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FACTORS AFFECTING LAND USE DECISIONS IN THE PENINSULA OF SANTA ELENA, ECUADOR: A TRANSACTION COSTS APPROACH

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Abstract

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Water scarcity has been appointed as the key-limiting factor for the development of agriculture in the Peninsula of Santa Elena (PSE) in Ecuador. To solve this problem, the Ecuadorian government carried out the construction of one of the biggest irrigation projects. However, after two decades of functioning, less than 30% of its capacity is being used. This article analyzes factors associated to Transaction Costs (CT) that influence land use decisions. The available decisions options are: to invest in agriculture, livestock production or to speculate with its value through land sales. The landowner's decision problem is analyzed through a Heckman's two-stage estimation procedure, which allows differentiating between factors associated to fixed and variable TC. The hypothesis is that factors related to fixed-TC influence the decision to participate (that is, the decision to use the land productively or speculatively, which is modeled in the first stage of Heckman's); while both, factors associated to fixed and variable TC, influence the level of participation (that is, decisions about land allocation to one or each decision option, modeled in the second stage). The results show that access to assets and access to information are among the more influential TC factors, which favor agricultural production instead of land speculation.

Key Words: *Transaction costs, Heckman's two-stage estimation procedure.*

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FACTORES QUE AFECTAN LAS DECISIONES DE USO DE LA TIERRA EN LA PENÍNSULA DE SANTA ELENA, ECUADOR: UN ENFOQUE DE COSTOS DE TRANSACCIÓN

Resumen

Por mucho tiempo el agua fue un factor limitante para el desarrollo de la agricultura en la Península de Santa Elena. La solución fue la construcción de uno de los proyectos de riego más grandes del Ecuador. Luego de dos décadas de funcionamiento menos del 30% de su capacidad estaría en uso. En este artículo se analizan factores asociados a Costos de Transacción (CT) que afectarían las decisiones de uso del suelo. Las opciones estudiadas son: cultivar o criar ganado, o, especular con su valor a través de la venta de tierras. El problema de decisión del propietario de tierras se analiza siguiendo el procedimiento de estimación de dos etapas de Heckman, que permite diferenciar entre factores asociados a CT fijos y variables. La hipótesis es que factores relacionados con CT fijos influyen en la decisión de participación (es decir, la decisión de utilizar la tierra de forma productiva o especulativa, modelada en la primera etapa de Heckman); mientras que factores asociados a CT fijos y variables influyen en el nivel de participación (esto es, la asignación de tierras a una o cada opción de decisión, modelada en la segunda etapa). Los resultados muestran que tenencia de ciertos activos y acceso a información están entre los factores más influyentes de CT que favorecen el uso agropecuario de la tierra en lugar de la especulación.

Palabras claves: *Costos de transacción, Estimación de dos etapas de Heckman.*

1. INTRODUCTION

Transaction Costs (TC) comprise one of the key concepts for the study of institutions and organizations within the field of New Institutional Economics (NIE). This field emerged as an alternative to Neoclassical Economics (NE) to explain situations in which the existence and evolution of institutions determine the quality or efficiency of an economic system. The concept of TC has become fundamental for explaining the origins, persistence, and change of certain institutions and organizations (Meramveliotakis & Milonakis, 2010).

Transaction cost economics has been applied to study a variety of situations in agriculture. Maasten (2001), Kherallah and Kirsten (2002) and other authors have stressed the importance of TC for the analysis of agricultural markets and policy. Some studies for example find that TC are high on agricultural markets in developing countries and therefore have a considerable influence on farmers' decisions regarding production and marketing. Some interesting works in this line are Alene, et al., (2008); Kyeyamwa, et al., (2008); Maltsoglou and Tanyeri-Abur, (2005); Ouma et al., (2010); Rujis et al., (2004); Somda et al., (2005); and Stifel et al., (2003).

This article analyzes a specific decision problem faced by landholders in the PSE regarding the use of rural land, either in production or speculation. We argue that the decision is influenced by factors associated to TC. Decisions analyzed are, namely, agricultural use of land, livestock production, and selling or abandonment of land. The first two options imply the generation of private profits as well as social returns linked to the public investment made in the irrigation project in the PSE (see Section 2). However, selling land or leaving it unproductive may lead to speculative behavior because the majority of landholders paid very low prices for the land they acquired[4].

