977	-0.023 (0.063)	0.719
Importance of price received (base is not important)				
Somewhat important	0.045 (0.056)	0.423	0.12 (0.10)	0.241
Very important	0.079 (0.084)	0.344	0.23 (0.14)	0.105
Region				
Zhaotong	-0.37 (0.17)	0.034	-0.85 (0.48)	0.075
South	-0.39 (0.13)	0.002	-0.74 (0.29)	0.012
West	-0.18 (0.17)	0.312	-0.067 (0.28)	0.814
Elevation (1000)	0.072 (0.19)	0.711	0.069 (0.35)	0.843
Located in metropolitan county (base is being located in the metropolitan county)				
Borders county	0.23 (0.11)	0.039	0.54 (0.26)	0.035
Two counties away	0.23 (0.098)	0.018	0.75 (0.19)	0.000
Farm organization in village (base is no organization)	0.14 (0.15)	0.345	0.14 (0.19)	0.456
Number of HH in village	-0.00010 (0.00047)	0.832	-0.00015 (0.00085)	0.861
Village potato area (ha)	0.0031 (0.00065)	0.000	0.0076 (0.0010)	0.000
Disease has greatly affected production in the past 5 years (base is no problem)	-0.22 (0.15)	0.144	-0.39 (0.26)	0.132
Cost of day labor (Yuan)	0.0013 (0.0039)	0.739	0.0034 (0.0079)	0.664

Note: Standard errors are clustered at the village level. The marginal effects are the average marginal effect.
Source: Household & community data sets, 2015.

Village potato area is an important predictor of adoption and its intensity. For a one ha increase in village potato area, the probability of adoption and area under C88 increases by 0.31 percentage points and 0.76 ha. As noted previously, it is likely that extension officers targeted

commercial farmers for C88 dissemination. For a one unit increase in the livestock index, the probability of adoption increases by 3.1 percentage points. For a one ha increase in total farm size, area under C88 increases by 0.9 ha. Wealthier farmers and those with more land area are more likely to adopt C88.

The coefficient for household size is positive in both models, indicating that increasing the household size by one person is associated with an increase in the probability and intensity of adoption by 3.8 percentage points and 0.083 ha, respectively. It may be inferred that C88 is a higher yielding variety and may require more household labor. The community survey, however, did not reveal any differences in labor requirements between alternative varieties and C88.

The coefficients for Zhaotong and the Southern region are negative. Compared to living in the Central region, living in Zhaotong and South decreases a farmer's probability of adoption by 37 and 39 percentage points, respectively. Farmers located in Zhaotong and the Southern region have 0.85 and 0.74 less ha under C88 compared to those living in the Central region. As previously mentioned, few farmers have been exposed to C88 in Zhaotong. The Southern region includes the prefectures Honghe and Wenshan, both of which are not located near a large city.

Compared to residing in a metropolitan county, living in a county that borders the metropolitan county or living two counties away increases a farmer's probability of adopting C88 by 23 percentage points. In terms of intensity of adoption, farmers residing in bordering counties or two counties away from the metropolitan county have 0.54 ha and 0.75 ha more area under C88, respectively, than those located in the prefecture center.

The farther a village is from the prefecture's metropolitan county, the more likely the farmer is to adopt and dedicate potato land to C88. We hypothesized that the closer a farmer is an urban area, the more likely he is to adopt new technologies. While the results indicate the opposite, model results only reflect a single point in time. In the case of C88, the variety has

been available for almost 20 years, but "Adoption studies [only] consider the reasons for adoption at one point in time… Thus, relative to adoption, diffusion may be viewed as a dynamic, aggregative process, over continuous time" (Thirtle & Ruttan, 1986, pp. 72-73). The models in this study analyze a farmer's decisions during late spring 2015 and do not account for the history of adoption decision and access to information over time.

Table 9 displays summary statistics by distance from the metropolitan county. Forty-one percent of all farmers who have ever grown C88 disadopted. Disaggregating the sample by distance from the metropolitan county, including only households in villages where at least one respondent to the household survey has heard of C88 and have ever grown C88, 77% of households located in the metropolitan county disadopted, compared to 18% of those who border the county and 45% of those who are located farther away. Additionally, on average and excluding those who do not currently grow C88, more distant households dedicated a significantly larger portion of potato land to C88 where households within the metropolitan ounty planted 0.11 ha of C88, while the furthest farmers devoted 0.78 ha. What makes the previous statement more interesting is that farmers located in the metropolitan county, on average, dedicated more land to potatoes but less to C88.

Table 9. Descriptive statistics for households only located in villages where at least one respondent to the HH survey has heard of C88 by a village's distance to a prefecture's metropolitan county in Yunnan

Variable	**Sample**	**Distance to Metropolitan County**		
		In County	**Border the County**	**Two Counties Away**
Number of villages	29	5	9	15
Have heard (%)	72	67	77	71
Have grown (%)	63	57	67	63
Have grown (%, including only those who have heard)	87	84	88	88
Stopped growing (%)	26	43	12	28
Stopped growing (%, including only those who have ever grown)	41	77	18	45

Variable	Sample	Distance to Metropolitan County		
		In County	Border the County	Two Counties Away
Participate in a farm organization (%)	16	26	24	8
Village visited by extension in the last year (%)	70	80	78	51
C88 area (ha, excluding zeroes)	0.53	.11	0.24	0.78
Potato area for HH (ha)	0.44	0.64	0.21	0.52
Average farm size (ha)	0.92	0.96	0.56	1.1
Current grow C88 (%)	33	8	44	34
Year first heard of C88 (min)	2004	1997	1998	1996
Year first heard of C88 (max)	2015	2015	2014	2015
Year first heard of C88 (average)	2004	2006	2004	2004
Year first grew C88 (min)	1996	1998	1998	1996
Year first grew C88 (max)	2015	2015	2015	2015
Year first grew C88 (average)	2004	2006	2004	2004

Source: Household & community data sets, 2015.

A hypothesis explaining this is that farmers residing far from the metropolitan county are less likely to come into regular contact with extension agents. Those closer to metropolitan counties are more likely to partake in farm organizations and more likely to have been visited by extension in the last year. To test the hypothesis that more remote households are less likely to disadopt, factors associated with disadoption are examined. A Heckman probit model is estimated where the first step analyzes whether a farmer has ever grown C88, conditional on living in a village where at least one surveyed farmers has heard of C88, and then the second step analyzes their decision to disadopt.

Variables hypothesized to influence the decision to grow and disadopt C88 are the same as those included the household adoption models but with two exceptions. First, since the data reflect conditions in 2015 and the decision to adopt or disadopt may have occurred earlier, the number of years since adoption is included in the second stage to control for this time lapse.

Second, the number of years since a farmer has adopted C88 (0 if they never have) is subtracted from the age of the head of household to represent the age at which the farmer adopted.

The results of this two-stage model are shown in Table 10. While the results mirror the household level adoption models, the most interesting result is the positive association between perception of late blight resistance and having grown C88. Also, the negative and positive association, respectively, between distance from a metropolitan county and village land area with disadopting C88.

Compared to the household adoption and intensity of adoption models, the subjective importance of late blight resistance has a significant and positive association with ever adopting. Households who value late blight resistance as a somewhat important trait are 4.8 percentage points more likely to have ever grown C88. As extension likely promoted the variety as late blight resistant, these results make sense. A household's perception of late blight resistance has no association with whether a farmer stops growing C88 which infers that late blight resistance is not a decisive factor in the decision to stop growing C88.

Table 10. Results from Heckman probit model: Joint estimates of determinants of growing and disadopting C88

	Ever Grown		**Stopped**	
Observations	436		436	
Independent Variable	Farmer has ever grown C88		Farmer stopped growing C88	
Dependent Variables	**Marginal Effect**	**P-value**	**Marginal Effect**	**P-value**
Age at time of adoption	-0.0071 (0.0023)	0.002	0.0015 (0.0025)	0.539
Primary occupation is farming (base is not primary occupation)	0.027 (0.049)	0.592	0.063 (0.069)	0.360
Education (base is no education)				
Primary	-0.059 (0.041)	0.143	-0.054 (0.049)	0.274
Secondary or higher	0.021 (0.034)	0.545	-0.051 (0.039)	0.197

	Ever Grown		Stopped	
Observations	436		436	
Independent Variable	Farmer has ever grown C88		Farmer stopped growing C88	
Dependent Variables	**Marginal Effect**	**P-value**	**Marginal Effect**	**P-value**
Household size	0.046 (0.019)	0.018	-0.059 (0.018)	0.001
Dependency ratio	-0.49 (0.16)	0.003	0.29 (0.12)	0.012
Total farm size (ha)	0.068 (0.031)	0.028	-0.016 (0.020)	0.419
Agricultural equipment wealth (Yuan, scaled by 100)	0.00065 (0.0012)	0.591	0.00060 (0.00054)	0.261
Livestock wealth (index)	0.015 (0.014)	0.28	-0.017 (0.011)	0.115
Importance of late blight resistance (base is not important)				
Somewhat important	0.048 (0.023)	0.040	0.089 (0.056)	0.108
Very important	-0.036 (0.034)	0.300	0.089 (0.059)	0.136
Importance of price received (base is not important)				
Somewhat important	0.095 (0.040)	0.018	-0.084 (0.084)	0.315
Very important	0.12 (0.065)	0.257	-0.12 (0.083)	0.142
Number of years since first year of C88 adoption			-0.0024 (0.0043)	0.581
Region				
Zhaotong	-0.31 (0.18)	0.086	0.31 (0.22)	0.149
South	0.17 (0.14)	0.239	0.57 (0.11)	0.000
West	-0.052 (0.20)	0.799	0.27 (0.14)	0.051
Elevation (1000)	0.18 (0.17)	0.287	-0.059 (0.24)	0.802
Located in metropolitan county (base is being located in the metropolitan county)				
Borders county	-0.023 (0.17)	0.890	-0.53 (0.099)	0.000
Two counties away	0.033 (0.13)	0.805	-0.31 (0.072)	0.000
Farm organization in village (base is no organization)	-0.043 (0.12)	0.712	-0.14 (0.15)	0.352

	Ever Grown		Stopped	
Observations	436		436	
Independent Variable	Farmer has ever grown C88		Farmer stopped growing C88	
Dependent Variables	**Marginal Effect**	**P-value**	**Marginal Effect**	**P-value**
Number of HH in village	-0.00020 (0.00053)	0.703	0.00073 (0.00077)	0.344
Village potato area (ha)	-0.00025 (0.00072)	0.732	-0.0059 (0.0031)	0.054
Disease has greatly affected production in the past 5 years (base is no problem)	-0.16 (0.098)	0.095	0.075 (0.17)	0.652
Cost of day labor (Yuan)	-0.0026 (0.0019)	0.173	0.00041 (0.0044)	0.926

Note: Standard errors are clustered at the village level (shown in parentheses). The marginal effects are the average marginal effect.
Source: Household & community survey data sets, 2015.

Whether a household has ever grown C88 is not dependent on distance from urban areas, but the decision to stop growing C88 is. Living in a bordering county or two counties away from the metropolitan county decreases the probability of disadoption by 68 and 47 percentage points, respectively, compared to living in the metropolitan center. Living farther away from the metropolitan county results in lower rates of disadoption.

Additionally, for a one hectare increase in village potato area, the probability of disadoption decreases by 0.59 percentage points. The previous household adoption models indicate that village potato area influences whether a household grew C88 in late spring 2015. In this model, village land area under potato does not influence if a household has ever grown but decreases the probability a household disadopts. Further research would be needed to conclude if this has any connection with extension, but it is probable that extension targeted commercial farmers.

If a households disadopts, he or she may replace C88 with another variety. The community survey highlights that the most common varieties that replaced C88 are Mira, Hui-2, and combinations of varieties. Of the households who plan to stop or have stopped cultivating

C88, 33% currently grow Hui-2. Interestingly, the year of first use for both varieties was prior to the release of C88, and while the area under Mira is declining, the area under Hui-2 is increasing (SIAC 2.1, 2015). Future research is necessary to determine why this may be, but it is important to note that farmers replaced C88 with older varieties and the area under one of them, Hui-2, is increasing.

While the previous household adoption models did not account for the dynamic process of adoption, there is enough evidence to conclude that location plays a role in the process of adoption and disadoption. While more research would be necessary to understand the full story of C88 in Yunnan, this study provides a glimpse into C88's narrative.

5.4 Economic Surplus Analysis

The results in Table 11 indicate that C88 adoption has led to significant economic benefits in the closed and small open economy models.

Table 11. Results of closed and small open economic surplus analyses for Yunnan from 1996 to 2015

	ε	n	% of Total Benefits to Consumers	% of Total Benefits to Producers	Total Benefits (000,000) from 1996 to 2015 (constant 2015 $)	Present value (000,000) of benefits from 1996 to 2015 (constant 2015 $)
Closed Economy	1.00	-0.65	61	39	$3,082	$3,730
Small Open Economy	1.00		0	100	$2,354	$2,835

The closed economy model indicates that the adoption of the variety has generated substantial benefits. The total benefits, base year 2015, from 1996 to 2015 are $3.08 billion with a present value of $3.73 billion. Consumers captured 61% of the benefits, while 39% of the benefits went to producers.

In the small open economy model, total benefits, base year 2015, from 1996 to 2015 equal $2.35 billion with a present value of $2.84 billion. All of the benefits accrue to producers in Yunnan. In the closed economy model, producers gained 39% of the benefits which equates to $1.21 billion. Under the trade assumption, Yunnan producers double their benefits.

Comparison to Robinson and Srinivasan

A goal of this study was to build upon Robinson and Srinivasan's work. The latter estimated the benefits of C88 adoption in China from 1996 to 2020 to be $3.47 billion. This value was obtained by multiplying estimated land area adoption profile from 1996 to 2020 by the yearly per hectare benefits derived from adoption[10]. The present value of benefits of $3.47 billion is estimated for the base year 1996 and with a discount rate of 3%.

To make ours and Robinson and Srinivasan's model findings comparable, we make three adjustments to the Robinson and Srinivasan's model: i) we shorten the benefit stream from 2020 to 2015, ii) we conisder only the number of hectares under C88 in Yunnan, and iii) we inflate the estimated yearly benefits per ha to 2015 dollars. To reflect benefits accruing to producers and consumers in Yunnan, we assume that 35% of the total C88 area is in Yunnan[11]. The $777 benefits per ha (base year 2006) were inflated using an inflation rate of 16%, meaning that the benefits per hectare in 2015 are $900[12].

After the adjustments, the sum of benefits of Robinson and Srinivasan's comparison model has a present value of $1.68 billion (Table 12) and are $1.51 billion less than our benefits

[10] The benefits per hectare in Robison and Srinivasan's study were taken from a stuy by Fugile (2007).
[11] The estimate of thirty-five percent is for 2009 and from Robinson and Srinivasan's study. We assume it holds for every year.
[12] The inflation rate for the United States from 2006 to 2015 was calculated using data from the World Bank Data Bank.

estimated using a small open economy model[13]. The difference in benefits between the two studies can be attributed to three factors: benefits per hectare, assumptions about adoption profiles, and market dynamics. To quantify and decompose the differences, we input our estimates for adoption and benefits from adoption into the Robinson and Srinivasan's comparison model to create the modified models (1, 2, and 3). We then subtracted the present value of the comparison model from the present value of each of the modified models (model 1, 2, 3). In doing so, we are able to attribute the differences in benefits to each of the three factors.

Table 12. The present value of benefits from 1996 to 2015 for this study's small open-economy model, Robinson and Srinivasan's comparison model and iterations to the comparison model (base year 2015)

Our model		**Robinson and Srinivasan's comparison model**	**Difference between our study and the comparison model**
$2,835,863,288		$ 1,684,176,968	($1,151,686,320)
Modification to the comparison model		**Modified model**	**Difference between iteration and comparison model**
1	Utilizes our benefits per ha	$780,335,329	($903,841,640)
2	Utilizes our adoption profile	$2,231,947,328	$547,770,360
3	Unexplained differences in our model and base model		($795,615,041)

Note: Discount rate is 3% for every model. All of the modified models' potato area is restricted to Yunnan and benefit stream is from 1996 to 2015.

Using Robinson and Srinivasan's adoption assumptions and our benefits per ha[14], the modified model has a present value of $780 million and is $904 million less than the comparison model. The difference between the Robinson and Srinivasan's and modified model 2 can be attributed to Fugile's (2007) per ha benefit, which accounts for a decrease in pesticide use and increased yield. The community survey however indicated that there was no difference in

[13] The small open economy is used as the comparison model because Robinson and Srinivasan's study does not account for price changes. Since we assumed that Yunnan does not influence potato prices in the small open economy model, this model serves as the best comparison tool to Robinson and Srinivasan's study.

[14] To calculate the benefits per ha in our model, we multiplied the price in the small open economy model ($375) by the K-shift in 2015. This estimate was then multiplied by the 2015 quantity in the market. To obtain the benefits on per ha basis, we divided the benefits by the number of ha under potatoes in Yunnan to receive $417.

fungicide use on C88 versus its use on the varieties it replaced. Additionally, from discussions with extension and community leaders, it appears there was no change in pesticide usage in C88 compared to alternative management regimes. As a result, Fugile's per ha benefit is taking into account a factor, decreased pesticide use, which our study did not find as factor.

Another major difference in the two studies concerns adoption. Using Robinson and Srinivasan's benefits per ha with our adoption profile results in a present value of $2.23 million, and is $548 million more than the comparison model. Robinson and Srinivasan used a logistic curve for adoption with the assumption that adoption would continue to increase until 2020 and cover 30% of potato land area in the southwest production zone. However, the research shows this is not the case, and that in fact the disadoption of C88 is significant. As a result, Robinson and Srinivasan overestimate adoption by assuming adoption will continue to increase until 2020, but the reason the modified model 2 is greater than the comparison model is because our adoption profile accounts for future increases in total land under potatoes.

The remaining dissimilarity between our study and Robinson and Srinivasan's is the unexplained differences due to assumptions about price changes and other market factors. For example, Robinson and Srinivasan's study did not account for any consumer effects or supply and demand shifts over time. The residual difference equals $796 million.

Chapter 6: Conclusions

The objectives of this study were to (1) to analyze the determinants of C88 adoption and (2) rigorously measure the economic benefits of C88 adoption.

The first objective was accomplished by using farm household data to econometrically model the determinants of village awareness and household adoption decisions about C88. Disease pressure, region, and village size were important factors in explaining the number of farmers who have heard of C88 in a given village. The factors that affected household adoption decision and intensity of adoption included household socioeconomic, farm, and village characteristics. One of the most significant factors explaning adoption of C88 was location in relation to metropolitan counties. The models showed that farmers located farther from metropolitan counties dedicated more land to C88. One hypothesis for this result was that farmers farther away are less likely to be visited by extension agents and to engage or participate in farm organizations, as shown by the summary statistics. To test the hypothesis, a two-step model was estimated to investigate factors affecting whether farmers ever adopt and, conditional on adoption, whether they disadopt. There was a strong and negative association between distance from a metropolitan area and the decision to stop growing C88.

Farmers have very limited access to seed beyond the initial dissemination by local government or extension which prevents households from replacing old seed and experimenting with new varieties. These observations may indicate that a household's decision to adopt is limited by which varieties are made available by extension and government officials. Varieties are chosen by government and extension officials and limits the ability for farmers to be exposed to several varieties and determine the varieties best suited for their farming conditions . To account for this, the two-step estimation strategy was used, where a village model was estimated first, and then household models. However, the lack of significant variables in the village model

might indicate a lack of validity in the models. Future research efforts may be made to analyze the complex relationships of high-level officials that make the decisions on where varieties are diffused.

Objective 2 was accomplished by analyzing the market benefits of C88 adoption using an economic surplus methodology. Adoption of C88 has had a large economic benefits in Yunnan. In the closed economy model, total benefits (base year 2015) from 1996 to 2015 were estimated at $3.08 billion with a present value of $3.73 billion. In the small open economy model, estimated benefits (base year 2015) from 1996 to 2015 were $2.35 billion with a present value of $2.84 billion. Robinson and Srinivasan's estimates varied from ours because of differences in adoption profiles, benefits per ha, and assumptions regarding market factors.

A limitation to the economic surplus analysis is the inability to use a two-market model, which would have been more appropriate since C88 is widely sold in the processing and fresh markets. If higher prices received for C88 compared with other varieties when sold the processing market could have been incorporated in the analysis, possibly more benefits would have accrued to producers and fewer benefits would have been distributed to consumers.

Although optimal, the two-market model would have required making assumptions for several model parameters that are difficult or practically impossible to validiate. A few examples of those assumptions are the proportion of C88 production that goes in each of the two markets and elasticities of demand and supply for the processing markets. While a two-market model would have been optimal, little is known about the various markets and many varieties are sold in multiple markets.

