Accessing Seed through Sharecropping:

A Risk-Sharing Strategy for Andean Farmers

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Summary
In the Northern Andes, one of the riskiest agriculture climates in the world, farmers use sharecropping to obtain seed, their most costly input. With survey data from Peru, this paper calculates that the cost of seed, when it is provided though sharecropping, is two times higher than the market price. We test the hypothesis that risk-averse farmers are willing to pay more to receive seed through sharecropping because the contract provides implicit crop insurance.[1]

Background
Potato cultivation in the Andes, the dominant subsistence activity since pre-Incan times, changed dramatically in the last quarter of the 20th Century. With the Green Revolution and subsequent biotechnology age, a multitude of genetically-improved potato varieties were deployed. These crops were designed to reduce risk, improve yields, and commercialize subsistence farming systems. Success in modern agriculture, however, entails the adoption of modern inputs such as improved potato varieties, chemical fertilizers, and pesticides. Can the poorest Andean farmers, who depend on potatoes as their primary subsistence crop, access credit and take on the risk of purchasing these expensive input packages?

This paper explores how farmers in the northern Andes of Peru mitigate the risk of purchasing expensive inputs by accessing seed and chemicals though sharecropping contracts. For decades farmers in this region received land and inputs through sharecropping contracts with hacienda owners (Deere, 1990). After the Agrarian Reform, which distributed land to small farmers, seed became the relatively more expensive input. Consequently, instead of exchanging land and labor through sharecropping contracts, farmers began exchanging seed and labor. Using survey data from Cajamarca we calculate the effective price farmers pay for their seed when it is obtained through sharecropping, and propose an explanation for why some farmers pay more to obtain seed through sharecropping, instead of buying or borrowing it.

[1] We are especially indebted to the farmers of San Miguel and the extension workers at CIP and CARE international, who generously offered their time and expertise on behalf of this project. This research was made possible with the financial generosity of the World Bank Research Committee RPO No. 683-56 and the Development Research Group. The authors take full responsibility for any mistakes.

Part 1: How farmers obtain seed

There are two systems through which Peruvian farmers can acquire potato tuber seed - the formal system and the informal system.[2] The formal system begins with commercial seed growers producing basic seed -- tuber seeds that are bred from true potato seed. Basic seed is uncontaminated by bacteria, fungi, or other pests. The price of basic seed is double to triple the price of common seed. Consequently, its primary buyers are large-scale potato producers.

In the 1980's the International Potato Center, in collaboration with the Peruvian government (INIAA), established seed production centers in six locations in Peru, including Cajamarca. The program was decentralized in order to provide scientists with maximum access to the diverse growing regions in Peru, each home to unique native potato varieties. This proximity to the countryside also afforded small farmer an opportunity to obtain basic seed. The center in Cajamarca is located approximately six to ten hours from the survey region by bus, and is therefore not a common source of fresh seed for the farmers included in the sample. Nevertheless, farmers can obtain seed from the center without having to travel to it by working with agricultural extension organizations, such as CARE International, who collaborate with the seed centers to help disseminate basic seed and improved varieties (Scheidegger, et.al., 1989).

Ninety percent of the potato production area in Peru is linked to the informal system (Scheidegger, et.al., 1989). This system relies on small farmers to select and store seed between seasons. Seed is replenished with fresh seed periodically, depending on the rate of seed degeneration in the region.[3] Typically, fresh seed is purchased from other local farmers or in local markets.

In the sample region, all of the farmers actively participate in the informal system. The majority grow their own seed to be used the following year. Of the farmers who purchased seed in the survey year, only two bought seed from INIA, the National Seed Research Institute. Ten percent of the sample traveled between three and six hours to purchase seeds in Cajamaca, the major regional market, where high quality new varieties can be obtained. Thirty-one percent bought seed locally, either at a local market or from a friend or neighbor. Those who obtained varieties from CARE or another NGO did not purchase them.

Due to risk and credit constraints, many farmers cannot afford to pay for seed at the beginning of the season. One option for these farmers is to receive seed loans denominated in monetary terms or in potatoes, which they pay back after the harvest. In the sample only four percent received loans for seed. These farmers received loans from family members or relatives, and their average interest rate for a loan was ten percent per month.

In addition to loans, farmers can obtain seed through sharecropping contracts that exchange seed for labor. The seed-sharecropping contract is between a "seed-lord," who provides seed, and a "seed-tenant," who provides labor. As in a land-sharecropping contract, the seed-lord may or may

[2] There are two forms of potato seed. The traditional seed is tuber-seed, which means that an actual potato is planted in the ground. The tuber-seed is the only type of seed used in the survey region, and in this paper the word "seed" always refers to tuber-seed. The second form is an actual seed. This is rarely used in traditional potato farming due to its longer growing period relative to tuber seed. Recently, however, a hybrid true potato seed (TPS) is being used in regions where no healthy tuber-seed is available. It is estimated the twenty percent of potato production will be replaced by TPS in these regions. (CGIAR, 2000) See also Elton, 2000.

