EPTD DISCUSSION PAPER NO. 81

LAND LEASE MARKETS AND AGRICULTURAL EFFICIENCY: THEORY AND EVIDENCE FROM ETHIOPIA

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September 2001

ABSTRACT

This paper develops a theoretical model of land leasing that includes transaction costs of enforcing labor effort, risk pooling motives and non-tradable productive inputs. We test the implications of this model compared to those of the "Marshallian" (unenforceable labor effort) and "New School" (costlessly enforceable effort) perspectives using data collected from four villages in Ethiopia. We find that land lease markets operate relatively efficiently in the villages studied, supporting the New School perspective relative to the other two models. Land contract choice is found to depend upon the social relationships between landlords and tenants, but differences in contracts are not associated with significant differences in input use or output value per hectare. We find that other household and village characteristics do affect input use and output value, suggesting imperfections in other factor markets. These results imply that interventions to improve the functioning of land lease markets are likely to be of little benefit for agricultural efficiency in the villages studied, whereas improvements in other factor markets may be more beneficial.

KEYWORDS: land lease markets, land tenure, sharecropping, agricultural efficiency

ACKNOWLEDGMENTS

We are grateful to the World Bank for providing financial support to this research; to the International Livestock Policy Research Institute for providing access to the data; to Sarah Gavian, who led the field research that collected this data and answered questions about the data; to Pamela Jagger and Amare Teklu for providing excellent research assistance; to Kei Otsuka, Elisabeth Sadoulet, Alain de Janvry, Peter Hazell, Simeon Ehui, Stein Holden, Nancy McCarthy, Gershon Feder, Hanan Jacoby, Chris Barrett and other participants at various seminars on this paper who provided valuable comments and suggestions; and to the many farmers who participated in the study. The authors bear sole responsibility for any errors or omissions.

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1. INTRODUCTION

The efficiency of land lease markets is a critical issue in many developing countries, where land sales markets are often thin and inhibited by problems of asymmetric information and limited development of credit markets. The issue is particularly important in Ethiopia, where land sales are officially prohibited by the new Constitution and where land leases were prohibited by the former Marxist government until 1991. Land leases have been permitted since the fall of the Derg regime and leasing is again common in many parts of Ethiopia, though restrictions have been imposed on lease arrangements in some regions of the country. Now is thus an opportune time to assess the efficiency of the lease markets developing in Ethiopia, and implications for land tenure policies.

There is an old and large literature on land tenure contracts and their implications for agricultural efficiency.[1] Adam Smith (1776), John Stuart Mill (1848), Alfred Marshall (1890), and numerous authors since have argued that share tenancy causes inefficient resource allocation because the share tenant receives as marginal revenue only a fraction of the value of his marginal product of labor, thus reducing the tenant's incentive to supply labor or other inputs. More recently, others have argued that if the tenant's work effort can be monitored without cost and enforced by the landlord, then resource allocation can be as efficient under sharecropping as

[1] For excellent reviews, see Otsuka, Chuma and Hayami (1992); Singh (1989); Otsuka amd Hayami (1988); and Binswanger and Rosenzweig (1984).

under owner-cultivation or fixed-rent tenancy (Johnson 1950; Cheung 1969).[2] Whether costs of monitoring and enforcement of contracts are sufficiently low to allow for efficient sharecropping is of course an empirical question.

The available empirical evidence on the efficiency of alternative land tenure contracts is mixed. The majority of studies do not find significant inefficiency of share tenancy (Otsuka and Hayami 1988). However, many of these studies did not adequately distinguish sharecroppers from fixed-rent tenants or owner-operators and did not control for other factors that may affect input use and productivity, such as land quality or differences in farmers' endowments or abilities (Shaban 1987). Several studies that did control for such characteristics have found evidence supporting the Marshallian perspective (Bell 1977; Shaban 1987; Sadoulet et al. 1994; Laffont and Matoussi 1995; Chunrong et al. 1996).

The existing empirical literature on the effects of alternative land tenure contracts is dominated by studies conducted in south and southeast Asia, with very little information available from sub-Saharan Africa.[3] In this paper, we investigate the efficiency of land lease markets using data collected by the International Livestock Research Institute in four villages of Ethiopia. In a recent paper, Gavian and Ehui (1999) found that total factor productivity was somewhat lower on informally contracted land (whether by cash rental, sharecropping, gift or borrowing) than on owner-cultivated land in these villages, while use of inputs was similar. However, Gavian and Ehui did not provide statistical tests of their results or control for other factors that may have caused measured differences in total factor productivity.

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[2] Marshall himself noted noted this possibility even while arguing for the inefficiency of sharecropping.

[3] There is a substantial and growing literature investigating the impacts of land rights and land titles on agricultural productivity in Africa (Platteau 1996), but little of it addresses the impacts of land lease contracts.

In this paper, we develop a theoretical model of land use, land contract choice, and other input use that includes transaction costs, as well as allowing risk pooling motives and non-tradable productive inputs such as draft animal services or human capital. We test the implications of this model compared to those of the "Marshallian" (unenforceable labor effort) and "New School" (costlessly enforceable effort) perspectives using data collected from four villages in Ethiopia. We do not find empirical support for the "Marshallian" prediction of inefficient sharecropping or for the implications of the transaction costs theory. Our findings support the "New School" perspective of a well functioning lease market, suggesting that interventions in such markets would be of limited benefit for agricultural efficiency (though they may do harm). Other household and village level factors are found to affect input use and output value, suggesting that improvements in other factor markets may be more beneficial.

2. LAND MARKETS IN THE STUDY VILLAGES

The study was conducted in the Arsi zone of the Oromia region of Ethiopia. In this area, there was an active land market before the Marxist Derg regime nationalized land in 1975. Since the fall of the Derg in 1991, land leasing and informal transfers (but not sales) have again been allowed, subject to restrictions set by the regional governments. Such transfers have again become common, while the regional government has avoided use of land redistribution.

To investigate the impacts of alternative land tenure contracts on agricultural efficiency, the International Livestock Research Institute conducted a survey in four Peasant Associations (PAs or villages) in the Tiyo *woreda* (district) of Arsi zone in 1994. A sample of 161 households was selected, stratified by whether the households "owned" (were allocated by the PA in a prior land distribution) any land. There were 115 PA-allocated ("landowning") households and 46 non-PA allocated ("landless") households in the sample. A household level survey collected information about household assets, management practices, etc., and a plot level survey collected information on crop inputs and outputs and tenure status of the plots operated by the sample households.[4]

Farmers are mainly semi-subsistence mixed crop-livestock producers in the study villages. Wheat and barley are the dominant crops. The villages are in a high potential cereal producing area with relatively assured rainfall, good soils and access to markets. As a result, use of purchased inputs such as fertilizer and improved seeds is greater in the study villages than in many other parts of Ethiopia, or elsewhere in sub-Saharan Africa.

Farms are very small in the study villages, averaging less than 3 ha. operated (including cropland and pasture) per landowning household and less than 1 ha. operated per landless household. (Gavian and Teklu, 1996). All landless households and many landowning households acquired ("imported") cropland through various means from other households. Many households also owned and/or imported private pastureland, though we focus only on cropland transactions and their implications in this paper. The survey did not collect reliable data on the amount of land "exported" by households, though we do know which households reported exporting land in the village census conducted prior to the survey.

In the sample, cropland exporters owned the most cropland on average, followed by households who neither imported nor exported ("cropland non-traders"); while cropland importers owned the least amount of land (Table 1). A few cropland exporters also imported land, though the average amount imported by cropland exporters is very small. The total amount

[4] If a household only operated PA-allocated plots, the plot survey was conducted only for one randomly selected plot. In all other cases, the survey included all plots operated by the household. More information on the study villages and the sample is available in Gavian and Ehui (1999) and Gavian and Teklu (1996).

of cropland operated is very similar for importers and non-traders, indicating that land lease markets have helped to equalize land access. Cropland importers tend to have a smaller labor endowment and own fewer oxen than non-traders (probably because they are younger households), but land imports still tend to reduce disparities between importers and non-traders in operated land-labor and land-oxen ratios. Interestingly, cropland exporters have the largest labor endowments of the three categories, though their land-labor and land-oxen endowment ratios are greater than those for cropland importers.

Table 1 – Characteristics of Cropland Non-Traders, Importers and Exporters

Item	Cropland Non-Traders		Cropland Importers		Cropland Exporters		All Households	
Number of sample households	60		78		23		161	
	---- means (standard errors in parentheses)[1]----							
Cropland owned (ha)	1.59	(0.09)	0.78	(0.14)	1.80	(0.22)	1.32	(0.06)
Cropland imported (ha)	0.00	(0.00)	0.86	(0.12)	0.18	(0.07)	0.36	(0.06)
Cropland owned plus imported (ha)	1.59	(0.09)	1.64	(0.22)	1.98	(0.23)	1.68	(0.09)
Household labor force (number of workers)	2.38	(0.20)	1.64	(0.12)	3.71	(0.49)	2.35	(0.14)
Value of oxen owned (EB)	1289	(133)	1077	(142)	1247	(173)	1201	(83)
Cropland owned per worker (ha/worker)	0.85	(0.06)	0.42	(0.09)	0.57	(0.10)	0.63	(0.04)
Cropland owned plus imported per worker (ha/worker)	0.85	(0.06)	1.07	(0.15)	0.66	(0.11)	0.90	(0.06)
Value of oxen owned per ha. of cropland owned (EB/ha)	795	(85)	1185	(188)	974	(230)	925	(82)
Value of oxen owned per ha of cropland owned plus imported (EB/ha)	795	(85)	647	(85)	789	(203)	738	(62)

[1]Means and standard errors were corrected for stratification and sampling weights.