Overall, this study builds the story of C88 in the Yunnan Province. Although C88 may not be as late blight resistant as previously understood, C88 is still a popular variety among consumers and producers and in the processing industry. This study contributed to the

understanding of C88 diffusion, its roles in the potato value-chain, and where and how benefits from adoption are distributed. The economic surplus analysis indicated significant benefits of C88 to consumers and producers in Yunnan despite disadoption. These findings validate CIP's research and the contribution of improved variety research to consumers and producers wellbeing.

References

Ahmadi-Esfahani, F., & Stanmore, R. (1997). Demand for Vegetables in a Chinese Wholesale Market. *Agribusiness*, 549-559.

Alston, J., Norton, G., & Pardey, P. (1995). *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Ithaca: Cornell University Press.

Cameron, A. C., & Miller, D. L. (2015). A Practitioner's Guide to Cluster-Robust Inference. *Journal of Human Resources*, 317-373.

Caviglia-Harris, J. (2003). Sustainable Agricultural Practices in Rondônia, Brazil: Do Local Farmer Organizations Affect Adoption Rates? *Economic Development and Cultural Change*, 23-49.

Chilonda, P., & Otte, J. (2006). Indicators to monitor trends in livestock production at national, regional and international levels. *Livestock Research for Rural Development*.

Crook, D., Li, C., Xie, K., & Forbes, G. (2013). *Evaluation of 15 potato varieties most widely grown in China for resistance to Late Blight.* Beijing: CIP- China Center for Asia Pacific.

Deputy Director of Exension, [Personal communication] (2015, August 8).

Director Du [Personal Interview]. (2015, August 16).

Director Liu [Personal commuication]. (2015, August 14).

Director Ma [Personal communication]. (2015, August 16).

Fan, S., Gulati, A., & Dalafi, S. (2007). Overview of Reforms and Development in China and India. In A. Fulati, & S. Fan, *The Dragon & the Elephant: Agricultural and Rural Reforms in China and India* (pp. 10-26). Baltimore: John Hopkins Press.

FAO. (2008). *Year of the Potato 2008*. Retrieved from Potato and water resources: http://www.fao.org/potato-2008/en/potato/water.html

FAOSTAT. (n.d.). *Top 20 Commodities by Country*. Retrieved from http://faostat.fao.org/site/339/default.aspx

Feder, G., & Umali, D. (1993). The Adoption of Agricultural Innovations: A Review. *Technological Forecasting and Social Change*, 215-239.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of Agricultural Innovations in Developing Countries: A Survey. *Economic Development and Cultural Change*.

Fugile, K. (2007). *Research Priority Assessment for the CIP 2005-2016 Strategic Plan: Projecting Impacts on Poverty, Employment, Health and Environment.* Lima, Peru: International Potato Center.

Gautum, M. (2000). *Agricultural Extension: The Kenya Experience.* Washington D.C.: World Bank OED.

Gereffi, G., & Fernandez-Stark, K. (2011). *Global Value Chain Analysis: A Primer.* Durham, NC: Center on Globalization, Governance & Competitiveness.

Hareau, G., Forbes, G., Xie, K., Alwang, J., Larochelle, C., & Norton, G. (2015). *Adoption and Diffusion of C88 Potato Variety in China: Spatial Variability of Productivity Gains and Cost Savings and Value Chain Development.* Rome: Standing Panel on Impact Assessment.

Huque, M., Rashid, M., & Rahman, M. (1996). Adoption of Improved Practices By Potato Farmers. *Bangladesh Journal of Agricultural Economics*, 59-69.

International Potato Center. (2009, August 15). *China*. Retrieved from International Potato Center: World Potato Atlas: https://research.cip.cgiar.org/confluence/display/wpa/China

Jansky, S., Jin, L., Xie, K., Xie, C., & Spooner, D. (2009). Potato Production and Breeding in China. *Potato Research*, 57-65.

Kaguongo., W., Ortmann, G., Wale, E., Darroch, M., & Low, J. (2010). *Factors influencing adoption and intensity of adoption of orange flesh sweetpotato varieties: evidence from an extension intervention in Nyanza and Western province, Kenya.* Cape Town: 48th Agricultural Economists Association of South Africa Conference.

Kai-yun, X., & Yi, W. (2001). CIP potato late blight research in China. *Journal of Agricultural University of Hebei*.

Khonje, M., Mkandawire, P., Manda, J., & Alene, A. D. (2015). *Analysis of adoption and impacts of improved cassava varieties in Zambia.* Milan: International Association of Agricultural Economists.

Labarta, R., Wambugu, S., Yirga, C., Mugabo, J., Nsabimana, J. d., Mulwa, C., . . . Yigezu, Y. (2012). *The adoption of improved potato and sweetpotato varieties in Ethiopia, Rwanda and Uganda: comparing expert opinion estimates and the results of nationally representative surveys.* Lima: International Potato Center.

Lambrecht, I., Vanlauwe, B., Merckx, R., & Maertens, M. (2014). Understanding the Process of Agricultural Technology Adoption: Mineral Fertilizer in Eastern DR Congo. *World Development*, 132-146.

L. Bin [Personal communication]. (2015, August 13).

Li, C. (2015, September 1). Professor and Researcher at Yunnan Normal University. (S. Myrick, Interviewer)

Li, C., Wang, J., Chien, D. H., Chujoy, E., Song, B., & VanderZaag, P. (2010). Cooperation-88: A High Yielding, Multi-Purpose, Late Blight Resistant Cultivar Growing in Southwest China. *American Journal of Potato Research*.

Lin, J. Y. (1990). *Education and Innovation Adoption in Agriculture: Evidence from Hybrid Rice in China.* Los Angeles: University of California, Los Angeles.

Maredia, M., & Reyes, B. (2014). *GUIDELINES FOR COLLECTING VARIETAL RELEASE AND ADOPTION DATA.* CGIAR.

Mauceri, M., Alwang, J., Norton, G., & Barrera, V. (2007). Effectiveness of Integrated Pest Management Dissmenination Techniques: A Case Study of Potato Farmers in Carchi, Ecuador. *Journal of Agricultural and Applied Economics*, 765-780.

Meador, M., Lei, Z., & Orlowski, J. (2013, October 28). *China- Potato Annual 2013.* Retrieved from Foreign Agricultural Service: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Potato%20Annual%202013_Beijing_China%20-%20Peoples%20Republic%20of_10-28-2013.pdf

Meador, M., Lei, Z., & Orlowski, J. (2013). *China- Potato Annual Report.* Beijing: USDA Foreign Agricultural Service.

Mensah, E., & Wohlgenant, M. (2014). A Market Impact Analysis of Soybean Technology Adoption . *Research in Business and Economics Journal* .

Norton, G. W., Ganoza, V. G., & Pomareda, C. (1987). Potential Benefits of Agricultural Research and Extension in Peru. *American Journal of Agricultural Economics*, 247-257.

OECD. (2016). *OECD Data*. Retrieved from Purchasing power parities (PPP): https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm#indicator-chart

Robinson, J., & Srinivasan, C. (2013). *Case-studies on the impact of germplasm collection, conservation, characterization and evaluation (GCCCE) in the CGIAR.* CGIAR.

Robinson, J., & Srinivasan, C. (2013). *Case-studies on the impact of germplasm collection, conservation, characterization and evaluation (GCCCE) in the CGIAR* . CGIAR Standing Panel on Impact Assessment.

Rogers, E. (2003). *Diffusion of Innovation.* New York: Free Press.

Scott, G., & Suarez, V. (2012). From Mao to McDonald's: Emerging Markets for Potatoes and Potato Productions in China 1961-2007. *American Journal of Potato Research*, 216-231.

Seaman, A., Loria, R., Fry, W., & Zitter, T. (2014). *Late Blight: A Serious Disease of Potatoes and Tomatoes*. Retrieved from Cornell University Cooperative Extension: http://www.nysipm.cornell.edu/publications/blight/

SIAC 2.1. (2015, March 10). Database 2: Perceived Adoption Rates of Modern Varieties. Kunming, Yunnan, China.

Sinja, J., Karugia, J., Baltenweck, I., & Romney, D. (2004). Farmer Perception of Technology and its Impact on Technology Uptake: The Case of Fodder Legume in Central Kenya Highlands. *AAAE Conference Proceedings.* Nairobi.

Smale, M., & Mason, N. (2014). Hybrid Seed and the Economic Well-Being of Smallholder Maize Farmers in Zambia. *The Journal of Development Studies*, 680-695.

Sui, Q., Li, X., & Yang, W. (2008). Analysis of potato production in China, Southwest China. *Journal of Agricultural Science*, 1182-1188.

Tambo, J., & Abdoulaye, T. (2012). Climate change and agricultural technology adoption: The case of drought tolerant maize in rural Nigeria. *MITIGATION AND ADAPTATION STRATEGIES FOR GLOBAL CHANGE*, 277-292.

Thirtle, C. G., & Ruttan, V. W. (1986). *THE ROLE OF DEMAND AND SUPPLY IN THE GENERATION AND DIFFUSION OF TECHNICAL CHANGE.* St. Paul: Economic Development Center.

Tobin, J. (1958). Estimation of Relationships for Limited Dependent Variables. *Econometrica* , 24-36.

UCLA: Statistical Consulting Group. (n.d.). *Stata Data Analysis Examples: Tobit Analysis*. Retrieved from Institute for Digital Research and Education: http://www.ats.ucla.edu/stat/stata/dae/tobit.htm

USAID. (n.d.). *2.6.2. Types of Value Chain Governance*. Retrieved from Microlinks: https://www.microlinks.org/good-practice-center/value-chain-wiki/types-value-chain-governance

Walker, T., & Adam, A. (2011). *Guidelines for data collection for Objective 2 of the DIIVA Project.*

Wang, Q., & Zhang, W. (2010). An Economic Analysis of Potato Demand in China. *American Journal of Potato Research*, 245-252.

World Bank. (2015, November 12). *World Development Indicators*. Retrieved from World DataBank: http://databank.worldbank.org/data/reports.aspx?source=2&country=CHN&series=&period=#

World Bank. (2016). *The World Bank*. Retrieved from World DataBank: http://databank.worldbank.org/data/home.aspx

Zhao, Y. (1999). Labor Migration and Earnings Differences: The Case of Rural China. *Economic Development and Cultural Change*, 767-782.

APPENDIX A: Household Survey

Yunnan Normal University. Address: No.298 121 Street KUNMING 650092
CIP-CCAP. Address: A12 Zhongguancun Nandajie, BEIJING 100081

Study: Assessing the Adoption of Cooperation-88 potato variety in the Yunnan Province of China

PREFECTURE CODE	COUNTY CODE	TOWNSHIP CODE	VILLAGE CODE	ENUMERATOR CODE	HOUSEHOLD ID CODE

FARM HOUSEHOLD SURVEY

Enumerator name: _____

Hello, my name is [name], and I am here to see if you are willing to participate in a survey for a research project. The project involves institutions such as the Yunnan Normal University and the International Potato Center. We are studying the adoption and economic impact of Cooperation-88, potato variety, on China's economy. The survey will last around 50 minutes. The survey requires you answer questions regarding your household and farm. This survey is voluntary, confidential, and anonymous. The information from this survey will not be used in any way other than for data analysis. Do you agree to participate in this survey? [Yes / no]

Z.1. Who is the most knowledgeable person on potato seed varieties in this household?
☐ Me / ☐ Someone else If the answer is "Me", continue to next section, if the answer is "Someone else", then ask to speak with this person.
Information for linking leaf or tuber sample for DNA finger printing

	Plot Number	Code of the leaf sample	Code of the tuber sample
a			

Section A. Identity of the Household

A.1. Location of the household

A.1.1. City/Prefecture

A.1.2. County

A.1.3. Township

A.1.4. Village

A.2. Date and time of the interview

A.2.1 Date of the interview:

A.2.2. Time started（24 hour clock）:

A.2.3. Time ended （24 hour clock）:

A.3. General information of the respondent.

A.3.1. First name _____ A.3.2. Last name _____

Section B – Current household composition and characteristics

B.1. Working age household members (>15years old only) living in the residence during 2015 (start with respondent and followed with spouse)

Family code	Name of working age household (HH) member	Sex性别 **Code A**	Relation to HH head **Code B**	Is this member involved in potato production? **Code (Y/N)**	Age (years)	Formal education		If column B.1.7=0, Can read/write? **Code C**	Main occupation **Code E**
						Code D	Years in Code D		
B.1.1	**B.1.2**	**B.1.3**	**B.1.4**	**B.1.5**	**B.1.6**	**B.1.7**	**B.1.8**	**B.1.9**	**B.1.10**
01									
02									
03									
04									
05									
06									
07									
08									

Code A	**Code B**	**Code C**	**Code D**	**Code E**	
0=Female 1=Male	1=Household head 2=Wife/husband 3=Son/Daughter 4=Parent 5=Brother/sister 6=Mother/father in law 7= Son in law/Daughter in law 8= **Other, specify**	0=No 1=Read 2=Write 3=Both	0=None 1=Primary 2=Secondary 3=Senior high school 4=Junior college 5=University 6=Technical secondary school	1. Farmer 2. Farm labor 3. House keeper 4. Student 5. Government	6. Self-employment (store owner, etc.) 7. Unemployed 8. Retired 9. Employed 10. Other (specify)

B.2 Non working age household members and migration

	Male	Female
B.2.1. Number of children between 0 and 5 years old		
B.2.2. Number of children between 6 and 14 years old		
B.2.3. Number of household member who live outside the household (e.g. migration for school, work)		

Section C - Current production

C.1. LAND HOLDING AND LAND CROPPING

C.1.1. What is the total amount of area and number of plots the cultivated owned?

C.1.1.1. Area	C.1.1.2. Unit	C.1.1.3. Total number of plots

Now, we want to talk more on the crops cultivated in those plots you own, rent and/or borrow.

C.1.2.1. Plot No.	**C.1.2.2. Name of the plot**	Plot area		**C.1.2.6. Land tenancy**	**C.1.2.7. Crop under cultivation in this plot**	**C.1.2.8. Number of mu with potato**	**C.1.2.9. Month when the potato was planted**	**C.1.2.10. Was this plot harvested at survey time**
		C.1.2.3. Amount of area	**C.1.2.4. Unit**	**Code** 1. Owned 2. Rented 3. Borrowed 4. **Other, specify**				**Code** 0. No 1. Yes 2. In progress
			Code 1. *mǔ* (666 2/3 m²) 2. *Fēn* (66 2/3 m²) 3. **Other, specify**					
01								
02								
03								
04								
05								
06								
07								
08								
09								

Now, we want to talk about the plots that you are planting with potatoes.

C.1.3.1. Plot Name	C.1.3.2. Potato varieties cultivated **Code** 1. Hui 2 2. Cooperation-88 3. Weiyu 3 4. Xuanshu 2 5. Mira 6 Unica 7. Lishu 6 8. **Other, specify**	C.1.3.3. What is the color of the skin of those varieties **Code** 1. Reddish 2 Dark Reddish 3. Cream 4. **Other, specify**	C.1.3.4. Main source of seed per variety **Code** 1. Own 2. Local market 3. Contractor 4. Friend/neighbor 5. Extension Station 6. **Other, specify**	Seeds used in planting time		Potato harvested / expected production when harvest		C.1.3.10. % of production sold per variety	C.1.3.11. What is the [expected]price per [unit]for [variety]? **Code** 1. Yuan/*Jin* 2. *Yuan/kg* 3. **Other, specify**	C.1.3.12. Main market per potato variety **Code** 1. *Local market* 2. Processor: 2a. Potato chip 2b. Starch 2c. French fries 3. *Province market* 4. Trader 5. **Other, specify**
				C.1.3.5. Amount of seed	C.1.3.6. Unit **Code** 1. *Jin* 斤(0.5 kg) 2. *Kilogram* 公斤 3. **Other, specify**	C.1.3.8. Amount harvested	C.1.3.9. Unit **Code** 1. *Jin* (0.5 kg) 2. *Kilogram* 3. t 4. **Other, specify**			

Use a different line for each variety

Section D – Adoption decisions

D.1. FARMER ORGANIZATION AND SOCIAL NETWORKS

D.1.1. How many years of experience do you have in potato cultivation (when family grows potatoes since they were a child, count from 15 years old)? _____

D.1.2. Who in the household decides which varieties to plant? ☐ Male | ☐ Female | ☐ Both male and female

D.1.3. Who in the household buys the seed? ☐ Male | ☐ Female | ☐ Both male and female

D.1.4. Who is your trusted source of information regarding potato varieties? (more than one option is possible)

☐ Family member ☐ Friend/Neighbor ☐ Cooperative

☐ Extension agent ☐ Market/store ☐ Newspaper/printed material

☐ **Other, specify** _____

D.1.5. Have you been visited by an extension agent in the last year?

☐ Yes | ☐ No | ☐ I don't remember, if mark the box "No", go directly to D.1.7

D.1.6. How often are you visited by an extension agent?

☐ Weekly ☐ Bi-weekly ☐ Monthly

☐ Every few months ☐ Twice a year ☐ Yearly

☐ **Other, specify** _____

D.1.7. Are you a part of a farmer organization? If so, what kind?

☐ No ☐ Farmer specialized cooperatives ☐ Rural economic cooperative

☐ Potato related company ☐ **Other, specify** _____

D.1.8. What is the name of that organization?

_____

D.2. ADOPTION HISTORY

D.2.1. Have you ever heard of the potato variety "Cooperation-88"?

☐ Yes | ☐ No, if mark the box "No", go directly to D.3 and complete just first column, and conclude they do not know C88

D.2.2. How did you first hear about Cooperation-88?

☐ Family member ☐ Friend/Neighbor ☐ Extension agent

☐ Television ad ☐ Newspaper/printed material ☐ I don't remember

☐ **Other, specify** _____

D.2.3. When did you first hear about Cooperation-88? (Year) _____ ☐ I don't remember

D.2.4. Did you grow Cooperation-88? ☐ Yes | ☐ No

D.2.5. When did you first grow Cooperation-88? (Year) _____ ☐ I don't remember

D.2.6. Why did you adopt Cooperation-88? (more than one option is possible)

☐ Good shape ☐ Low cost (inexpensive to buy) ☐ Late blight resistance

☐ High price ☐ Ability to engage in contract farming ☐ High yield

☐ Stores well ☐ Good taste ☐ Required to by the government

☐ **Other, specify** _____

D.2.7. Did Cooperation-88 replaces another variety you used to grow?

☐ Yes | ☐ No | ☐ N/A, if mark "Yes", Specify the variety that replaces: _____

D.2.8. Do you plan to grow Cooperation-88 next early or late spring season?

☐ Yes | ☐ No, if mark the box "Yes" goes to Next Section (D.3)

D.2.9. Why do you plan to stop growing Cooperation-88? (more than one option is possible)

☐ Seed is too expensive ☐ Seed not available ☐ Yield are reducing year by year

☐ Required by contract to grow others ☐ Low market price ☐ **Other, specify** _____

D.2.10. When was the last time you bought seed of C88? _____

D.2.11. What seed category did you buy for C88?

☐ Basic seed ☐ Certified ☐ Tubers from market

☐ I don't remember ☐ **Other, specify** _____

D.2.12. What was the yield on the first harvest?_____

D.2.13. How many cropping cycles have you been growing this variety before buying seed again?_____

D.2.14. After these cropping cycles, what was the reason for buying seed?

☐ Yield reduction ☐ Small tubers ☐ Small plants

☐ Mosaics ☐ Tuber malformation ☐ Black scurf on tubers

☐ Wilting ☐ I don't remember ☐ **Other, specify** _____

D.3. VARIETAL TRAITS

Trait ID	Trait	How important is this trait in your choice of potato variety?	Did any of these traits influence your decision to adopt or not to adopt C88?	How well does C88 perform this [trait] currently?
		1	**2**	**3**
	PRODUCTION			
D.3.1	Late blight resistance			
D.3.2	Virus resistance			
D.3.3	Seed price			
D.3.4	Yield			
	PROCESSING AND MARKETING			
D.3.5	Seed was provided			
D.3.6	Price received			
D.3.7	Storability			
D.3.8	Market demand			
	CONSUMPTION			
D.3.9	Color of the tuber			
D.3.10	Size of the tuber			
D.3.11	Taste of the potato			
		Code 1 1. Not important 2. Important 3. Very important 4. I don't know	Code 2 1. Not influential 2. Influential 3. Very influential 4. I don't know	Code 3 1. Poorly 2. Moderately 3. Well 4. I don't know

Section E – Household assets

E.1. HOUSEHOLD CHARACTERISTICS

E.1.1. Do you own the house? ☐ Yes | ☐ No

E.1.2. Do you have access to electricity inside your house? ☐ Yes | ☐ No

E.1.3. Which is the main walling material of main residential house? (more than one option possible if those are the main material)

☐ Burned bricks ☐ Mud ☐ Stone

☐ Concrete ☐ Gypsum ☐ **Other, specify** _____

E.1.4. Which is the main roofing material of main residential house? (more than one option possible if those are the main material)

☐ Iron sheet ☐ Tiles ☐ Wood/ grass

☐ **Other, specify** _____

E.1.5. Which is the main floor material of main residential house? (more than one option possible if those are the main material)

☐ Concrete ☐ Tiles ☐ Unpaved/dirt

☐ **Other, specify** _____

E.1.6. Which is the household main source of water (e.g. drinking /cooking)

☐ Piped inside the house ☐ Borehole protected and covered

☐ Piped outside the house ☐ Borehole unprotected & uncovered

☐ Stream/River ☐ Reservoir ☐ **Other, specify** _____

E.1.7. What type of toilet do you have?