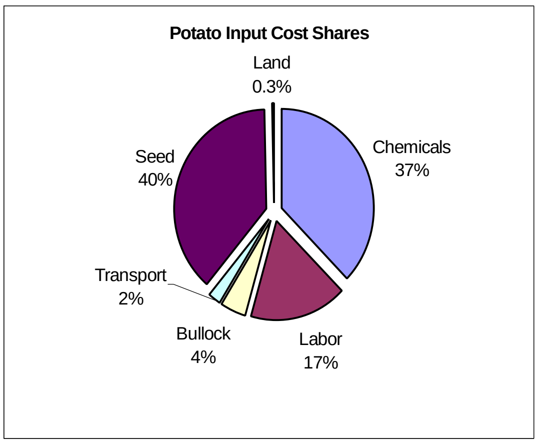
[3] In the survey region, the rate of degeneration is approximately seven years for improved varieties and higher for native varieties.

not provide other inputs such as land, bullocks, fertilizers, and chemicals in addition to the seed. At the end of the season, the seed-tenant is required to pay a percentage of the harvest to the seed-lord. Forty percent of the farmers in the sample received seed on at least one plot through sharecropping, making it the most popular form of obtaining seed off-farm.

Part 2: The Cost of Sharecropping

In the survey region, sharecropping contracts include a variety of different input bundles. The most frequent bundles provided to seed-tenants contain (a) seed and chemicals, (b) seed, chemicals, and land, and (c) seed, chemicals, bullocks, and land. Figure 1 illustrates the relative importance of the agricultural inputs needed for potato cultivation in cost terms. It makes sense that seed and chemicals represent the bulk of these costs and are therefore the primary components in sharecropping input packages. Typically, the seed-lord determines the contents of the bundle, and offers one type to several seed-tenants. In the sample region, seed-tenants are always required to pay the seed-lord fifty percent of their harvest. Despite zero variation in the harvest-share, input-shares vary between twenty-five and one hundred percent.

Figure 1



To compare farmers with different plot sizes, we calculate the cost of sharecropping in percentage terms. We do this by dividing the value of the share of the harvest the seed-tenant gives to the seed-lord by the market value of the inputs provided by the landlord. In mathematical terms:

$$\frac{(\alpha p_q q)}{(\vec{p}_x \vec{x})}$$

where α is the share of production the seed-tenant gives to the seed-lord (50%)

p_q is the price of potatoes

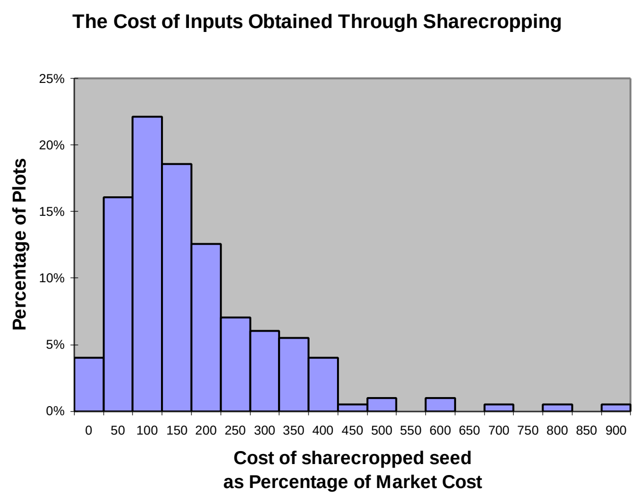
q is the quantity of potatoes harvested on that plot

$\vec{p}_x$ is a vector of input prices, and

$\vec{x}$ is a vector of inputs provided by the seedlord.

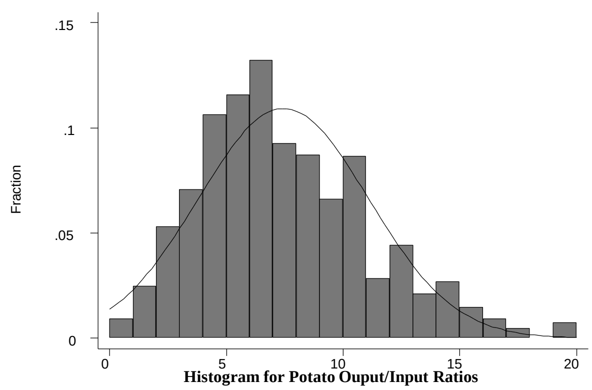
The histogram below displays the distribution of these costs. Loans for seed have an average interest rate of 10% per month. The average growing period for a potato is 5 months. Thus, the total interest payments on a seed loan are 50% of the cost of the seed. Farmers that pay below 150% of the cost of the inputs received an implicit insurance – the value of the harvest they gave to the seed-lord was less than the value of the inputs they received from the seed-lord with interest. This was the case for forty-two percent of the plots. On the next eighteen percent, farmers paid between 150% and 200% of the market value of the seed. The fourth quintile paid between 200% and 300%, and the upper quintile paid over 300% of the market price of seed. On average, farmers paid 200% of the market price.

Figure 2



Ideally, we would calculate the cost of seed-sharecropping over a series of years because weather patterns, and therefore yields, vary drastically from season to season. If this year were a particularly good year for the potato crop, our estimates of the cost of sharecropping would be overstated. The figure below depicts the distribution of potato output/input ratios.[4] According to potato experts, in Cajamarca, the distribution of output ratios resembles a normal distribution. A ratio of 1-3 is very bad, 4-6 is bad, 7-9 is regular, 10-15 is good, and greater than 15 is excellent. The average output ratio for the sample was 7.6 with a standard deviation of 4.2. Thus, this year's distribution resembles the distribution of a normal year.[5]

Figure 3



[4] Tuber scientists call this measurement the multiplication ratio. It is one of the two most commonly used productivity measures, the other measure being yield estimates based on harvest sampling (Terrazas, et. al, 1998).
[5] Based on correspondence with Oscar Ortiz, an agricultural extension expert at the International Potato Center.

Part 3: Why pay more for seed through seed sharecropping?