The means of acquiring access to land are land gifts, fixed-rental, and sharecropping, and borrowing (in order from most to least common). Gift fields are given free of any explicit charge for an indefinite period, while borrowed fields are also free but provided for a specified period. In terms of contract duration, gift and borrowed land are most like PA-allocated land, since the duration is generally longer for this type of land than for rented or sharecropped land. Gift and borrowed land are usually provided by relatives, often parents providing land to newly married children. Although there are not explicit charges, many tenants contribute labor to the landowner. Because of their similarities, these two categories are combined in the analysis.

Fixed rental involves a cash payment paid in advance to the landlord. The tenant pays for all inputs, reaps all of the benefits and bears all of the risk from his production. The landowner is usually not related to the tenant, the contract is almost always for only one year, and a written contract is used in most cases. The average rental cost was 352 EB (US $56) per ha. for the rented sample fields in 1993/94 (*Ibid.*).

Sharecropping agreements provide a share of the harvest to the landowner, usually one-half or one-third. The landowner is usually not a relative of the share tenant. The contract is usually for only one year, but is three or more years in about one-third of cases. In contracts in which the landowner receives a one-half share, the landowner often provides a share of the inputs in production and harvesting, including purchased inputs and harvesting labor, though the terms vary significantly across contracts. It is rare for the landowner to provide oxen or pre-harvest labor, however. Direct credit linkages between landlords and tenants are also relatively rare, with the tenant borrowing from the landlord in only two cases and the landlord borrowing from the tenant in three cases. After deducting the landowner's share of inputs from his share of the outputs, the average cost of a sharecrop contract was 935 EB (US $148) per ha. (*Ibid.*). This high cost, relative to the cost of cash rental, suggests that tenants choose sharecropping because of its risk pooling advantages or because they are unable to rent due to lack of cash or credit. Consistent with this, the most common reasons reported for sharecropping were to share risk and lack of cash.

Households farming owner-operated fields tend to own more cropland, have more labor, and tend to be older and less educated than the households operating imported fields (Table 2). Recipients of gift/borrowed plots tend to have fewer workers in the household and to be poorer in general (less land owned, less livestock), younger, more educated, of longer residence in the village, and more likely to be related to the landowner than operators of land acquired under other tenure arrangements. There are few clear differences between characteristics of tenants who have acquired land under fixed rental and those using sharecropping, except that sharecropping is not used by recent immigrants to the villages and is less common among ethnic *Oromo* people. This suggests that the choice of sharecropping vs. fixed rental depends on social relationships that may determine the transaction costs of screening and monitoring tenants.

Table 2 – Characteristics of Households and Cultivated Plots under Different Tenure Arrangements

Item	Type of Tenure: PA-allocated		Fixed rent		Sharecrop		Gift/borrowed		All fields	
Number of sample fields	149		64		31		56		300	
	- means (standard errors in parentheses)[1]									
Characteristics of operator households										
- Cropland owned (ha)	1.93	(0.12)	1.00	(0.25)	1.20	(0.31)	0.16	(0.09)	1.46	(0.14)
- Household labor force	2.69	(0.18)	1.95	(0.22)	2.05	(0.28)	1.28	(0.10)	2.31	(0.15)
- Value of oxen owned (EB)	1666	(134)	1670	(232)	1688	(313)	676	(137)	1537	(139)
- Value of other livestock owned (EB)	1874	(202)	1669	(274)	1538	(336)	687	(130)	1646	(181)
- Age of household head (years)	41.1	(1.9)	30.0	(1.6)	31.0	(2.3)	24.3	(1.1)	35.9	(1.5)
- Education of household head										
-- % illiterate	38.4	(6.4)	14.1	(5.6)	15.3	(6.9)	4.1	(2.7)	27.3	(5.0)
-- % can read and write	20.3	(5.1)	7.1	(3.9)	7.6	(4.7)	0.0	(0.0)	14.1	(4.0)
-- % completed primary school	17.9	(5.9)	26.3	(7.9)	32.3	(12.5)	39.7	(8.9)	23. 7	(5.3)
-- % completed secondary school	23.4	(5.9)	52.6	(9.5)	44.9	(12.5)	56.2	(9.0)	34.9	(6.0)
- Length of family residence in village										
-- % whose father was born in village	42.6	(6.5)	56.1	(9.8)	52.2	(12.6)	67.3	(8.4)	49.2	(6.1)
-- % whose father immigrated but were born in village	47.4	(6.9)	39.5	(9.9)	47.8	(12.6)	29.5	(8.2)	43.7	(6.3)
-- % who immigrated to village	10.0	(3.7)	4.4	(3.7)	0.0	(0.0)	3.2	(2.8)	7.1	(2.8)
- Ethnicity - % Oromo	74.1	(5.8)	75.6	(8.6)	63.3	(12.8)	71.5	(7.7)	72.9	(5.4)
- Relationship to landowner - % with landowner a relative	N/A		31.0	(6.0)	31.5	(11.1)	89.3	(5.5)	45.2	(5.4)
- Number of years household has farmed the plot	8.31	(0.93)	0.59	(0.12)	1.80	(0.49)	1.62	(0.28)	5.45	(0.60)
Characteristics of Fields										
- % having red soil	4.6	(1.3)	11.4	(4.2)	11.1	(4.7)	12.1	(4.1)	7.4	(1.3)
- % flat or gently sloped (not stony)	77.3	(4.0)	78.6	(5.7)	82.7	(7.2)	86.3	(4.4)	79.3	(2.7)
- % with no reported erosion problems	78.2	(3.9)	82.6	(5.0)	70.7	(8.9)	71.8	(7.4)	77.3	(3.2)
- % irrigated	23.1	(3.7)	14.9	(5.0)	15.3	(7.2)	19.8	(6.0)	20.5	(3.0)
- Distance from field to compound (meters)	1281	(100)	1816	(179)	1469	(311)	1338	(225)	1398	(89)
Input use and outputs – 1993/94										
- total labor hours per ha	190	(12)	188	(21)	139	(14)	192	(22)	184	(9)
- total oxen hours per ha	376	(16)	402	(38)	309	(28)	359	(29)	371	(14)
- total value of output per ha (EB)	2872	(111)	2623	(181)	2534	(293)	2233	(183)	2710	(85)

[1]Means and standard errors were corrected for stratification, sampling weights, and clustering (non-independence of observations within households.) Difference in means among tenure categories statistically significant at 1% level for all variables.

There are also some differences in the characteristics of the plots operated under different tenure arrangements. Owner-operated plots are less likely to have red soils and more likely to be irrigated than imported plots. Rented plots are least likely to have reported erosion problems, but are further from the operator household's residence than other tenure categories. Sharecropped plots also tend to be somewhat further from the residence than owner-operated or gift/borrowed plots. Overall, however, it is not clear that the average quality of land is superior or inferior in any tenure category.

Total labor and oxen use per hectare are lower on sharecropped fields than on other fields. The value of output per hectare is highest on owner-operated fields and lowest on gift/borrowed fields. These differences in input use and output per hectare may be due to other factors than tenure status however, such as the differences in tenant household characteristics or plot quality characteristics mentioned above. Below we investigate whether such differences are robust after controlling for differences in village and household characteristics and plot quality.

3. THEORY OF LAND TENANCY CONTRACTS

Restrictions on land sales, as in Ethiopia, need not be a source of inefficiency, and achieving efficiency may not even require land lease markets to function. If there are perfect markets for other factors of production, those factors can be hired in or out by landowners until all factors of production earn equal marginal products by all landowners, resulting in productive efficiency (Binswanger and Rosenzweig 1984). Tenancy is thus not necessary unless there is some other market imperfection besides an imperfect land market.

In the presence of production risk and missing insurance markets, households can use share contracts to achieve perfect risk pooling and productive efficiency, provided that the intensity of labor effort can be costlessly monitored and enforced (Johnson, 1950; Cheung, 1969). Cheung thus takes risk pooling as an argument for the existence of sharecropping. Newbery (1975) has shown, however, that if the production technology is constant returns to scale and labor can be costlessly monitored then the same degree of risk pooling and productive efficiency can be achieved by a combination of fixed rental and wage contract. Thus some additional market imperfection is necessary to explain the choice of sharecropping.

One of the most commonly cited arguments for sharecropping to exist is the difficulty of monitoring labor effort. If labor effort is unobservable, sharecropping will dominate wage labor because of its incentive advantages and dominate fixed rental because of its risk pooling advantages (Stiglitz 1974). Although this argument is persuasive, it is not clear how it could lead to multiple contract forms coexisting in the same communities, unless, as seems unlikely in the context of smallholders in Ethiopia, some tenants are risk neutral while others are risk averse (Binswanger and Rosenzweig, 1984).[5]

Cash constraints could lead to multiple contract forms. Tenants who are cash constrained might be unable to pay a cash rent and thus be forced to use share tenancy. For similar reasons, cash constrained landlords may prefer to use cash rental. Whether such differences in contracts have any implications for agricultural efficiency, however, depends upon whether there are transaction costs of monitoring and enforcing contracts. If labor can be costlessly monitored, then any outcome achievable via a cash rental contract can also be achieved via a share rental contract, as in Cheung's model. Thus, transaction costs are essential to explain why productive inefficiency may result as a result of differences in lease contracts.