☐ Flush toilet ☐ Pit toilet ☐ None

☐ **Other, specify** _____

E.1.8. What type of fuel do you use more frequently? (more than one option possible)

☐ Wood ☐ Electricity ☐ Biofuel (wastes of crops, manure)

☐ Gas ☐ Coal ☐ **Other, specify** _____

E.2. HOUSEHOLD ASSETS

E.2.1. Which of the following household belongings do you have?

ASSET	Number of [asset]	Year of purchase [asset]	Price in current conditions	ASSET	Number of [asset]	Year of purchase [asset]	Price in current conditions
☐ E.2.1.1. Bicycle				☐ E.2.1.2. Tricycle			
☐ E.2.1.3. Rural truck – 3WH				☐ E.2.1.4. Rural truck – 4WH			
☐ E.2.1.5. Motorbike				☐ E.2.1.6. Car			
☐ E.2.1.7. Washing machine				☐ E.2.1.8. Mobile phone			
☐ E.2.1.9. TV				☐ E.2.1.10. Solar heater			
☐ E.2.1.11. Computer				☐ E.2.1.12. Refrigerator			
☐ E.2.1.13. Water dispenser				☐ E.2.1.14. **Other**_____			

E.2.2. Which of the following farm assets do you have?

ASSET	Number of [asset]	Year of purchase [asset]	Price in current conditions	ASSET	Number of [asset]	Year of purchase [asset]	Price in current conditions
☐ E.2.2.1. Potato storage				☐ E.2.2.2. Rice Shucker			
☐ E.2.2.1. Milling machine				☐ E.2.2.2. Rice thresher			
☐ E.2.2.3. Grain storage				☐ E.2.2.4. Plant Shredder			
☐ E.2.2.5. Plough				☐ E.2.2.6. Wheel barrow			
☐ E.2.2.7. Sickle				☐ E.2.2.8. Shovel			
☐ E.2.2.9. Rake				☐ E.2.2.10. Hoe			
☐ E.2.2.11. Motor hoe				☐ E.2.2.12. Tractor			
☐ E.2.2.13. Backpack sprayers				☐ E.2.2.14. **Other**_____			

E.2.3. Which of the following animals do you have?

ANIMAL	Number of [animal]	Year of purchase [animal]	Price in current conditions	ANIMAL	Number of [animal]	Year of purchase [animal]	Price in current conditions
☐ E.2.3.1. Heifer/Cow				☐ E.2.3.2. Bulls/steers			
☐ E.2.3.3. Horse				☐ E.2.3.4. Donkey			
☐ E.2.3.5. Goat				☐ E.2.3.6. Sheep			
☐ E.2.3.7. Pig				☐ E.2.3.8. Duck			
☐ E.2.3.9. Rabbit				☐ E.2.3.10. Chicken			
☐ E.2.3.11. Mule				☐ E.2.3.12. **Other**_____			

APPENDIX B: Community Survey

Yunnan Normal University. Address: No.298 121 Street KUNMING 650092

CIP-CCAP. Address: A12 Zhongguancun Nandajie, BEIJING 100081

Study: Assessing the Adoption of Cooperation-88 potato variety in the Yunnan Province of China

PREFECTURE CODE	COUNTY CODE	VILLAGE CODE	ENUMERATOR CODE

Village SURVEY

Enumerator name: _____

Hello, my name is [name], and I am here to see if you are willing to participate in a survey for a research project. The project involves institutions such as the Yunnan Normal University and the International Potato Center. We are studying the adoption and economic impact of Cooperation-88, potato variety, on China's economy. The survey will last between 50-60 minutes. The survey requires you answer questions regarding farms in your village.

This survey is voluntary, confidential, and anonymous. The information from this survey will not be used in any way other than for data analysis.

Do you agree to participate in this survey? [Yes or no]

Module A: Identification

Identification

A.1.	Date of Interview	
A.2	Time Started (24 hour clock)	
A.3	Time Ended (24 hour clock)	
A.4	Enumerator Code	

Location

A.5	Prefecture	
A.6	County	
A.7	Township/ town	
A.8	Village Committee	
A.9	Village	
A.10	Survey ID	

Focus group participants

	1	2	3	4	5	6
	Name	**Age**	**Sex**	**Role in the community**	**Main Occupation**	**Farm size**
	List	Year	0. Female 1. Male	List	List	Mu
A.11						
A.12						
A.13						
A.14						
A.15						

Module B: General Village Information

Enumerator: This survey will focus on your entire village. Please feel free to discuss before giving an answer. To begin the survey, I will ask you general questions about your village.

B.1	**How many households are there in your village?**	Number	
B.2	**What proportion of households participate in farming?**	%	
B.3	**What is the average farm size of all farmers in your village?**	Mu	
B.4	**Out of the households that farm, what proportion of households grow potatoes?**	%	
B.5	**What is the total area under potato cultivation in your village?**	Mu	
B.6	**What is the average amount of land under potato cultivation for a potato farmer?**	Mu	

Module C: Potato Varieties

Enumerator: Next, I will ask questions about potato production in your village. I will begin with questions about potato varieties.

Popular potato varieties

		1	2	3	4	5	6			7		8		9	10	11
	Rank of potato variety	**What are the top three most widely grown potato varieties in your village?**	**Are there other names for [variety] in your village?**	**When was [variety] first introduced to your village?**	**What proportion of potato growing households grow [variety] in your village?**	**What is the proportion of potato land in your village devoted to [variety]?**	**What are the top 3 characteristics that make [variety] popular in your village?** **Code below**			**What is the main cultivation method for [variety]?**		**What is the average yield of this [variety]?**		**What is the current price for [variety] in your village?**	**What is the lowest price for [variety] in the last six months in your village?**	**What is the highest price for [variety] in the last six months in your village?**
		Name of variety	Name	Year	%	%	1	2	3	Intercropping	Monocropping	1 Quantity	2 Unit	Yuan/ kg	Yuan/ kg	Yuan/ kg
C.1	1															
C.2	2															
C.3	3															
C.4	C88*															

**Enumerator: If C88 does not appear in the top 3 most important varieties, ask C.5. If it is in the top 3, ask C.6.*

Code

1. Purchase for a low price
2. Sell for a high price
3. High yield
4. Disease resistant
5. Readily available
6. Contract stipulates usage
7. Larger potatoes
8. Available market
9. Fewer inputs
10. Shorter season
11. Good shape
12. Tastes good
13. Good color
14. Other (specify)

C.5	**Do farmers in your village currently grow C88?**	No >> C.12 Yes>> Complete the C.4 row for C88 in the grid above then move to C.6

Enumerator: Ask C.6 if C88 the answer to C.5 was yes or C88 was in the top three grown varieties.

History of C88

C.6	**What variety did C88 replace?**	Name	
C.7	**What was the average yield for the variety C88 replaced?**	1. Quantity	
		2. Unit	
C.8	**What was the average price received for the variety C88 replaced?**	Yuan/ kg	
C.9	**Has the area under C88 in your village been increasing or decreasing in the last 5 years?**	1. Increasing >> C.10 2. Decreasing>> C.11 3. Stagnant>> Module D	
C.10	**Why has the area under C88 been increasing the last 5 years? Please list the top 3 reasons in order of importance**. *Enumerator: Move to Module D*	1	
		2	
		3	
C.11	**Why has the area under C88 been decreasing the last 5 years? Please list the top 3 reasons in order of importance.** *Enumerator: Move to Module D*	1	
		2	
		3	

Enumerator: Next, I will ask you few additional questions regarding Cooperation-88 potato variety and the history of its use in your village.
(Do not ask if the village is currently growing C88).

C.12	**Has C88 ever been grown in your village?**	0. No >> Module D 1. Yes	
C.13	**What is Cooperation-88's alternative or local name?**	List	
C.14	**When was C88 introduced?**	Year	
C.15	**What were the top 3 characteristics that made C88 popular? (Use code on page 3)**	1	
		2	
		3	
C.16	**What variety did C88 replace?**	Name	
C.17	**What was the average yield for the variety C88 replaced?**	1. Quantity	
		2. Unit	
C.18	**What was the average price received for the variety C88 replaced?**	Yuan/kg	
C.19	**When did farmers in your village stop growing C88?**	Year	
C.20	**Why did farmers stop growing C88? Please list the top 3 reasons in order of importance.**	1	
		2	
		3	
C.21	**What variety replaced C88?**	Name	

Module D: General Production and Cost of Production

Pests and Disease History

D.1	**Has disease greatly reduced your final potato production in your village for the past 5 years?**	0. No >>D.4 1. Yes	
D.2	**What disease(s) have been an issue in your village for the past 5 years?**	• Late blight • Early blight • Powdery scab • Black Scurf • Bacterial wilt • Bacterial black leg • Bacterial ring rot • Do not know • Other (specify)	
D.3	**What have farmers in your village done to resolve and prevent this disease issue in the future?**	• Adopt better seed varieties • Use more fungicides • Crop rotation • Nothing • Do not know • Other (specify)	
D.4	**Have pests greatly reduced your final potato production in your village for the past 5 years?**	0. No>> D.7 1. Yes	
D.5	**What pest(s) have been an issue in you village for the past 5 years?**	• White grubs • Wire worm • Mole cricket • Cut worm	

		• Aphid • Potato tuber worm • Cantharides • Do not know • Other (specify)	
D.6	**What have farmers in your village done to resolve and prevent this pest issue in the future?**	• Adopted more resistant seed varieties • Used more fungicides • Crop rotation • Used a parasitoid • Used pest traps • Nothing • Do not know • Other (specify)	

(Enumerator: The next section will be about cost of production. These costs will be asked about the variety that C88 replaced.)

Enumerator: This next section will be about the cost for farmers in your village to produce potato. The cost questions are about the variety that C88 replaced that was mentioned earlier. For example, I may ask if you hire labor for the [replaced variety]. I will then ask if you hire more or less labor to produce C88.

Labor

	1	2	3	4	5	6
Activity ID	**For an average potato farmer in your village, how many man days of unpaid family members and community members help with [activity] in 1 season per 1 mu?**	**For an average potato farmer in your village, is labor hired for [activity] in 1 season per 1 mu?**	**On average, how many man days of labor would a farmer hire for 1 season per 1 mu?**	**On average, how much does it cost to hire a laborer for a day for [activity]?**	**For an average potato farmer in your village, does producing C88 use more, less, or the same amount of labor compared to [replaced variety]?**	**How many [more or less] man days of labor for [activity] does C88 use than the replaced variety for 1 season per 1 mu?**
	Number	0. No>> Next activity 1. Yes	Number Skip if no hired labor	Yuan	1. Less >> D.X.6 2. More>> D.X.6 3. Same>> Next activity	Number or %
D.7 Plowing and other land preparation						
D.8 Planting						
D.9 Hilling						
D.10 Fertilizer application						
D.11 Pesticide (fungicide, insecticide, and herbicide) application						
D.12 Weeding						
D.13 Harvesting (cleaning, bagging, sorting)						

Rented Tools and Machinery

		1	2	3	4	5	6	7
		Does an average potato farmer in your village have to rent tools or machinery for [activity] for 1 season? Enumerator: Tools can be for the farmer or the hired labor	Which tools or machinery would an average farmer rent for 1 season for [activity]?	How much would it cost an average farmer to rent this tool or machinery for a day to complete [activity]?	How many days would the average farmer need to use the tool or machinery for [activity]?	For an average farmer, would cultivating C88 require [tool]?	For an average farmer, would cultivating C88 require to use [tool] [more or less] days compared to [replaced variety]?	How many more or less days using [tool] would cultivating C88 use?
		0. No >> Next activity 1. Yes	List	Yuan	Number	0.No, it would not require this tool 1. Yes, it would require this tool	1. More>> D.X. 7 2. Less>> D.X.7 3. Same>> D.42	
D.14	**Plowing and other land preparation**							
D.15	Tool 1							
D.16	Tool 2							
D.17	Tool 3							
D.18	**Planting**							
D.19	Tool 1							
D.20	Tool 2							
D.21	Tool 3							
D.22	**Hilling**							
D.23	Tool 1							
D.24	Tool 2							
D.25	Tool 3							

D.26	**Fertilizer application**							
D.27	Tool 1							
D.28	Tool 2							
D.29	Tool 3							
D.30	**Pesticide (herbicide, insecticide, and fungicide) application**							
D.31	Tool 1							
D.32	Tool 2							
D.33	Tool 3							
D.34	**Weeding**							
D.35	Tool 1							
D.36	Tool 2							
D.37	Tool 3							
D.38	**Harvesting (cleaning, sorting, and bagging)**							
D.39	Tool 1							
D.40	Tool 2							
D.41	Tool 3							

Tools and Machinery

	1	2
	For an average potato farmer in your village, what tools or machinery do they own for potato cultivation?	**If a potato farmer were to buy this [tool/machinery] in your village today, how much would the farmer purchase it for?**
	List	Yuan
D.42		
D.43		
D.44		
D.45		
D.46		
D.47		

Inputs

D. 48	**How much does C88 seed cost per [unit]?**	1. Yuan	
		2. Unit	

		1	2	3		4	5	6	7	8
	Input	**Does an average farmer in your village purchase [input] for their potato production?**	**Why does an average farmer not use this input?**	**For an average potato farmer in your village, how much [input] would be applied to 1 mu?**		**What is the price of one [unit] of [input] in your village?**	**For an average potato farmer in your village, how many times is [input] applied per growing season to 1 mu?**	**What is the product name of [input]?**	**For an average potato farmer, does C88 require more, less, or the same amount of [input] for 1 mu of land compared to [replaced variety]?**	**How much [more or less] of [input] does C88 require for 1 mu of land?**
		0. No>> D.X.2 1. Yes	List reason Move to next activity	1 Quantity	2 Unit	Yuan/ unit	Number	List	More >> D.X.8 Less >> D.X.8 Equal >>Next activity	% or number
D.49	**Seeds**									
D.50	**Chemical fertilizer**									
D.51	Fertilizer 1									
D.52	Fertilizer 2									
D.53	Fertilizer 3									

D.54	**Compost and manure**									
D.55	**Fungicide**									
D.56	Fungicide 1									
D.57	Fungicide 2									
D.58	Fungicide 3									
D.59	**Herbicide**									
D.60	Herbicide 1									
D.61	Herbicide 2									
D.62	Herbicide 3									
D.63	**Insecticide**									
D.64	Insecticide 1									
D.65	Insecticide 2									
D.66	Insecticide 3									

Module E: Marketing and Potato Sales

Enumerator: Next, I will ask you questions regarding the where potato farmers in your village sell their harvest.

Sales

		1	2	3	4	5	6	7	8
	Sale Point	**Do potato farmers in your village sell their harvest to [sale point]?**	**What proportion of potato farmers sell potatoes to [sale point]?**	**What is the primary reason that people sell to [sale point]?**	**How often is [sale point] during harvest time?**	**How far away is [sale point] from your village?**	**What is the most common mode of transportation to [sale point]?**	**For an average potato farmer in your village, how much would it cost to transport a 1 ton of potatoes using [mode of transportation] to [sale point]?**	**What is the name of [sale point]?**
		0. No>> next sale point 1. Yes	%	1. Easily accessible 2. Higher price 3. Closer to village 4. Other (specify)	1. Daily 2. 2-3 times a week 3. Weekly 4. Bi- weekly 5. Once a month 6. Once every few months 7. Twice a year 8. Yearly 9. Other (specify)	Kilometers	List	Yuan/ ton	List
E.1	Local market								
E.2	Province market								
E.3	Trader								
E.4	Wholesaler (directly)								
E.5	Processor (directly)								

Enumerator: Next, I will ask you a few questions regarding the potato traders who visit your village.

Potato Traders*

** Only ask if the participants indicate potato traders visit their village*

	1	2	3	4	5	6	7	8
	What are the names of the traders that visit this village?	**What is the sex of the trader?**	**How often does [trader] visit your village during harvest time?**	**Where is [trader] from?**	**What are the top 3 varieties [trader] buys?**	**Under the same situation, what would be the price paid by [trader] for [variety]?**	**Who does [trader] sell [variety] to next?**	**What is the name of the company or person [trader] sells to?**
	List	0. Female 1. Male	1. Daily 2. Once a week 3. Bi-weekly 4. Monthly 5. Annually 6. Other (specify)	List	1. C88 2. Hui-2 3. Weiyu No. 3 4. Xuanshu No. 2 5. Mira 6. Lishu No. 6 7. Hongyanwo (Gama No.2) 8. Unica 9. Other (specify)	Yuan	1. Wholesaler 2. Chip processor 3. French fry processor 4. Starch processor 5. I don't know 6. Other (specify)	List
E.6 Trader 1								
E.7 Variety 1								
E.8 Variety 2								
E.9 Variety 3								
E.10 Trader 2								
E.11 Variety 1								
E.12 Variety 2								
E.13 Variety 3								
E.14 Trader 3								
E.15 Variety 1								
E.16 Variety 2								
E.17 Variety 3								

E.18 Trader 4								
E.19 Variety 1								
E.20 Variety 2								
E.21 Variety 3								

Module F: Extension Services and Farmer Organizations

Enumerator: Next, I will ask you questions regarding extensions services and farmer organizations in your village.

Extension Services

F.1	**Does an agricultural extension agent visit your village?**	0. No>> F.3 1. Yes>> F.2	
F.2	**How often does an agricultural extension agent visit your village?**	1. Daily 2. 2-3 times a week 3. Weekly 4. Bi- weekly 5. Once a month 6. Once every few months 7. Twice a year 8. Yearly 9. Other (specify)	

Farmer Organizations

F.3	**Are there any farmers' organizations in your village?**	0. No>> End interview 1. Yes	

	1	**2**	**3**	**4**	**5**
	What is the name of the farmer organizations in your village?	**What proportion of farmers participate in [organization]?**	**Can women participate in [organization]?**	**What is primary purpose of [organization]?**	**What is the secondary purpose of [organization]?**
	List	%	0. No 1. Yes	1. Training 2. Market members' potatoes 3. Supply seeds 4. Credit 5. Rent land 6. Other (specify)	1. Training 2. Market members' potatoes 3. Supply seeds 4. Credit 5. Rent land 6. Other (specify)
F.4					
F.5					
F.6					
F.7					
F.8					
F.9					

Thank you for taking the time to fill out our survey. Your input is greatly appreciated.

APPENDIX C: Sample Design and Size

Sample size was calculated using four criteria: 1) Intra-class correlation coefficient (ICC), 2) Optimal cluster size, 3) Design effect, and 4) Minimum sample size.

1. ICC

The intra-class correlation reflects the degree of homogeneity between the clusters. Traditionally, the correlation is obtained from previous surveys from the study area. Since there was little information on previous surveys from the study area, we assumed the value of 0.0585 based on previous adoption statistics and knowledge. ICC measures the variability among households for the variable in interest which in this case is potato varieties. A high ICC value was chosen because farmers in Yunnan because farmers have fewer varieties to choose among for their adoption decision. Originally, an ICC of 6% was chosen but had to be decreased slightly to decrease the number of clusters to account for the high cost of transportation in Yunnan as well as to maintain the methodology of interviewing at least 600 households. This is why 0.0585 was used.

2. Optimal Cluster Size

The optimum cluster size, b_{opt}, is determined by a basic cost calculation as seen in Equation 1.

(1) $$b_{opt} = \sqrt{\frac{C_1}{C_2}\frac{(1-\rho)}{\rho}}$$

Where C_1 is the cost of an additional cluster, C_2 is the cost of an additional household, and ρ is the intra class correlation. The costs of sampling an additional household, C_2, and cluster, C_1, is presented in Table 4. The variables were calculated by adding the costs estimated for each component by Dr. Canhui Li, professor and researcher at Yunnan Normal University. The resulting b_{opt} was 15.0843 which represents the optimal number of households to select at the second stage.