Why would some Andean farmers pay more to obtain their seed through sharecropping? Here we present an argument to answer this question. The idea is inspired by Stiglitz's 1974 paper in which he theoretically demonstrates the risk-sharing benefits of sharecropping. He uses a principal-agent model to show that when both the landlord and the tenant are risk-averse, neither will want to absorb all of the risk. Instead, both will prefer sharecropping to pure wage or rental contracts.

A similar argument applies for why some farmers choose to obtain seed through sharecropping. In a region where there are no formal insurance markets, sharecropping provides informal crop insurance. In the event of a crop failure, the farmer who receives seed through sharecropping pays nothing for the seed. We expect risk-averse farmers to be willing to pay more to obtain seed through sharecropping because they are, in effect, paying for insurance as well as the seed. Risk-neutral farmers (or less risk-averse farmers) will forgo the insurance option and will choose the cheapest option for obtaining seed, which is to buy or borrow it.

An alternative hypothesis for why some farmers pay more for seed through seed-sharecropping is that they are credit-constrained. Since they do not have access to loans for purchasing seed, they are forced into paying a higher price for seed through seed-sharecropping contracts.

We can test these hypotheses using household survey data from a World Bank LSMS-style survey, which was implemented in Cajamarca, Peru, in 1999. The survey was conducted during two household visits. On the first visit detailed plot-level data were gathered, including the costs and quantities of seed, chemical, and labor inputs for each agricultural activity (from land preparation through harvest). The second visit requested information on each household member's education level, marital status, off-farm income sources, credit sources, and the household's experience with agricultural and other extension services. The second visit also included a full household consumption recall for the last year and an itemized account of all household and farm assets. In addition to the household questionnaire, village-level surveys were used to obtain information on: the community's access to utilities, public goods and services, the village's experience with NGO's and community-based organizations, and to recent weather-related shocks. Monthly market-level surveys recorded price data on agricultural inputs and outputs, as well as other products for home consumption.

Although the questionnaire did not include precise questions on risk-aversion, it contained detailed data on wealth. Several studies establish a systematic relationship between wealth and risk-aversion (Moscardi and de Janvry, 1977, and Bar-Shira et. al., 1997). Hence, in the analysis below we use wealth as a proxy for risk-aversion.

Descriptive statistics

Of the 486 households in our sample, 333 obtained seed from others, as opposed to using their stored seed. The 333 households that obtained seed from others can be divided into three groups: (1) those that obtained seed only through sharecropping, (2) those that obtained seed via sharecropping and by buying or borrowing seed, and (3) those that only bought or borrowed seed.

Table 1 compares household, production, and asset characteristics across these groups of households. There is a clear progression in wealth (in the form of asset holdings, potato income, off-farm income, household consumption, and dairy income) as households move out of seed-sharecropping. As farmers become wealthier, they become less risk-averse, so they obtain their seed through other sources.

Table 1: Comparing groups that obtain seed from sharecropping groups that buy or receive seed

	Group 1: SHARECROPPERS		Group 2: BUYS SEED OR GETS SEED LOAN		
	Group 1a: Obtain seed only in sharecropping contract	Group 1b: Also buy or borrow seed		P-values for T-test group 1 vs. group 2	P-value for T-test group 1a vs. group 1b
Observations	152	40	141		
Household characteristics					
Family size	5.5	6.5	5.0	0.01	0.03
Dependency ratio	0.99	1.14	0.95	0.46	0.41
Age of household head	41	43	45	0.01	0.43
Education of household head (years)	2.4	2.4	2.5	0.41	0.99
Production characteristics					
Total pototao seed planted per household member	139	150	172	0.08	0.61
Total potato seed per household member received in sharcropping arrangements	112	78	0	0.00	0.07
Number of workers	3.0	3.5	2.8	0.14	0.05
Number of plots	2.4	3.3	2.3	0.03	0.00
% of sharecropped plots in which seedlord is family member	1.4	1.3	0.42	0.00	0.51
Total arable land	4.2	7	10	0.00	0.09
Workers per arable land	1.9	1.3	1.2	0.06	0.08
Workers per unit of land currently used for potato cultivation	11.1	8.9	10.86	0.90	0.35
Total seed stored	247	446	570	0.00	0.01
Assets					
Herd value (soles)	2438	4110	6318	0.00	0.00
Total land (hectares)	4.8	8.1	11.8	0.00	0.04
Number of inherited cows	0.18	0.18	0.59	0.02	0.98
Value of farm assets (soles)	376	485	470	0.08	0.09
Value of household assets (soles)	185	316	761	0.00	0.00
Income and consumption					
Potato income (soles/person)	342	476	511	0.11	0.19
Off-farm income (soles/person)	107	228	311	0.00	0.03
Household consumption (soles/person)	761	896	1359	0.00	0.33
Credit constraint	0.38	0.6	0.44	0.89	0.01
Cash constraint					
Dairy income (soles)	1426	2027	3400	0.00	0.07
% of plots that lost all seed from El Nino	0.4	0.34	0.03	0.04	0.49

Access to credit

Credit constraints might explain why some farmers pay more to receive seed through sharecropping. Table 1 shows no significant difference in credit constraint levels between sharecroppers and non-sharecroppers.[6] However, only eighteen of the farmers in our sample receive a loan to obtain seed. Table 2 tabulates the reasons why farmers who needed seed did not

[6] The credit constraint is a 0/1 variable. Farmers were categorized as credit constrained if they did not have access or did not have a guarantee for loans from both formal banks and NGOs.

receive a loan from a bank. The most frequent reason why both groups do not receive bank-loans is the high interest rate. This response reveals farmers' risk preferences. Although seed-sharecroppers pay two times the value of their seed when they receive it through seed-sharecropping (as shown in Part II), they are not willing to take out a loan that requires them to pay between three and ten percent per month in interest, depending on the financial institution. Farmers are unwilling to take a loan because they risk not being able to pay it back in the event of crop failure. The sharecropping contract, on the other hand, never requires that they pay more than what they earn, and risk-averse farmers are willing to pay a premium for this contingency. These results support the hypothesis that although many seed-tenants have access to loans, they are reluctant to take out a loan because they are risk-averse.

