Measuring Transactions Costs from Observed Behavior: Market Choices in Peru

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Abstract

Farmers incur proportional and fixed transactions costs in selling their crops on markets. Using data for Peruvian potato farmers, we propose a method to measure these transactions costs. When opportunities exist to sell a crop on alternative markets, the observed choice of market can be used to infer a monetary measure of transactions costs in market participation. The market choice model is first estimated at the reduced form level with a conditional logit, as a function of variables that explain transactions costs. We then use these market choice equations to control for selection in predicting the idiosyncratic prices that would be received on all markets and the idiosyncratic proportional transactions costs that would be incurred to reach all markets. The net between the two gives us a measure of effective farm-level prices. This allows us to estimate a semi-structural conditional logit of the market choice model. In this model, the choice of market is a function of predicted effective farm-level prices, and of market information that accounts for fixed transactions costs. We can use the estimated coefficients to derive the price equivalence of the fixed cost due to information. We find that the information on market price that farmers receive from their neighbors reduces fixed transactions costs by the equivalent of doubling the price received, and is equal to four times the average transportation cost.

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JEL classification: D23, D83, O12

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1. Introduction

Institutional economics posits that agents making decisions on different types of transactions do so in a costly way (Williamson). For example, farmers deciding where to sell a particular crop base their decisions not only on the price they expect to receive in each market but also on additional costs related to transacting in these markets.

Two broad categories of transactions costs, proportional and fixed transactions costs, have been identified in the literature (Key, Sadoulet, and de Janvry). Proportional transactions costs change according to how much a household sells or buys (e.g., per unit transportation costs and price premiums deriving from bargaining capacity). Fixed transactions costs are independent of the quantities sold or bought. They include information, bargaining, and monitoring costs. Information costs occur before the exchange takes place and include aspects such as searching for attributes that could facilitate the transactions, seeking better prices, and looking for potential buyers. Bargaining or negotiation costs are incurred during the exchange and include the time to negotiate a contract, reach an agreement, and make arrangements for payment. The extent to which a person is able to minimize these costs is usually assumed to be function of individual characteristics (education, skills, gender), product attributes like quality, and the relationship between agents participating in the transactions. Finally, monitoring costs are incurred to ensure that the conditions of an exchange are met (for example enforcing the payment schedule agreed upon or the specified quality of the product).

While the body of descriptive and theoretical literature on transactions costs is extensive, the empirical literature has been lagging. This is importantly because transactions costs have a large unobservable component, and hence their measure can only be indirectly revealed from the behavior of potential agents in these markets. In addition, with the exception of transactions costs attributes like distance to markets and transportation costs, aspects like market information or search and bargaining procedures are rarely included in most surveys and are unlikely to be comprehensive when included.

Most of the precursor empirical studies used the joint decision of market participation (which depends on both fixed and proportional transactions costs) and amount transacted (which only depends on the proportional transactions costs) to identify the presence or to measure these two types of transactions costs. Presence of transactions costs is simply revealed by identification of some of their determinants as regressors in the market participation and quantity transacted equations (Goetz for the peanut market in Senegal; Skoufias for the land rental market in Peru; Sadoulet, de Janvry, and Benjamin for the labor market in rural Mexico).[1] Using the same method, but assuming that all proportional transactions costs are included in the observed transactions prices, Renkow, Hallstrom, and Karanja measure fixed transactions costs of semi-subsistence farm-households in Kenya and find that on average these costs are equivalent to a 15 percent ad-valorem tax (but as high as 70% for some households), while purchasing prices are on average 35% above selling prices. Complementing this approach, some studies analyze the transactions costs that enter into idiosyncratic price formation[2] (Escobal with an hedonic price equation for a sample of households from Peru; Staal, Delgado, and Nicholson for milk producers in Kenya and Ethiopia; Park, Jin, Rozelle, and Huang, for price differentials across Chinese provinces; Minten and Kyle using

[1] Presence of transactions costs are also identified by the presence of travel distance or time variables in farmers' crop choices (Omamo) and in land values (Jacoby)

[2] When comparing prices across markets or regions, a large element of the difference is simply due to transportation costs. The transactions costs that are more difficult to measure and seldom studied are those that vary across households within the same geographical location.

a survey of traders in Kinshasa). Proportional and fixed transactions costs can be separately identified, even when they share the same determinants, through estimation of a minimum threshold level of transactions implied by the presence of fixed transactions costs. This is done by estimating a censored regression with unobserved threshold (Cogan for the married women labor supply in the United States; Key, Sadoulet, and de Janvry for the corn market in Mexico). This last method can give a measure of proportional transactions costs, but can only reveal the presence and the determinants of fixed transactions costs, not give a measure of these fixed costs. Finally, one can use the choice between different markets with different structure of transactions costs to reveal the role of these costs in market choices (Hobbs for cattle marketing in the U.S.)

In this paper, we use the market choices made by farmers to reveal a monetary measure of proportional and fixed transactions costs. This is done in two steps. The first step uses a reduced form conditional logit market choice model to control for selectivity in predicting the prices received in all markets and the proportional transactions costs incurred in reaching all markets. The second step uses a semi-structural conditional logit market choice model to estimate the role of fixed transactions costs represented by information about prices available to farmers. We can derive a monetary measure of the fixed transactions costs from the estimated coefficients.

In section 2, we discuss the decision process that farm households face in allocating their marketed surplus across various markets. The empirical strategy to estimate the market selection model is developed in section 3. Section 4 presents insights from the transactions specific survey and section 5 discusses the empirical results.