Table 4. Cost of adding a cluster (e.g. village)

Category	Cost of surveying 1 HH	Cost of a cluster (10HH per village)
Enumerators (5)	$ 60.0	$ 300.0
Supervisors	$ 15.0	$ 200.0
Driver	$ 10.0	$ 400.0
Supplies	$ 2.0	$ 30.0
Guides	-	$ 300.0
Total	**$ 87.00**	**$ 1,230.00**

3. Design Effect

The design effect (Deff) is "the ratio of the variance of the estimator under the design and the variance of the estimator under a simple random sampling design" (Walker & Adam, 2011, p. 8). Although under cluster sampling, Equation 2 can be used where its use depends on the b_{opt} and the ICC. By using previous parameters, the resulting Deff was 1.819.

(2) $Deff = 1 + (b_{opt} - 1)\rho$

4. Sample Size Calculation

For the clustered random sampling, the confidence interval approach was chosen. We wish to be 95% confident that the estimated adoption rate is within 4% of the true adoption rate. To determine the sample size with these parameters, we used Equation 3.

(3) $$n \geq \frac{z_{0.95}^2 NP(1-P)}{(N-1)l^2 + z_{0.95}^2 P(1-P)}$$

Where n is the sample size, $z^2_{0.95}$ is the z value for the 95% confidence interval, N is the estimated total potato area in Yunnan, P is the estimated adoption rate of C88 in Yunnan, and *l* is the precision level of the sample or how closely the sample estimate is to the true population value. Table 5 has the values used in this study. The P used was the adoption rate for C88 in late spring calculated

during an expert panel on potato varieties in Yunnan in March 2015. It was estimated with 95% confidence and a 4% precision level that a minimum sample size of 338 was required.

Table 5. Parameters used to calculate minimum sample size

Parameter	Value
$z^2_{0.95}$	1.96
N	400,000
P	0.17
l	0.04
Minimum sample size	338

To determine the final sample size, the calculated minimum sample size from above must be multiplied by the Deff. This corrects the sample upwards to compensate for the loss of variability among households in clusters who are expected to show less variability in various outcome variables, such as the number of potato varieties and the adoption rate of those varieties (Labarta, et al., 2012). The final estimated minimum sample size was 616 households. With a cluster size of fifteen, the final sample size was 615 in 41 villages (Table 6).

Table 6. Parameters used to calculate final sample size

Deff	1.819
Minimum sample size	338
Final sample size	615
Final number of villages	41

Once the required number of households was determined, probability proportionate to size (PPS) was used to select at four levels: city/county, town, village committee, and village. Each level was weighted by the potato area of each level. City/county level were selected based on data from the proposal to the Special Programs on Impact Assessment entitled “Adoption and Diffusion of C88

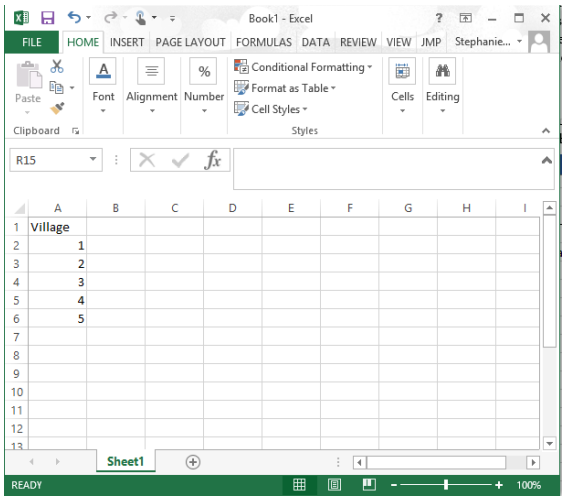
Potato Variety in China: Spatial Variability of Productivity Gains and Cost Savings and Value Chain Development". The selected counties were determined prior to arriving in China.

There was no reliable data about the lower levels; therefore, the PPS selection for the lower levels were completed after arriving in China. To obtain this information, government officials and extension agents from the county/city were contacted to provide the potato area for the towns. This process continued until the village level. Once the village was reached, the village leader would provide a list of current households and from this list a random selection, without weighing the households by potato area, of fifteen households was developed.

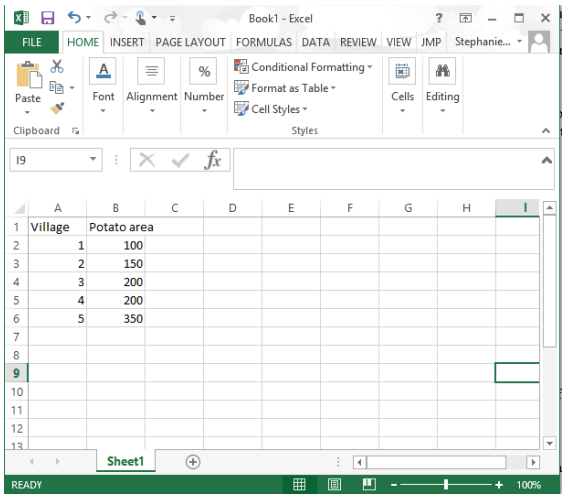
APPENDIX D: Random Sampling Procedure

Random sampling for this study was done at 6 different geographic levels: prefecture, city/county, town, village committee, village, and household. Each unit within the levels were weighted based on potato area. Potato area was provided by lists given by government officials at each level. Below is the procedure for how to complete a random sample for a village in Excel.

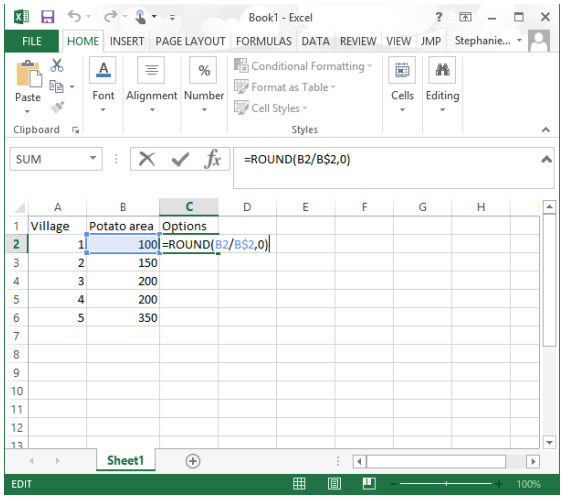
1. Open a blank Excel file.
2. In the first column, type the village names or numbers. If writing numbers, please write the coordinating villages names on a separate sheet of paper.



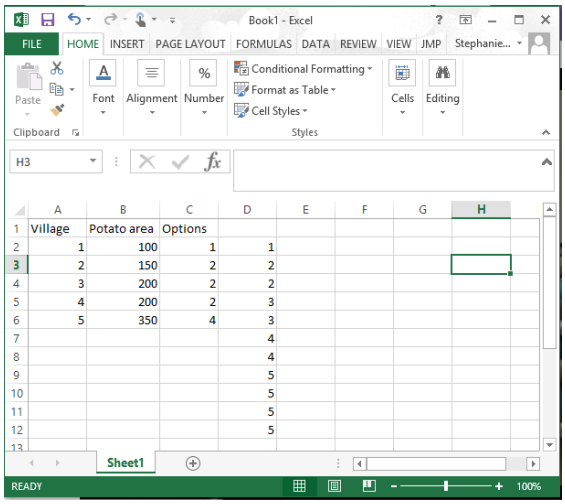
3. In the second column, type the potato area for each village.



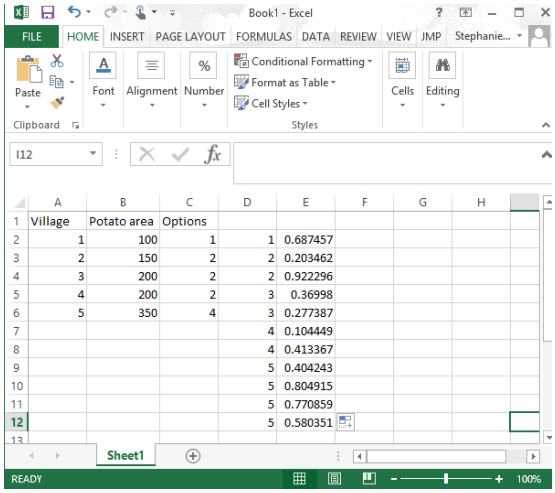
4. Next, identify the smallest potato area. In the third column, you will type the command =round() and within the parentheses, divide each row by the cell containing the smallest potato area. In the denominator, use a "$" in the denominator before the row number. After the denominator, put a comma then 0 indicating you want no decimal places. Drag the code down the options column.



5. In another blank column, type out each village the number of times indicated in the option. For example, village 1 was chosen 5 times. You will write village 1 in a different row 5 times.

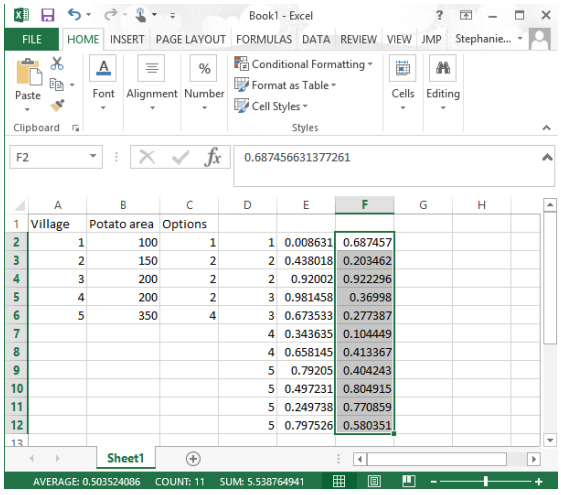


6. In the next blank row, type the code =rand() and then drag down the entire list of options.



	A	B	C	D	E	F	G	H
1	Village	Potato area	Options					
2	1	100	1	1	0.687457			
3	2	150	2	2	0.203462			
4	3	200	2	2	0.922296			
5	4	200	2	3	0.36998			
6	5	350	4	3	0.277387			
7				4	0.104449			
8				4	0.413367			
9				5	0.404243			
10				5	0.804915			
11				5	0.770859			
12				5	0.580351			
13								

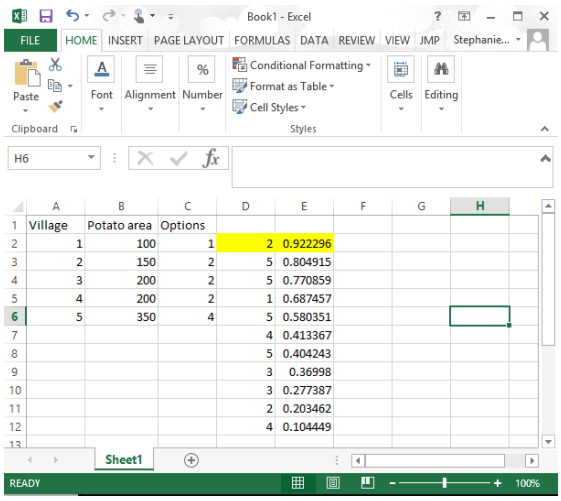
7. Copy the random values and paste as a value in the next blank column.



	A	B	C	D	E	F	G	H
1	Village	Potato area	Options					
2	1	100	1	1	0.008631	0.687457		
3	2	150	2	2	0.438018	0.203462		
4	3	200	2	2	0.92002	0.922296		
5	4	200	2	3	0.981458	0.36998		
6	5	350	4	3	0.673533	0.277387		
7				4	0.343635	0.104449		
8				4	0.658145	0.413367		
9				5	0.79205	0.404243		
10				5	0.497231	0.804915		
11				5	0.249738	0.770859		
12				5	0.797526	0.580351		
13								

8. Delete the first column of random values.

9. Next, click the Sort button. Choose custom sort. Pick the two columns with the random values and options. Sort the column of random values largest to smallest.



10. This will be the villages, in order, in which you visit. If two villages are supposed to be visited in the county, please choose the top two. 15 surveys must be completed in each village.

11. If the village is listed twice in a row, you will complete 30 surveys there.

APPENDIX E: Value Chain Interviews

Date: August 8, 2015
Location: Zhaotong City, Zhaotong, Yunnan, China
Interviewee: Mr. Hu
Occupation: Researcher and Potato Breeder

1. Does the local government (or other level of government) decide in every town/village what varieties are available?
   Yes. The local government gets advice from the extension station and the potato seed company.

2. Are seeds always free?
   No.

3. How do they make the decision for which varieties are available and not?
   The local government gathers advice and then makes the decision.

4. Who gives these seeds to farmers?
   The local government gets the seed from the extension station and the seed company.

5. Why do people not multiply seed and sell them to another town?
   The people from the lower altitudes trade seed with those in the higher altitudes.

6. Why do farmers not know about any diseases or pests?
   In this city, a lot of the young and educated people are leaving the farming areas. This means the disabled, women, children, and others are left who have do not have interest in these things. Potato prices are not very high. We sometimes offer to pay the farmers to attend trainings and the farmers say no because they have no interest. Even if they do come, some come to get the money but do not pay attention to the training. Also, there are no farmer cooperatives.

7. Where do farmers say there is no extension?
   Extension agents visit the village, but few farmers know what extension is.

8. What is extension doing when they are not helping farmers in the field?
   We are also responsible for projects given to us from the province. Our main job is training farmers and to solve any problems during the growing season.

9. How did he get C88? Who did he hear about C88 from? Where did he first hear about it?
   The invitro plantlet was from Canhui. We heard about it from Canhui as well.

10. Why does he think C88 will be successful in Zhaotong? Market demand such as the potato chip factory? Late blight resistance? Tastes good?
    C88 has a good market here. Most people know about C88. We are now exploring the suitable high altitude areas for C88 and its growth in the winter season. We also

would like to do a trial in early spring. The local market is driving the demand. In Ludian County in Zhaotong, there is a chip processing company. This variety is highly demanded by chip processors so we think this will be beneficial to farmers.

11. How does C88 compare to the current varieties?
    The advantages to C88 is the good quality, good taste, and shallow eyes. The late blight resistance of C88 is better than medium and early maturing varieties. The market also demands C88. The disadvantages to C88 is the smooth skin. Farmers harvest based on market demand so they harvest C88 too early since it is a later maturing variety. This causes the skin to be damaged.

12. Does anyone plan to spread the seed? Who multiples the seed?
    Yes. All the seed companies here plan to multiply C88.

13. Where does he plan to spread the seed? And why?
    We plan to spread it in the winter, early spring, and high altitude areas. We want to spread the seed in Ludian County in hopes they connect with the chips processing company. It will help the company with transportation costs.

Some notes on the processing company, Yunnan Lishi Industry (Group) Ltd. Co.:
This company was built in 1996.
This company processes 28,000 tons of potatoes in 2013. In 2014, this company processed almost 40,000 tons of potatoes.
In the most recent 3 years, Zhaotong City released 5 varieties that are good for chip processing.

Notes:
C88 was introduced to Zhaotong City in 2001. In this city, we have four processing companies. We have 200 Rural Farmer Cooperatives in the City (this is all of Zhaotong).

Date: August 8, 2015
Location: Huize, Quijing, Yunnan, China
Interviewee: -
Occupation: Deputy Director of Extension

1. What areas of the county do you primarily work? How do you choose which areas to work in?

   We work all over the county.

2. Does your office provide trainings? What other services does your office provide?

   Yes, we provide training. We also teach farmers how to plant, till, and harvest potatoes. We help farmers to solve any problems during the growing season. We focus mainly on big farms (100-200 mu). We also help farmers who show interest in learning more. We call these farmers "technology demonstration farmers". These farmers show interest by writing a letter or filling out an application. During harvest time, we will conduct demonstrations and invite big farmers, technology demonstration farmers, staff from the town level extension, and the leader of the town level extension station. These farmers can see the yield of any variety we chose. Farmers then can show interest in which varieties they like so our station can provide seed for these varieties for big farmers. During these demonstrations, about 150 people attend. We are also responsible for doing maize and wheat demonstrations. We get money to do these demonstrations from the province as well as the Ministry of Agriculture (MoA).

   The largest variety in Huize County is Hui-2, because it is adaptable and has a stable yield. Most of the late spring harvest goes to other places such as Guangdong Province and Chongqing City. People in Chongqing City buy this variety mainly for hot pot restaurants. Only 30% stays in Huize County. 70% goes to the other places.

3. Where can you find seed potato (cities, town, villages)? How do farmers get seed?

   Seed can be found in the market. In the high altitude areas, farmers do not buy new seed often. They usually use their seed for ten years. In the mid and low altitude areas, they buy new seed. In the west and central region of Yunnan Province, farmers often buy new seed like Honghe Prefecture.

   We also have a Farmer Rural Cooperative. This cooperative and the large farmers grow 6000 mu per year of generation 2 seed to sell.

4. Is seed potato from extension free to farmers?

   Sometimes. It depends.

5. How do you decide which varieties to multiply and to spread?

   We choose and multiply the varieties that we believe have market demand. We are very knowledgeable about what the market wants. We also own a seed company. We produce 8 million mini-tubers per year. We distribute 3 million mini tubers to the big farmers for free. 5 million mini tubers are given to our seed company. Our company

sells part of these 5 million and the other part we multiply to get generation 2 to then sell. We grow 600 mu per year to produce generation 2 seed.

6. Why did farmers stop using C88 so quickly?
   In 2001, C88 was released. C88 was widely grown until 2010. The majority of C88 was grown in Jiache village. The peak of C88 adoption was 2005 and the planting area was 200,000 mu. C88 still grow in Jiache village because it is a higher altitude. C88 has problems with late blight and seed generation. By this point, most farmers have stopped growing C88. Also, the price for C88 is not much higher when compared to other varieties. Farmers also like variety diversity so they have begun to diversify more.

7. How fast was the seed degeneration of C88?
   10 years.

8. If you had to say, what was the yield of the first year?
   The first year was greater than 3 tons per mu.

9. Was/is there a market for C88?
   Yes, there is still a market for C88. The price of C88 is about 0.4 Yuan/kilogram greater than Hue-2.

Notes:
This extension station is also a breeding institute so they want to spread their own varieties.

Date: August 13, 2015
Location: Angel Potato Chips, Xuanwei, Quijing, Yunnan, China
Interviewee: Director Zeng
Occupation: Business Manager for Angel Potato Chips

1. What products does your business sell?
   We sell potato chips in six different flavors.

2. How long has your business existed?
   The business began in Kunming in 1986 and moved to Xuanwei in 2012.

3. Is your business located in other places?
   We have 3 branches: Ludian County in Zhaotong City, Xian City in Shaanxi Province, and Liupanshui City in Guizhou Province.

4. Have you seen an increase or decrease in demand in the past 5 years for your products? Why do you think so?
   There has been an increase in demand by 15-20% per year. The increase is because the customers like any kind of chips.

5. How many people do you currently employ?
   We employ 100 people.

6. What is the wage for an employee? Are there different pay scales depending on the worker?
   The salary of the people who work in the factory depends on the production. Administrative staff have a stable salary. The salary for all staff increases by 10% every year.

7. How many potatoes do you demand all year? Can you receive potatoes whenever you want or are there times during the year that are difficult to buy potatoes?
   We plan to process 20,000 tons every year. The real production is 4,000-5,000 tons per year. We cannot receive potatoes whenever we want. During the early spring season (January-April), we have trouble getting enough potatoes, but we can still get some potatoes. We have a constant demand throughout the year.

8. Does your company own and operate a farm? Why do you do this instead of purchasing from farmers?
   We do not have our own farm.

9. What varieties do you buy?
   >90% of our potatoes are C88. We also use Atlantic and Xuanshu-2 which accounts for less than 10%.

10. How much do you pay for a [unit] of [variety]?

    Xuanshu-2 costs 0.2-0.3 Yuan/ kilogram less than C88. Atlantic costs 0.5-0.6 Yuan/kilogram more than C88. C88 costs 1.5 Yuan/ kilogram. The quality of C88 is better than Xuanshu-2 which is why it costs more. Atlantic costs more because it is better quality and there is less production in this area compared to C88 and Xuanshu-2.

11. What traits do you look for in a variety?

    The size of the C88 potato is 60-200 grams per tuber which is ideal. For all varieties, the specific gravity should be 1.0881, the reduced sugar should be 150-250 milligrams/kilogram, the starch content should be 14.169%, and the dry matter content should be 19.921%.

12. How do you choose which varieties to buy?

    We choose our varieties based on the above traits.

13. Does your business pick-up the potatoes or are the potatoes brought to the business? What kind of costs does this incur?