Table 2

Why do farmers not receive a loan from a bank?

Reason	Seed-sharecroppers	Non-sharecroppers
Do not need loan	18%	21%
High interest rate	32%	29%
Credit source does not exist	11%	18%
Do not have guarantee	28%	19%
Other	12%	13%

Empirical model

Using an empirical model, we can perform a test of these hypotheses. The household's decision of whether or not to obtain seed through sharecropping is modeled econometrically as a dichotomous 0/1 decision. The household compares the expected utility of profits from buying the seed with the expected utility of profits from obtaining seed through sharecropping. Ideally, the structural probit would have this form:

$$EU_{Sharecrop} - EU_{Buy} > 0 \rightarrow \alpha = 1$$
$$EU_{Sharecrop} - EU_{Buy} \leq 0 \rightarrow \alpha = 0$$
$$P(\alpha = 1) = P(\vec{x}\hat{\beta} + C\hat{\gamma} + u) > 0 \rightarrow P(u > -(\vec{x}\hat{\beta} + C\hat{\gamma}))$$
$$P(\alpha = 0) = P(\vec{x}\hat{\beta} + C\hat{\gamma} + u) \leq 0 \rightarrow P(u \leq -(\vec{x}\hat{\beta} + C\hat{\gamma}))$$

where $\vec{x}$ is a vector of household and plot characteristics, and C is the ratio of the cost of seed through sharecropping to the market price of seed.

However, the structural probit cannot be directly estimated because we only have data on the price of sharecropping for those households that sharecrop. We must predict the cost of sharecropping for the non-sharecropping households. To do this we regress the cost of sharecropping on household and plot characteristics, controlling for selectivity bias. This is done by simultaneously estimating the regression for the cost of sharecropping and a reduced-form probit for receives seed through sharecropping. The regression for the cost of sharecropping is:

$$(1) \quad C = \vec{x}\delta + z_1\eta + \varepsilon_1$$

where $\vec{x}$ is a vector of household and plot characteristics, z_1 identifies the cost equation from the reduced form equation of the receive seed probit, and ε_1 is an error term.

The selection probit, the reduced form of the receive seed probit, takes this form:

$$(2)\quad \begin{aligned} P(a = 1) &= P(\vec{x}\hat{b} + z_1 m_1 + z_2 m_2 + e_2) > 0 \rightarrow P(e_2 > -(\vec{x}\hat{b} + z_1 m_1 + z_2 m_2)) \\ P(a = 0) &= P(\vec{x}\hat{b} + z_1 m_1 + z_2 m_2 + e_2) \leq 0 \rightarrow P(e_2 \leq -(\vec{x}\hat{b} + z_1 m_1 + z_2 m_2)) \end{aligned}$$

where z_2 identifies the selection probit from the cost regression and e_1 is an error term. Assuming error terms with the following normal distributions,

$$\begin{aligned} &e_1 \sim N(0, s) \\ &e_2 \sim N(0,1) \\ &corr(e_1, e_2) = r \end{aligned}$$

regression (1) and (2) can be estimated simultaneously using a maximum-likelihood technique. (See the appendix, Part A, for the maximum likelihood function.) The coefficient estimates are used to predict the cost of sharecropping for the entire sample, $\hat{C}$. Finally, the reduced form of the structural probit is estimated for the entire sample, using the predicted cost of sharecropping variable:

$$(3)\quad \begin{aligned} &EU_{Sharecrop} - EU_{Buy} > 0 \rightarrow a = 1 \\ &EU_{Sharecrop} - EU_{Buy} \leq 0 \rightarrow a = 0 \\ &P(a = 1) = P(\vec{x}\hat{b} + \hat{C}\hat{g} + z_1 m_1 + u) > 0 \rightarrow P(u > -(\vec{x}\hat{b} + \hat{C}\hat{g} + z_1 m_1)) \\ &P(a = 0) = P(\vec{x}\hat{b} + \hat{C}\hat{g} + + z_1 m_1 + u) \leq 0 \rightarrow P(u \leq -(\vec{x}\hat{b} + \hat{C}\hat{g} + z_1 m_1)) \end{aligned}$$

Results

Table 3 presents the results of the simultaneous estimation of the cost of seed regression and the selection probit. These results are used to predict the cost of sharecropping for the entire sample. Identification requires that at least one exogenous variable in the selection probit (the probit that models the household's decision to receive seed through sharecropping) must not significantly impact the cost of sharecropping (Deaton, 1997). The identifying variable in the selection probit is the variable for last year's production shock -- "Impact of El Niño squared."[7] This variable was not significant when it was included in the cost regression, a requirement for proper identification. (See the appendix, Part B, for these results.)

The cost regression has low explanatory power. The only significant variable is CARE works in the community, which is used to identify the cost equation from the structural equation. Since CARE provides seed through its agricultural extension programs, this variable is a proxy for the price of seed in a community. The regression results show that when CARE works in a community, the price of seed through sharecropping is lower. This makes sense because farmers who offer seed through seed-sharecropping contracts will have to compete with CARE.