Depending on the costs and benefits of each decision option, landholders decide the one that satisfies their interests. For example, if a landholder is interested in farming the land, she may consider the costs of all agricultural inputs needed and the profits from produce sales. More importantly, TC derived from the institutional structure around agriculture in the PSE may be also considered because of their negative influence on production decisions. Examples of TC are access to market information, availability of technical assistance, quality of roads, distance to canals, and access to financing. Thus, rents derived from land speculation may be more appealing, particularly if the institutional structure encourages that sort of behavior. Consequently, significant social losses arise because of that behavior and the inefficiency of the public irrigation projects.

In this article, the landowner's decision problem is analyzed by means of the Heckman's two-stage estimation procedure, which allows differentiating between factors associated to fixed and variable TC. The first stage involves estimating a Probit model for landholders that decide to engage in any production activity or incur on land sale. This stage identifies fixed TC factors affecting the decision to participate. In the second stage an Ordinary Least Square (OLS) analysis is estimated but correcting for selectivity bias. This stage in turn identifies (fixed and variable) TC factors affecting the level of participation.

[4] A detailed study on land transfers in the PSE can be found in Herrera et al, 2005 and 2006.

2. LAND PROPERTY STRUCTURE IN THE PSE

During the period 1980-1995 the Santa Elena Aqueduct Hydraulic Project (PHASE in Spanish) was built to mitigate the serious scarcity of irrigation water in the PSE. Before its completion in 1995, interests from investors (and speculators) were encouraged to purchase land in the surroundings of the irrigation canals. Regulations at that time did not limit sales of land, which were originally owned by small landholders (e.g. peasants and commoners).

In addition, there were no regulations to compel original and new landholders to use land for production purposes once irrigation was available. Thus, though some landholders decided to invest in agricultural or livestock projects, others decided to partition the land and sale it or to keep it unproductive, but still generating capital gains because of the public investment on the irrigation project.

There is not accurate and updated information about land tenure and land use in the area of influence of the PHASE. A land cadaster made in 2009 by Escuela Superior Politécnica del Litoral (ESPOL) reported 54.095 ha in the area of influence of the irrigation canals. This figure varied along time and differs from what was officially announced when the project started operations in 1995 (42.000 ha). Regarding the cultivated area, by 2000 (according to Herrera et al, 2005), there were about 6.500 ha cultivated, being the most important crops: mangoes, cocoa and maize. Cultivated land increased to 7.700 ha by 2009, and to 8.600 ha by 2010, based on unpublished information from “Plan Tierras” from the Ministry of Agriculture of Ecuador.

The efficiency of the irrigation system, measured by the ratio between cultivated area and the influence area, reached 12% in 2000, 14% in 2009, and 16% in 2010. Even though the cultivated area doubled during the last 6 years, because of additional incentives offered to smallholders in the PSE (e.g. irrigation infrastructure, seeds, fertilizers, etc. provided only for organized small farmer’s located up to five km from the main canal[5]), efficiency is still below 35%.

This inefficiency may indicate that other factors, different to input costs and output prices, are operating in the PSE to limit agricultural development. We argue that these factors take the form of TC. This inefficiency occurs despite regulations enacted in 2008 supposedly compel landholders within the influence area of the project to use land for production purposes.

Table 1 shows the irrigation areas and cultivated areas per land plot sizes. The table reveals that speculative behavior from new landholders has occurred as only about 3% of the irrigated land remains in the hands of small landholders[6] (that is, land plots less than 10 ha, which total 1.736,3 ha). That share increases to 8% if the upper limit is set at 20 ha. On the other hand, about 92% of the land is concentrated in medium-big sized landholders, which total 600 land plots and represent 54% of the plots in the area of influence of the PHASE. Regarding cultivated land, only 14.2% of the land is allocated in this use. No official information about land use for livestock is available.

[5] The Ministry of Agriculture of Ecuador created the Project for Integrated Development of Agriculture, Environment, and Society in the PSE (PIDAASSE in Spanish). The objective is to increase the agricultural use of land in the area. More information can be found at http://www.agricultura.gob.ec/pidaasse/
[6] According to Herrera (2005), before the construction of the PHASE, it was about 90%.