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[5] In his seminal treatment of the topic, Stiglitz (1974) proved that fixed rental would only occur if the tenant is risk neutral. However, he assumed that landlords are risk neutral in his model with unenforceable labor effort. We are not aware of any paper that has proved whether fixed rental is possible with risk averse tenants and landlords and costly monitoring of labor. We show this to be possible in our model below.

In this paper, we consider a model in which tenants' effort is observable but costly to monitor and enforce. In this case, coexistence of fixed rental and sharecropping contracts may occur as a result of differences in transaction costs. Below, we derive the empirical implications of this model and contrast those to the implications of the "New School" model with costless enforcement and the "Marshallian" model with unenforceable effort. We also consider the empirical implications of slight variations of the model, such as allowing for cash constraints.

Model

Suppose that production is determined by three factors of production: land (H), labor (L) and capital services (K). Production by household i on plot p (Y^{ip}) is assumed to be a constant returns to scale function of the amount of each factor applied to the plot:

1) $Y^{ip} = \theta F^{ip}(H^p, L^p, K^p)$

The production function may vary across households and plots, though we will suppress the household superscript to simplify notation. θ is a random variable with an expected value of 1 and positive variance, and which is unknown to households at the time decisions about H and L are made. We assume that θ is the same for all households in a village, such as may result from weather or price related risks, though the model could be readily extended to incorporate idiosyncratic risks.

Households are endowed with land ($\underline{H}^i$), labor ($\underline{L}^i$) and capital ($\underline{K}^i$). We assume that a local labor market and a lease market for land exist, but that there is no market for capital. Below, we consider the implications of relaxing the assumption that capital is not marketed. If a household hires labor, the household pays a wage (w) to the worker plus a transaction cost (cl^i)

of monitoring the worker's effort. We assume that the transaction cost is a non-decreasing function of the amount of labor hired ($cl^i_L \geq 0$).[6]

If a plot of land (s) is leased out, the landlord charges a lease payment, which is a linear combination of a share of output (1-α) and a fixed rent (β):

$$2)\ \ Lease\, payment = (1-\alpha)\theta F^s(H^s, L^s, K^s) + \beta H^s$$

If $0<\alpha<1$ and $\beta=0$, then the contract is a pure share contract. If $\alpha=1$ and $\beta>0$, then the contract is a fixed rent contract. We assume that β is unrestricted; i.e., a mixture of share and rental in a contract is possible.

The landlord can monitor and enforce the tenant's use of inputs on the plot, and hence is able to select the level of inputs, but pays a transaction cost for this (ch). We assume that this cost is a non-decreasing function of the size of the plot, and the amount of labor and capital applied by the tenant ($ch_H \geq 0$, $ch_L \geq 0$, $ch_K \geq 0$). We also assume that the monitoring costs are a non-increasing function of the share of output received by the tenant, since the tenant has greater incentive to apply effort if he receives a higher share ($ch_\alpha \leq 0$).[7]

For simplicity, we assume that each landlord household operates only one owned plot and leases out one plot, and that each tenant operates his own plot plus one leased in plot. Thus, each landlord deals with only one tenant, and vice versa. This assumption does not affect the predictions of the model to be tested.

Households seek to maximize the expected utility of income and leisure ($Eu^i(Q^i, M^i)$), where u^i is a strictly concave function. We assume that tenants select their level of leisure (M^t)

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[6] We use subscripts to denote partial derivatives.

[7] If no monitoring is necessary for a fixed rent contract, then we would have ch=0 when α=1. However, the landlord may need to monitor the use of the land even in a fixed rental contract, to assure that the tenant does not misuse the land (Murrell 1983; Datta et al. 1986). Thus we allow ch to be greater than zero when α=1.

and labor use on their own plot (L^t), considering the lease terms specified by the landlord (α, β, H^s, L^s, K^s). As in Cheung's model, landlords are able to specify the level of inputs on leased plots, though there are transaction costs associated with monitoring and enforcing these.

The tenant's maximization problem is thus:

$$\begin{aligned} 3)\quad & \mathop{Max}_{L^t, M^t} Eu^t\{\theta F^t(\underline{H}^t, L^t, \underline{K}^t - K^s) + \alpha\theta F^s(H^s, L^s, K^s) \\ & - \beta H^s - w*(L^t + L^s + M^t - \underline{L}^t) - cl^t(L^t + L^s + M^t - \underline{L}^t) + g(z^t), M^t\} \end{aligned}$$

where $g(z^t)$ is the tenant's income from other assets (z^t) and the other variables are as defined above.

The first order conditions for this problem are (assuming an interior solution):

$$4)\quad \frac{Eu^t_M}{Eu^t_Q} = w + cl^t_L$$

$$5)\quad \frac{Eu^t_Q\theta}{Eu^t_Q} F^t_L = w + cl^t_L$$

Unenforceable Contracts

Before we consider the landlord's problem, it is useful to point out that if the landlord can not enforce the tenant's labor or capital use on the leased in plot, the tenant will also choose L^s and K^s to maximize 3), resulting in two additional first order conditions:

$$6)\quad F^t_L = \alpha F^s_L$$

$$7)\quad F^t_K = \alpha F^s_K$$

Equations 6) and 7) illustrate the "Marshallian" result that if the tenant's inputs are unenforceable, productive inefficiency results. If the same production function applies to the tenant's own plot and leased in plot ($F^t(\,)=F^s(\,)$) and if L and K are normal inputs (holding H constant), then equations 6) and 7) imply that labor and capital use per hectare and yield will be lower on sharecropped than tenant's own plot if $\alpha<1$ (Shaban 1987).[8]

Enforceable Contracts

Returning to the case of enforceable contracts, the landlord's problem is given by:

$$8)\quad \begin{aligned} &Max_{L^l,M^l,H^s,L^s,K^s,\alpha,\beta}\, Eu^l\{\theta F^l(\underline{H}^l - H^s, L^l, \underline{K}^l) + (1-\alpha)\theta F^s(H^s, L^s, K^s) \\ &+ \beta H^s - w^*(L^l + M^l - \underline{L}^l) - cl^l(L^l + M^l - \underline{L}^l) - ch(H^s, L^s, K^s, \alpha) + g(z^l), M^l\} \end{aligned}$$

subject to the tenant's participation constraint

$$9)\quad \begin{aligned} &Eu^t\{\theta F^t(\underline{H}^t, L^t, \underline{K}^t - K^s) + \alpha\theta F^s(H^s, L^s, K^s) \\ &- \beta H^s - w^*(L^t + L^s + M^t - \underline{L}^t) - cl^t(L^t + L^s + M^t - \underline{L}^t) + g(z^t), M^t\} = \underline{U}^t \end{aligned}$$

and the first order conditions of the tenant's problem ((4) and (5)).

The first order conditions for this problem (assuming an interior solution) lead to the following conditions, in addition to equations 4), 5) and 9):[9]

[8] The assumption that L and K are normal for fixed H holds for the CES class of production functions (Shaban 1987).
[9] These results are proved in the Appendix.

10) $$\frac{Eu_M^l}{Eu_Q^l} = w + cl_L^l$$

11) $$\frac{Eu_Q^l\theta}{Eu_Q^l} F_L^l = w + cl_L^l$$

12) $$\frac{Eu_Q^t\theta}{Eu_Q^t} - \frac{Eu_Q^l\theta}{Eu_Q^l} = \frac{ch_\alpha}{F^s}$$

13) $$F_L^s = \frac{w + cl_L^t + ch_L}{\frac{Eu_Q^l\theta}{Eu_Q^l} + \frac{\alpha ch_\alpha}{F^s}}$$

14) $$F_K^s - F_K^t = \frac{Eu_Q^t}{Eu_Q^t\theta}[ch_K + ch_\alpha(1-\alpha)\frac{F_K^s}{F^s}]$$

15) $$F_H^s - F_H^l = \frac{Eu_Q^l}{Eu_Q^l\theta}[ch_H - ch_\alpha \alpha \frac{F_H^s}{F^s}]$$

Equations 4), 5), and 9) to 15) determine M^t, L^t, M^l, L^l, H^s, L^s, K^s, α and β based on the exogenous variables of the system ($\underline{H}^t$, $\underline{L}^t$, $\underline{K}^t$, z^t, $\underline{U}^t$, $\underline{H}^l$, $\underline{L}^l$, $\underline{K}^l$, w) and the functions u^t( ), u^l( ), F^t( ), F^s( ), F^l( ), g( ), cl^t( ), cl^l( ), and ch( ).