[7] El Niño occurred the year prior to the year when the survey was conducted.

Table 3: COST OF SHARECROPPING (CONTROLLING FOR SELECTIVITY)

Dependent variable - Cost of sharecropping

Explanatory variables		**Model 1**	
		Coef	**P-value**
Observations	**1176**		
Fixed factors in production and producer characteristics			
Age of household head		0.00	0.39
Number of workers in family		-0.03	0.72
Wealth/ risk aversion			
Total land owned		0.01	0.73
Total land owned squared		0.68	0.68
Number of inherited cows		0.03	0.81
Dependency rate		0.04	0.56
Credit constraint		-0.05	0.81
Seed availability			
Impact of El Nino		-0.50	0.30
Effective price of seed (z1)			
CARE works in community (access)		-0.187	0.08
Plot characteristics			
Irrigated plot		0.21	0.21
Sandy soil		0.19	0.14
Yellow soil		-0.10	0.66

REDUCED FORM PROBIT

Dependent variable - Seed-tenant=1 / Not-seed tenant=0

Explanatory variables			
		Coef	**P-value**
Observations	**1176**		
Fixed factors in production and producer characteristics			
Age of household head		0.00	0.24
Number of workers in family		0.08	0.06
Wealth/ risk aversion			
Total land owned		-0.04	0.00
Total land owned squared		0.00	0.00
Number of inherited cows		-0.14	0.01
Dependency rate		0.01	0.90
Credit constraint		0.23	0.06
Seed availability (z2)			
Impact of El Nino		-0.86	0.19
Impact of El Nino Squared		1.49	0.02
Effective price of seed (z1)			
CARE works in community (access)		0.01	0.93
Plot characteristics			
Irrigated plot		0.13	0.22
Sandy soil		-0.09	0.38
Yellow soil		-0.26	0.07
Rho		-0.42	0.57
Wald chi2(12)		30.97	
Prob > chi2		0.00	

The results of the structural probit on the decision to obtain seed are presented in Table 4. Both production characteristics are significant with the expected signs. As the age of the household head increases, the household's probability of receiving seed declines. And as the number of workers in the household increases, the household's probability of receiving seed increases. Total land, the main proxy for wealth, is significant. As, total land ownership increases the household is less likely to receive seed through sharecropping. The proxy for last year's seed storage and its squared term are very significant. As the percentage of plots on which the household stored no seed during the previous year increases, the probability for the household to receive seed from seed-sharecropping increases. Plot characteristics also play a role. Irrigated plots increase and yellow soils decrease the household's probability to receive seed. Finally, as the predicted cost of sharecropping increases, the household is less likely to receive seed. The model correctly predicts 887 out of 1177 of the households.

Table 4: STRUCTURAL PROBIT FOR RECEIVES SEED

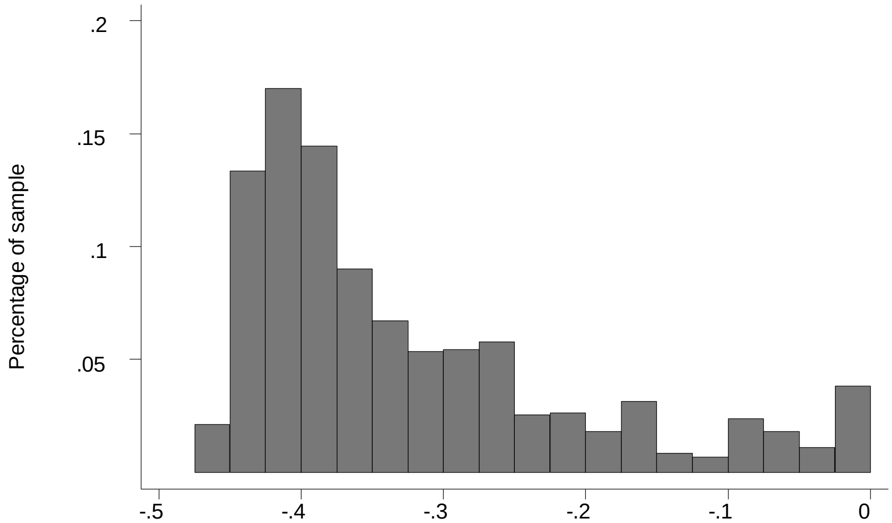
Dependent variable - Seed-tenant=1 / Not-seed tenant=0

Explanatory variables		**Coef**	**P-value**
Observations	**1176**		
Fixed factors in production and producer characteristics			
Age of household head		-0.01	0.01
Number of workers in family		0.12	0.00
Wealth/ risk aversion			
Total land owned		-0.02	0.00
Number of inherited cows		-0.11	0.11
Dependency rate		0.08	0.20
Credit constraint		0.021	0.88
Seed availability			
Impact of El Nino		-1.62	0.01
Impact of El Nino Squared (z2)		1.97	0.00
Plot characteristics			
Irrigated plot		0.25	0.06
Sandy soil		0.19	0.13
Yellow soil		-0.32	0.04
Predicted cost of sharecropping		-1.13	0.02
Pseudo R2		0.15	
Wald chi2 (12)		94.17	
Prob > chi2		0.00	
Prediction table	**Does not**	**Receives**	
Predict does not receive seed	789	234	1023
Predict receives seed	56	98	154
	845	332	1177