Table 1. - Landholders structure, and cultivated areas based on cadastral data from 2009

Land plot sizes	Influence of the PHASE in ha	%	Number of land plots	%	Cultivated land in ha	% of total cultivated	% Cultivated over influence of the PHASE
Up to 5 ha	746,3	1%	374	34%	78,1	1.02%	10,5%
5.1 to 10 ha	990,0	2%	135	12%	170,1	2.22%	17,2%
10.1 to 20 ha	2.509,5	5%	170	15%	173,7	2.27%	6,9%
20.1 to 50 ha	6.253,5	12%	203	18%	354,7	4.63%	5,7%
50.1 to 100 ha	7.561,9	14%	104	9%	830,1	10.83%	11,0%
100.1 to 200 ha	9.135,1	17%	66	6%	960,7	12.53%	10,5%
200.1 to 500 ha	12.144,3	22%	42	4%	1.484,1	19.36%	12,2%
+ 500.1 ha	14.754,7	27%	15	1%	3.614,8	47.15%	24,5%
Total	54.095,2	100%	1.109	100%	7.666,2	100%	14,2%

Source: Land use cadaster, ESPOL (2009).

Between 2000 and 2003, when irrigation water was already available in the surroundings of the canals, many analysts pointed to the price of water as the next limiting factor for the development of irrigated agriculture in the PSE. The valid price at that time was USD 0.03 per cubic meter for commoners and USD 0.04 for private landholders. In 2003, a new regulation decreased prices to USD 0.01 and USD 0.02 respectively; however, the impact of such measure was negligible, based on the figures of 2009 and 2010. In this regard, Herrera et al. (2006) proved that even with a zero charge for irrigation water, there were still other factors limiting the development of agriculture in the PSE.

According to Herrera et al. (2005), such factors were related to the institutional structure of the governance of irrigated agriculture in the PSE, which justifies the identification of the TC factors influencing land use decisions.

In the last decade drastic changes were introduced in the institutional structure for water management in the country and the study area. Constitutional provisions approved in 2008 a new Water Law (valid since 2014), a Land Law (valid since 2016), and new organizations were created for the management of those resources. But few things have changed in the PSE in relation to land use and agriculture, and the efficiency of the irrigation project. One of the problems of this new institutional structure is that it gives government agencies the sole responsibility of managing the irrigation system, and limits farmer’s organizations and participation, just the opposite to what is recommended by Herrera et al. (2005, 2008).

3. TRANSACTION COSTS ON THE ANALYSIS OF LAND USE DECISIONS

There have been many attempts to develop methodologies to measure TC, but unavailability of information and complex institutional structure for decision-making prevented to obtain accurate measurements. According to Escobal (2000), this problem explains why TC researchers largely follow the approach proposed by Williamson (1979), which avoids the necessity to directly measure TC associated with different interchange relations (which are unobservable). Instead attention is addressed to the effects that observable attributes have over the differential costs of market participation, which can be identified and measured. According to Williamson (1996), the absolute magnitudes of differences in TC do not matter as much as the explicit identification of TC related factors.

An interesting approach to model TC is developed by Makhura (2001), relying on Omamo (1998) and Key et al (2000) who in turn expand the household decision model of De Janvry, Fafchamps and Sadoulet (1991), Goetz (1992) and Strauss (1984). Adapting Makhura's model to the PSE, the decision problem faced by a landholder who wants to maximize utility *(u)* is related to contracting in either of the decisions options discussed earlier. That is, landholders may participate in a particular activity for which it is necessary to allocate some land and other resources. Assume *k* goods are produced (q_k) using input allocation (x_{ik}), and that production may be sold (s_k) or consumed(c_k). Sales enter the utility function through revenue generated from sales $(p_k s_k)$, the sum of which is used to purchase other goods (R_k). That is, the household will purchase an equivalent of R_k in other goods. The neo-classical subjective equilibrium for a landholder doing a particular activity and participating in a particular market (agricultural market, livestock market and land market) is as follows:

$$\text{Max } U = u\,(c_k, R_k; H_u)$$

Where *Hu* represents a set of factors shifting the utility function. By adding several constraints to this function, it would be possible to get the Lagrangian and obtain a feasible solution. One of the main implications of this model is that market participation is endogenously affected by prices, and exogenously determined by farmer's characteristics. The model assumes that participation in the market is a response to an observable price signal, where market participation with exchange of output is not cost free. Thus, the decision price faced by a farmer may differ from the observable price due to unobservable TC (Makhura, 2001). However, the TC can be proxied by observable factors such as assets or information access.