    In each village, we make connections with a trustworthy local. This person will collect all of the potatoes for us. They then hire a truck to bring the potatoes to us.

    (These business people pay the farmers for their potatoes. The company will reimburse the business person after they have received the potatoes. The company usually pays the business person based on the amount of potatoes received, a small salary, or per diem).

14. Where do you get your potatoes from? Specific towns or villages.

    We get our potatoes from Xuanwei City and Xundian County in Kunming City.

15. Do you contract with these farmers?

    No, we do not contract. We have no conditions with the farmers which is why we do not contract. We send a buyer to the areas in Yunnan where C88 is growing. This helps us determine how many potatoes we will be able to purchase at harvest. At this time, we can tell farmers that if their potatoes are of good quality, we will pay a specific price.

    (It is more of a verbal agreement. The company tells the farmers that if they send their potatoes to the company, they will pay a specific price. If the company receives the potatoes and they do not like them, they are allowed to send them back.)

16. How do you ensure quality in your potatoes? Do you have standards for the farmers?

    We send staff to the field to inspect the potatoes before we purchase them. We use test paper to test for reduced sugar. We also cut the potato in half and see what the quality of the potato is inside. We also do visual inspections of the skin and the size of the potato. We only buy medium-sized tubers with the specific traits I had mentioned.

17. Does price vary over the year? When are the peaks?

Yes, the price of C88 varies over the year. From January to February, the price is higher. It is about 2.8 Yuan/kilogram. From July to August, the price is lower. It is about 1.5 Yuan/kilogram.

18. Do you mix the varieties when making the chips?

No, we do not. There are different standards for processing the chips for each variety. For example, the temperature of the oil is different for each variety.

19. How much do you sell your products for?

A small bag is 1 Yuan/ 18 gram bag.

20. Who do you sell to?

We sell our potatoes to an agent who then sells the potato chips to grocery store and other markets. We do not sell directly. The places we sell our products are Yunnan, Guizhou, and Sichuan Provinces.

21. When did you first buy C88?

I do not remember clearly, but I think it was 2005. I joined this company in 1997, and at this time, the raw material was Gama-2.

22. Do you still buy C88?

Yes.

23. Is/was the price higher for C88? If so, why?

Yes, because the quality is higher than other varieties. It is less than Atlantic though.

24. What do you like about C88? What do you not like about C88?

I like C88 very much! I dislike that it has a disease that none of the other varieties have. (Junhong says it is a problem with boron and the potassium level in the soil or verticillium wilt.)

25. Is C88 different than the other varieties you buy? If so, what?

The quality of C88 is better.

26. Do you have storage for potatoes?

No, we do not. We can buy fresh potatoes all year around in Yunnan.

27. Do you see any of these issues below as constraints to your production of [product]?
    a. No market to sell to
    b. Not high enough quality/ can't meet standards
    c. Storage
    d. Distance to market
    e. Consumers will not accept your price
    f. Traders or farmers will not accept your price
    g. Transportation is too costly
    h. Roads are not safe

    No, we do not have any constraints to production.

Notes: This company is owned by the government.
Atlantic has low late blight resistance which makes it unsuitable for this area. This is part of the reason for why it is more expensive.
Farmers like to sell to potato chip factories because they only want medium sized potatoes. The large ones can be sent to market for an even higher price. The smaller potatoes can be sold to restaurants, especially barbeque restaurants.

Date: August 13, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Wholesaler group (2 people)
Occupation: Wholesaler

1. What crops does your business sell?
   We only sell potatoes.

2. How long has your business existed?
   We have been in business since 1983.

3. How many people do you currently employ?
   We do not employee anyone. Our two families work together. Mainly it is myself and my business partner. Sometimes our wives help us.

4. Where do you get your potatoes from? Specific towns or villages.
   We get our potatoes from Longchang, Baoshan, Lefeng, Geyi, Reshui, Luoshui, and Banqiao.

5. Do you contract with these farmers? Do you buy from a trader? How do you get in contact with the person in which you buy the potatoes from?
   No, we do not do contracts. We buy from a businessman in each village. We pay the business man 100-120 Yuan/ton. This 100-120 Yuan includes 20 Yuan for the bags and the bagging of the potatoes, 10 Yuan in case of loss when carried, and 20 Yuan for carrying the potatoes. The businessman will employ people to assist in these activities. Therefore, the income for the businessman is 60 Yuan/ ton.

6. How do you ensure quality in your potatoes? Do you have standards that farmers must meet?
   The businessman and both of us will visit the village before the potatoes are loaded onto the trucks. During this time, our wives will help us do the business in Xuanwei. We check them by cutting the potatoes in half and inspecting the outside of the potato for its color, shape, and size.

7. Does your business pick-up the potatoes or are the potatoes brought to the business? What kind of costs does this incur?
   The potatoes are brought to us. The cost of transport is 50-60 Yuan per ton in the truck.

8. How many potatoes do you demand all year?
   We sell 40,000-50,000 ton per year. In the Xuanwei market, there are 50 other wholesalers.

9. What varieties do you buy?
   We buy Xuanshu-2, Hue-2, Weiyu-3, Gama-2, and C88.

10. What traits do you look for in a variety?
It depends on the market. We have partners in other counties and provinces that we work with. If they need a certain variety, we will work together to get them that variety which is why it depends on the market.

11. How do you choose which varieties to buy?
It depends on the demand.

12. Does price vary over the year? When are the peaks?
Yes. The winter season costs us the most. The potatoes in late spring are the lowest.

13. How much do you sell [variety] for?
We earn 40-50 Yuan/ton.

Xuanshu-2: 1.1-1.2 Yuan/kilogram
Hue-2: 0.8-0.9 Yuan/kilogram
Weiyu-3: 1.3-1.4 Yuan/kilogram
Gama-2: 1.1-1.2 Yuan/kilogram
C88: 1.4-1.5 Yuan/kilogram

14. Who do you sell to? Where do you sell? Is your business located in other areas?
We sell to larger wholesalers in other cities and provinces in Southwest China, such as Hubei, Hunan, and Chongqing. We have relations with these people because they are our friends. We do not have branches.

15. When did you first buy C88?
We first bought C88 in 2000.

16. Do you still buy C88?
Yes.

17. Is/was the price higher for C88? If so, why?
Right now the price is higher but sometimes it is lower. In recent years, there has been more fluctuation because of disease. 10 years ago the demand for C88 was very high. It is lower now because of maybe climate change, disease, and decrease in yield. The market for Xuanshu-2 is relatively stable.

18. What do you like about C88? What do you not like about C88?
We do not like the disease. If the problem of the disease can be solved then we will really like C88.

19. Is C88 different than the other varieties you buy? If so, what?
Yes. The yield for C88 is not stable which makes the market for C88 unstable.

20. Do you have storage for potatoes?
We have a little storage based on the market demand. Sometimes we store a little until demand is better.

21. Do you see any of these issues below as constraints to your production of [product]?
- No market to sell to
- Not high enough quality/ can't meet standards
- Storage
- Distance to market
- Consumers will not accept your price
- Traders or farmers will not accept your price
- Transportation is too costly
- Roads are not safe

Between May to June, there are very little potatoes in Xuanwei.

Notes:
The wholesale manger:
We sell 200,000 tons from the Xuanwei market to another market every year. In 2010, C88 accounted for 50,000 tons. Now it accounts for less than 30,000 tons. We have no business with the chip processing company. We became a part of this market in 2010. I am also the leader of the Potato Marketing Association for Xuanwei. We have 50 members in this organization which are wholesalers.

Date: August 13, 2015
Location: Yundian Starch Company, Xuanwei, Quijing, Yunnan, China
Interviewee: Director Lin
Occupation: CEO for Yundian Starch Company

1. What products does your business sell?
   We sell potato and cassava starch.

2. How long has your business existed?
   We have been in business since 2012. The government convinced me to move here by giving me a subsidy to rent the land.

3. Is your business located in other places?
   We have 2 other branches in Honghe Prefecture.

4. Have you seen an increase or decrease in demand in the past 5 years for your products? Why do you think so?
   We have seen a significant decrease in demand, because European starch is cheaper. Many people import European starch instead of buying from China. Consumers have less income than in previous years and the economic growth for business has declined. People's spending power has gone down. In 2013, the price for our product was 8500 Yuan/ton and now is 6200 Yuan/ton. European starch is 6100 Yuan/ ton. Our starch is mainly used for instant foods, restaurants, and households. The use of starch in these products has decreased significantly, especially restaurants, which has hurt our business.

5. How many people do you currently employ?
   ~70 people. If we can get enough raw materials, we employ 100 people. The ratio of people in the factory to administrative people is 7:1. Employment in the recent year did not change very much.

6. What is the wage for an employee? Are there different pay scales depending on the worker?
   The salary for people in the factory per month is 2500-3000 Yuan. The salary for the administrative workers is stable.

7. How many potatoes do you demand all year? Can you receive potatoes whenever you want or are there times during the year that are difficult to buy potatoes?
   We demand 6000 tons of potatoes per year. We never get 6000 tons though because the potato production is not enough. It is especially hard during the rainy season.

8. What varieties do you buy?
   We purchase any varieties. The main varieties are Dianshu-6 and Hue-2. We also like Unica, C88, Xuanshu-2, and Weiyu-3.

9. How much do you pay for a [unit] of [variety]?
   Dianshu-6: 0.9 Yuan/kilogram
   Hue-2: 0.7 Yuan/kilogram
   Unica: 0.9 Yuan/kilogram
   C88: 0.9 Yuan/kilogram for good quality potatoes
   Xuanshu-2: 0.8 Yuan/kilogram
   Weiyu-3: 0.8 Yuan/kilogram

10. Does price vary over the year? When are the peaks?
    Yes. It also depends on the starch price in the market. After October, the market needs a lot of starch. In about May, the price of starch is higher. The price for potatoes changes as the price for starch changes.

11. What traits do you look for in a variety?
    We only care about high starch varieties.

12. How do you choose which varieties to buy?
    We choose varieties that have high starch. I do not care about price because I will give a farmer a high price if the variety has high starch.

13. Does your business pick-up the potatoes or are the potatoes brought to the business? What kind of costs does this incur?
    Farmers will send the potatoes to the company. At the beginning of the season, we tell the local government what price we are willing to pay for potatoes. We receive potatoes from farmers and traders that were not sold in the market or anywhere else. One reason our potato starch is more expensive than the European starch is because we have trouble receiving potatoes with high starch. For example, European starch companies can use 4 tons of potato to get 1 ton of starch (4:1). Here, we use 6 tons of potatoes and only get 1 ton of starch (6:1). This is because many of the potatoes we receive are low quality and small with a low starch content.

14. Where do you get your potatoes from? Specific towns or villages.
    We get our potatoes from this province and others. The places where our potatoes come from are Weining County in Guizhou Province, Xundian Conty, Luliang County, Xuanwei City, Huize County, Chuxiong Prefecture, Luxi County, Yingjiang County, Mengzi County, and Jiangshui County.

15. Do you contract with these farmers? Do you buy from a trader? How do you get in contact with the person in which you buy the potatoes from?
    We do not contract. We buy from traders. Farmers will come to our company and we will buy the potatoes. If they are from Xuanwei, we must buy the potatoes at the price we had promised to the local government. We always buy the potatoes when farmers come because we need them. If farmers come from outside Xuanwei, we may give them a lower price since we are not bound to a price.

16. How do you ensure quality in your potatoes? Do you have standards that farmers must meet?
    No.

17. If trader, do you know how much the trader pays the farmers?
    No, but we know the traders can earn 20-30 Yuan/ton.

18. Do you mix the varieties when making the starch?
    Yes.

19. How much do you sell your products for?
    1.98 Yuan/ 200 grams. 6200 Yuan/ton.

20. Who do you sell to?
    Restaurants, medicine companies, instant food companies, and households.

21. When did you first buy C88?
    In 2012 because that is when we built our company.

22. Do you still buy C88?
    Yes.

23. Is/was the price higher for C88? If so, why?
    A little higher because the starch is higher.

24. What do you like about C88? What do you not like about C88?
    It all depends on the starch level. In this city, the starch of C88 is not very high. It is higher in other areas such as Shangri-La. C88 has a medium-level of starch.

25. Is C88 different than the other varieties you buy? If so, what?
    Yes, it has lower starch and lower yield compared to Dianshu-6, Hue-2, and Xuanshu-2.

26. Do you have storage for potatoes?
    No, because we can get potatoes year around.

27. Do you see any of these issues below as constraints to your production of [product]?
    - No market to sell to
    - Not high enough quality/ can't meet standards
    - Storage
    - Distance to market
    - Consumers will not accept your price
    - **Traders or farmers will not accept your price**
        - Part of the reason we do not receive enough potatoes is because farmers can sell their potatoes elsewhere for a higher price. As I mentioned, this is why we receive lower quality and smaller potatoes.
    - Transportation is too costly

- Roads are not safe

Notes: Many starch processors do not care about price because they do not have enough raw materials so they have little choice in what they get.

Date: August 13, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Li Bin
Occupation: Extension Officer

1. Does the local government (or other level of government) decide in every town/village what varieties are available?

   Yes. The real decision is not made by the local government. The local government provides the seed for a low price for the varieties that they believe will be good for the natural conditions.

2. Are seeds always free?

   No. Before 2014, the local government gave subsidized seeds. It cost 0.12 Yuan per mini tuber. Now, from 2015, the local government does not give the farmers a subsidy. The farmers have to buy the seed for 0.22 Yuan per mini tuber. These prices are for most varieties. Most farmers grow Xuanshu-2, Weiyu-3, or C88.

3. How does the local government make the decision for which varieties are available and not?

   They make the decision based on advice from the extension station as well as other research institutes. Most of the decision is based on the advice from the extension station. Here the extension is a part of the Agriculture Bureau.

4. Who gives these seeds to farmers?

   This extension station mainly focuses on big farmers. The extension station gives seed to the big farmers. The big farmers will then sell the seed to farmers around them. We mainly focus on the big farmers because we did not have enough staff or money to help all the small farmers.

5. Why don't any farmers sell their seeds to another town?

   People do this, but it is only a few people. This is because most villages plant potato for home consumption or for their animals. Many farmers do not want to buy high quality seed for this reason.

6. Why do farmers not know about any diseases or pests when there is a problem?

   Extension does training for the farmers, but the farmers in the villages have poor education. In the village, there are disabled people, old people, females, and children. These people do not want to learn more and farmers cannot remember everything that they are trained on. I did a training in a village and when I returned, I showed them the same pictures. The people did not remember the disease or pests.

   For big farmers, we used a helicopter to spray fungicide on their fields. We spend about 80 Yuan/mu for large farmers. We do not have enough staff to do training for all farmers. Even if we want to, extension cannot pay for our per diem.

7. Why do farmers say there is no extension?
   Staff and money are an issue. Most small farmers may say that because we focus on the bigger farmers.

8. When was C88 introduced to this area?
   I introduced C88 to this area in 1997 or 1998.

9. Who introduced C88 to this area?
   Me.

10. Who multiplied the C88 seed?
    Our extension station multiplied the seed from 2009 to now.

11. Did extension sell or give the C88 seed?
    Yes, we sold the seed to the farmers.

12. Do farmers still grow C88 here? Where?
    Yes, they still grow it in Reshui, Dongshan, Baoshan, Lefeng, and Banqiao. Most of the area is an altitude above 2,200 meters.

13. Where do these farmers mostly sell their C88 potatoes?
    Most sell to the local market. In the winter season, big farmers sell seed.

14. Does C88 receive a higher price? Why?
    It depends on the market.

15. Where can farmers buy C88 seed?
    The small farmers buy the seed from the extension station, but most of the small farmers buy the seed from the big farmers.

16. Do farmers buy C88 seed?
    A few small farmers do but the big farmers do. The big farmers buy generation 1 tubers (mini tuber or basic seed). They then multiply the seeds and sell generation 2 or 3 seed to other farmers.

17. Why did he choose to introduce C88?
    I think the shape, yield, and taste are good.

18. Which varieties are replacing C88 and what varieties replaced C88?
    C88 replaced Gama-2 and Mira. Xenshu-2 and Weiyu-3 are replacing C88.

19. Why did farmers buy the C88 seed from extension?
    We introduce farmers to varieties by inviting them to a demonstration plot and describing the benefits of each variety. Once the farmers see the variety, they can purchase it from us.

20. What is better about C88 than the varieties it replaced and what is better about the varieties that are replacing C88?

    Higher yield, better taste, and good shape.

21. What is the average C88, varieties it replaced, and the varieties replacing C88?

    The average yield for C88 is 2-3 tons per mu. The yield of Gama-2 and Mira was 1-1.5 ton per mu. The yield for Xenshu-2 and Weiyu-3 is 2-3 tons per mu.

22. Does producing C88 cost more, less, or the same than the variety it replaced?

    It costs the same.

Notes:
In the next year, they hope to expand multiply more C88 seed and sell it to the areas mentioned above. This year they produced 1 million C88 mini tubers.

Date: August 14, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Mrs. Liu
Occupation: Director of Yunnan Agriculture Technology Extension Station and Virus-Free Potato Seed Research Center

1. What services for the provincial level extension provide to lower level extension stations?
   We give general training, not technical training, for lower level extensions. The training is to learn more on management and administration.

2. What do you think is important to consider when choosing which seeds to multiply or to breed?
   We only give suggestions to lower level extension stations and seed companies.

3. How does the provincial level extension help prefecture and local governments about deciding which varieties to grow?
   We only give suggestions since we do not know the market as well as the local governments. We travel and examine the varieties in the field. Once we see how the varieties perform, we then can give recommendations to specific areas based on our observations.

4. Which traits do you believe are important to farmers and the market?
   Yield is the most important.

5. What do you see as major problems for potato production in Yunnan?
   Seed quality is a major problem. Disease spreads easily and can infect seed in the surrounding area. To solve this problem, we are working with local extension stations and seed companies to improve their seed quality.

6. Many extension stations give subsidies for seed. Do you give subsidies for specific varieties or all varieties?
   We only give suggestions on which varieties to give subsidies before. Since 2008, the provincial government has given subsidies for mini tubers. This stopped in 2012. The provincial government gave 1.5 million Yuan per year for mini tubers. The government also gave subsidies for generation 2 seed. 23 million Yuan per year was given for the generation 2 seed.

7. If specific varieties, how do you choose which varieties to give a subsidy for?
   It depends on the local extension station.

8. Many small farmers do not buy seed. They just replace the variety. Do you think this is a problem?
   Yes, this is a problem. Farmers want good quality seed for cheap. They do not care about the variety. The farmers only care about a high price. There is not enough good quality seed for every farmer in this province. We give subsidies for seed multiplication to the local extension station and companies. The companies and

extension stations have contracts with the local farmers to multiply seed. If the price for seed is high, farmers will break the contracts and sell in the market.

9. Where is C88 popular?

   C88 is most popular in the winter season. C88 is still one of the most popular varieties in the province. C88 is most popular in Dali, Huize County, and Xuanhei City.

10. What are the advantages and disadvantages of C88?

    The advantages of C88 are good quality and adaptability. It is especially good in winter and late spring. Two years ago Hue-2 and C88 were the most popular varieties in the winter season. The yield of C88 has decreased since then and has caused the variety to become less popular.

    The disadvantages of C88 is the decreasing yield, especially in Honghe Prefecture. C88 was replaced by Lishu-6, because the yield of this variety is better than C88. Lishu-6 also has good disease resistance.

Notes:
The agricultural extension stations do not focus on linking small farmers to market. Instead, they focus on large farmers and seed companies. Their main focus is seed currently.

The provincial extension is focused on a project where they integrate practices to determine the best practices to give the farmers the highest yields. This practices may include fungicides, drip irrigation, and different types of fertilizer. They focus this project on the main production areas of the province.

Date: August 15, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Director Li
Occupation: CEO of Guanghui Planting Ltd. Co.

1. How long has your business been operating?
   I have been in business as a trader or wholesaler since 1996. The company was built in 2010.

2. How many people do you employ?
   We employ about 30. Only 7 to 8 are stable positions.

3. Do you breed your own varieties or do you get varieties from others?
   No, we do not breed our own varieties. We get our varieties from extension stations, Yunnan Academy of Agricultural Sciences, and other seed companies.

4. What varieties does your company sell?
   We sell C88, Unica (Qingshu-9), Lishu-6, and Dianshu-6.

5. What traits do you view are important? Do you look for these traits when breeding or purchasing potato varieties?
   I think yield and late blight resistance are important. Sometimes I purchase varieties based on market demand.

6. How much does it cost to purchase a potato plantlet?
   It costs 0.27 Yuan per plantlet. I buy the plantlets, because if I buy mini tubers from other people, then I cannot guarantee quality. I buy the plantlets and multiple myself. Usually the price would be lower than 0.27 Yuan per plantlet if you have your own greenhouse, but I do not.