Part 3: The marginal effect of cost

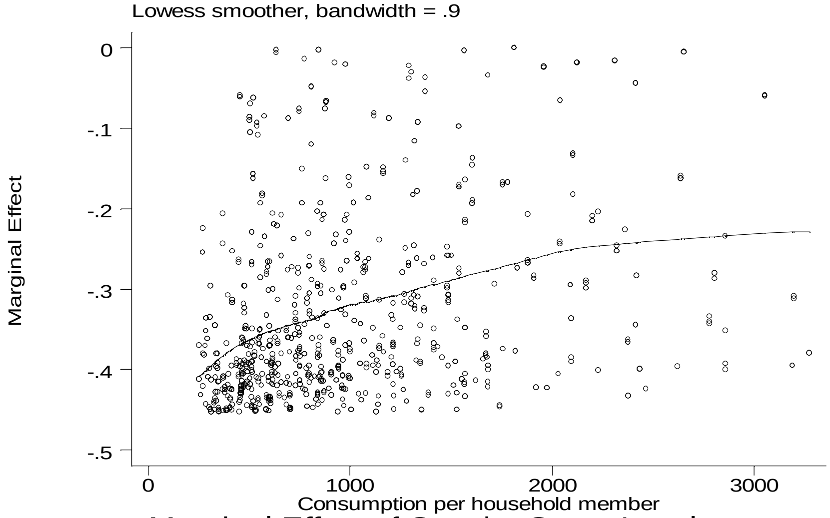
The previous section shows that the cost of sharecropping significantly impacts the household's probability to receive seed through sharecropping. This section identifies which groups are more sensitive to this cost.

Below is a histogram of the marginal effect of the cost of sharecropping on the probability to receive seed through sharecropping. Thirty-two percent of the sample has a marginal effect at or below -0.4. This means that as the price of seed-sharecropping increases by one, the probability to receive seed through sharecropping drops by 0.4 or more. Fifty-two percent of the sample has a marginal effect between –0.4 and –0.2. And sixteen percent of the sample has a marginal effect between –0.2 and zero.

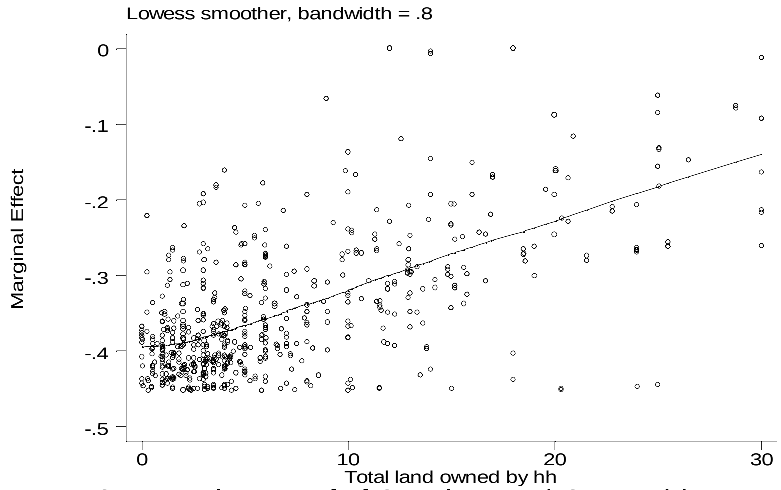


Histogram of Marginal Effect of Cost

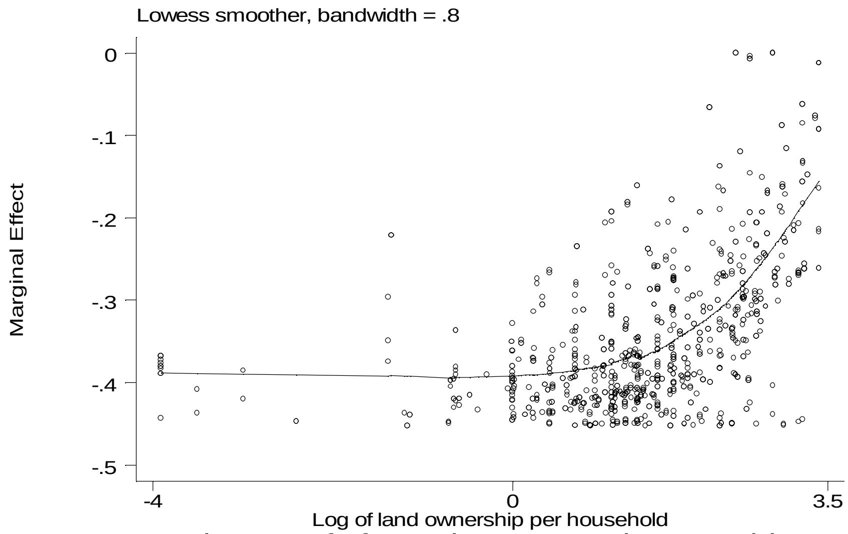
Wealthy households are less sensitive to the cost of sharecropping. Below, wealth (measured by per-capita consumption, land ownership, arable land ownership, and the value of farm assets) is plotted against the marginal effect of cost. In each case, as wealth increases, the marginal effect of cost decreases in magnitude (it tends toward zero.)