2. Decision timeline

In order to conceptualize the marketing problem faced by a producer, consider a farm household that produces an agricultural product. The household's decision process can be divided into three phases. Initially, during the planting season, household h chooses the optimal allocation of resources to determine the total quantity to be produced. Following a typical farm-household setting, this decision is based on the expected price of the product and on available resources such as labor, land, and other exogenous incomes. The corresponding supply function can be represented by $Q(p, w, z_h^q)$ where p and w are output and variable input expected prices, respectively, and z_h^q are fixed factors in production.

The second decision phase, at the harvest season, entails household h's realization of the effective total quantity produced Q_h and an assessment of how much to sell and consume.[3] Home consumption c_h is a function of the product price p and consumption shifters z_h^c, that is $c_h = c(p, z_h^c)$. Based on this, household h's marketed surplus q_h is given by:

(1) $$q_h = Q_h - c_h .$$

Departing from the typical household framework, we further assume that a particular household h sells its marketed surplus q_h in several transactions of equal size. The number of transactions for a particular household n_h depends on the marketed surplus and on fixed transactions costs determined by z_h^n, i.e., $n_h = n(q_h, z_h^n)$. As such, the quantity of transaction i is given by:

[3] Other options that could be incorporated in this decision are the possibilities of storage and payment in kind. However, these do not add much to our analysis at this point so we omit them for simplicity.

(2) $$q_{hi} = \frac{q_h}{n_h},$$

where q_{hi} is the quantity sold by household h in its i^{th} transactions.[4]

The final decision for the household is on which market to sell its marketed surplus and specifically each of the individual sales q_{hi}. We focus on farm-households that are net-sellers (that is $q_h > 0$) and drop the household subscript h for simplicity (so that i indicates both the transaction and the household). Then, if there exist J available markets where a farm-household can sell q_i, the farm-household's decision is based on three factors.

First, selling in market j for a given transaction i is associated with proportional transactions costs TC_{ij}^p per unit of product. These costs are a function of the distance d_{ij} and time m_{ij} to reach market j, as well as of other individual-specific characteristics z_{ij}^p such as road quality. Proportional transactions costs are thus given by:

(3) $$TC_{ij}^p = TC^p(d_{ij}, m_{ij}, z_{ij}^p).$$

Second, the household considers the expected price p_{ij} to be received on each candidate market j. This price is decomposed in:

(4) $$p_{ij} = \bar{p}_j + B(q_i, z_i^b)$$

where $\bar{p}_j$ is a market specific exogenous price and $B(q_i, z_i^b)$ is the potential price markup that the household expects to receive. This markup depends on the quantity sold q_i and on other bargaining related attributes such as ability, experience, and product quality z_i^b.

Finally, selling on market j is associated with fixed costs $TC^f(z_{ij}^f)$ that are invariant to the specific quantity sold and include costs like searching for potential buyers and obtaining information about prices, markets, or types of contractual agreements available at different markets.

Based on the above, and for a given transactions i, a farm-household chooses to sell q_i in the market j_i that yields the highest net profits among the $k = 1,\ldots,J$ markets. This can be written in semi-structural form as:

(5) $$j_i = \arg\max_k \left\{ \Pi_{ik} = q_i \cdot (p_{ik} - TC_{ik}^p) - TC^f\left(z_{ik}^f\right), k = 1,\ldots,J \right\}$$

or, in reduced form, as:

(6) $$j_i = \arg\max_k \left\{ \Pi_{ik} = q_i \cdot \left[(\bar{p}_k + B(q_i, z_i^b) - TC_{ik}^p(d_{ik}, m_{ik}, z_{ik}^p) \right] - TC^f(z_{ik}^f), k = 1,\ldots,J \right\}.$$

[4] As we show later, our data suggest that indeed households divide their marketed surplus roughly equally across n transactions and across time.

3. Empirical strategy

Equations (5) and (6) offer a simple framework to empirically explore the role of transactions costs on market choice. The empirical strategy in using this framework is as follows:

Step 1

i) Instrument the quantity transacted.

ii) Use the reduced form model to predict market choice as a conditional logit, where the exogenous variables are the instrumented quantity transacted and the variables that explain transactions costs.

Step 2

i) Predict the idiosyncratic price that would be received by each farmer on each market, controlling for market selection using the reduced form model prediction of market choice.

ii) Predict the idiosyncratic proportional transactions costs associated with transportation for each farmer to each market, controlling for market selection using the reduced form model prediction of market choice.

iii) Derive effective farm-level prices and (optionally) the monetary value of proportional transactions costs from these predictions.

iv) Use the semi-structural form model to predict market choice as a conditional logit, where the exogenous variables are the instrumented quantity transacted, predicted effective farm-level prices, and information on market prices available to farmers in the village as a determinant of fixed costs.

v) Derive a price equivalent for the fixed cost using the estimated coefficient for information relative to the estimated coefficient for effective farm-level price.

vi) Simulate the impact on market choice that changes in proportional transactions costs (transportation) and fixed transactions costs (information on market prices) would have on market choice.

3.1. Reduced form market choice

Focusing on equation (6) for now, we specify the econometric model as follows:

(7) $$\Pi_{ik}^{*} = X_{ik}\beta + W_i\beta_k + \varepsilon_{ik}$$

where Π_{ik}^{*} are the latent net profits from transaction *i* in each market *k*, $X_{ik} = \left\{\bar{p}_k, d_{ik}, m_{ik}, z_{ik}^{p}, z_{ik}^{f}\right\}$ is a vector of characteristics that vary across alternatives *k*, $W_i = \left\{1, q_i, z_i^{b}\right\}$ are attributes that are invariant across market alternatives, β and β_k are parameters to be estimated, and ε_{ik} are i.i.d. error terms.[5]

Let j_i denote the market choice that maximizes profits for transaction *i*:

[5] While β shows the effect of an attribute specific parameter (such as distance to a market), β_j captures the market specific impact of individual characteristics (such as experience) on the market choice.