7. How much do you sell each variety for? Does price vary on the time of the year or the location?
   Unica (Qingshu-9): 2.1-2.2 Yuan/kilogram
   C88: 2.3-2.4 Yuan/kilogram
   Lishu-6: 2.3-2.4 Yuan/kilogram
   Dianshu-6: 1.4-1.5 Yuan/kilogram

   The quality of Dianshu-6 is not very good which is why it has a lower price. There is high market demand for C88 and Lishu-6 for the winter season which is why it costs more. Yes, price varies over the year and location. Price will be higher in the winter season, like October or December, for C88 and Lishu-6 because there is high demand for these varieties. Price is really dependent on the demand for the seed. If I do not sell the seed until March then the price will decrease.

8. In the last twelve months, what percent of your production did you sell?
   I sold 99%. Last year I sold 3000 tons.

9. Was this amount more or less than previous years?
   It was about the same.

10. When do you sell the most seeds during the year (months)?
    I sell most of my seed from September to December.

11. Have your prices been higher or lower than previous years?
    More or less the same.

12. Where do you sell your seed? In towns and villages?
    We sell approximately 60% of our seed to other province's governments for subsidy for farmers. The government may give me a higher price. The rest of my production is sold to other seed companies.

13. How do you decide where to sell your seeds? Do you introduce varieties to places or do you sell seeds based on what the farmers already grow?
    If a person is interested in my seed, they contact me. I do not need to market.

14. Who do you work with the most often? What is your relationship with local governments, universities, extension, and any other institutions?
    I work mainly with other province's governments. 30-50 people will visit my field during the growing season to see my plants to see if my seed is of quality.

15. Do you find it difficult to sell seed when farmers reuse their seed for many years and extension sometimes provides the seed for free?
    No, I do not.

16. How do you deal with seed quality issues?
    I will give the farmers the technology to know how to apply fertilizer and other ways to ensure good quality. I sometimes give them fungicide.

17. Do you have contracts with farmers to produce seed for you? What does these contracts stipulate?
    Yes, I do with 4-5 village committees. In each village committee, I have 2-3 employees. I will ask these employees to supervise the contract farmers to ensure quality.

    (These are not formal contracts. They are formal verbal agreements. This company owner has a good reputation with the farmers. He will not make an agreement with an untrustworthy farmer.)

18. Has demand for C88 seed increased or decreased in the last 5 years?

It has been stable. If C88's yield remains high, I think it will replace Lishu-6 in the winter season. The average yield for C88 in this area is about 1.2 ton per mu.

19. Do you see any of these issues below as constraints to your business?

a. No market to sell to
b. Not high enough quality/ can't meet standards
c. Storage

It is a little problem. The 1% that I do not sell I would like to store. I want to keep the seed when the price is low so I can wait until the price higher. I also would like to use the storage to sort through the seed.

d. Distance to market
e. Farmers will not accept your price
f. Transportation is too costly
g. Roads are not safe

Date: August 16, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Director Du
Occupation: Director of Liushao Town Extension and Xundian Gaoyuan Company

1. Does your office provide trainings? What other services does your office provide?
   Yes, we provide trainings. We have demonstration plots for new varieties and cultivation methods. We have a project on integrating new technologies and cultivation methods to increase yields.

2. What are the main varieties?
   The two main varieties are Unica and Xuanshu-2.

3. Do farmers still grow C88 in your area? Why not?
   No, they do not.

4. What is the history of C88 in your town?
   Mira, since the early 1980's, was the primary potato variety in my town. Farmers liked Mira because it had a high yield and good quality. The average yield of Mira was 1.5 ton per mu. In fact, many farmers from the nearby village would barter 1.5 kilograms of rice for 0.5 kilograms of Mira with our farmers. The average price for Mira was 0.3-0.4 Yuan/kilogram.

   In 1997, I brought a small box of C88 from Dr. Li's office to Liushao. We conducted the demonstration plots and the yield of C88 was very high. C88's average yield was 2.5 ton per mu. C88 also had high disease resistance, good shape, good skin color, good colored flesh, and light, shallow eyes. Quickly after C88 was released, C88 replaced Mira.

   Mira solved the problem of hunger in our town, but C88 increased people's incomes. The average price of C88 was 0.5-0.7 Yuan/kilogram. C88 had a significant influence on farmer's income. At the same time, the roads were being improved which helped farmers reach markets. Until 2003, C88 accounted for 90% of Xuandian County. Our town was also selling to two other locations: Guangzhou Province and Nanning City in the Guangxi Zhuang Autonomous Region. This was significant because these two locations originally purchased their potatoes from the north of China. Later on, they chose to start buying from us. From this, the market demand and price for C88 increased significantly. The price increased to 3.2-3.5 Yuan/ kilogram. The price also increased because of global inflation. As price increased, the income of farmers increased. However, since farmers always used saved seed with no crop rotations, C88 yield continually decreased until 2009.

   In 2009, there was a very serious drought which caused the yield of C88 to be 500-700 kilogram/mu. The yield decrease was not only because of the drought, but because the late blight resistance of C88 decreased. Farmers began to lose faith in C88, so we introduced new varieties to the farmers such as Unica. Because the skin

color of Unica is similar to C88, consumers were not able to distinguish the difference between Unica and C88. In the beginning, the price of Unica and C88 were the same price. A few years after this, the consumers were able to tell that the taste of C88 and Unica are different. Today, the price of C88 is still higher than Unica because consumers still prefer the taste of C88.

5. If you had to say, what was the yield of the first year of C88? What is the average yield of C88?

   The highest yield in the spring season was 3.5 ton per mu. The yield of the first winter season was 4 ton per mu. The yield of C88 is still high but it is less than 4 ton per mu because the late blight in winter season is very low.

6. Does a market still exist for C88 in your town?

   In the town, there is no market, but there is a market for C88 in the county.

7. How long has your seed company been operating?

   We have been operating since 1999. At that time, I just bought potato seed and sold the seed to the farmers. I also sold wild potatoes. In 2000, Oishi chip company built their company in Kunming. They asked me to help them get some raw materials. I sent C88 to the company as a sample. Before 2000, this company only used Mira. The company said C88 could be a substitute for Atlantic since Atlantic is not very common here. The company wanted me to grow Atlantic so I did in Yingjiang County, Dehong Prefecture. I grew 3000 mu of Atlantic. The yield of Atlantic was half of C88.

8. Where is your business located? Does it have any branches?

   We have no branches. Our company is only located in Liushao Town.

9. How many people do you employ?

   I employ 24 in total. 5 people are for marketing.

10. Do you breed your own varieties or do you get varieties from others?

    We do not breed. We only introduce varieties from Yunnan Agricultural University, Yunnan Normal University, and Yunnan Academy of Agriculture Sciences.

11. What varieties does your company sell?

    We produced 200 tons of Unica, 200 tons of Lishu-6, and 100 tons of Xianshu-2 this year.

12. What traits do you view are important? Do you look for these traits when breeding or purchasing potato varieties?

    C88 and Mira have a long history in Yunnan Province. Farmers and consumers have grown accustomed to these two varieties. Therefore, the customers and farmers like the yellow fleshed varieties. This is why I think the shape of the tuber, the flesh color, and skin color are the most important.

13. How much does it cost to purchase a potato plantlet?
    It does not cost; it is for free. The Yunnan Academy of Agriculture Sciences gave them to me for free. I get 1 to 2 bottles of plantlets a year.

14. How much do you sell each variety for? Does price vary on the time of the year or the location?
    Unica: 2 Yuan/kilogram
    Lishu-6: 3.5 Yuan/kilogram
    Xianshu-2: 3 Yuan/ kilogram

15. In the last twelve months, what percent of your production did you sell?
    I sold 100%.

16. Was this amount more or less than previous years?
    Before last year, I would buy and sell other seed as well as produce my own. This year I began to only sell my seed which is why it is less than previous years.

17. Do you find it difficult to get seed potatoes year around?
    No. This year I grew 500 mu for seed production.

18. When do you sell the most seeds during the year (months)?
    I sell most of my seeds between September and October.

19. Have your prices been higher or lower than previous years?
    My prices have been higher than previous years. Lishu-6 was a little higher because of the market demand. Xianshu-2 was lower than last year because of the market demand. Unica was lower last year because the seed of Unica has to compete with the Unica seed from the north of China. We harvest at the same time so there is more competition.

20. Where do you sell your seed? In towns and villages? Specific locations would be good.
    I sell most of my seed to the county near my town and in Baise City in the Guangxi Zhuang Autonomous Region.

21. How do you decide where to sell your seeds? Do you introduce varieties to places or do you sell seeds based on what the farmers already grow?
    The businessmen will find me, and I will sell there. Yes, I introduce varieties to places and do demonstration trials in the area.

22. Who do you work with the most often? What is your relationship with local governments, universities, extension, and any other institutions?
    I work with the prefecture level Agriculture Bureau, extension station, and big farmers the most. Most are in Dehong Prefecture.

23. Do you find it difficult to sell seed when farmers reuse their seed for many years and extension sometimes provides the seed for free?

    Yes, I find it difficult. The speed of degeneration for C88 is slow. The yield of different certified seed is more or less the same. This means the farmers do not like to buy new seed. The seed degeneration of Unica is faster than C88. Only a few educated farmers have realized they had to buy new seed to increase their yields.

24. How do you deal with seed quality issues?

    I can control all of the seed quality since I do not buy seed from farmers. I do the entire process at my company.

25. How do you market your seeds? Through farmer organizations? Extension?

    I do not market my seed. If anyone wants my seed, they come find me.

26. Why do you not sell C88?

    A bigger company in my area sells C88. I cannot compete with the big company. If anyone wants C88 seed from me, I buy it from the big company and sell to my customer.

27. Do you see any of these issues below as constraints to your business?
    a. No market to sell to
    b. Not high enough quality/ can't meet standards
    c. Storage
    d. Distance to market
    e. Farmers will not accept your price
    f. Transportation is too costly
    g. Roads are not safe

    No, I do not have constraints.

Date: August 16, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Director Ma
Occupation: Director of Kaiyuan City Hongling Planting Professional Cooperative

1. Where are you located?
   We are located in Zhongheying Town, Hui nationality village.

2. How many years has your cooperative been operating?
   We have been operating 3 years.

3. How many members are in your cooperative?
   We have 64 members.

4. How does a farmer become a member of your cooperative?
   Any farmer can join the cooperative.

5. What does the typical farmer in your cooperative look like? Farm size?
   A typical farm has about 14 mu.

6. What services do you provide to your members?
   We provide training, seed, and new variety introduction.

7. Does your cooperative charge fees?
   No.

8. What varieties of potatoes do most of the members in your cooperative grow?
   99% of members grow Lishu-6.

9. Do you have any contracts with seed companies?
   We have an informal contract to buy seed from the Lijiang Academy of Agricultural Sciences. The amount of seed we purchase for our members depends on the needs of the members.

10. Do you subsidize seeds for members?
    No.

11. Do your members grow seed potato?
    No. We grow 100% marketable potatoes.

12. How do you market seed to your members? Demonstration plot?
    We have our own demonstration plots where we show farmers how a variety will do in our village.

13. Why does your cooperative not grow C88?

    In 2000, the local agriculture bureau introduced C88 to us. Our farmers grew C88 for 2 years. Farmers stopped because the yield was too low and the business men in Beijing did not like the variety. We used to grow C88 and send it to the large Beijing market in the winter.

Notes:

The cooperative buys the seed from Lijiang Academy of Agricultural Sciences and sells it at a higher price to the farmers than what they purchased it for.

This cooperative does their own trials for new varieties for their farmers. If the trial fails, the cooperative will accept the loss.

This village won an award called the Yunnan Technology Demonstration Village, and because of this, each household in the village gets a higher subsidy.

Lishu-6, compared to C88, is above 3 ton per mu. C88 is, at most, 2 ton per mu. The price for Lishu-6 is 2.6 Yuan per kilogram.

Date: August 17, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Deputy Director Peng
Occupation: Deputy Director of Jinghong City Mengwang Rice Agricultural Specialized Cooperative

1. Where are you located?
   We work in Mengwang village.

2. How many years has your cooperative been operating?
   We started last year.

3. How many members are in your cooperative?
   50 members. We also have 12 people who are stockholders in the cooperative.

4. How does a farmer become a member of your cooperative?
   We have no relationship with farmers.

5. What does the typical farmer in your cooperative look like? Farm size?
   We do not have a relationship with farmers but we rent about 10,000 mu. We allocated 4200 mu for potato production last year. This year, we only allocated 2000 mu for potato production. We reduced the area of potato because we realized half the area we were using was not suitable for potato production. We grow half the land in C88 and the other is Lishu-6. We sell Lishu-6 to the market in north China such as Xi'an, Shanghai, and Henan Province. We sell C88 to Chongqing City, Guiyang City, and Chengdu City. This year the Beijing businessmen asked us to grow C88 for them. The price of C88 1.6 Yuan/kilogram. The price of Lishu-6 is 1.6-1.7 Yuan/kilogram. The average yield of Lishu-6 is 1.7 ton per mu. The average yield of C88 is 1.2 ton per mu.

6. What services do you provide to your members?
   To our members, we provide trainings. We ask someone from the Agricultural Bureau to give trainings to our staff. We do rice, fruit, vegetables, and fruit.

7. Does your cooperative charge fees?
   We do not.

8. What varieties of potatoes do most of the members in your cooperative grow?
   Lishu-6 and C88. Our members do not grow the potatoes. We grow the potatoes.

9. Do you have any contracts with seed companies?
   No. We bought C88 from Jiache village. We bought 220 tons for 2.1 Yuan/kilogram from this village. We also bought seed from a cooperative in Dali Prefecture for 2.1 Yuan/kilogram. We bought 500 tons of Lishu-6 from farmers in Lijiang and Shangri-La for 2.9 Yuan/kilogram.

10. How do you market seed to your members? Demonstration plot?

We do not market, but we introduce some varieties and do the demonstration trials. We then will market those seeds if the trials go well.

Date: August 17, 2015
Location: Xuanwei, Quijing, Yunnan, China
Interviewee: Director
Occupation: Director of Yinjing County Yinhe Potato Specialized Cooperative

1. Where are you located?
   We are located in Yinjing County.

2. How many years has your cooperative been operating?
   We have been operating for 2 years.

3. How many members are in your cooperative?
   There are more than 4000 households.

4. How does a farmer become a member of your cooperative?
   Anyone can join.

5. What does the typical farmer in your cooperative look like? Farm size?
   The average for our farmers is around 20 mu.

6. What services do you provide to your members?
   We do trainings on cultivation methods, disease control, and pest control. We also purchase seeds from a company and then resell the seeds to our farmers. We also spray fungicide and fertilizer to our farmers' fields for a charge.

7. Does your cooperative charge fees?
   No.

8. What varieties of potatoes do most of the members in your cooperative grow?
   Most of our farmers grow C88 (95%) and Lishu-6 (5%).

9. Do you have any contracts with seed companies?
   No. The seed from the companies has similar quality to that of seed producing farms. Buying from farmers means we get similar quality for a lower price. We buy most of our C88 seed from the farmers of Jiache village.

10. Do you subsidize seeds for members?
    No.

11. How do you market seed to your members? Demonstration plot?
    We do demonstration plots. We pay the trial expenses. We introduced Unica but it got a low yield (1.7-2 ton per mu). During transportation, Unica rots easily. The average yield of C88 is 2 ton per mu. The average yield of Lishu-6 is 2 ton per mu.

Location: Kunming City, Yunnan
Date: August 18, 2015

Wholesaler 1

1. What areas do you buy your potatoes from?
   We buy our potatoes from Xundian County, Liushao village.

2. Who do you get your potatoes from? Local contact? Contract farmers? Trader?
   We work with business men who collect the potatoes from the farmers. We pay them 200 Yuan for 11 tons.

3. Do you pick-up the potatoes or are the potatoes brought to you? Is transportation a constraint for you?
   We pick-up the potatoes from the businessmen. It costs 1,300 Yuan per 11 tons.

4. How many potatoes do you demand all year?
   We demand 99 tons per year.

5. What varieties do you buy?
   We purchase C88, Unica, and Dianshu-6. In July and August, we mainly sell Unica and Dianshu-6. In May and June, we mainly sell C88.

6. What traits do you look for in a variety?
   It depends on the market demand.

7. How much do you currently sell [variety] for? What are the peaks and lows for [variety] during the year?
   C88 is 2.8 Yuan/kilogram for potatoes that weigh more than 200 grams and 1.7-1.8 Yuan/kilogram for potatoes that weigh more than 80 grams. The highest price is in June. The lowest price is in August. The price of C88 is higher than Unica and Dianshu-6. Unica is higher than Dianshu-6.

8. Do you have storage for the potatoes?
   No. We do not store any potatoes.

9. What is the price of you purchase potatoes for from the farmers?
   1.3 Yuan/kilogram.

10. When did you first buy C88? Do you still buy C88? Why not?
    We started this business in 2012 and we began selling C88 then.

Wholesaler 2

1. What areas do you buy potatoes from?
   We purchase our potatoes from Xundian County, Tangdian town.

2. Who do you get your potatoes from? Local contact? Contract farmers? Trader?
   We do not contract. We buy the potatoes ourselves.

3. Do you pick-up the potatoes or are the potatoes brought to you? Is transportation a constraint for you?
   The cost is 300 Yuan/8 ton for the gasoline.

4. How many potatoes do you demand all year?
   We demand 480 tons for 4 months. We only do business from May to August.

5. What varieties do you buy?
   We sell only C88.

6. What traits do you look for in a variety?
   It depends on the market demand.

7. How much do you currently sell [variety] for? What are the peaks and lows for [variety] during the year?
   We sell C88 for 1.8-1.9 Yuan/ kilogram. We pay farmers 1.2-1.3 Yuan/kilogram. The highest prices are in May and June. The lowest price is in August.

8. Do you have storage for the potatoes?
   No.

9. When did you first buy C88? Do you still buy C88? Why not?
   The first year we sold C88 was in 2001.

10. Is/was the price higher for C88? If so, why?
    The price of C88 is higher than other varieties, because the taste is good and high dry matter content.

Wholesaler 3

1. What areas do you buy potatoes from?
   We purchase our potatoes from Luquan County, Zehei village.

2. Who do you get your potatoes from? Local contact? Contract farmers? Trader?
   We buy the potatoes ourselves. We have no businessmen.

3. Do you pick-up the potatoes or are the potatoes brought to you? Is transportation a constraint for you?
   It costs 0.18-0.2 Yuan per ton for transportation. We pick-up the potatoes.

4. How many potatoes do you demand all year?
   We just began this month. We have sold 21 ton.

5. What varieties do you buy?
   We sell Unica and C88.
6. What traits do you look for in a variety?
   It depends on the market demand.

7. How much do you currently sell [variety] for? What are the peaks and lows for [variety] during the year?
   We sell C88 for 1.7-1.8 Yuan per kilogram and buy it from farmers for 1.3-1.4 Yuan per kilogram. We sell Unica for 1.5-1.7 Yuan per kilogram and buy it from farmers for 1.1 Yuan/ kilogram. Since this is our first month, we do not know the prices year round.

8. Do you have storage for the potatoes?
   No.

9. When did you first buy C88? Do you still buy C88? Why not?
   This year since it is our first month.

10. Is/was the price higher for C88? If so, why?
    Yes, the price of C88 is higher, because it tastes good.

Wholesaler 4

1. What areas do you buy potatoes from?
   We purchase our potatoes for Xudian County, Liushao village.

2. Who do you get your potatoes from? Local contact? Contract farmers? Trader?
   We buy the potatoes ourselves.

3. Do you pick-up the potatoes or are the potatoes brought to you? Is transportation a constraint for you?
   It costs 0.1 Yuan per kilogram for transportation. We pick the potatoes up.

4. How many potatoes do you demand all year?
   We sell 240 tons of potatoes from May to November.

5. What varieties do you buy?
   Qunshu-10, Unica, and Xianshu-2.

6. What traits do you look for in a variety?
   It depends on market demand.

7. How much do you currently sell [variety] for? What are the peaks and lows for [variety] during the year?
   We sell Unica for 1.5 Yuan/kilogram and buy it from farmers for 1.2 Yuan/kilogram. We sell Xianshu-2 for 1.4-1.5 Yuan/kilogram and buy it from farmers for 1.3 Yuan/kilogram.

   In May and June, the price is higher. In July and August, the price is lower.

8. Do you have storage for the potatoes?
   No.
9. When did you first buy C88? Do you still buy C88? Why not?
   We have never sold C88.