Key et al (2000) argue that TC, as any other cost, may vary with the amount exchanged, implying the existence of Variable Transaction Costs (V_{TC}). Likewise, TC may be fixed, regardless of the amount exchanged, implying the existence of Fixed Transaction Costs (F_{TC}). An example of this can be household's differential access to assets and information asymmetries (particularly small households), leading them to face different TC.

Thus, education or contact with extension services may be proxies for information that represent differences in F_{TC} (e.g., with respect to the capacity to engage in a certain transaction) as well as in V_{TC} (e.g., in case that information requirements change with the amount transacted) while ownership of land, livestock or transport facilities will mainly represent differences in V_{TC} (more specific investments are needed the higher the amount exchanged) but differences in F_{TC} as well (Makhura, 2001).

The effect of TC over market participation decisions is explained by sellers receiving lower net prices due to TC, thus discouraging market participation; and, by rising the effective value of production consumed by the household, resulting in a higher level of consumption and a lower level of market participation. That is, TC affect the decision to participate and the level of participation. In terms of the utility maximization problem, the objective function now becomes:

$$\text{Max } U_t = u_t\ (c^t, R^t; H_u)$$

Where the superscript t denotes the effect of the TC. As TC tend to widen the price band between the selling price and the purchase price, it is possible that if the decision price falls within that band, some farmers will not participate in the market. These conditions imply that when farmers decide not to participate in the market, V_{TC} will not exist and F_{TC} will determine whether the farmer participates or not.

An optimal solution for this problem cannot be found by solving the First Order Conditions (FOC), since the presence of F_{TC} creates a discontinuity in the Lagrangian. The alternative proposed by Key et al (2000) is to first solve for the optimal solution conditional to market participation, and then choose the participation level leading to the highest level of utility. A key feature of this model is that by taking the correct derivatives of the Lagrangian under TC, it should allow to solve for a system of demand equations, as well as for output supply, input and market participation equations, all affected by TC. Given however that our interest is to model how TC would affect the decision to use the land among specific options, and the allocation of land in each option, it may be necessary to solve for a system of market participation equations.

Then, based on the form of both the utility function and the market participation equations, it is possible to postulate an important hypothesis for the subsequent analysis. Under TC, participation decisions depend on FTC but are affected by both FTC and VTC when the farmer effectively decides for one or all decision's option. That is, both F_{TC} and V_{TC} will affect the magnitude of participation. Note, however, that F_{TC} will shift the supply curve with respect to both R and the price, increasing the threshold at which market participation can take place. Thus, extremely high TC (particularly F_{TC}) will lower the decision price considerably so that it might not be worthwhile to participate in one of the decision options (Makhura, 2001).

4. FACTORS AFFECTING LAND USE DECISIONS IN THE PSE: EMPIRICAL EVIDENCE

The empirical strategy seeks to answer the following: i) which are the F_{TC} factors that determine the decision to participate in a particular activity (agriculture, livestock or land sale); and, ii) which are the F_{TC} and V_{TC} factors that determine the level of participation. The idea is to find TC-related factors that ideally defined (i.e., under perfect governance structures) would allow decreasing TC and therefore increase the level of productive activity of landholders in the PSE.