Fixed Transaction Costs

If all transaction costs are fixed costs, these equations imply

16) $$\frac{Eu_M^t}{Eu_Q^t} = \frac{Eu_M^l}{Eu_Q^l} = w$$

17) $$\frac{Eu_Q^t\theta}{Eu_Q^t} = \frac{Eu_Q^l\theta}{Eu_Q^l}$$

18) $$F_L^s = F_L^t = F_L^l = \frac{Eu_Q^l}{Eu_Q^l\theta} w$$

19) $$F_K^s = F_K^t$$

20) $$F_H^s = F_H^l$$

If the production functions for the tenant's own and sharecropped plots are the same ($F^t(\ ) = F^s(\ )$) and are constant returns to scale, then $F^s_H = F^t_H$.[10] Similarly, $F^s_L = F^l_L$ and $F^s_H = F^l_H$ imply that $F^s_K = F^l_K$. Thus, even though there is no capital market, equalization of all marginal rates of substitution and marginal products between each landlord and tenant occurs through the operation of the labor and land lease markets if transaction costs are constant. This does not guarantee unconstrained *pareto* optimality in the economy, since with positive fixed transaction costs there may be households that do not participate in these factor markets, or differences across landlord-tenant pairs in the marginal products and rates of substitution. Of course, if transaction costs are zero, the model reduces to Cheung's model, and *pareto* optimality is achieved.

In the efficient markets case with zero transaction costs, the total amount of land operated by any household will not depend upon its own endowment of land or labor, though it will depend upon the household's endowment of capital, due to the non-marketability of capital. Thus a simple test of the efficient land and labor markets hypothesis is whether the land area operated by households is affected by their endowments of land or labor. Under efficient land markets, these endowments should have no effect on area operated, or on factor intensities or yields.

If there are no transaction costs, the choice of contract is indeterminate, as shown by Newbery. However, if there are cash constraints, this may determine the contract choice even in the absence of transaction costs. For example, suppose that the tenant is required to pay the land rent prior to earning labor income, that other income ($g(z^t)$) can be used to pay rent, and that he is

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[10] This can be shown by writing the production function as $F(H,K,L)=Hf(k,l)$, where $k=K/H$, $l=L/H$, and $f(\ )$ is a strictly concave function. Since $F_K=f_k(k,l)$ and $F_L=f_l,(k,l)$ and $f(\ )$ is strictly concave, we can invert this system to determine $k=g(F_K,F_L)$ and $l=h(F_K,F_L)$. Since $F_K^s=F_K^t$ and $F_L^s=F_L^t$, this implies that $k^s=k^t$ and $l^s=l^t$, and thus that $f(k^s,l^s)= f(k^t,l^t)$. Since $F_H=f-f_kk-f_ll$, this implies that $F_H^s= F_H^t$.

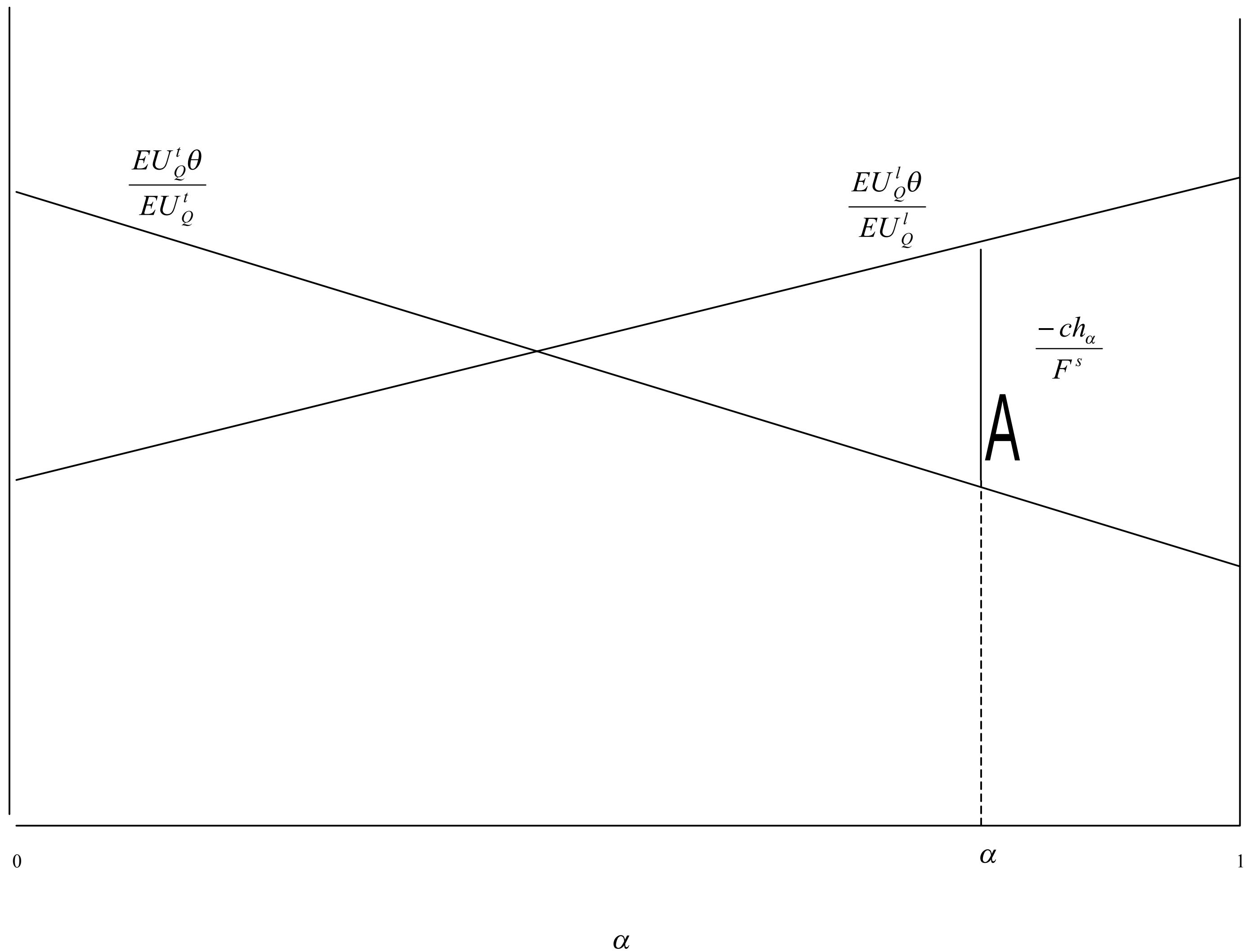
unable to borrow to pay land rent. Then the maximum rent he can pay is $g(z^t)$. Clearly, the smaller is $g(z^t)$, the more likely the tenant is to be limited to a sharecropping contract. A test of the presence of cash constraints is thus whether factors determining non-crop income (such as ownership of livestock other than oxen) increase the likelihood of sharecropping relative to fixed rental. If transaction costs are zero but there are cash constraints, such factors could affect contract choice but not factor intensities or yields. If transaction costs are positive, on the other hand, such factors may affect contract choice even in the absence of cash constraints (since non-crop income affects equation 9).

A test of the assumption of non-marketable capital is whether the household's endowment of capital has any effect on area operated. If capital is marketable with no transactions costs, this endowment should also not affect area operated. If capital is not marketable (but labor and land are marketable without transaction costs), then households with greater capital endowments will operate more land if capital and land are complements ($F_{KH}>0$), and less land if capital and labor are substitutes ($F_{KH}<0$). The capital endowment will not affect factor ratios or yields in this case, however. If capital is marketable but subject to transaction costs, the effect of capital endowment would be analogous to the effect of labor endowment when labor is marketable but subject to transaction costs.

Variable Transaction Costs

In the case with variable transaction costs, the unconstrained *pareto* optimum is no longer achieved, since there will be differences in marginal rates of substitution and marginal products of factors across households. For example, if $ch_\alpha < 0$, equation 12) implies that the marginal rate of substitution between risky income and riskless income ($Eu_Q\theta/Eu_Q$) will be greater for the landlord than the tenant, and suggests that the tenant will bear more risk (and the landlord less risk) than if the transaction cost were constant. This is illustrated in Figure 1.

Figure 1- Determination of the Tenant's Share



If the utility functions exhibit constant or increasing absolute risk aversion, $Eu^l_Q\theta/Eu^l_Q$ is an increasing function of α and $Eu^t_Q\theta/Eu^t_Q$ is a decreasing function of α.[11] The landlord seeks to increase α above the level at which perfect risk pooling occurs, sacrificing optimal risk pooling in order to reduce transaction costs. This suggests that a pure rental contract will be more likely in situations where the transaction costs of monitoring land leases are larger and more responsive to changes in α.[12] We expect this to be more likely if the tenant and landlord are unrelated than if they are relatives or long associates. Thus, we expect sharecropping to be more common among relatives or long associates, and rental contracts to be more common among unrelated individuals.

Many of the differences in marginal products are ambiguous and depend on the relative magnitudes of the marginal transaction cost terms. For example, if $ch_\alpha=0$ or $\alpha=1$ and $ch_L>0$, equations 5), 12) and 13) imply that $F^s_L>F^t_L$. In this case the tenant will put relatively less effort into the leased plot than his own plot because of the landlord's transaction costs of monitoring the tenant's labor on that plot. On the other hand, if $ch_\alpha<0$, $ch_L=0$, and $\alpha<1$, it can be shown that $F^s_L<F^t_L$. In this case the tenant is encouraged to put more effort into the sharecropped plot because of the risk sharing of the output from that plot. The results for capital are similar: if $ch_\alpha=0$ or $\alpha=1$ and $ch_K>0$, equation 14) implies that $F^s_K>F^t_K$. However, if $ch_\alpha<0$, $\alpha<1$ and $ch_K=0$, $F^s_K<F^t_K$.

If capital services were tradable, subject to transaction costs, the model's qualitative predictions about capital would be the same as those for labor, since capital would enter the model in exactly the same way as labor. Since we have just shown that the qualitative

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[11] The proof is given in the Appendix. The assumption of constant or increasing absolute risk aversion is a sufficient but not necessary condition. These results may also hold with decreasing absolute risk aversion.