(8) $$j_i = \arg\max_k \left(\Pi^*_{ik}, k = 1, \ldots, J\right)$$

Assuming that the ε_{ik} are distributed with a type I extreme value distribution, the choice of market *j* for transaction *i* is given by:

(9) $$\Pr(j_i = j \mid X_{ik}, W_i) = \frac{\exp\left(X_{ij}\beta + W_i \beta_j\right)}{\sum_{k=1}^{J} \exp\left(X_{ik}\beta + W_i \beta_k\right)},$$

which corresponds to a conditional logit model that can be estimated using maximum likelihood techniques.

One concern in estimating equation (9) consistently is that the quantity sold q_i is endogenously chosen by the household. To address this endogeneity issue, and following equation (2), we instrument the quantity sold q_i as a function of production, household characteristics, and factors that affect the number of transactions.[6]

3.2. A semi- structural approach to market choice

Estimating the semi-structural equation (5), which explicitly includes net prices ($p_{ij} - TC^p_{ij}$), allows us to identify the impact of fixed transactions costs in net price equivalent. This approach requires the joint estimation of a system of three equations based on (3), (4) and (5):

The price equation:

(10) $$p_{ij} = P_{ij}\gamma + \mu_{ij},$$

where $P_{ij} = \{\bar{p}_j, q_i, z^b_i\}$, γ are parameters to be estimated, and μ_{ij} are normally distributed i.i.d. error terms with mean 0;

The proportional transactions cost equation:

(11) $$TC^p_{ij} = TC_{ij}\delta + v_{ij},$$

where $TC_{ij} = \{d_{ij}, m_{ij}, z^p_{ij}\}$, δ are parameters to be estimated, and v_{ij} are normally distributed i.i.d. error terms with mean 0;

The market choice:

(12) $$j_i = \arg\max_k \left(\Pi^*_{ik} = X_{ik}\beta + W_i\beta_k + \varepsilon_{ik}, k = 1, \ldots J\right),$$

where Π^*_{ik} are the latent net profits from sales *i* in each market *k*, $X_{ik} = \{p_{ik} - TC^p_{ik}, z^f_{ik}\}$, $W_i = \{1, q_i\}$, β and β_k are parameters to be estimated, and ε_{ik} are error terms distributed with a type I extreme value distribution.

Joint estimation of the above system raises some problems. Specifically, expected prices p_{ij} and proportional transactions costs TC^p_{ij} are only observed for a transactions *i* if it occurred in a

[6] The exclusion restrictions and identification test for this instrumentation are discussed below.

particular market *j*, i.e. $j_i = j$. However, the model specification in equation (12) requires that we know the full vector of net prices for all transactions and all markets (i.e., $p_{ik} - TC_{ik}^p, \forall k$).

We thus proceed with a two-stage estimation approach. First, for each market j we estimate equations (10) and (11) correcting for market selection bias:

(13) $$p_{ij} = P_{ij}\gamma + \hat{\lambda}_{ij}\xi + \mu_{ij}^* \text{ for } i \mid j_i = j$$

and

(14) $$TC_{ij}^p = TC_{ij}\delta + \hat{\lambda}_{ij}\zeta + \nu_{ij}^* \text{ for } i \mid j_i = j,$$

where the market correction term ($\hat{\lambda}_{ij}$) is estimated from the reduced form market choice model from section 3.1, while μ_{ij}^* and ν_{ij}^* are normally distributed with mean 0 for the sample of market participants.[7]

Using these results, we can then predict $\hat{p}_{ij}$ and $T\hat{C}_{ij}^p$ for all transactions i and all $j = 1, \ldots, J$ markets:

(15) $$\hat{p}_{ij} = P_{ij}\hat{\gamma} + \hat{\lambda}_{ij}\hat{\xi}$$

and

(16) $$T\hat{C}_{ij}^p = TC_{ij}\hat{\delta} + \hat{\lambda}_{ij}\hat{\zeta}.$$

Using these predictions, we can form a vector of net prices ($\hat{p}_{ij} - T\hat{C}_{ij}^p$) for all transactions i and all markets *j*. This, along with the (instrumented) quantity sold $\hat{q}_i$ and the fixed transactions costs $TC^f(z_{ij}^f)$, allows us to consistently estimate the market choice model:

(17) $$\Pr(j_i = j \mid X_{ij}, W_i) = \frac{\exp\left(X_{ij}\beta + W_i\beta_j\right)}{\sum_{k=1}^{J} \exp\left(X_{ik}\beta + W_i\beta_k\right)},$$

where $X_{ij} = \{\hat{p}_{ij} - T\hat{C}_{ij}^p, z_{ij}^f\}$ and $W_i = \{1, \hat{q}_i\}$.

The estimated coefficient on the z_{ij}^f variable gives the role of fixed transactions costs in market choice. Since the effective farm-level price $\hat{p}_{ij} - T\hat{C}_{ij}^p$ variable is measured as a price, the ratio of the fixed transactions costs coefficient to the price coefficient gives us a net price equivalent for the fixed transactions costs.

4. Transactions costs insights from rural Peru

The data used in this paper come from a survey of 220 small-scale farm-households in the province of Tayacaja in Peru, designed and implemented in early 2001 by Javier Escobal at the

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[7] Specifically, for market *j*, $\hat{\lambda}_{ij} = \frac{\varphi(X_{ij}\hat{\beta} + W_i\hat{\beta}_j)}{\Phi(X_{ij}\hat{\beta} + W_i\hat{\beta}_j)}$, with $X_{ij} = \{\overline{p}_j, d_{ij}, m_{ij}, z_{ij}^p, z_{ij}^f\}$ and $W_i = \{1, q_i, z_i^b\}$.