According to Makhura (2001) an OLS regression could be applied if all landholders were participating in some activity; however not all participate. Some of them may prefer not to participate in an activity, while others may not participate at all. The problem is that if OLS were estimated excluding the non-participants, sample selectivity bias arises, as the decision to participate is random, that is, the non-participants are a self-selected sample. This is so because it is likely that some landholders facing high TC may choose not to participate, which would account for much of the missing participation data. Consequently, we use the two-stage Heckman procedure as we seek to decompose TC into V_{TC} and F_{TC}. Bear in mind however that estimates are consistent but not efficient relative to a full information maximum likelihood procedure (Makhura, 2001). The Heckman procedure assumes that the participation decision and the level of participation are determined simultaneously, which means that error terms of the two equations are correlated. It is also assumed that zero-responses represent the decision "not to participate", then no individual landholder is observed at the standard corner solution. Hence, the equation of the level of participation is defined only over landholders effectively participating, although corrected with the information of the non-participants.

The Heckman's two-stage procedure is specified by a selection equation as follows:

$$z^*(unobserved) = y'w + u \qquad u \sim N(0,1) \tag{6}$$

$$z = 1\, if\ z^* > 0$$

$$z = 0\, if\ z^* \leq 0$$

and a regression or observation equation:

$$y = \beta' x + e \qquad e \sim N(0, \sigma 2) \tag{7}$$

Where y is observed if and only if $z = 1$. The variance of u is normalized to 1 because only z, not z^*, is observed. The error terms (u and e) are assumed to be bivariate normally distributed with correlation coefficient ρ, while γ and β are the parameters vector.

The selection equation is estimated by maximum likelihood, from which the inverse mills ratio is estimated. The level of participation, y, is observed only when the selection equation equals 1, and is then regressed by OLS on the explanatory variables, x, and the vector of mills ratios which contains the information from the non-participants.

Therefore, the second stage adds in the regression the estimated expected error as an extra explanatory variable, which removes the part of the error term correlated with the explanatory variable and thus avoiding the bias. For model estimation, a questionnaire was applied to 100 landholders in the PSE during the second semester of 2015. Table 3 describes the variables used for the analysis.

Table 2. - Variables used for model estimation

Dependent variables	Description	Name
1. Short cycle crops	Probability of farming short cycle crops (yes = 1)	(SCFARM)
	Hectares in short cycle crops (ha)	(SCHECT)
2. Permanent crops	Probability of farming permanent crops (yes = 1)	(PFARM)
	Hectares in permanent crops (ha)	(PHECT)
3. Livestock	Probability of having livestock (yes =1)	(LIVES)
	Number of animals owned (head)	(HEADS)
		(LANDS)
4. Land sale	Probability of participating with land sale contracts (yes =1)	
	Hectares of land sold during the last five years (ha)	(LSHECT)
Independent variables	**Description**	**Name**
Farm endowment or access to assets	Total size of the farm (ha)	(TOTAREA)
	Irrigated land that uses some technology (ha)	(IRRIAREA)
	Percentage of facilities available at the farm (phone, car, etc.)	(FACIL)
	Non-farm income (yes=1)	(NFARMACT)
Access to information	Distance to the nearest city (km.)	(DISTCITY)
	Conditions of the road (good = 1)	(CONDROAD)
	Level of education (primary = 1, secondary =2, etc.)	(MAXED)
	Contact with extension (yes =1)	(VISITEC)
Farm/farmer characteristics	Gender (female = 1)	(GEND)
	Age (years)	(AGE)
	Location (Chongón = 1, Daular = 2, etc.)	(LOCAT)
	Commune member (yes =1)	(COMMEM)
Interaction factors	Distance and road conditions to the nearest city	-
	Level of education and non-farm income	-

The dependent variable of participation is measured by the probability of doing so (YES=1) while the level of participation is measured in terms of land resources dedicated to (in hectares), or the number of units in which participation is defined (e.g. number of animals). Differentiation between short cycle crops and permanent crops is very important in the PSE since amount of investment and risk perception (mainly associated to market access) are quite different for each option (Herrera et al, 2004), being the commoners who mostly farm short cycle crops.

According to Makhura (2001), explanatory variables reflecting the effect of TC over both farmer's decisions and the level of participation can be divided into three constructs, namely, access to assets (or farm endowment), access to information and specific farm/farmer characteristics. The variables used to measure the effects of access to assets over both, the participation decision and level of participation are production assets (arable land and irrigation technology), investment or liquidity assets (non-farm income) and other assets in which are mainly included transportation and communications. The reasoning behind each type of assets is as follows: "access to arable land" and "irrigation technologies" are necessary for agriculture. By relying on Makhura (2001), the more arable land the farmer has the higher the production levels are likely to be, and thus the higher the probability of participating in the market. The same criterion can be applied for irrigation technology. Liquid assets in turn are required to provide investment, for example in market activities such as paying for information or transport. In this case the availability of non-farm income can help to overcome some TC until income is obtained.