Wholesaler 5

1. What areas do you buy potatoes from?
   We buy all our potatoes from Xundian County and Luquan County from May to November. After October (November to February), we buy potatoes from Gansu Province and Quinghai Province. From February to April, we buy potatoes from Dehong Prefecture and Lincang City.

2. Who do you get your potatoes from? Local contact? Contract farmers? Trader?
   We buy potatoes from the businessmen. We give the businessmen 50 Yuan per ton.

3. Do you pick-up the potatoes or are the potatoes brought to you? Is transportation a constraint for you?
   Sometimes we buy the potato ourselves. Sometimes the businessmen arrange the transportation.

4. How many potatoes do you demand all year?
   We demand 1000 ton per year.

5. What varieties do you buy?
   We buy C88, Unica, and Xuanshu-2.

6. What traits do you look for in a variety?
   It depends on the market.

7. How much do you currently sell [variety] for? What are the peaks and lows for [variety] during the year?
   I sell C88 1.7-1.8 Yuan per kilogram and we buy from farmers for 1.3 Yuan/kilogram. Unica sells for 1.5 Yuan/kilogram and we buy it from the farmers for 1.3 Yuan/kilogram. Xuanshu-2 sells for 1.5 Yuan/kilogram and we buy it from the farmers for 1.1 Yuan/kilogram. For Unica and Xuanshu-2, the price is more or less the same year around. The highest price for C88 is in February and March. The lowest price for C88 is in July and August.

8. Do you have storage for the potatoes?
   No.

9. When did you first buy C88? Do you still buy C88? Why not?
   I started selling C88 in 2002.

10. Is/was the price higher for C88? If so, why?
    The price for C88 is higher than other varieties because the consumers know C88 very well since it has a long history in the Yunnan Province. The consumers say C88 has a good taste.

Date: August 19, 2015
Location: Kunming, Yunnan, China
Interviewee: CEO Chen
Occupation: CEO of Brother Food Company

1. What products does your business sell?
   We sell potato chips and potato puffs.

2. How long has your business existed?
   We have been in business since 1998.

3. Is your business located in other places?
   No.

4. Have you seen an increase or decrease in demand in the past 5 years for your products? Why do you think so?
   Demand has increased, because potato chips are safe. People do not get sick from potato chips like instant noodles and cookies. These products have chemicals used for preservation that can cause people to become sick.

5. How many people do you currently employ? Has this changed in the past 12 months?
   We employ 750 people. About 15 of these people are management.

   No, it has not changed. Due to the economic recession, not many people have left because they cannot find a better job so they stay with the company.

6. How many potatoes do you demand all year? Can you receive potatoes whenever you want or are there times during the year that are difficult to buy potatoes?
   We demand 50,000 tons. From February to April, we process more than 10,000 tons. From May to July, we process more than 9,000 tons. From August to January, we process more than 30,000 tons.

   From November 15th to mid-December, we cannot get enough C88 because the quality of C88 from the autumn season is not very good. There is not enough C88 seed for farmers to grow C88. To minimize risk, we purchase Atlantic from north China.

7. Does your company own and operate a farm? Why do you do this instead of purchasing from farmers?
   No. We cooperate with big farmers, farmer specialized cooperatives, village committees, and some local extension stations to help us find and purchase C88.

8. What varieties do you buy?
   C88 and Atlantic.

9. What traits do you look for in a variety?

   We focus on C88 because it is the standard of our company. The color of our symbol is gold and C88 is the same color. C88 is has good quality and good taste so we use C88.

10. Does your business pick-up the potatoes or are the potatoes brought to the business? What kind of costs does this incur?

    We ask the locals to help us purchase C88. We pay the business men 50-100 Yuan/ton.

11. Where do you get your potatoes from? Specific towns or villages.

    From February to April, we buy our potatoes from Dehong Prefecture and Baoshan City. From May to July, we buy our potatoes from Honghe Prefecture and Jiaozhou City in Shandong Province. From August to January, we purchase our potatoes from Inner Mongolia, Hebei Province, Xundian County, and Luquan County.

12. Do you contract with these farmers? Do you buy from a trader? How do you get in contact with the person in which you buy the potatoes from?

    No.

13. How do you ensure quality in your potatoes? Do you have standards that farmers must meet?

    We do not control the quality. The big farmers, cooperatives, and the others I work with know how to control quality themselves. We, as a company, check the reduced sugar level in the potatoes during harvest. The farmers will send one 20 ton truck to my company, and we process it.

14. How much do you pay for a [unit] of [variety]? Does price vary over the year? When are the peaks?

    In January and February, the price is highest and is 3.1 Yuan/kilogram. After transportation, it is 3.5 Yuan/kilogram. The lowest price is in May. It costs 0.6-0.7 Yuan/kilogram.

15. Do you mix the varieties when making the chips?

    No.

16. How much do you sell your products for?

    Our revenue is about 0.1 to 0.2 billion per year.

17. Who do you sell to?

    We sell directly to the supermarket and little stores. The transportation is free to town and county level stores in Yunnan, Sichuan, and Guizhou.

18. When did you first buy C88?

    2002. Before that, we used Mira, Zhongdianhong, Hue-2, and Gama-2.

19. Do you still buy C88?
    Yes. Since 2003, most of our production is C88. At this time, C88 was a higher price by 0.1-0.2 Yuan/kilogram. In 2013, we started to buy Atlantic from other provinces since we do not have enough C88.

20. Is/was the price higher for C88? If so, why?
    Yes, because C88 has better quality.

21. What do you like about C88? What do you not like about C88?
    I really like C88.

22. Is C88 different than the other varieties you buy? If so, what?
    Yes.

23. Do you have storage for potatoes?
    Yes, but it is only for 3 days.

24. Do you see any of these issues below as constraints to your production of [product]?
    a. No market to sell to
    b. Not high enough quality/ can't meet standards
    c. Storage
    d. Distance to market
    e. Consumers will not accept your price
    f. Traders or farmers will not accept your price
    g. Transportation is too costly
    h. Roads are not safe

Notes:

This company is the largest private potato chip company in all of China.

This company helped farmers in Donghe Prefecture earn a lot of money from C88. In 2003, the company bought 70 tons of C88 from Donghe Prefecture. The following year more farmers grew C88 and the price was high so the company bought 1000 tons. The following year, we bought 5,000 tons from Donghe. Now Donghe Prefecture grows 100,000 mu of potatoes with 80,000 mu being C88. C88 also has a strong contribution to Vietnam and Myanmar. In March, there is a lot of C88 being exported to these two countries.

Date: September 1, 2015
Location: Yunnan Normal University, Kunming
Interviewee: Dr. Canhui Li
Occupation: Professor and Researcher at the Roots and Tuber Crop Research Institute of Yunnan Normal University

1. What is the history of C88?

In 2001, an annual report of reported the release of Cooperation-88 (C88) information was released and had incorrect information. The American Potato Research publication has the correct information.

In 1994 and 1995, C88 was an advanced clone but not a variety yet. By 1996, C88 was officially named. In 2001, C88 was formally released by the local government and was considering illegal before then. The first year, 2001, the area under C88 reached up to 70,000 hectares. In 2004, it was named a national variety which meant it passed through all the trials of Chinese government (provincial variety and district variety as well). By passing the three levels of trials, district, regional, and national levels, C88 can be spread and grown in any of the places on which the C88 passed the trials. In 2004, 2008, and 2009, C88 was released o Sichuan, Guizghou, and Guanshi Provinces, respectively. C88 is mostly grown in the winter in Guanshi. Since C88 was formally released by four provinces, C88 should be automatically released as a national variety, but it has not.

In 2009, I prepared the paper that I published in the American Journal of Potato Research. I had conducted a survey in all four provinces and the total planting area of C88 was about 460,000. Most of the data is from the summer cropping season with a little from winter. The real impact of C88 is during the winter. In 2012, the planting area was up to 380,000 hectare in Yunnan for all seasons. The Yunnan Agricultural Department collected planting data of C88 from 2010 to 2012. After this, the provincial and local governments do not collect the data for specific varieties anymore- just total potato planting area. It no longer does so there is no new data about the variety since then. In general though, the whole potato area of the Yunnan province increased very quickly as well as the area of C88. In 2008, the potato area of Yunnan was 8 million mu. In 2010, it jumped to 10 million mu. Total planting area increased about 2 million mu. The southern region of Yunnan during the winter has increased dramatically where about 75% of the area is C88.

Specifically in Yunnan, the majority of the C88 area is now in the southwest area. When it was first released, C88 was popular in the south and central areas. Now C88 is most popular in the west and central areas of the Yunnan Province of summer. Fifty-five percent to 60% of planting area in central Yunnan is C88. In the western part, over 70% of the total planting area is C88. The winter cropping season is mostly in the north part. In winter, C88 covered about 75% of Yunnan.

C88 also has a strong impact on the processing industry in Yunnan. The most popular variety for potato chip processing in Yunnan is C88, especially from January to July. It is basically the only variety that can be used. The processing plant in Zhaotong uses mostly C88.

Something to note is that in some places are of C88 decreased very quickly, but that is not true for all areas. C88 has become the traditional variety in some places so there is a large gap in some places where they grew C88. There are fewer places where the area of C88 decreased very quickly. Maybe in future studies we can compare C88 to a control variety to determine its impact.