Grupo de Análisis para el Desarrollo (GRADE). These farm-households are part of about 1500 households in the region dedicated mainly to potato production.[8] The survey covers two distinct regions, a richer area endowed with good road access (the integrated region) and a poorer area significantly farther away and less well connected to markets (the isolated region).

4.1. Markets and transactions

Farmers sell potatoes in two local markets (Pazos and Pichus) and two distant ones (Huancayo and Lima).[9] The two local markets open twice a week while the two distant ones are open every day. The distant markets are larger and attract more sellers and buyers. Farmers also sell at the farmgate to merchants who travel around these communities in search of potatoes. Table 1 summarizes access and participation to these markets by farm households in the survey. Note that households from the isolated region are substantially further away from all markets in terms of travel time and mostly sell in the local markets. By contrast, households from the integrated region sell more in distant markets and also more at the farmgate. In general, the average quantity sold in distant markets is significantly higher than the quantities sold locally or at the farmgate. In addition, households in the integrated region sell more per transactions than those in the isolated region.

Table 1. Access to markets and transactions

	Integrated region	Isolated region
Number of farm households	136	84
Average travel time to (minutes):		
Pazos (local market)	38	194*
Pichus (local market)	30	88*
Huancayo (distant market)	89	245*
Lima (distant market)	220	374*
Sales transactions:		
Total number	653	443
Farmgate (%)	31.1	12.2*
Local markets (%)	24.8	79.2*
Distant markets (%)	44.1	8.9*
Average number per household	4.8	5.3*
Average transaction size (in quintals)		
Farmgate	52.9	17.9*
Local markets	36.8	23.8*
Distant markets	104.5	81.3

* significantly different from those in the integrated region at the 10% level or less.

Most farm-households in our data engage in four to six sales transactions during a year. Therefore, an immediate concern is determining whether division of the total marketed surplus q_h into a number of smaller sales q_{hi} is jointly determined with market choice. If this were the case, it would invalidate the empirical methodology outlined above as we would need to also account for the endogeneity of quantities and the timing of all individual sales. A detailed analysis of these

[8] For an extensive description of the region see Escobal.

[9] There are a number of other small markets where farmers could potentially transact, but are not included in the analysis due to too few observations and their relative significance.

transactions revealed that farm-households divide their total marketed surplus in sales of relatively equal size, fairly equally spaced in time during the year. Considering all farm-households with more than one transaction (*n* = 2,...,7), where transactions are ranked by date from harvest time, we find no significant differences between the average quantity or the average share of marketed surplus for any two transactions *k* and *l*, with $k,l = 1,\ldots,n$. Pair-wise correlations between quantities of sequential sales are high and positive, supporting the hypothesis that consecutive sales are similar. There is no significant difference between the times spanned between any two consecutive sales.

Finally, exploring whether there exists a strategic market-specific pattern in the various sales does not reveal anything systematic. Farm-households sell in many markets and nothing suggests a strategic sequencing of market destinations (or clusters of markets). While all these insights are not conclusive, they do support the hypothesis that market choice for individual sales can be treated as independent and we proceed as such.[10]

The survey included a question about why the household chose the market where it sold. The main reasons farmers indicated for making the market choice were: expectation of a higher price, availability of more buyers, and a higher trust level in potential buyers on that market (Table 2).

Table 2. Preferences for markets by region

	Integrated region			Isolated region		
	Farmgate	Local	Distant	Farmgate	Local	Distant
The farmer prefers to sell in this market because of (%):						
Higher prices	23**	44*	38	4**	55*	89*
More buyers	30	26	33*	0	30*	0*
More trust in buyers	27**	20*	25	4	5	11
Only option available	20	9*	3*	86**	2*	0
Other reasons	0	1*	0*	6**	8	0*

* significantly different from the group to its left at the 10% level or less.
** significantly different from the distant market at the 10% level or less.

4.2. Transactions costs

Perhaps the most interesting aspect of the survey is the availability of transactions costs related information. In particular, the survey contains data on 1096 potato sales transactions in the five markets described above. As discussed earlier, one way of classifying transactions costs is between transportation, information, bargaining, and monitoring. There is obviously a great variation in transportation costs to different markets. Farmers from the integrated area pay transportation costs varying from an average 2 soles/qt to local markets to 4 and 7 soles/qt to the two distant markets.[11] Farmers from the isolated areas pay transportation cost three time higher, with average 6, 11, and 15 soles/qt to the local and the two distant markets, respectively. These transportation costs represent 10 to 15% of the price received for farmers in the integrated area and 30% for farmers in the isolated area.

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[10] However, we do correct for clustering of multiple transactionss by each farm-household in the econometric analysis.
[11] All costs and prices are deflated and expressed in constant prices of December 2000. The exchange rate was 3.5 soles/US$.

Prices also vary a lot across markets. Prices received at the farm gate are lowest at 17 and 20 soles/qt in the isolated and integrated area, 25 soles/qt in the two local markets, and 32 and 41 soles/qt in the two distant markets. Surprising, however, is the fact that prices received also vary even when controlling for the market, the season of the sale, and the transactions volume. There is for example a 24 to 32 percent variation in the prices received within the same market (Table 3).[12] The high variation is consistent with the hypothesis that the price markup is indeed important and as such the ability to bargain may be a crucial factor in the determination of this market price. The ability to affect the price received depends on a number of factors: the farmer's negotiating skills, the product's attributes (such as quality), or the relationship with the other party. Farmers that sell in distant markets are wealthier, more educated, and have more farming experience compared with those that sell in local markets, implying that they may be better equipped to negotiate. As for product quality, more than 80 percent of transactions in distant markets are for improved potato varieties, as opposed to 65 percent at the farmgate and 50 percent in local markets.[13]. A third of all farmers had problems with agreeing on the quality of the product, implying high fixed transactions costs[14]. Even though some farmers reported that they managed to resolve these types of problems, the majority did not, and may have had to settle for a lower price than expected.