Access to information, on the other hand, helps the decision making process of individuals by improving negotiation skills and thus lowering TC. This construct is measured by: i) Contact with extensionists, which provide farmers technical or marketing information to help manage the risk of farming; ii) Educational level, which provides farmers skills to understand the information and make a proper interpretation of it; iii) Proximity to markets, which indicates how far farmers have to travel to obtain information, either from markets or extension officers, and; iv) Road conditions, which can encourage or discourage farmers from using it.

Interaction factors were also included to account the simultaneous effects of some variables on TC. This is the case of 'distance to…' and 'road conditions' variables because good road conditions and close distances may imply lower TC. For the case of educational level and non-farm income, the reason is that only with "well educated individuals" plus "non-farm income available", it would be possible to interpret information better and invest in some productive activity, thus lowering TC.

That is, if a landholder has additional non-farm income but no good education, then interpretation of information may not necessarily be efficient in order to lower TC. For each option a Heckman two-stage estimation procedure was applied. The model was specified depending on the contractual options as follows:

Prob (SCFARM or PFARM or LIVES or LANDS) = f (TOTAREA, IRRIAREA, FACIL, NFARMACT, DISTCITY, CONROAD, MAXED, VISITEC, GEND, AGE, LOCAT, COMMEM, DISTCITY*CONROAD, NFARMACT*MAXED)

Which corresponds to the Probit specification of the first stage, and

SCHECT or PHECT or HEADS or LSHECT = f (TOTAREA, IRRIAREA, FACIL, NFARMACT, DISTCITY, CONROAD, MAXED, VISITEC, GEND, AGE, LOCAT, COMMEM, DISTCITY*CONROAD, NFARMACT*MAXED)

Which corresponds to the Heckit or OLS estimation accounting for selectivity bias. The same variables are used in both equations to reflect that the explanatory variables only represent observable attributes as proxies for measuring the effect of TC over the decision to participate and the level of participation. However, it is not clear whether the observable attributes will act as fixed or variable TC related-factors. In addition, as it occurs with any cost, classification is not always straightforward between fixed and variable costs, given that at certain levels fixed costs can become variable costs. The first stage of the Heckman procedure identifies the F_{TC} affecting the decision to participate, while the second stage identifies F_{TC} and V_{TC}. This implies that explanatory variables that are significant in the second stage can be directly related to V_{TC}, otherwise they can only be related to F_{TC}.

Table 3 shows the results for short cycle crops and permanent crops and table 4 for livestock and land sale. For each Probit specification, marginal effects were calculated using the '*mfx*' Stata code, which is equivalent to calculating the change in the probability of participating as a result of a unit change in the explanatory variables. A negative sign implies that a unit increase in the explanatory variable will lead to a decrease in the probability of participating. For the Heckit specification, on the other hand, direct and total effects were calculated. Direct effects determine the change in the level of participation resulting from a unit change in the explanatory variables for respondents who participate, while total effects determine the change in the level of participation resulting from a unit change in the explanatory variable for the entire sample. A positive sign implies that a unit change in the variable would lead to positive change in the level of participation.