APPENDIX F: Stata Output

```
. do "C:\Users\Steph\AppData\Local\Temp\STD00000000.tmp"

. use "C:\Users\Steph\Documents\Thesis\Data\STATA\village adoption 6.14.16.dta", clear

.
. tobit heard i.region elevation i.prefecturecity i.villagefarmorg numHH villagepotatoarea_ha
i.Disease costoflabor, ll(0)

Tobit regression                                  Number of obs     =         41
                                                  LR chi2(11)       =      61.28
                                                  Prob > chi2       =     0.0000
Log likelihood = -85.805962                       Pseudo R2         =     0.2631

------------------------------------------------------------------------------
             heard |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
            region |
                2  |  -12.31981    2.43977    -5.05   0.000    -17.30248   -7.337133
                3  |   .1296506   3.500106     0.04   0.971     -7.01852    7.277822
                4  |   -2.03032   2.704012    -0.75   0.459    -7.552651     3.49201
                   |
         elevation |   .0020808    .002035     1.02   0.315    -.0020752    .0062369
                   |
      prefecturecity |
                1  |  -1.553827   2.410271    -0.64   0.524    -6.476258    3.368604
                2  |  -1.186888     2.0251    -0.59   0.562    -5.322695    2.948919
                   |
  1.villagefarmorg |  -.3725961   2.045183    -0.18   0.857    -4.549418    3.804226
             numHH |   -.022106    .007448    -2.97   0.006     -.037317   -.0068951
villagepotatoarea_ha |   .0195854   .0161321     1.21   0.234    -.0133608    .0525316
          1.Disease |  -3.466273   1.798254    -1.93   0.063    -7.138797    .2062508
       costoflabor |  -.0568335   .0348699    -1.63   0.114    -.1280475    .0143804
             _cons |   18.49658    6.92614     2.67   0.012     4.351516    32.64165
-------------------+----------------------------------------------------------------
            /sigma |   3.687819   .5004171                      2.665831    4.709807
------------------------------------------------------------------------------
          12  left-censored observations at heard <= 0
          29     uncensored observations
           0 right-censored observations

. margins, dydx(*)

Average marginal effects                          Number of obs     =         41
Model VCE    : OIM

Expression   : Linear prediction, predict()
dy/dx w.r.t. : 2.region 3.region 4.region elevation 1.prefecturecity 2.prefecturecity
1.villagefarmorg numHH
               villagepotatoarea_ha 1.Disease costoflabor

------------------------------------------------------------------------------
                     |            Delta-method
                     |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
            region |
                2  |  -12.31981    2.43977    -5.05   0.000    -17.10167   -7.537947
                3  |   .1296506   3.500106     0.04   0.970    -6.730432    6.989733
                4  |   -2.03032   2.704012    -0.75   0.453    -7.330087    3.269447
                   |
         elevation |   .0020808    .002035     1.02   0.307    -.0019077    .0060694
                   |
      prefecturecity |
                1  |  -1.553827   2.410271    -0.64   0.519    -6.277873    3.170218
                2  |  -1.186888     2.0251    -0.59   0.558    -5.156012    2.782236
                   |
  1.villagefarmorg |  -.3725961   2.045183    -0.18   0.855    -4.381082     3.63589
             numHH |   -.022106    .007448    -2.97   0.003    -.0367039   -.0075081
```

```
villagepotatoarea_ha |   .0195854   .0161321     1.21   0.225     -.012033    .0512038
           1.Disease |  -3.466273   1.798254    -1.93   0.054    -6.990786    .0582393
         costoflabor |  -.0568335   .0348699    -1.63   0.103    -.1251774    .0115103
------------------------------------------------------------------------------
Note: dy/dx for factor levels is the discrete change from the base level.

.
. clear

. use "C:\Users\Steph\Documents\Thesis\Data\STATA\adoption 6.14.16.dta", clear

.
. probit adopt age i.farmer i.education family workingage totalarea_ha agequip100
c.livestock_index##c.livestock_index i.
> lateblight i.pricereceived i.region elevation1000 i.prefecturecity  i.villagefarmorg numHH
villagepotatoarea_ha i.Diseas
> e costoflabor if villageheard==1, vce(cluster a14_code)

Iteration 0:   log pseudolikelihood = -275.87466
Iteration 1:   log pseudolikelihood = -167.02369
Iteration 2:   log pseudolikelihood = -156.94693
Iteration 3:   log pseudolikelihood = -156.59403
Iteration 4:   log pseudolikelihood = -156.59271
Iteration 5:   log pseudolikelihood = -156.59271

Probit regression                                 Number of obs     =        436
                                                  Wald chi2(25)     =    3643.15
                                                  Prob > chi2       =     0.0000
Log pseudolikelihood = -156.59271                 Pseudo R2         =     0.4324

                                                  (Std. Err. adjusted for 29 clusters in a14_code)
------------------------------------------------------------------------------
                             |               Robust
                       adopt |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------------------+------------------------------------------------------------------
                         age |  -.0023524   .0106032    -0.22   0.824    -.0231343    .0184294
                    1.farmer |   .4473962   .4460964     1.00   0.316    -.4269366    1.321729
                             |
                   education |
                           2 |    .099313   .2057836     0.48   0.629    -.3040155    .5026415
                           3 |   .1573507   .2176991     0.72   0.470    -.2693316    .5840331
                             |
                      family |   -.005433   .0729966    -0.07   0.941    -.1485038    .1376378
                  workingage |   .2531617   .0847248     2.99   0.003     .0871042    .4192192
                totalarea_ha |   .0986679   .0737623     1.34   0.181    -.0459035    .2432393
                  agequip100 |  -.0004329   .0022797    -0.19   0.849    -.0049011    .0040353
             livestock_index |   .1578887    .058755     2.69   0.007      .042731    .2730463
                             |
c.livestock_index#c.livestock_index |  -.0018741   .0009023    -2.08   0.038    -.0036426   -.0001056
                             |
                  lateblight |
                           2 |   .1159735   .2351799     0.49   0.622    -.3449707    .5769176
                           3 |  -.0271562   .2108621    -0.13   0.898    -.4404384    .3861259
                             |
               pricereceived |
                           2 |   .2149237   .2699971     0.80   0.426    -.3142609    .7441082
                           3 |   .3945375   .3904276     1.01   0.312    -.3706866    1.159762
                             |
                      region |
                           2 |  -1.922637   1.100001    -1.75   0.080    -4.078599    .2333251
                           3 |  -2.291333   .7922421    -2.89   0.004    -3.844099   -.7385666
                           4 |  -.6622274   .8068425    -0.82   0.412     -2.24361     .919155
                             |
              elevation1000 |   .3006028   .9450262     0.32   0.750    -1.551615     2.15282
                             |
             prefecturecity |
                           1 |   1.268988    .657031     1.93   0.053    -.0187689    2.556745
                           2 |   1.327346   .6129541     2.17   0.030     .1259783    2.528714
                             |
           1.villagefarmorg |    .621465   .6251134     0.99   0.320    -.6037348    1.846665
                      numHH |  -.0005122   .0023124    -0.22   0.825    -.0050444    .0040201
```

```
          villagepotatoarea_ha |   .0149208   .0040094     3.72   0.000     .0070625     .022779
                     1.Disease |  -1.049613   .7810338    -1.34   0.179    -2.580411    .4811855
                   costoflabor |   .0052385   .0188273     0.28   0.781    -.0316623    .0421393
                         _cons |    -4.2576   3.017587    -1.41   0.158    -10.17196    1.656762
------------------------------------------------------------------------------------------------
Note: 1 failure and 0 successes completely determined.

. margins, dydx(*)

Average marginal effects                        Number of obs     =        436
Model VCE    : Robust

Expression   : Pr(adopt), predict()
dy/dx w.r.t. : age 1.farmer 2.education 3.education family workingage totalarea_ha agequip100
livestock_index
               2.lateblight 3.lateblight 2.pricereceived 3.pricereceived 2.region 3.region 4.region
elevation1000
               1.prefecturecity 2.prefecturecity 1.villagefarmorg numHH villagepotatoarea_ha
1.Disease costoflabor

------------------------------------------------------------------------------
                     |            Delta-method
                     |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
                 age |   -.000481   .0021703    -0.22   0.825    -.0047347    .0037726
           1.farmer  |   .0874884   .0826855     1.06   0.290    -.0745722    .2495489
                     |
           education |
                   2 |   .0201209   .0416237     0.48   0.629    -.0614601    .1017019
                   3 |   .0320688   .0440552     0.73   0.467    -.0542778    .1184155
                     |
              family |   -.001111   .0149265    -0.07   0.941    -.0303663    .0281444
          workingage |   .0517681   .0187307     2.76   0.006     .0150566    .0884797
        totalarea_ha |   .0201762   .0150162     1.34   0.179     -.009255    .0496075
          agequip100 |  -.0000885   .0004658    -0.19   0.849    -.0010014    .0008243
     livestock_index |   .0304824   .0115402     2.64   0.008     .0078639    .0531008
                     |
           lateblight |
                   2 |   .0236913   .0475942     0.50   0.619    -.0695917    .1169742
                   3 |  -.0054676   .0425413    -0.13   0.898     -.088847    .0779118
                     |
       pricereceived |
                   2 |   .0435367   .0569699     0.76   0.445    -.0681222    .1551955
                   3 |   .0817885   .0845144     0.97   0.333    -.0838567    .2474337
                     |
              region |
                   2 |  -.3637707    .173108    -2.10   0.036     -.703056   -.0244853
                   3 |  -.3925839   .1244956    -3.15   0.002    -.6365908   -.1485769
                   4 |  -.1639442   .1776782    -0.92   0.356    -.5121872    .1842987
                     |
       elevation1000 |   .0614692   .1936892     0.32   0.751    -.3181546     .441093
                     |
      prefecturecity |
                   1 |   .2288808   .1067036     2.15   0.032     .0197456    .4380159
                   2 |   .2415323   .0964529     2.50   0.012      .052488    .4305765
                     |
    1.villagefarmorg |   .1371778   .1465298     0.94   0.349    -.1500153    .4243709
               numHH |  -.0001047    .000477    -0.22   0.826    -.0010397    .0008302
villagepotatoarea_ha |   .0030511   .0006491     4.70   0.000     .0017789    .0043232
          1.Disease  |  -.2196445   .1554634    -1.41   0.158    -.5243472    .0850583
         costoflabor |   .0010712   .0038543     0.28   0.781    -.0064831    .0086255
------------------------------------------------------------------------------
Note: dy/dx for factor levels is the discrete change from the base level.

.
. tobit c88area age i.farmer i.education family workingage totalarea_ha agequip100
c.livestock_index##c.livestock_index i
> .lateblight i.pricereceived i.region elevation1000 i.prefecturecity  i.villagefarmorg numHH
villagepotatoarea_ha i.Disea
> se costoflabor if villageheard==1, ll(0) vce(cluster a14_code)
```

```
Tobit regression                                Number of obs     =        436
                                                F(  25,    411)   =   11217.58
                                                Prob > F          =     0.0000
Log pseudolikelihood = -157.69189               Pseudo R2         =     0.5402

                                                (Std. Err. adjusted for 29 clusters in a14_code)
------------------------------------------------------------------------------------------------
                               |               Robust
                      c88area |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------------
                          age  |  -.0031822   .0038822    -0.82   0.413    -.0108136    .0044493
                       1.farmer|   .1293848   .1365577     0.95   0.344    -.1390539    .3978234
                               |
                    education  |
                            2  |   .0577388   .0756852     0.76   0.446    -.0910396    .2065172
                            3  |   .0622714   .0722398     0.86   0.389    -.0797341    .2042769
                               |
                       family  |  -.0027175     .03203    -0.08   0.932    -.0656806    .0602457
                    workingage |   .1189684   .0349493     3.40   0.001     .0502666    .1876701
                  totalarea_ha |   .0895724   .0086137    10.40   0.000     .0726401    .1065047
                   agequip100  |  -.0004235   .0007718    -0.55   0.583    -.0019407    .0010936
                livestock_index|   .0335116   .0207299     1.62   0.107    -.0072383    .0742614
                               |
c.livestock_index#c.livestock_index|  -.0007912   .0002566    -3.08   0.002    -.0012955   -.0002868
                               |
                    lateblight |
                            2  |  -.0054913     .05805    -0.09   0.925    -.1196032    .1086206
                            3  |  -.0336132   .0583467    -0.58   0.565    -.1483084     .081082
                               |
                pricereceived  |
                            2  |   .1156299    .100978     1.15   0.253    -.0828678    .3141277
                            3  |   .2414554   .1417626     1.70   0.089    -.0372148    .5201257
                               |
                        region |
                            2  |  -.8492054   .4776227    -1.78   0.076    -1.788093    .0896828
                            3  |  -.7398065    .290901    -2.54   0.011    -1.311646   -.1679671
                            4  |  -.0486458   .2817097    -0.17   0.863    -.6024174    .5051257
                               |
                elevation1000  |   .0469899   .3403492     0.14   0.890    -.6220525    .7160323
                               |
                prefecturecity |
                            1  |   .5477172   .2498888     2.19   0.029     .0564976    1.038937
                            2  |   .7769547   .1866135     4.16   0.000     .4101186    1.143791
                               |
            1.villagefarmorg   |   .1331004   .1794108     0.74   0.459    -.2195769    .4857777
                       numHH   |  -.0001718   .0008445    -0.20   0.839    -.0018319    .0014883
          villagepotatoarea_ha |   .0075373   .0009935     7.59   0.000     .0055844    .0094903
                   1.Disease   |   -.390441   .2658364    -1.47   0.143    -.9130097    .1321277
                costoflabor    |   .0029201   .0078264     0.37   0.709    -.0124646    .0183048
                       _cons   |  -1.764557   1.077862    -1.64   0.102    -3.883366    .3542523
-------------------------------+----------------------------------------------------------------
                       /sigma  |   .4140595    .060369                      .2953891      .53273
------------------------------------------------------------------------------------------------
          293  left-censored observations at c88area <= 0
          143     uncensored observations
            0 right-censored observations

. margins, dydx(*)

Average marginal effects                        Number of obs     =        436
Model VCE    : Robust

Expression   : Linear prediction, predict()
dy/dx w.r.t. : age 1.farmer 2.education 3.education family workingage totalarea_ha agequip100
livestock_index
               2.lateblight 3.lateblight 2.pricereceived 3.pricereceived 2.region 3.region 4.region
elevation1000
               1.prefecturecity 2.prefecturecity 1.villagefarmorg numHH villagepotatoarea_ha
1.Disease costoflabor

------------------------------------------------------------------------------
```

```
                     |            Delta-method
                     |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+------------------------------------------------------------------
                 age |  -.0031822   .0038822    -0.82   0.412    -.0107912    .0044268
            1.farmer |   .1293848   .1365577     0.95   0.343    -.1382634    .3970329
                     |
           education |
                   2 |   .0577388   .0756852     0.76   0.446    -.0906015    .2060791
                   3 |   .0622714   .0722398     0.86   0.389    -.0793159    .2038587
                     |
              family |  -.0027175     .03203    -0.08   0.932    -.0654952    .0600603
          workingage |   .1189684   .0349493     3.40   0.001     .0504689    .1874678
        totalarea_ha |   .0895724   .0086137    10.40   0.000       .07269    .1064548
          agequip100 |  -.0004235   .0007718    -0.55   0.583    -.0019363    .0010892
     livestock_index |   .0300809   .0196311     1.53   0.125    -.0083954    .0685571
                     |
          lateblight |
                   2 |  -.0054913    .05805    -0.09   0.925    -.1192672    .1082846
                   3 |  -.0336132   .0583467    -0.58   0.565    -.1479706    .0807442
                     |
       pricereceived |
                   2 |   .1156299    .100978     1.15   0.252    -.0822833    .3135431
                   3 |   .2414554   .1417626     1.70   0.089    -.0363942    .5193051
                     |
              region |
                   2 |  -.8492054   .4776227    -1.78   0.075    -1.785329    .0869179
                   3 |  -.7398065    .290901    -2.54   0.011    -1.309962   -.1696511
                   4 |  -.0486458   .2817097    -0.17   0.863    -.6007867     .503495
                     |
       elevation1000 |   .0469899   .3403492     0.14   0.890    -.6200823    .7140622
                     |
      prefecturecity |
                   1 |   .5477172   .2498888     2.19   0.028     .0579441     1.03749
                   2 |   .7769547   .1866135     4.16   0.000     .4111989     1.14271
                     |
    1.villagefarmorg |   .1331004   .1794108     0.74   0.458    -.2185384    .4847391
               numHH |  -.0001718   .0008445    -0.20   0.839     -.001827    .0014834
villagepotatoarea_ha |   .0075373   .0009935     7.59   0.000     .0055902    .0094845
           1.Disease |   -.390441   .2658364    -1.47   0.142    -.9114708    .1305888
         costoflabor |   .0029201   .0078264     0.37   0.709    -.0124193    .0182595
------------------------------------------------------------------------------------------
Note: dy/dx for factor levels is the discrete change from the base level.



. heckprobit stopped agesinceadoption i.farmer i.education family kidspercent totalarea_ha agequip100
c.livestock_index##c.livesto
> ck_index yearsincefirstgrown3 i.lateblight i.pricereceived i.region elevation1000 i.prefecturecity
i.villagefarmorg numHH villag
> epotatoarea_ha i.Disease costoflabor if villageheard==1, select(evergrown= agesinceadoption
i.farmer i.education family kidsperce
> nt totalarea_ha agequip100  c.livestock_index##c.livestock_index i.lateblight i.pricereceived
i.region elevation1000 i.prefecture
> city i.villagefarmorg numHH villagepotatoarea_ha i.Disease costoflabor) vce(cluster a14_code)

Fitting probit model:

Iteration 0:   log pseudolikelihood =  -185.8589
Iteration 1:   log pseudolikelihood = -103.78105
Iteration 2:   log pseudolikelihood = -98.703016
Iteration 3:   log pseudolikelihood = -97.517519
Iteration 4:   log pseudolikelihood = -97.288093
Iteration 5:   log pseudolikelihood = -97.286109
Iteration 6:   log pseudolikelihood = -97.285778
Iteration 7:   log pseudolikelihood =  -97.28573
Iteration 8:   log pseudolikelihood = -97.285729

Fitting selection model:

Iteration 0:   log pseudolikelihood = -287.13386
```

```
Iteration 1:   log pseudolikelihood = -147.58118
Iteration 2:   log pseudolikelihood = -141.80499
Iteration 3:   log pseudolikelihood = -141.38954
Iteration 4:   log pseudolikelihood = -141.38826
Iteration 5:   log pseudolikelihood = -141.38826

Fitting starting values:

Iteration 0:   log pseudolikelihood = -190.61547
Iteration 1:   log pseudolikelihood = -103.71704
Iteration 2:   log pseudolikelihood = -98.653514
Iteration 3:   log pseudolikelihood = -97.445715
Iteration 4:   log pseudolikelihood = -97.187669
Iteration 5:   log pseudolikelihood = -97.186262
Iteration 6:   log pseudolikelihood = -97.185975
Iteration 7:   log pseudolikelihood = -97.185924
Iteration 8:   log pseudolikelihood = -97.185923

Fitting full model:

Iteration 0:   log pseudolikelihood = -238.93603
Iteration 1:   log pseudolikelihood = -238.63832
Iteration 2:   log pseudolikelihood = -238.63196
Iteration 3:   log pseudolikelihood = -238.63194

Probit model with sample selection              Number of obs     =        436
                                                Censored obs      =        161
                                                Uncensored obs    =        275

                                                Wald chi2(1)      =          .
Log pseudolikelihood = -238.6319                Prob > chi2       =          .

                                                      (Std. Err. adjusted for 29 clusters in a14_code)
------------------------------------------------------------------------------------------------------
                                     |               Robust
                                     |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------------------+----------------------------------------------------------------
stopped                              |
                   agesinceadoption |   .0061969   .0174551     0.36   0.723    -.0280145    .0404082
                           1.farmer |   .3682809   .4080618     0.90   0.367    -.4315055    1.168067
                                    |
                          education |
                                  2  |  -.3163056   .2613294    -1.21   0.226    -.8285019    .1958906
                                  3  |  -.2703876   .1985428    -1.36   0.173    -.6595243     .118749
                                    |
                             family |  -.3172258   .0902639    -3.51   0.000    -.4941399   -.1403118
                         kidspercent |   1.490496   .6275045     2.38   0.018     .2606098    2.720382
                        totalarea_ha |  -.0692278   .0649805    -1.07   0.287    -.1965873    .0581317
                          agequip100 |   .0035455   .0031187     1.14   0.256    -.0025671     .009658
                       livestock_index |  -.0946608   .0585409    -1.62   0.106    -.2093987    .0200772
                                    |
c.livestock_index#c.livestock_index |   .0011573   .0007331     1.58   0.114    -.0002796    .0025941
                                    |
                    yearsincefirstgrown3 |  -.0130749   .0243479    -0.54   0.591    -.0607959     .034646
                                    |
                          lateblight |
                                  2  |   .5234383   .3203855     1.63   0.102    -.1045057    1.151382
                                  3  |   .4905747   .3205774     1.53   0.126    -.1377455    1.118895
                                    |
                      pricereceived |
                                  2  |  -.4061457   .4610827    -0.88   0.378    -1.309851    .4975598
                                  3  |  -.5923394   .4403607    -1.35   0.179    -1.455431    .2707517
                                    |
                             region |
                                  2  |   1.640361    1.49712     1.10   0.273     -1.29394    4.574662
                                  3  |   5.274819   2.888337     1.83   0.068    -.3862169    10.93585
                                  4  |   1.423057   1.062469     1.34   0.180    -.6593446    3.505458
                                    |
                       elevation1000 |  -.2689956   1.323851    -0.20   0.839    -2.863696    2.325705
                                    |
                      prefecturecity |
```

```
                                1  |  -3.589581   1.767342    -2.03   0.042    -7.053507   -.1256549
                                2  |  -2.346817   1.416348    -1.66   0.098    -5.122808    .4291735
                                   |
                  1.villagefarmorg |  -.7351446   .6661527    -1.10   0.270     -2.04078    .5704908
                             numHH |   .0039863   .0044851     0.89   0.374    -.0048045     .012777
                villagepotatoarea_ha |  -.0333157    .019488    -1.71   0.087    -.0715114      .00488
                         1.Disease |   .3522792   .8980308     0.39   0.695    -1.407829    2.112387
                       costoflabor |   .0014231   .0256206     0.06   0.956    -.0487923    .0516385
                             _cons |   3.661778    3.11913     1.17   0.240    -2.451605    9.775161
-------------------------------------+----------------------------------------------------------------
evergrown                            |
                     agesinceadoption |  -.0392683   .0106171    -3.70   0.000    -.0600775   -.0184592
                            1.farmer |    .143812   .2625625     0.55   0.584    -.3708011    .6584251
                                   |
                           education |
                                   2  |   -.324806   .2058822    -1.58   0.115    -.7283276    .0787156
                                   3  |   .1188494   .1991144     0.60   0.551    -.2714077    .5091066
                                   |
                              family |   .2532141    .092629     2.73   0.006     .0716646    .4347636
                         kidspercent |  -2.669118   .7853837    -3.40   0.001    -4.208442   -1.129794
                        totalarea_ha |   .3751537   .1747778     2.15   0.032     .0325956    .7177119
                          agequip100 |   .0035902   .0066333     0.54   0.588    -.0094107    .0165912
                       livestock_index |   .0920803   .0813366     1.13   0.258    -.0673366    .2514971
                                   |
c.livestock_index#c.livestock_index |  -.0026395   .0012603    -2.09   0.036    -.0051096   -.0001695
                                   |
                           lateblight |
                                   2  |   .2723462   .1368708     1.99   0.047     .0040844     .540608
                                   3  |  -.1905615   .1908428    -1.00   0.318    -.5646065    .1834834
                                   |
                         pricereceived |
                                   2  |    .466892   .1804975     2.59   0.010     .1131234    .8206607
                                   3  |    .588419   .3464968     1.70   0.089    -.0907022     1.26754
                                   |
                              region |
                                   2  |  -1.342819   .7020829    -1.91   0.056    -2.718877    .0332378
                                   3  |   .9300682   .9622862     0.97   0.334    -.9559781    2.816115
                                   4  |  -.2298914   .9068432    -0.25   0.800    -2.007271    1.547489
                                   |
                         elevation1000 |   .9806445   .9910896     0.99   0.322    -.9618554    2.923144
                                   |
                        prefecturecity |
                                   1  |  -.1229707   .8934532    -0.14   0.891    -1.874107    1.628165
                                   2  |   .1828798   .7388998     0.25   0.805    -1.265337    1.631097
                                   |
                  1.villagefarmorg |  -.2405707   .6592553    -0.36   0.715    -1.532687    1.051546
                             numHH |  -.0011068   .0029257    -0.38   0.705    -.0068411    .0046275
                villagepotatoarea_ha |   -.001354   .0039568    -0.34   0.732    -.0091091    .0064011
                         1.Disease |   -.891029   .4993264    -1.78   0.074    -1.869691    .0876328
                       costoflabor |  -.0143938   .0101105    -1.42   0.155      -.03421    .0054225
                             _cons |   .5873681   2.753742     0.21   0.831    -4.809867    5.984603
-------------------------------------+----------------------------------------------------------------
                          /athrho |   .1388688   .5748062     0.24   0.809    -.9877307    1.265468
-------------------------------------+----------------------------------------------------------------
                              rho |   .1379829   .5638623                      -.756393    .8525647
------------------------------------------------------------------------------------------------------
Wald test of indep. eqns. (rho = 0): chi2(1) =     0.06   Prob > chi2 = 0.8091

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. do "C:\Users\Steph\AppData\Local\Temp\STD00000000.tmp"

. margins, dydx(*) predict(psel)

Average marginal effects                        Number of obs     =        436
Model VCE    : Robust

Expression   : Pr(evergrown), predict(psel)
dy/dx w.r.t. : agesinceadoption 1.farmer 2.education 3.education family kidspercent totalarea_ha
agequip100 livestock_index
               yearsincefirstgrown3 2.lateblight 3.lateblight 2.pricereceived 3.pricereceived
2.region 3.region 4.region
               elevation1000 1.prefecturecity 2.prefecturecity 1.villagefarmorg numHH
villagepotatoarea_ha 1.Disease costoflabor

------------------------------------------------------------------------------
                     |            Delta-method
                     |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
    agesinceadoption |  -.0071476   .0023155    -3.09   0.002    -.0116859   -.0026092
            1.farmer |   .0267499   .0499737     0.54   0.592    -.0711967    .1246965
                     |
           education |
                  2  |  -.0599214   .0409339    -1.46   0.143    -.1401505    .0203076
                  3  |   .0205575   .0339732     0.61   0.545    -.0460287    .0871437
                     |
              family |   .0460897   .0194779     2.37   0.018     .0079137    .0842658
         kidspercent |  -.4858299   .1629414    -2.98   0.003    -.8051891   -.1664706
        totalarea_ha |   .0682851   .0310445     2.20   0.028      .007439    .1291311
          agequip100 |   .0006535   .0012164     0.54   0.591    -.0017306    .0030376
     livestock_index |   .0149719   .0138108     1.08   0.278    -.0120967    .0420405
yearsincefirstgrown3 |          0  (omitted)
                     |
           lateblight |
                  2  |    .047818   .0232523     2.06   0.040     .0022443    .0933916
                  3  |  -.0356364   .0343556    -1.04   0.300    -.1029722    .0316994
                     |
       pricereceived |
                  2  |   .0950628   .0402519     2.36   0.018     .0161705     .173955
                  3  |   .1180538   .0649612     1.82   0.069    -.0092678    .2453754
                     |
              region |
                  2  |  -.3149632   .1832302    -1.72   0.086    -.6740878    .0441615
                  3  |   .1691902   .1438342     1.18   0.239    -.1127197    .4511002
                  4  |   -.051628   .2023924    -0.26   0.799    -.4483097    .3450538
                     |
       elevation1000 |   .1784958   .1677774     1.06   0.287    -.1503419    .5073335
                     |
      prefecturecity |
                  1  |  -.0228515   .1656854    -0.14   0.890     -.347589     .301886
                  2  |   .0326985   .1327909     0.25   0.805    -.2275669     .292964
                     |
    1.villagefarmorg |  -.0434275   .1174356    -0.37   0.712     -.273597     .186742
               numHH |  -.0002015   .0005275    -0.38   0.703    -.0012354    .0008325
villagepotatoarea_ha |  -.0002465   .0007209    -0.34   0.732    -.0016594    .0011665
           1.Disease |    -.16313   .0976218    -1.67   0.095    -.3544651    .0282052
         costoflabor |  -.0026199   .0019237    -1.36   0.173    -.0063902    .0011504
------------------------------------------------------------------------------
Note: dy/dx for factor levels is the discrete change from the base level.

. margins, dydx(*) predict(pcond)

Average marginal effects                        Number of obs     =        436
Model VCE    : Robust

Expression   : Pr(stopped=1|evergrown=1), predict(pcond)
```

```
dy/dx w.r.t. : agesinceadoption 1.farmer 2.education 3.education family kidspercent totalarea_ha
agequip100 livestock_index
              yearsincefirstgrown3 2.lateblight 3.lateblight 2.pricereceived 3.pricereceived
2.region 3.region 4.region
              elevation1000 1.prefecturecity 2.prefecturecity 1.villagefarmorg numHH
villagepotatoarea_ha 1.Disease costoflabor

------------------------------------------------------------------------------
                     |            Delta-method
                     |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
    agesinceadoption |   .0015347   .0024993     0.61   0.539    -.0033639    .0064332
           1.farmer  |   .0627228   .0685416     0.92   0.360    -.0716163    .1970619
                     |
           education |
                   2 |  -.0540346   .0493533    -1.09   0.274    -.1507652    .0426961
                   3 |  -.0505436   .0391542    -1.29   0.197    -.1272845    .0261972
                     |
              family |   -.059899   .0180643    -3.32   0.001    -.0953044   -.0244937
         kidspercent |   .2971515   .1183926     2.51   0.012     .0651063    .5291967
        totalarea_ha |  -.0164696   .0203635    -0.81   0.419    -.0563814    .0234421
          agequip100 |   .0006013   .0005353     1.12   0.261    -.0004479    .0016504
     livestock_index |  -.0170988   .0108409    -1.58   0.115    -.0383467     .004149
yearsincefirstgrown3 |   -.002358   .0042745    -0.55   0.581    -.0107359      .00602
                     |
          lateblight |
                   2 |   .0899889   .0559485     1.61   0.108    -.0196681     .199646
                   3 |   .0888999   .0595645     1.49   0.136    -.0278444    .2056441
                     |
       pricereceived |
                   2 |  -.0844698   .0841407    -1.00   0.315    -.2493825    .0804429
                   3 |  -.1215112   .0827631    -1.47   0.142     -.283724    .0407015
                     |
              region |
                   2 |    .314278   .2177163     1.44   0.149    -.1124381     .740994
                   3 |   .5654242   .1066366     5.30   0.000     .3564202    .7744282
                   4 |   .2693824   .1380304     1.95   0.051    -.0011523    .5399171
                     |
       elevation1000 |  -.0589278   .2352998    -0.25   0.802    -.5201069    .4022513
                     |
      prefecturecity |
                   1 |  -.5306739    .098816    -5.37   0.000    -.7243496   -.3369981
                   2 |  -.3105216   .0715284    -4.34   0.000    -.4507147   -.1703286
                     |
    1.villagefarmorg |  -.1372603   .1473512    -0.93   0.352    -.4260634    .1515427
               numHH |   .0007306   .0007718     0.95   0.344    -.0007821    .0022434
villagepotatoarea_ha |  -.0059939   .0031098    -1.93   0.054    -.0120889    .0001012
           1.Disease |   .0746381   .1655164     0.45   0.652    -.2497682    .3990444
         costoflabor |   .0004095   .0044367     0.09   0.926    -.0082863    .0091053
------------------------------------------------------------------------------
Note: dy/dx for factor levels is the discrete change from the base level.
```