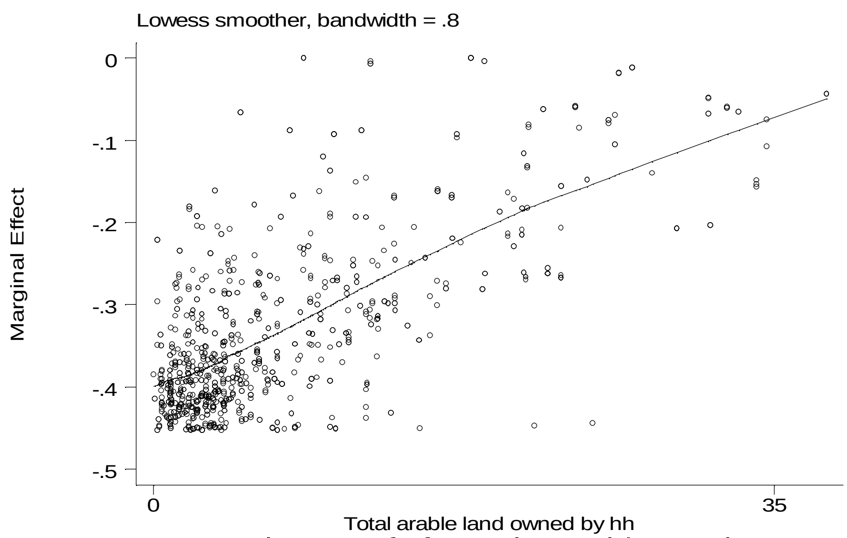
Marginal Effect of Cost by Cons. Level



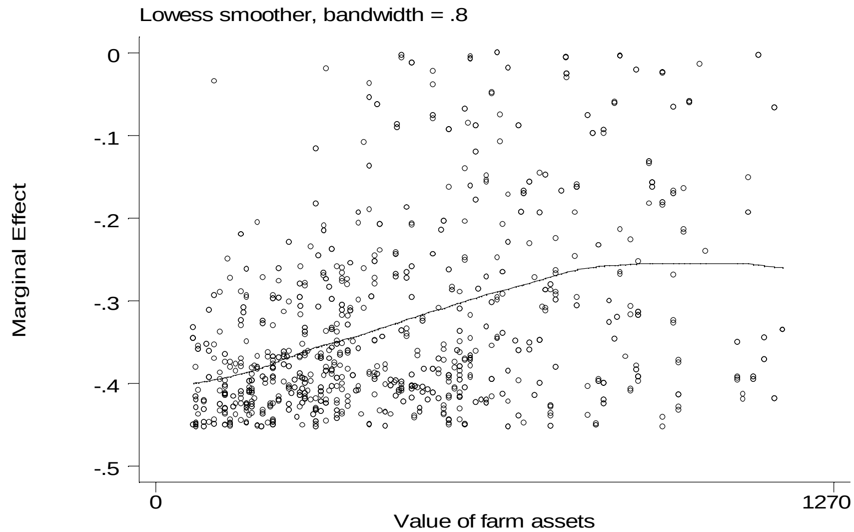
Censored Marg Ef of Cost by Land Ownership



Censored Marg Ef of Cost by Log Land Ownership

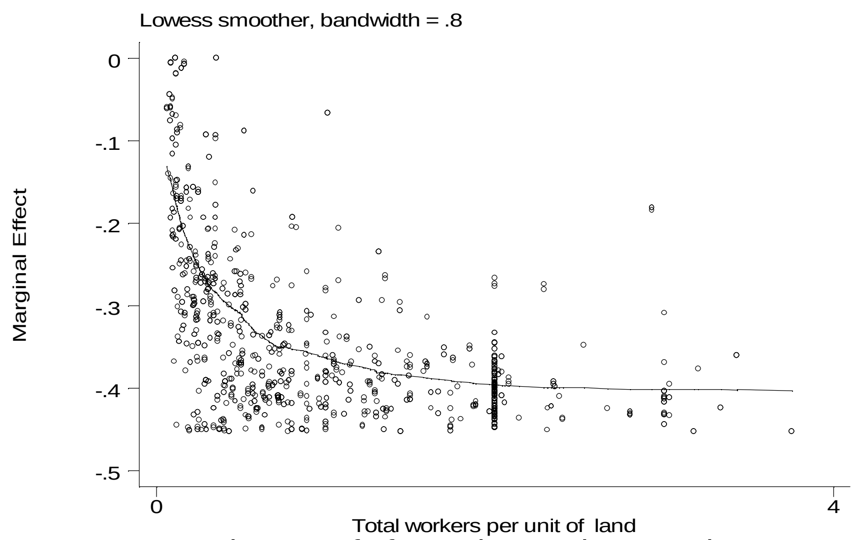


Censored Marg Ef of Cost by Arable Land



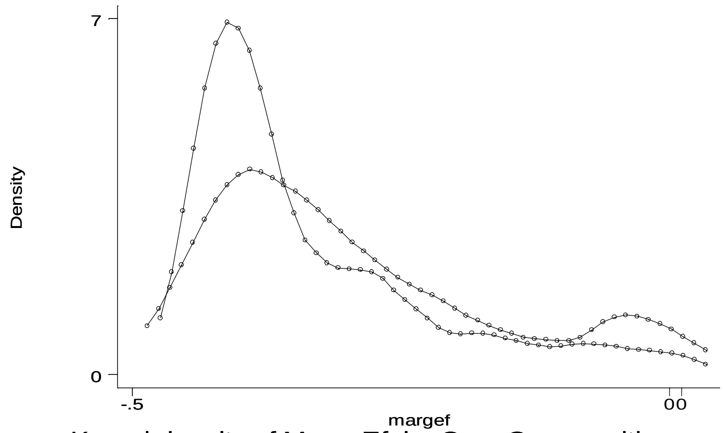
Censored Marg Ef of Cost by Farm Asset Value

Households with surplus labor are also more sensitive to the cost of sharecropping. The graph below shows that as the number of worker/ land ratio increases, the marginal effect increases in magnitude.