Table 3: Probit and Heckit Results for Short Cycle and Permanent Crops

Variable Description	Short Cycle Crops				Permanent Crops			
	Probit results (decision)		Heckit results (level)		Probit results (decision)		Heckit results (level)	
	Coeff.	Marginal Effect (dy/dx)	Direct Effect	Total Effect	Coeff.	Marginal Effect (dy/dx)	Direct Effect	Total Effect
Constant	-1,72***		4,322	12,242	-0,337		-14,132	81,1234
	(0,953)		(11,01)	(19,73)	(0,933)		(45,43)	(113,11)
Landholders Endowment (Assets)								
Size of farm (ha)	0,0008	0,0002	0,0163	0,0140	0,0005	0,0002	0,0412	-0,0029
	(0,001)	(0,000)	(0,013)	(0,009)	(0,001)	(0,000)	(0,041)	(0,086)
Irrigated land (ha)	-,006***	-,002***	0,083***	0,112***	0,014***	0,0039**	-0,0125	-0,0075
	(0,004)	(0,001)	(0,046)	(0,046)	(0,011)	(0,002)	(0,058)	(0,104)
Facilities at the farm	1,492***	0,521***	5,8133	2,8319	-2,172**	-0,699**	7,4285	60,3101
(%)	(0,863)	(0,202)	(8,431)	(10,02)	(0,836)	(0,294)	(39,71)	(84,31)
Non-farm inc.	-1,52***	-0,541**	4,7823	8,1734	0,9176	0,2946	32,4247	-8,0013
(yes=1) †	(0,764)	(0,221)	(8,039)	(9,639)	(0,636)	(0,245)	(36,22)	(70,91)
Information Access								
Distance to nearest	0,0622	0,0492	-0,7034	-0,6950	0,04230	0,0102	0,1453	-1,4213
town (km.)	(0,041)	(0,018)	(0,745)	(0,815)	(0,051)	(0,065)	(6,154)	(5,853)
Road Conditions	-0,1127	-0,0735	-6,5763	-5,5963	1,6294*	0,8533*	21,0133	-50,1256
(1=good) †	(0,583)	(0,2184)	(4,935)	(4,402)	(0,5148)	(0,2963)	(24,73)	(51,753)
Education level	-0,1280	-0,0483	1,1473	1,2692	0,7463**	0,3753**	15,0064	-18,1523
	(0,438)	(0,204)	(2,935)	(2,642)	(0,284)	(0,326)	(17,31)	(30,853)
Contact with extension	-0,63***	-0,15***	2,1045	3,1875	0,1045	0,0653	-23,1***	-40,1***
(1=yes) †	(0274)	(0,146)	(3,853)	(4,006)	(0,185)	(0,284)	(12,61)	(47,85)
Landholders Characteristics								
Gender (1=female) †	0,4238	0,1593	-5,2211	-5,3274	-0,091	-0,0211	-10,174	-4,2954
	(0,643)	(0,210)	(4,853)	(6,486)	(0,483)	(0,221)	(20,09)	(40,01)
Age	0,0112	0,0029	-0,0193	-0,0623	-0,007	-0,0125	-0,1563	0,3875
	(0,016)	(0,004)	(0,210)	(0,864)	(0,010)	(0,003)	(0,683)	(1,113)
Location	0,7642*	0,1572*	0,1562	-0,7342	-0,152	-0,0613	-4,3097	5,9742
	(0,218)	(0,034)	(1,536)	(2,593)	(0,219)	(0,051)	(5,071)	(10,18)
Affiliation to	1,2345**	0,3001*	-1,5172	-4,852	-0,040	-0,0295	2,0742	9,8365
Communes (1=yes) †	(0,673)	(0,071)	(6,411)	(6,102)	(0,613)	(0,263)	(30,09)	(39,01)
Interaction factors								
Distance and road	0,0521	0,0273	0,3264	0,6523	-0,067	-0,0425	2,8135	5,423
cond. to nearest town	(0,084)	(0,072)	(0,763)	(0,284)	(0,071)	(0,041)	(7,863)	(8,001)
Education level and	0,427***	0,293***	-3,8422	-4,101	-0,210	-0,0592	-15,953	4,5384
Non-farm income	(0,632)	(0,151)	(5,473)	(3,021)	(0,319)	(0,296)	(19,10)	(20,12)
Model Chi-square	52,63*				28,32***			
N	100				100			
N participating	73				64			
Lambda			-6,26***				-102,3**	
			(2,425)				(34,632)	
% correctly predicted			76				75	
R-square			0,32				0,2732	
Adjusted R square			0,12				0,2439	
F-test			1,64***				1,72	

*** = 10% significance; ** = 5% significance; * = 1% significance
† dy/dx is for discrete change of dummy variable from 0 to 1
Standard errors in parenthesis

In the case of short cycle crops, the Probit model correctly predicts 76% of the observations with significant chi-square of 52.63. The number of participants censored is 73 out of 100, which means that there are 73 respondents farming short cycle crops. Seven variables have coefficients significantly different from zero, that is, they are associated to F_{TC} affecting the decision to participate. From them, 4 are positively associated (FACIL, COMMEM, LOCAT, NFARMACT*MAXED), that is, those variables help to reduce F_{TC} and thus encourage landholders to farm short cycle crops. In turn, three variables (IRRIAREA, NFARMACT, and

VISITEC) show the opposite effect, that is, they reduce the probability of farming short cycle crops.