Characteristics of information and search costs are also reported in Table 3. Ex-ante information on the price in the market in which farmers are selling varies from 24 percent for farmgate sales to 53 percent and 85 percent for local and distant market sales. What is interesting also is to note that farmers that sell at the farmgate are well informed on prices in the other markets, local and distant. By contrast, farmers that sell on the local markets have little information on prices in alternative markets. Farmers that sell in distant markets are relatively well informed of their closest competitor. Interestingly, however, 22 percent of these farmers admit that their price expectations were higher than the price they ended up receiving. Another aspect of information costs is that related to search costs for finding market specific information and potential buyers. Almost two thirds of the households that sold in distant markets found the buyer prior to the transactions, compared with only a third of the households that sold in local markets. In addition, finding a buyer is costly: half of the farmers that sold beyond the farmgate needed on average more than two hours to sell their product, a third needed between one to two hours while the rest did not find a buyer in the same day, implying that the search costs are not trivial.

Finally, after the transaction takes place, the farmer may still incur additional costs. For example, the farmer may enter an agreement to get paid in the future and as such he can incur costs related to enforcing the sales agreement. For farmers that sold in distant markets, it took more than four days to get paid, compared to only two for those that sold in local markets. This could be one explanation as to why 40 percent of the farmers that sold in distant markets signed a contractual agreement with the buyer.

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[12] All comparisons of the price variation controlling for the size of the transactions, the timing of the sale, and choice of market revealed high coefficients of variation. We only report the prices by market.

[13] In fact, field discussions revealed that native potato varieties have higher consumption incidences among local communities than the improved varieties.

[14] This entails the verification and subsequent agreement between the two parties that the potatoes are of a specific quality and variety (for example between good and bad condition, or between native or improved variety). While the variety is usually easier to verify, agreeing on the quality can be more challenging.

Table 3. Transactions costs related variables, by market destination

	Farmgate	Local	Distant
Information and search (ex ante)			
Found a buyer and fixed price ahead (%)	37**	35	63*
Knew buyer (%)	64**	81*	88*
Buyer lives in same area (%)	35**	11*	0*
Time to sell in market (%)			
Less than an hour	n.a.	12	16*
Between 1 and 2 hours	n.a.	37	29*
More than 2 hours	n.a.	43	43
Did not sell the same day	n.a.	8	11*
Knew price in market of transaction (%)	24**	53*	84*
Knew prices in the other markets (%):			
Farmgate		9	18*
Local market	66**	8*	52*
Distant market	53**	16*	22*
The price received was [...] compared to the expected price (%):			
Higher	4	2	3
Lower	35**	21*	22
Same	60**	76*	75
Bargaining and negotiation			
Number of negotiation rounds before agreeing on price	1.3**	1.5*	1.9*
Farmer bargained himself (%)	58**	79*	63*
Average price received (soles/qt)	19**	25*	34*
Coefficient of variation of price received (%)	26	32	24
Number of available buyers if sold at farmgate	2.7	n.a.	n.a.
Had problems agreeing on quality (%)	42**	29*	36*
Managed to agree on quality (%)	40**	18*	50*
Buyer paid cash (%)	60**	65*	37*
Land owned (hectares)	4.8**	4.7	6.6*
Farm experience (years)	17**	19*	19
Improved variety (%)	65**	52*	82*
Household head age (years)	47**	50*	49
Household head education (years)	5.3**	5.3	5.7*
Household head is male (%)	95	91*	94*
Household head is indigenous (%)	57	64*	57*
Monitoring and enforcement (ex post)			
Time to get paid (days)	3.0**	2.1*	4.5*
Number of times that farmer had to ask for payment	1.5**	1.6*	2.0*
Trust in buyer (1 lowest, 10 highest)	4.4**	4.6*	5.0*
Signed an agreement (%)	21**	28*	41*

* significantly different from the group to its left at the 10% level or less.
** significantly different from the distant market at the 10% level or less.

5. Econometric results

5.1. Reduced from estimation of market choice

We first estimate a reduced form IV conditional logit of market selection based on equation (9) above. The results are reported in Table 5 and the first stage instrumentation for the quantity sold is reported in Table 4.[15]

Table 4. First stage estimation of transaction quantities
Dependent variable: quantity sold (in qt)

	Coefficient	t-stat.
Production characteristics		
Integrated region (yes=1)	39.8	4.9
Farming experience (years)	-0.35	0.7
Indigenous (yes=1)	-1.9	0.3
Improved variety (yes=1)	18.1	3.8
Number of adults	9.2	2.9
Land owned (hectares)	13.0	8.3
Year 2 (=2000)	-21.7	3.3
Household (consumption) characteristics		
Number of children	3.1	0.8
Number of elders	11.6	1.8
Constant	-76	2.9
Observations	1096	
R-squared	0.43	

t-stat based on standard errors corrected for clustering at the household level.

The independent variables in the market selection model are of two types: Variables $W_i = \left\{1, q_i, z_i^b\right\}$ that do not vary across markets have a market specific coefficient β_j (with value 0 for the base choice of farm gate), and variables $X_{ij} = \left\{d_{ij}, m_{ij}, z_{ij}^f\right\}$ that have a unique coefficient β. Among the first category of variables, we include regional fixed effects, and allow for differential parameters for the quantity sold in the two regions. The average price on the market is subsumed in the market fixed effect.

[15] The exclusion restrictions are land owned, the number of children, and the number of elders in the household. Robust standard errors are reported to correct for household clustering since there are more than one transactions for each household. A Hausman test for overidentification could not reject the validity of the instruments (χ^2 =25.6).