[12] We say "suggests" since we do not offer a formal proof of this hypothesis. The proof is difficult due to the large number of endogenous variables in the system of equations 4), 5), and 9)-15). However, the intuition that the landlord would increase α if doing so would reduce transactions costs seems compelling to us.

predictions of the model are the same for capital and labor even when capital is not marketable, we cannot test the assumption of non-marketable capital relative to the assumption of marketable capital with transactions costs. However, we can test these models relative to the no-transaction costs model as noted earlier.

Equation 15) provides the least ambiguous prediction of the model. If $ch_H>0$ or $ch_\alpha<0$, then $F^s_H>F^l_H$.[13] A positive marginal cost of monitoring land use by the tenant will cause the landlord to restrict land availability to the tenant, even when the tenant has a higher marginal product of land. This effect is even stronger when the transaction cost depends on the tenant's share, since the tenant is forced to bear more risk, which tends to reduce the optimal level of land use in this case.

The difference between the tenant's and landlord's marginal products of land implied by equation 15) also has implications for differences in yields and factor intensities. If the production function is of the CES class, then yield is a positive function of the marginal product of land.[14] Thus, if $ch_H>0$ or $ch_\alpha<0$, the tenant's yield on the leased in plot must be higher than the landlord's yield on his own plot. Defining factor intensities as k=K/H and l=L/H, this implies that $k^s > k^l$ or $l^s > l^l$, or both. This prediction stands in sharp contrast to the Marshallian prediction that factor intensities and yields are higher on owner-operated than sharecropped plots (Shaban 1987).

Note, however, that our prediction compares tenants' to landlords' factor intensities and yields. The difference between tenants' and landlords' factor intensities and yields for the unenforceable contracts case depends on the elasticity of substitution between land and labor, with no difference arising if the elasticity of substitution is unity (Otsuka and Hayami 1988). By

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[13] Recall that we have assumed that $ch_H\geq0$ and $ch_\alpha\leq0$; the result holds even if only one of these in non-zero.
[14] Specifically, if $F(H,K,L)=(A_1H^\rho+ A_2K^\rho+ A_3L^\rho)^{1/\rho}$, then $F/H=(F_H/A_1)^{1/(1-\rho)}$.

contrast, our model predicts differences between landlords' and tenants' factor intensity and yields even if the elasticity of substitution is unity.

If the marginal transaction costs of monitoring fixed rent contracts are zero, then our model predicts that factor intensities and yields will be the same on the tenant's plots under fixed rent as on the tenant's or landlord's own plots. This could be the case if the transaction costs were needed only to ensure that the tenant applies sufficient variable inputs to the plot. However, as mentioned previously, the owner may also need to monitor the tenant's use of the plot to ensure that the tenant is not depleting soil fertility or otherwise damaging the plot (Murrell 1983; Datta et al. 1986). In this case, there would be differences in factor intensities and yields between owner-operated plots and plots leased in under fixed rental.

Summary of Model Predictions

The predictions of the transaction costs model are summarized in Table 3, along with the predictions of the costless enforcement of contracts ("New School") model and the unenforceable contracts ("Marshallian") model.

Table 3 – Predictions of Alternative Land Tenancy Theories

Variable Affected	Determinant Factors	Costless Enforcement of Contracts ("New School")	Unenforceable Contracts ("Marshallian")	Enforceable Contracts with Transaction Costs
Area operated by tenant	Tenant's factor endowments	- No effect of land or labor endowments - No effect of capital endowment if capital marketable -If capital not marketable, positive effect if $F_{HK} > 0$, negative effect if $F_{HK} < 0$	?	- Significant effects (direction not clear)
Land contract choice		- No prediction (combination of wage and fixed rental equivalent to sharecropping) unless a cash constraint binding	- Sharecropping always chosen if both landlord and tenant risk averse	- Relationship between tenant and landlord favors sharecropping
Factor intensity and yield	Tenant's factor endowments	- No effect	?	- Significant effects (direction not clear)
	Tenant's own (l^t, k^t, y^t) vs. sharecropped (l^s, k^s, y^s) vs. fixed rental plot (l^r, k^r, y^r)	$l^s = l^r = l^t$ $k^s = k^r = k^t$ $y^s = y^r = y^t$	$l^s < l^r = l^t$ $k^s < k^r = k^t$ $y^s < y^r = y^t$	$l^s \neq l^t$ or l^r in general $k^s \neq k^t$ or k^r in general $y^s \neq y^t$ or y^r in general $l^t = l^r$, $k^t = k^r$ and $y^t = y^r$ if no monitoring of fixed rental needed (If monitoring of rental needed, $l^r \neq l^t$, $k^r \neq k^t$, $y^r \neq y^t$ in general)
	Tenant's leased in plot vs. landlord's own plot (l^l, k^l)	$l^s = l^r = l^l$ $k^s = k^r = k^l$	$l^s < l^l = l^r$ if elast. of subst. (σ) < 1 $l^s = l^l = l^r$ if $\sigma = 1$ $l^s > l^l = l^r$ if $\sigma > 1$ $y^s < y^l = y^r$ if $\sigma < 1$ $y^s = y^l = y^r$ if $\sigma = 1$ $y^s > y^l = y^r$ if $\sigma > 1$	$l^s > l^l$ or $k^s > k^l$ (or both) $y^s > y^l$ $l^l = l^r$, $k^l = k^r$ and $y^l = y^r$ if no monitoring of fixed rental needed (If monitoring needed, $l^r \neq l^l$, $k^r \neq k^l$, $y^r \neq y^l$ in general)

The New School model predicts that land and labor endowments have no impact on area operated and predicts equalization of factor intensities and yields, but makes no prediction about contract choice (unless there are cash constraints). The Marshallian model predicts that sharecropping is always preferred to fixed rental if both landlords and tenants are risk averse, that tenants will apply less inputs and achieve lower yields on sharecropped plots than their own plots or plots leased under fixed rental, and that sharecroppers' input intensity and yields relative to landlords' will depend on the elasticity of substitution between land and inputs. Our model of enforceable contracts with transactions costs predicts that all factor endowments may influence area operated, contract choice, factor intensity and yields; that a relationship between landlords and tenants favors the choice of sharecropping; and that yields and at least some factor intensities are higher on sharecropped land than on the landlord's owner-operated land. The model also predicts different factor intensities and yields on tenant's own land vs. leased land in general, though which is larger depends on the relative magnitudes of various marginal transaction costs.

4. ECONOMETRIC APPROACH AND RESULTS

The theory presented in section 3 predicts that land use, lease contract choice, use of labor, oxen and output may depend on many factors. If transaction costs are negligible, most of these factors are irrelevant and only endowments of non-marketed assets and prices should matter. Of course, we would not expect to observe sole owner-operators if transaction costs are negligible, so we have *a priori* reason to believe that transaction costs are important in land markets in the villages studied. The empirical implications of this are to be determined.

We have data on three types of dependent variables: 1) cropland area operated; 2) choice of land tenure contract when land is imported; and 3) labor use, oxen use, and value of output per unit of land. The econometric model is different for each of these types of dependent variables.

CROPLAND AREA OPERATED

Econometric Model

We do not observe actual cropland area operated, but rather the area "owned" (allocated by the Peasant Association) plus the area "imported" (acquired by fixed rental, sharecropping, gift or borrowing). We do not have reliable information on the amount of cropland "exported". Cropland area operated is thus observed for cropland importers (who do not export), but left-censored for other households. We therefore use a censored regression model for area operated.

Define h_{op} as ln(area operated by a cropland importer), h as $\ln(\underline{H}+H_{imported})$ and $\underline{h}$ as $\ln(\underline{H})$. We assume that

21) $\boldsymbol{h_{op}} = \beta_h \boldsymbol{x_h} + \boldsymbol{u_h}$

for cropland importers, where x_h is a vector of observed variables affecting desired area operated, and u_h is an unobserved error term. Note that h_{op} is observed only for households that import but do not export cropland. For these households, we have that

22) $\boldsymbol{h} = \boldsymbol{h_{op}} = \beta_h \boldsymbol{x_h} + \boldsymbol{u_h}$

For all other households, we have that[15]:

23) $\boldsymbol{h} \geq \beta_h \boldsymbol{x_h} + \boldsymbol{u_h}$

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[15] If a household does not import land (either autarkic or an exporter), then desired operated area (if it were to import) must be less than or equal to its endowment ($\underline{h}$) plus some positive amount (Δh) necessary for an importer to overcome fixed transaction costs. Ideally, Δh should be included on the left side of relation 23) and estimated. However, this parameter is not identified, and excluding it biases only the intercept of β_h (assuming that Δh is constant or randomly distributed and uncorrelated with x_h). If a household is both an exporter and importer, relation 23) holds because area operated is less than area owned plus imported (by the amount exported).

We estimate this model two ways: 1) maximum likelihood estimation, assuming that u_h is independently and identically normally distributed across households, and 2) censored least absolute deviation (CLAD) estimation using the method of Buchinsky (1994), which avoids any distributional assumption concerning u_h.