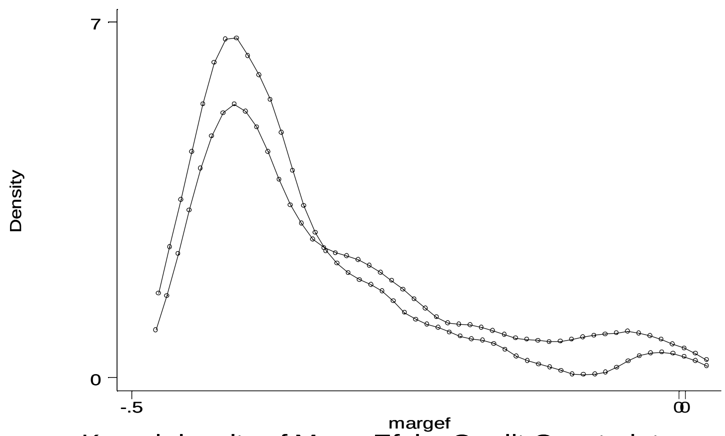
Censored Marg Ef of Cost by Workers per hect.

Households in CARE communities are significantly more sensitive to cost than households in communities without CARE. The average marginal effect of cost is -0.34 for households in CARE communities and -0.30 for households in communities without CARE. This might be because households in CARE communities have alternative sources of seed and other inputs. The smoothed distribution of the marginal effect for each group is plotted in the graph below.



Kernal density of Marg. Ef. by Care Communities

There is a significant difference in the marginal effect of cost between credit constrained and non-credit constrained households. The former has an average marginal effect of –0.35, while the later has –0.31. The graph below depicts the smoothed distribution of the marginal effect of cost for each group.



Kernal density of Marg. Ef. by Credit Constraint

Conclusion

This paper explores how Andean farmers use sharecropping contracts to obtain seed, their most expensive input. The sharecropping contract confers insurance because farmers are not responsible for repaying the seed if the harvest fails. We show that farmers who receive seed through sharecropping possess the typical traits of a group that needs insurance: they are younger and poorer (in terms of land), have more family labor, and are more likely to have suffered from prior weather shocks than other farmers.

While sharecropping provides necessary, and perhaps vital, insurance for poor farmers, it does so at a very high cost. We calculate that farmers pay twice the market price, on average, to receive inputs through sharecropping. We also calculate the impact of the price on a farmer's likelihood to receive seed through sharecropping. We find that farmers who are poor and have more surplus-labor (as measured by the worker/land ratio) are more sensitive to price when deciding whether to receive seed through sharecropping. Thus, the farmers who are in greater need of insurance may decide not to receive seed through sharecropping due to its high price.

These results highlight the need for formal insurance in the rural Andes. Although it is unlikely that for-profit entities would offer insurance in a region known for its risky climate, it is conceivable that NGOs and governmental extension organizations that are active in the region might incorporate insurance or limited liability into their credit contracts with poor farmers. This would enable poor farmers to purchase their inputs in advance, without incurring the risk of a negative-income.

Appendix: Part A

The log likelihood for observation k for simultaneous estimation of equations (1) and (2) takes this form:

$$l_k = \begin{cases} a = 0 \rightarrow \ln \Phi\left(-(\vec{x}'\hat{b} + z_1 m_1 + z_2 m_2)\right) \\ a = 1 \rightarrow \left(\dfrac{\ln \Phi\left(\vec{x}\hat{b} + z_1 m_1 + z_2 m_2 + (C_k - \vec{x}d - z_1 h\right) r / s - \frac{1}{2}\left(\frac{C_k - \vec{x}d - z_1 h}{s}\right) - \ln \sqrt{2p}\, s}{\sqrt{1 - p^2}} \right) \end{cases}$$

Appendix: Part B

Appendix Part B: Test of Identifier

Dependent variable - Cost of sharecropping

Explanatory variables		**Model 1**	
		Coef	**P-value**
Observations	**1176**		
Fixed factors in production and producer characteristics			
Age of household head		0.12	0.33
Number of workers in family		-0.16	0.21
Wealth/ risk aversion			
Total land owned		0.09	0.03
Total land owned squared		-0.01	0.27
Number of inherited cows		0.27	0.22
Dependency rate		0.02	0.93
Credit constraint		-0.44	0.20
Seed availability			
Impact of El Nino		1.03	0.59
Impact of El Nino squared		-2.59	0.18
Effective price of seed (z1)			
CARE works in community (access)		-0.204	0.57
Plot characteristics			
Irrigated plot		-0.01	0.98
Sandy soil		0.36	0.24

REDUCED FORM PROBIT

Dependent variable - Seed-tenant=1 / Not-seed tenant=0

Explanatory variables		**Coef**	**P-value**
Observations	**1176**		
Fixed factors in production and producer characteristics			
Age of household head		0.00	0.22
Number of workers in family		0.08	0.04
Wealth/ risk aversion			
Total land owned		-0.04	0.00
Total land owned squared		0.00	0.01
Number of inherited cows		-0.14	0.01
Dependency rate		0.01	0.89
Credit constraint		0.23	0.04
Seed availability (z2)			
Impact of El Nino		-0.86	0.13
Impact of El Nino Squared		1.49	0.01
Effective price of seed (z1)			
CARE works in community (access)		0.00	0.92
Plot characteristics			
Irrigated plot		0.13	0.17
Sandy soil		-0.09	0.344
Yellow soil		-0.26	0.052
Rho		-0.85	

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