Table 5. Reduced form estimation of market choice (IV conditional logit)

	Coefficient	t-statistic	Relative risk ratios	Coefficient	t-statistic
Markets (base category: farmgate)					
Pazos (local market)	0.06	0.1	1.060	0.67	0.8
Pichus (local market)	0.09	0.1	1.100	0.76	1.0
Huancayo (distant market)	-1.98	-1.8	0.140	-1.85	-1.7
Lima (distant market)	-3.49	-0.6	0.030	-3.01	-0.5
Resides in integrated region * Pazos	-2.07	-3.2	0.130	-1.62	-2.7
Resides in integrated region * Pichus	-5.16	-0.1	0.010	-5.75	-0.1
Resides in integrated region * Huancayo	0.27	0.3	1.310	0.92	1.0
Resides in integrated region * Lima	1.68	0.3	5.360	2.24	0.4
Quantity sold (instrumented q_i, in quintals)					
Quantity * Pazos	0.016	1.5	1.016	0.017	1.6
Quantity * Picus	0.006	0.5	1.006	0.008	0.7
Quantity * Huancayo	0.044	2.6	1.045	0.043	2.6
Quantity * Lima	0.054	1.5	1.055	0.054	1.6
Quantity * Resides in integrated region * Pazos	-0.023	-1.9	0.977	-0.023	-2.1
Quantity * Resides in integrated region * Pichus	-0.006	0.0	0.994	-0.005	0.0
Quantity * Resides in integrated region * Huancayo	-0.038	-2.1	0.963	-0.038	-2.2
Quantity * Resides in integrated region * Lima	-0.032	-0.9	0.969	-0.033	-1.0
Bargaining and negotiation: z_i^b					
Indigenous * Pazos	0.12	0.4	1.130	-0.18	-0.6
Indigenous * Pichus	0.45	1.2	1.570	0.29	0.7
Indigenous * Huancayo	-0.19	-0.6	0.830	-0.26	-0.9
Indigenous * Lima	-0.61	-1.1	0.550	-0.74	-1.3
Improved variety * Pazos	0.72	2.4	2.060	0.67	2.2
Improved variety * Pichus	-0.28	-0.6	0.750	-0.48	-1.0
Improved variety * Huancayo	0.59	1.8	1.800	0.56	1.7
Improved variety * Lima	1.03	1.5	2.800	0.99	1.5
Experience * Pazos	0.07	3.5	1.070	0.06	2.4
Experience * Pichus	0.06	1.5	1.070	0.06	1.6
Experience * Huancayo	0.05	2.5	1.050	0.04	2.2
Experience * Lima	0.08	2.7	1.080	0.08	2.8
Proportional transactions costs: d_{ij}, m_{ij}					
Distance to market (in 100 km)	0.73	0.8		1.17	1.2
Distance to market squared	-0.30	-0.9		-0.47	-1.3
Time to market (in hours)	-0.37	-1.8		-0.55	-2.6
Time to market squared	0.02	1.0		0.04	1.9
Information: z_{ij}^f					
Farmers in village know the market price (%)	0.012	3.2			
Number of observations	5480			5480	
Percent correct prediction	47%			46%	
Pseudo R-squared	0.28			0.28	
Log-likelihood value	-1264			-1277	

t-stat based on standard errors corrected for clustering at the household level.

Marginal effects of attributes X_k of market *k* in a conditional logit model are given by:

$$\frac{d\Pr_j}{dX_k} = \Pr_j\left(\delta_{jk} - \Pr_k\right)\beta,$$

where $\Pr_j$ is the probability of choosing market *j*, and δ_{jk} is the indicator variable equal to 1 when $j = k$ and 0 otherwise. These are best interpreted as:

$$\frac{d\left(\frac{\Pr_j}{1-\Pr_j}\right)}{dX_j} = \frac{\Pr_j}{1-\Pr_j}\beta.$$

The parameter β thus represents the marginal effect of the attribute on the relative change of the odd ratio for that choice.

Marginal effects of the farmer's characteristics *W* are best seen on the probability of choosing one market *j* relative to the farm gate (the base choice, noted 0):

$$\frac{\Pr_j}{\Pr_0} = \frac{\exp\left(X_{ij}\beta + W_i\beta_j\right)}{\exp\left(X_{i0}\beta\right)} = \frac{\exp\left(X_{ij}\beta\right)}{\exp\left(X_{i0}\beta\right)}\exp\left(W_i\beta_j\right).$$

Hence, the relative risk e^{β_j} represents the effect of a unit increase in *W* on the likelihood of choosing the corresponding market relative to selling at the farm gate. Those relative risk ratios are reported in Table 5 for these variables.

In terms of proportional transactions costs, and as expected, the longer it takes to reach a specific market, the less likely a farmer will choose to sell in that market. An increase in travel time from two to three hours for a particular market would decrease the odds of choosing to sell in that market by 29 percent (computed as $\beta_{time} + 2\beta_{time^2} time$). Farmers residing in the integrated region are less likely to sell in local markets, compared to selling at the farmgate (by 87 percent in Pazos and almost 100 percent in Pichus). This implies that buyers may be more willing to come to the farmgate if roads are better. In addition, as they are better connected to the distant market, these farmers are also relatively more likely to sell in distant markets than the farmers from the isolated area (by 31 percent in Huancayo, and 4 times more likely to sell in Lima relative to the farmgate).

A number of fixed transactions costs related variables also affect the market choice decision. For example, indigenous farmers are 57 percent more likely to sell in Pichus (a local market) relatively to selling at the farmgate and 45 percent less likely to sell in Lima (a distant market) relative to the farmgate. This could be suggesting that fixed costs such as language barriers or discrimination may constrain the ability of indigenous farmers to integrate in some markets. Experience (reflecting the ability to negotiate), increases the odds of a farmers selling in any of the markets compared with farmgate. Finally, the higher the quantity the farmer has available to sell, the higher the likelihood of selling in a particular market, especially distant markets, as opposed to selling at the farmgate.