Although this result can be confusing, a comparison of the sign of these coefficients with those of the Probit specification for permanent crops in the same table (all have the expected positive sign), confirms that they work favoring the decision to farm permanent crops. This means that farmers endowed with investment in irrigation technology, with non-farm income available, and contact with extensionists, may prefer to farm permanent crops rather than short cycle crops, which are less investment-demanding, less risky and therefore less profitable. Another explanation is that these three TC factors, only help to reduce F_{TC} for the case of permanent crops and not for short cycle crops. Taking a closer look at marginal effects, the availability of facilities at farm level (phone, car, electricity, etc.), being a commoner, and the interaction between education and non-farm income, are the TC factors with higher impact over the probability of participation (52%, 30% and 28% respectively), that is they reduce the $F_{TC.}$

Heckit results for the level of participation have an R-square and an adjusted R-square of 32% and 12% respectively with an overall significant fit given by the F-test of 1.64. The inverse mills ratio (lambda) for this case is significant at 10%, which means that (although not strongly) sample selectivity bias would have occurred if the level of participation had been estimated without taking into account the decision to participate. The only significant factor in the Heckit specification is IRRIAREA. This variable is significant in both specifications (Probit and Heckit), which implies that it can only be related to F_{TC}. Given that no V_{TC} factors were found for the case of short cycle crops, this implies that both, the decision to participate and the level of participation, are affected only by TC factors associated with F_{TC}. The same sort of analysis can be done for permanent crops, livestock and land sale.

In the rest of cases, TC factors are mostly related to F_{TC} except for educational level, which has been found is an important V_{TC} factor for permanent crops and livestock. That is, the more educated landholders are, the more resources they will devote to farm permanent crops and rise cattle. Given that the analysis was performed over observable TC factors of individual decisions, the effect of V_{TC} must be considered at an aggregate level. This means that, given that education is a fixed factor, better educated individuals will incrementally devote more resources to productive activities.

A special case is that of land sale, where age and distance to nearest town are significant determinants of V_{TC}, which means that the older the landholder is, and the closer the land plot is to a town, the more land resources they will put for sale. Only for the case of livestock the inverse mills ratio (lambda) is not significant, which means that sample selection bias is not present and the decision to participate has no effect over the decision of the level of participation. This implies that only total effects must be considered for analyzing the significance of the coefficients.

5. CONCLUSIONS

Several conclusions can be drawn from the previous analysis:

The classification of TC into fixed and variable seems to be consistent with the way factors influence the decision process modeled in each stage of the Heckman's procedure.

Some variables used as proxies for measuring the influence of TC over land use decisions by landholders, are significant. Therefore, they should be considered for institutional design. That is, optimal institutional arrangements designed to help to reduce TC. Additionally, such process of institutional design should consider the environments in which the governance of the different institutions of agriculture (land access, irrigation, markets, input supply, financing, etc.) are defined. It may occur that by changing the institutional environment other institutional arrangements become possible (e.g. market cooperatives or irrigation bodies) and then lower the transaction costs faced by individual decision makers.

Based on the results, access to assets is among the more influential factors that help to reduce TC for the case of using the land in agriculture. This suggests that landholders engaged in farming activities are those who have certain assets (mainly irrigation infrastructure), which make TC lower for them. Institutional design should then consider securing access to finance, particularly, for small-mid-sized landholders, in order to promote agriculture and avoid land speculation.

Another significant TC factor is the availability of non-farm income, which it is argued contribute positively to reduce the risk of farming. A sound institution could then promote the supply of agricultural insurance, or the promotion of other non-farm activities particularly for women.

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