According to the theory presented earlier, area operated may be affected by the household's endowments of land, labor, capital, other assets determining household income, factors associated with the household's reservation utility or preferences, factors affecting the household's agricultural productivity, factors affecting transaction costs, relative prices and wages, and the endowments, preferences and production functions of potential land tenancy partners. The household's physical endowments are represented in the regression specification by the logarithms of land owned, household labor supply, value of oxen owned, and value of other livestock owned.[16] We also include dummy variables for households with no land, oxen, or other livestock, since these cases otherwise cause difficulties for the log-log specification used.[17] Human capital endowments (potentially affecting both farm productivity and non-farm sources of income) are represented by the logarithm of age of the household head and the level of education of the household head. Transaction costs may be affected by many of these factors, as well as by social status and networks of the household. We represent these by indicators of the length of time the farm household has been settled in the village and the ethnicity of the household. Relative prices and the characteristics of potential tenancy partners are represented by village level dummy variables, which also may reflect differences across villages in

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[16] We used a logarithmic specification for these variables and the dependent variable to reduce problems of non-normality and sensitivity to outliers. Similar qualitative results were obtained using a linear specification (regression results available from the authors upon request).

[17] The terms with ln(0) for such cases were set to zero and a separate coefficient computed for the dummy variable.

agroclimatic factors affecting farm productivity, access to markets or off-farm sources of income.

Results

The censored regression results are presented in Table 4. The maximum likelihood estimates support the transaction costs model, since area operated is found to be positively (and statistically significantly) associated with land ownership. The positive effect of oxen ownership also supports the transaction costs model, implying imperfections in oxen rental markets and that oxen and land are complementary inputs. Area operated also varies significantly across villages.

Table 4 – Determinants of ln(Cropland Area Operated) – Censored Regressions

Explanatory variable	Maximum Likelihood Estimation	Censored Least Absolute Deviations Estimation
Village (cf. Abichiu Peasant Association)		
- Bilalo Peasant Association	-0.204	-0.285
- Ketar Genet Peasant Association	-0.414**	-0.910***
- Mekro & Chebote Peasant Association	-0.411**	-0.711**
ln(Crop land owned) (ha)	0.353**	-0.004
Landless (dummy variable=1 when cropland owned=0)	-0.363**	-0.031
ln (Household labor supply) (number of workers)	0.048	0.348
ln(Value of oxen owned) (EB)	0.338***	0.400
No oxen (dummy variable=1 when oxen owned=0)	1.842**	2.167
ln(Value of other livestock owned) (EB)	0.051	0.075
No other livestock (dummy variable=1 when other livestock owned=0)	0.158	0.273
ln(age of household head) (years)	-0.338	-0.035
Education of household head (cf. illiterate)		
- Read and write	-0.115	-0.119
- Finished primary school	0.130	0.166
- Finished secondary school	0.346	0.200
Length of time in village (cf. father born in village)		
- Father immigrated to village, farmer born in village	0.043	-0.173
- Farmer immigrated to village	0.049	0.044
Ethnicity of household Oromo	-0.016	-0.356
Intercept	-1.450	-2.653
Number of uncensored/total observations	78/161	77/161[b]
Pseudo R^2		0.479

a. *, **, *** indicate statistical significance at the 10%, 5% and 1% levels respectively. Coefficients and standard errors of maximum likelihood estimator were corrected for sample weights and stratification.
b. Number of predicted uncensored observations after convergence of algorithm.

In the CLAD estimation, only village effects are statistically significant. The effect of oxen ownership is in the same direction and similar in magnitude as in the maximum likelihood (ML) model, but is no longer statistically significant due to the larger standard errors in the CLAD model. By contrast, the effect of land ownership is much smaller in magnitude and of the opposite sign in the CLAD model to that expected (for the coefficient of ln(area operated)). We obtained similar qualitative results using linear versions of the ML and CLAD models, with the linear ML model supporting the hypothesis that area operated depends on area owned, but this not being supported by the linear CLAD model.[18] Interestingly, however, higher oxen ownership significantly increases area operated in the linear versions of both models.

The results of the CLAD model reduce our confidence in the implication of the ML model that imperfections in the land lease market exist, and suggest that those results hinge upon distributional assumptions of the ML model. On the other hand, the insignificant effect of oxen ownership in the logarithmic version CLAD model may simply be a result of the lower statistical power of that model (given the similar magnitude of the coefficients in both models). Next we examine the other evidence available concerning the efficiency of land markets in the study villages.

CONTRACT CHOICE

Econometric Model

For imported fields, we model the choice of tenure arrangement using a multinomial logit model. We include the same explanatory variables as in the regression for land imports. Since the data are for specific tenancy contracts (in contrast to the cropland area regression), we can

[18] Regression results available from the authors upon request.

include explanatory variables specific to the particular landlord as well. One factor that may be an additional important indicator of the transaction costs of the contract is the relationship between the landowner and tenant. If the landowner is a relative of the tenant or if the tenant and the landlord have established a long-term relationship, the transaction costs may be lower, thus tending to favor sharecropping or gift/borrowing over a fixed rental arrangement. Thus we include variables indicating whether the landlord is a relative of the tenant and the number of years the farmer has farmed the plot.

Results

As expected, the length of time the tenant has farmed the plot is positively associated with both sharecropping and gift or borrowing arrangements (Table 5). Recent immigrants to the village are very unlikely to acquire plots by sharecropping, while gift and borrowed plots are much more common when the landowner is a relative of the tenant. These findings confirm our expectations about the importance of social relationships in determining transaction costs and land contract choice.

Table 5 – Determinants of Lease Contract Choice - Multinomial Logit Model

Explanatory Variables[a]	Sharecropping Contract	Gift/Borrowed
Village (cf. Abichiu Peasant Association)		
- Bilalo Peasant Association	0.080	-0.173
- Ketar Genet Peasant Association	-0.737	-1.101
- Mekro & Chebote Peasant Association	0.386	-1.491*
ln(Crop land owned) (ha)	0.237	-1.165
Landless (dummy variable=1 when cropland owned=0)	-0.884	-0.456
ln(Household labor supply) (number of workers)	-0.171	-1.760***
ln(Value of oxen owned) (EB)	-0.520	-0.657
No oxen (dummy variable=1 when oxen owned=0)	-4.000	-2.957
ln(Value of other livestock owned) (EB)	-0.329	-0.322
No other livestock (dummy variable=1 when other livestock owned=0)	-43.866***	-1.391
ln(Age of household head) (years)	0.372	1.577
Education of household head (cf. illiterate)		
- Read and write	-0.954	-40.755***
- Finished primary school	-0.428	2.489
- Finished secondary school	-0.841	2.252
Length of time in village (cf. father born in village)		
- Father immigrated to village, farmer born in village	0.246	1.261
- Farmer immigrated to village	-44.759***	0.435
Ethnicity of household Oromo	-0.738	-0.332
Landlord is a relative of tenant	0.038	3.440***
Number of years farmer has farmed the plot	1.576***	1.939***
Mean predicted probabilities|actual contract[b]		
- Fixed rent	0.408	0.186
- Sharecrop	0.458	0.119
- Gift/borrowed	0.134	0.695

a. *, **, *** indicate statistical significance at the 10%, 5% and 1% levels respectively. Omitted category is cash rental. Coefficients and standard errors were corrected for sample weights, stratification and clustering. Standard errors are robust to heteroskedasticity. Intercepts are not reported. Number of observations is 151.

b. The mean predicted probabilities for fields under fixed rental are: fixed rent 0.597, sharecrop 0.244, gift/borrowed 0.159.

Other factors affecting contract choice include lack of ownership of livestock other than oxen (negative association of dummy variable with sharecropping), household labor supply (negative association with land gifts/borrowing), and literacy (literate households less likely to receive land through gifts/borrowing). The negative associations of household labor supply and literacy with land gifts/borrowing suggests that gifts and loans of land may be reserved for poorer relatives who have fewer alternative income earning opportunities. Households with greater human capital endowments may be better able to afford to rent or sharecrop land, which may be of higher quality (more on this below). We do not have a strong hypothesis to explain the negative association between lack of other livestock and sharecropping. Given that sharecropping can be a way for tenants who lack access to liquidity to lease land, we expected if anything a positive relationship between lack of livestock and sharecropping (relative to fixed rental). This finding does not support the hypothesis of cash constraints determining land contract choice.[19]

INPUT USE AND OUTPUT VALUE PER HECTARE

Econometric Model

The econometric model estimated for these dependent variables can be summarized as follows:

24)
$$y_{hp} = a + b_i D_{ih} + b_x D_{xh} + b_r D_{rp} + b_s D_{sp} + b_g D_{gp} + b_{ir} D_{ih} D_{rp} + b_{is} D_{ih} D_{sp} + b_{ig} D_{ih} D_{gp} + b_h x_h + b_p x_p + v_{hp}$$

where y_{hp} is ln(labor use per ha.), ln(oxen use per ha.), or ln(value of output per ha.) for household h and plot p; D_{ih} and D_{xh} are dummy variables equal to 1 if household h is a land

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[19] Very similar results were obtained using a probit model to compare determinants of sharecropping vs. fixed rental.

importer or exporter, respectively; D_{rp}, D_{sp} and D_{gp} are dummy variables equal to 1 if plot p is rented, sharecropped or gift/borrowed, respectively; x_h and x_p are vectors of household and plot characteristics affecting the dependent variables; v_{hp} are unobserved factors affecting the dependent variables, and a, b_i, b_x, b_r, b_s, b_g, b_{ir}, b_{is}, b_{ig}, b_h, b_p are coefficient vectors to be estimated.