Knowing the prices in different markets can allow a farmer to make a more informed decision about where to sell. We thus expect a positive effect of this knowledge on the probability of selling in a specific market. However, as collecting such information for a farmer is likely to be endogenous to the market selection, we proxy it using the share of households in a farmer's village that knew prices in the specific market. Indeed, we find that a higher level of information about prices in a specific market, let say an increase in knowledge of the price by 10 percent of the village farmers, would increase the odds of selling in the market by 12 percent, corroborating the story that information is indeed crucial for market selection. We also report in the last two columns the estimation of the model without the information variable, as a test of robustness against the potential bias that would come from the village information level being itself endogenous. The results show a remarkable stability in the estimated coefficients.

5.2. Estimation of the semi-structural model and quantification of transactions costs

The semi-structural estimation requires the preliminary estimation of prices and proportional transactions (transportation) costs. Results are reported in Tables 6 and 7. While, in general, few parameters are significantly different from zero and the goodness-of-fit of these models is low, the F-tests for the full specification for all but one model (transportation costs to Huancayo) are significant at the 5 percent level. The selectivity parameter in the price equation reveals that farmers who choose to sell at the farmgate are those who get the lower prices, i.e., those with weakest bargaining power vis-à-vis a traveling buyer. The transportation costs equation indicates that access to good infrastructure (which in our data is confounded with being in the integrated area) lowers transportation costs to the local market of Pichus by a factor of 21. The selectivity parameters indicate that farmers who sell in Lima or in Pazos face lower transportation costs for unobserved reasons, in addition to the identified determinants. On the other hand, Pichus, which serves the isolated area, is chosen by people who have unobserved characteristics that imply higher transportation costs.

Table 6. Explaining prices received (by market)
Dependent variable: log of price received

		Farmgate		Local markets				Distant markets			
				Pazos		Pichus		Huancayo		Lima	
		Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Quantity sold (in qt)	q_i	13.6	0.1	188.3	1.5	342.1	1.3	166.5	0.5	-614.5	0.4
Head farm exper. (years)	z_i^b	2.3	0.2	-9.1	0.8	-27.9	1.0	-4.2	0.4	-10.7	0.8
Head farm exper. squared	z_i^b	-0.2	0.6	0.2	0.9	0.7	0.9	0.2	0.7	0.1	0.4
Improved variety (yes=1)	z_i^b	2.3	0.1	-41	1.5	-130	1.9	-181	4.4	-52	0.5
Knew buyer (yes=1)	z_i^b	31.6	0.8	27	0.9	-42	0.8	-171	3.0	-79	1.0
Selectivity (Table 5)		-151.4	2.5	-39.4	0.8	61.3	0.6	15.0	0.2	52.5	0.5
Constant		-1480	11.8	-1281	10.3	-1275	4.5	-928	5.6	-590	1.0
Observations		257		329		184		258		68	
R-squared		0.08		0.01		0.10		0.14		0.11	
F-test		5.4		3.0		23.4		9.1		2.3	

Coefficients reported are multiplied by 1000
t-stat based on standard errors corrected for clustering at the household level.

Table 7. Explaining transportation costs (by market)
Dependent variable: log of transportation cost paid

		Local markets				Distant markets			
		Pazos		Pichus		Huancayo		Lima	
		Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Integrated region (yes=1)	z_{ij}^{p}	4536	1.6	-21185	2.2	1485	0.4	-101	0.1
Distance to market (km)	d_{ij}	-21	0.2	35	2.3	19	0.3	-15	0.6
Distance to market squared	d_{ij}^{2}	-1.7	2.1	5.8	2.9	0.01	0.5	0.01	1.0
Time to market (in minutes)	m_{ij}	60.5	3.1	-5.35	0.1	-6.51	0.6	6.55	1.2
Time to market squared	m_{ij}^{2}	-0.14	4.7	-0.34	2.8	-0.08	0.7	-0.01	1.0
Selectivity (Table 5)		-5176	2.1	8523	2.1	364	0.1	-1071	3.0
Constant		-6436	1.5	-22655	5.3	-5693	0.7	3022	0.4
Observations		329		184		258		68	
R-squared		0.20		0.34		0.02		0.43	
F-test		10.81		8.1		1.85		4.01	

Coefficients reported are multiplied by 1000
t-stat based on standard errors corrected for clustering at the household level.

Having estimated price and transportation cost models, we predict prices and proportional costs for each farmer and market, and use these to calculate predicted net prices $\left(\hat{p}_{ij} - T\hat{C}_{ij}^{p}\right)$.[16] Using these net prices, we estimate a semi-structural market selection model, equation (17). Table 8 presents the results. As expected, a higher (net) price in a market increases the odds of selling in that market. A 2 soles/qt increase in the price (which is equal to 10 percent of the average observed price) would increase the odd of sales in that market by 4.8 percent. In addition, information about market prices (capturing the impact of fixed transactions costs) increases the odds of selling in that market. An increase in knowledge of the price by 10 percent of the village farmers increases the odd of selling in that market by 18 percent, a somewhat higher value than given by the reduced form model, although the 95 percent confidence intervals of the two parameter estimates overlap. Estimation of the model without the information variable suggests that information is correlated with the market dummies but not with the other variables.

[16] Note than this could be used to derive a measure of idiosyncratic proportional transactions costs as the difference between the predicted effective farm-level price and the highest effective price. This difference can be decomposed into transactions costs due to transportation ($T\hat{C}_{ij}^{p}$) and other unobservable transactions costs measured as a residual.

Table 8. Market choice (IV semi-structural conditional logit)

	Sample mean	Coefficient	t-statistic	Relative risk ratio	Coefficient	t-statistic
Markets (base category: farmgate)						
Pazos (local market)	0.24	0.07	0.3	1.07	0.63	2.7
Pichus (local market)	0.30	0.37	1.2	1.45	0.69	2.2
Huancayo (distant market)	0.17	-1.30	-4.5	0.27	-0.76	-2.6
Lima (distant market)	0.24	-3.47	-6.5	0.03	-3.47	-8.1
Quantity sold (predicted q_i in quintals)						
Quantity * Pazos	8.6	-0.009	-3.0	0.99	-0.007	-3.3
Quantity * Pichus	4.3	-0.024	-4.8	0.98	-0.029	-0.6
Quantity * Huancayo	15.1	0.008	2.7	1.01	0.009	0.4
Quantity * Lima	23.9	0.025	6.3	1.03	0.024	8.1
Effective price $\hat{p}_{ij} - T\hat{C}_{ij}^{p}$						
Predicted net price received (soles/qt)	21	0.0242	4.3		0.0165	3.9
Information z_{ij}^{f}						
Farmers in village know the market price (%)	27	0.0183	8.0			
Number of observations		5480			5480	
Percent correct prediction		37%			38%	
Pseudo R-squared		0.20			0.16	
Log-likelihood value		-1420			-1488	

t-stat based on standard errors corrected for clustering at the household level.

Since net prices have a meaningful monetary measure, we convert the coefficient for market price information in net price equivalent, by dividing it with the net price coefficient. Hence the market price information that farmers receive on average from their neighbors (a 27 percent average level of informed farmers) is equivalent to an increase of 20 soles/qt in net price. The value of that information is large, equivalent to 77 percent of the average 26 soles/qt price, and four times the average transportation costs of 5 soles/qt (Table 4).

5.3. Simulations and comparing transactions costs

The analysis above has allowed us to estimate the magnitude of fixed transactions costs, namely of information on prices, vis-à-vis proportional transactions costs. In order to further explore the response from reductions among these two transactions costs, we simulate how farmers would allocate their marketed surplus under alternative transactions costs scenarios.

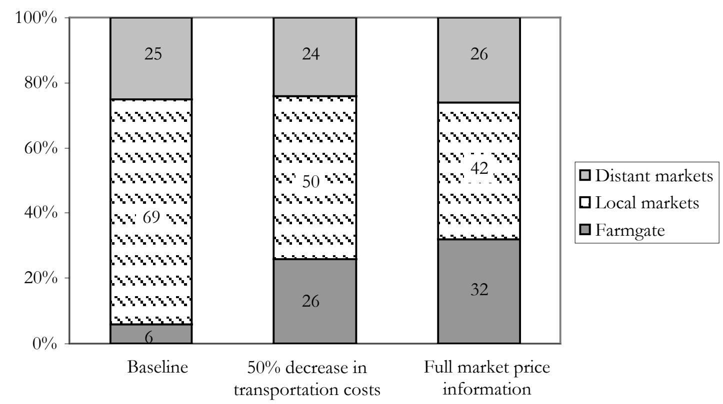
In particular, we focus on farmers that reside in the isolated region and on two cases: (i) a reduction in transportation costs by 50 percent; and (ii) complete information about market prices among farmers in the village. For each scenario, we predict the conditional probability for market selection by each farmer, and use these probabilities as weights for calculating counterfactual regional sales among the three different types of markets -- farmgate, local, and distant -- as:

$$\hat{Q}_j = \sum_i \hat{\Pr}\left(j_i = j \right) q_i .$$

The resulting regional market shares are presented in Figure 1. In the baseline, those shares are six percent, 69 percent, and 25 percent for farmgate, local market, and distant market sales, respectively. These shares can be contrasted with those in the integrated area, where farmgate sales represent 23 percent of all sales, distant market 63 percent, and local markets only 14 percent. The simulation results suggest that in either scenario, reducing transactions costs in the isolated region significantly increases sales at the farmgate at the cost of selling less in local markets.

First, reducing transportation costs (proportional transactions cost) by half would increase the region's farmgate sales from six to 26 percent of the overall sales. This implies that as the region becomes more accessible, both buyers and farmers may find it more favorable to buy (sell) at the farmgate as opposed to in local markets. In the context of the isolated region, this could be indicating that local markets may be serving as markets of last (or only) resort for farmers who are otherwise constrained to sell at the farmgate because they are inaccessible to local merchants.

Figure 1. Simulated distribution of regional sales under alternative proportional and fixed transactions costs scenarios (isolated region)



Similarly, access to full information about market prices (reducing fixed transactions costs) would increase farmgate sales from six to 32 percent of overall sales in the region. This supports the earlier findings as it shows that in addition to transportation costs and road quality, eliminating information asymmetries alone would have large impacts on the choice of marketing channels.

6. Conclusions

While transactions costs are difficult to measure, understanding the impact they have on behavior is crucial as it can inform policy design aimed at reducing them. This paper shows how different types of transactions costs influence decisions and outcomes for farm-households in rural Peru. We find that in addition to proportional costs such as the distance to reach a market or access to good roads, fixed transactions costs like information about prices, relationships with potential buyers, or bargaining abilities are also important determinants of market selection.

The methodology we proposed allows to quantify some of these transactions costs on the basis of observed behavior using a semi-structural conditional logit approach to market choice. The results show that fixed transactions can be very large. The market price information that farmers receive from their co-villagers is equivalent to a doubling of the effective price received, and raises the effective price by an amount equal to four times the average transportation costs. Simulations on the effect of reducing these transactions costs show that while farmers in the isolated region would benefit from reductions in transportation costs, the same impact could be accomplished at a fraction of the cost via improvement in information flows.

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