We include interactions between households' land trade status and the tenure status of the plot to be able to test the specific hypotheses following from the theory presented in section 3. For example, to test the implication of the transaction costs model that yields will be higher on sharecroppers' leased-in plots than landlords' owner-operated plots, we cannot determine this from the average effect of either the land trade status of the household or the tenancy status of the plot. We need interaction terms for this.

The following hypotheses are tested:

Hypothesis	Test
1) y(rented|importer) - y(owned|importer) = 0	$b_r + b_{ir} = 0$
2) y(shared|importer) - y(owned|importer) = 0	$b_s + b_{is} = 0$
3) y(gift/borrowed|importer) - y(owned|importer) = 0	$b_g + b_{ig} = 0$
4) y(rented|importer) – y(owned|exporter) = 0	$b_r + b_{ir} + b_i – b_x = 0$
5) y(shared|importer) – y(owned|exporter) = 0	$b_s + b_{is} + b_i – b_x = 0$
6) y(gift/borrowed|importer) – y(owned|exporter) = 0	$b_g + b_{ig} + b_i – b_x = 0$

Tests 1) – 3) compare inputs and outputs on a tenant's imported plots and his own plots. These tests are comparable to the tests for Marshallian inefficiency in studies such as Bell (1977) and Shaban (1987). Marshallian inefficiency implies that $b_s + b_{is} < 0$, but $b_r + b_{ir} = 0$. Tests 4)-

6) test the predictions of the theory presented in Section 3 that inputs and outputs should be greater on tenants' imported plots than on landlords' own plots, as a result of transaction costs.

We estimated two versions of the model. In one, x_h includes the same explanatory variables used to predict area operated. Such household level factors are not expected to affect factor use and output per hectare unless there are factor market imperfections (Udry 1996). In the second version, we included household level fixed effects to account for all possible household level factors (measured or unmeasured) affecting the dependent variables. The fixed effects model was estimated for the subsample of households who were cropland importers and also operated PA-allocated land. This is similar to the approach devised by Shaban to test for Marshallian inefficiency. In the fixed effects regressions, we could not include household level factors (x_h, D_{ih}, D_{xh}). Thus, we could not test hypotheses 4)-6) using the fixed effects regressions.

The measured plot level characteristics assumed to affect input use and output include the type of soil (red soil expected to be less productive than black soil), the slope of the field (flat or gently sloping fields expected to receive more inputs and produce greater output than steeply sloping fields), whether there had been erosion problems on the field (ambiguous impact on inputs but expected to reduce productivity), the use of irrigation on the field (expected to increase input use and value of output), and the distance of the field from the household compound (expected to reduce input use and output).

The endogeneity of the contract choice for imported fields could lead to biased estimates in the model above. To address this issue, we estimated equation (24) using instrumental variables, taking as instruments for contract choice the predicted probabilities of each import contract from a multinomial logit regression.[20]

In all of the above regressions, coefficients and standard errors are adjusted to account for sample stratification and sample weights. The estimated standard errors are robust to heteroskedasticity and to possible non-independence of multiple observations from the same household.

To better understand the mechanisms by which land tenure contracts and other factors affect crop output, and to test for impacts of land contracts on total factor productivity, we also estimate a structural model of output value using three-stage least squares. We assume that the production function is a Cobb-Douglas form, with ln(output/ha) as a linear function of ln(labor use/ha), ln(oxen use/ha), ln(age of household head), and a set of dummy variables representing land tenure categories, village level effects, education levels, and plot quality characteristics.[21] In the three-stage least squares model, ln(labor use/ha) and ln(oxen use/ha) were estimated using the same fixed effects specification discussed earlier.

Results

In the regressions without household fixed effects, we find statistically significant effects of the plot tenure variables and the interaction terms between land trade status of the household and plot tenure (Table 6).

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[20] To increase the efficiency of the instrumental variables estimator, we included household level fixed effects in the multinomial logit model used to predict the instruments for contract choice. Regression results are available from the authors upon request.

[21] Use of the Cobb-Douglas specification was supported by estimation of a constant elasticity of substitution production function using nonlinear least squares, including plot area (H), labor use (L) and oxen use (K) as inputs: Output = $(a_1 H^{\rho} + a_2 L^{\rho} + a_3 K^{\rho})^{-v/\rho}$. Estimation results were a_1 = 84.7 (s.e.=1598), a_2 = 5 e-07 (598 e-07), a_3 = 0.00015 (0.00910), ρ = 0.119 (0.618), v = 0.943 (0.061). Constant returns to scale and unitary elasticity of substitution cannot be rejected, given these estimates.

Table 6–Determinants of Input and Output per Hectare– Instrumental Variables Regressions

Explanatory Variables[a]	Without Household Fixed Effects[c]			With Household Fixed Effects[d]		
	ln(labor/ ha)	ln(oxen time/ha)	ln(output value/ha)	ln(labor/ha)	ln(oxen time/ha)	ln(output value/ha)
Cropland importer	0.182*	0.006	-0.003			
Cropland exporter	0.135	-0.030	-0.076			
Fixed rent plot[b]	0.029	0.163	0.029	0.006	-0.110	-0.059
Sharecropped plot[b]	-1.538***	-0.985***	-0.341**	-0.008	-0.034	-0.119
Borrowed/gift plot[b]	-0.797***	-0.627***	-0.170	-0.234	-0.879***	-0.393
Importer x fixed rent interaction[b]	-0.285	-0.294	0.046			
Importer x sharecropped interaction[b]	1.238***	0.817***	0.313			
Importer x borrowed/gift interaction[b]	0.578**	0.360*	-0.068			
Village (cf. Abichiu)						
- Bilalo	-0.225*	-0.309***	-0.320***			
- Ketar Genet	-0.388***	-0.226	0.578***			
- Mekro & Chebote	-0.430***	-0.644***	0.304***			
ln(Crop land owned) (ha)	0.013	-0.007	-0.033			
Landless (dummy variable=1 when cropland owned=0)	0.055	0.156	0.096			
ln(Household labor supply) (number of workers)	0.188**	0.103*	0.119			
ln(Value of oxen owned) (EB)	0.0569	0.0113	0.128*			
No oxen (dummy variable=1 when oxen owned=0)	0.480	0.115	0.865*			
ln(Value of other livestock owned) (EB)	-0.0291	-0.0090	-0.0225			
No other livestock (dummy variable=1 when other livestock owned=0)	0.008	-0.017	-0.095			
ln(Age of household head) (years)	-0.423***	0.154	-0.162			
Education of household head (cf. illiterate)						
- Read and write	-0.147	0.006	0.109			
- Finished primary school	-0.168	0.107	-0.062			
- Finished secondary school	-0.198*	0.014	0.104			

Explanatory Variables[a]	Without Household Fixed Effects[c]			With Household Fixed Effects[d]		
	ln(labor/ ha)	ln(oxen time/ha)	ln(output value/ha)	ln(labor/ha)	ln(oxen time/ha)	ln(output value/ha)
Length of time in village (cf. father born in village)						
- Father immigrated to village, farmer born in village	-0.016	-0.203***	-0.124*			
- Farmer immigrated to village	-0.044	-0.077	0.058			
Ethnicity of household Oromo	0.002	-0.031	-0.083			
Number of years farmer has farmed the plot	-0.0095	-0.046	0.058	0.229	-0.021	0.016
Red soil on field	-0.007	0.064	0.069	0.300	0.280	0.030
Flat or gently sloping field	0.022	-0.012	-0.093	-0.144	-0.049	-0.028
Erosion problem on field	-0.039	-0.026	-0.003	0.014	0.0005	-0.047
Irrigated field	-0.106	-0.095	-0.136**	-0.306*	-0.082	-0.163
Distance from field to compound (km.)	-0.0476**	0.0133	-0.0149	-0.061	-0.001	-0.043
R^2	0.202	0.353	0.357	0.416	0.549	0.453

a. *, **, *** indicate statistical significance at the 10%, 5% and 1% levels respectively. Coefficients and standard errors were corrected for sample weights, stratification and clustering. Standard errors are robust to heteroskedasticity. Intercepts are not reported.
b. Instrumental variables used for tenure categories and interactions include predicted probabilities of each land lease type, predicted by a multinomial logit model including household fixed effects, and interactions between predicted probabilities of land lease types and cropland importer dummy.
c. Number of observations = 300.
d. Number of observations = 127.

To interpret these coefficients, we need to consider the sums of coefficients to test the specific hypotheses discussed above. In the hypothesis tests based on the no-fixed effects regressions, we find that labor use is more than 30% lower on importers' sharecropped plots than on their owner-operated plots, and that this difference is statistically significant at the 5% level (Table 7). However, we find no statistically significant differences in oxen use or yield on importers' sharecropped vs. owner-operated plots, and the estimated yield difference is only 3%. Furthermore, in the fixed-effects regressions, there are no statistically significant differences in input use or yields between importers' sharecropped and owner-operated plots, and the magnitude of the differences are relatively small. The results thus provide little support for the hypothesis of Marshallian inefficiency of sharecropping.

Table 7 – Hypothesis Tests about Impacts of Land Tenure Variables

Hypothesis	Without Household Fixed Effects			With Household Fixed Effects		
	ln(labor/ ha)	ln(oxen time/ha)	ln(output value/ha)	ln(labor/ha)	ln(oxen time/ha)	ln(output value/ha)
All land tenure x land trade effects = 0	***	***	*		***	
	p=(0.000)	(0.000)	(0.089)	(0.785)	(0.001)	(0.578)
Importer rented plot – importer own plot = 0	-0.256	-0.131	0.075	0.006	-0.110	-0.059
	(0.168)	(0.362)	(0.565)	(0.979)	(0.554)	(0.743)
Importer sharecropped plot – importer own plot = 0	-0.300**	-0.168	-0.028	-0.008	-0.034	-0.119
	(0.035)	(0.154)	(0.845)	(0.975)	(0.819)	(0.582)
Importer gift/borrowed plot – importer own plot = 0	-0.219	-0.267*	-0.238	-0.234	-0.879***	-0.393
	(0.157)	(0.066)	(0.104)	(0.295)	(0.000)	(0.163)
Importer rented plot – exporter own plot = 0	-0.209	-0.095	0.148	NE	NE	NE
	(0.382)	(0.585)	(0.264)			
Importer sharecropped plot – exporter own plot = 0	-0.253	-0.132	0.045	NE	NE	NE
	(0.196)	(0.382)	(0.758)			
Importer gift/borrowed plot – exporter own plot = 0	-0.172	-0.231	-0.165	NE	NE	NE
	(0.416)	(0.191)	(0.277)			

a. *, **, *** indicate statistical significance at the 10%, 5% and 1% levels respectively. p values in parentheses.

We also find no statistically significant difference between input use and yields on importers' cash rented plots and their owner-operated plots, and that the predicted differences are relatively small (especially in the fixed-effects regressions). This is consistent with the assumption that the transactions costs of monitoring fixed rental contracts are low, leading to relatively efficient use of rented plots as well.

We find that estimated input use and yields are substantially lower on importers' gift/borrowed plots than on their owner-operated plots, though the difference is statistically significant only for oxen use. Perhaps this is because operators of gift/borrowed plots own fewer oxen on average than owner-operators. Such differences also could be due to unobserved differences in land quality between rented or borrowed in plots and farmers' own plots. As noted in section 2, there are some differences in observed quality measures on owned vs. imported plots. Most of these differences are relatively small, however, and they do not provide a clear pattern in terms of which types of land are of higher quality. Thus, the available evidence does not provide strong cause to be concerned about this as a general problem (though we discuss further indirect evidence below suggesting that borrowed plots are lower in unobserved quality).

We do not find statistically significant differences in output value per hectare on importers' sharecropped in or rented in plots and exporters' owner-operated plots, as predicted by the transaction costs theory. The estimated differences are in the right direction (higher for importers' rented or sharecropped plots than exporters owner-operated plots) but are relatively small in magnitude, particularly for sharecropping (yields about 5% higher on importers' sharecropped plots). Furthermore, predicted differences in input use are in the opposite direction to that predicted by the theory (though not statistically significant). We thus find little support for the transaction costs theory from the input and output regressions, consistent with the findings from the CLAD regression for area operated. The results are more consistent with the "New School" model of efficient land lease markets.

Several household-level factors significantly affect input use and output per hectare, indicating that other factor market imperfections may be important. Labor use per hectare is greater for households having a larger labor endowment, and less where the head of household is older. Oxen ownership has a positive impact on output value (significant at the 10% level) (Table 6). More educated household heads apply less labor (10% level). We also find a positive effect of household labor supply on oxen use (10% level), supporting the hypothesis that capital and labor are complementary. Household level fixed effects are highly jointly significant (at the p=0.01 % level) in all regressions. These household level effects suggest that factor markets do not function perfectly to equalize factor ratios and yields, and that imperfections in labor and/or oxen markets are responsible. Other market imperfections could be responsible for such effects, however (Udry 1996).

One interesting result is that households that have not been long established in the village (i.e., households in which the father immigrated to the village, compared to households in which the father was born in the village) use less oxen input per hectare and achieve lower yields. This suggests that farmers' options for leasing or borrowing oxen depend upon social relationships as developed through long presence in the community.

Few of the plot quality variables had a statistically significant impact on input use or yields in the regressions. This may be because the land in the study villages is generally of good quality for agriculture, with limited variation in slope and soil conditions within the study villages. Labor use is lower on plots that are more distant from the household compound (though the effect is statistically significant only in the regression without household fixed effects), indicating the importance of transportation costs in affecting the intensity of production. Surprisingly, the value of output is lower on irrigated plots, though this effect is not statistically significant in the fixed effects regression. Perhaps unobservable differences between owners of irrigated plots and owners of non-irrigated plots account for the difference in the regression without fixed effects.

The results support the hypothesis of labor or capital market imperfections leading to differences in factor intensities and output per hectare across households. Before accepting this hypothesis, however, it is well to consider alternative explanations for these results. It is possible that some omitted variable bias contributes to these effects. For example, unobservable plot quality characteristics may be correlated with household endowments, leading to spurious conclusions. It is difficult to be completely certain that such a bias is not present without panel data; however, we do control for several observable plot quality characteristics and find little impact of most of these variables, as noted above. Furthermore, there is little correlation between observable plot quality characteristics and household endowments; e.g., the R^2 in regressions of labor and oxen endowments on plot quality is less that 0.05 in both cases. Thus we do not have evidence to suggest that unobservable plot quality characteristics are likely to be strongly correlated with household factor endowments.

Regression diagnostics indicated the presence of non-normal errors and heteroskedasticity in most of the regressions, although these problems were reduced by the use of the log-log specification. The estimates are asymptotically normal, the sample size is relatively large, and the standard errors are robust to heteroskedasticity, so these problems should not lead to incorrect inferences. Nevertheless, the efficiency of the estimators may be affected by the use of instrumental variables and problems of multicollinearity. Very similar results were found when ordinary least squares rather than instrumental variables estimation was used (ignoring the endogeneity of land contract choice), indicating that the use of instrumental variables did not greatly reduce efficiency.[22] Similar results were also found using a linear rather than a logarithmic specification. Multicollinearity is a problem mainly for the oxen endowment variables (the correlation between ln (oxen owned) and the no oxen dummy is -0.98) and for some of the tenure variables (variance inflation factors greater than 10 for several of these). Dropping the ln (oxen owned) variable from the regressions has little impact on the regression results, except that the no oxen dummy no longer has a significant impact on output. Thus multicollinearity between the oxen endowment variables does not cause major problems for the other regression results. The multicollinearity among the tenure variables is unavoidable, since all of these must be included for the hypothesis tests. In any case, we find statistically significant impacts of these variables despite the multicollinearity.

These results provide little evidence to support the Marshallian view of the inefficiency of sharecropping. This may partly be due to the fact that landlords share some inputs in production, which can help to reduce or offset the incentive effects. However, landlords share very little of the inputs of pre-harvest labor or oxen, so one would still expect less of these inputs to be applied on sharecropped fields, if the Marshallian assumption of no monitoring and enforcement of labor effort were correct. Some form of monitoring and enforcement appears to take place with sharecropping contracts in these Ethiopian villages.

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[22] Estimation results available from authors upon request.

Finally, we estimate the structural model of output value using three-stage least squares (Table 8). We find that oxen use has a strong impact on output value, but that labor input and most other factors have a statistically insignificant impact. The land tenure variables are jointly statistically insignificant, implying that land tenure does not have a direct measurable impact on total factor productivity. We do find that productivity is lower on gift/borrowed plots than on importers' own plots, controlling for input use. This finding suggests (as do some of the earlier findings) that gift/borrowed plots are of lower unobserved quality. Other factors associated with differences in productivity include village level effects and education (output value 15% higher for household heads who finished secondary school than for illiterate household heads). Thus, although higher education was found to be associated with lower intensity of labor use, it is also found to be associated with higher productivity, thus compensating in terms of impact on total production.

Table 8 – Structural Model of Output Value (Three-Stage Least Squares Regression)

Explanatory Variables[a]	ln(output value/ha)
ln(labor use/ha)[b]	-0.085
ln(oxen use/ha)[b]	0.394***
Cropland importer	-0.007
Cropland exporter	-0.015
Fixed rent plot[b]	-0.091
Sharecropped plot[b]	-0.181
Borrowed/gift plot[b]	-0.182
Importer x fixed rent interaction[b]	0.125
Importer x sharecropped interaction[b]	0.130
Importer x borrowed/gift interaction[b]	0.015
Village (cf. Abichiu)	
- Bilalo	-0.131
- Ketar Genet	0.621***
- Mekro & Chebote	0.615***
ln(Age of household head) (years)	-.026
Education of household head (cf. illiterate)	
- Read and write	0.076
- Finished primary school	-0.030
- Finished secondary school	0.137*
Red soil on field	0.076
Flat or gently sloping field	-0.069
Erosion problem on field	0.039
Irrigated field	-0.093
Distance from field to compound (km.)	-0.027
Intercept	5.752***
R^2	0.476
Hypothesis Tests	
All land tenure x land trade effects = 0	(p = 0.396)
Importer rented plot – importer own plot = 0	0.034 (0.662)
Importer sharecropped plot – importer own plot = 0	-0.051 (0.586)
Importer gift/borrowed plot – importer own plot = 0	-0.167** (0.041)
Importer rented plot – exporter own plot = 0	0.042 (0.683)
Importer sharecropped plot – exporter own plot = 0	-0.043 (0.707)
Importer gift/borrowed plot – exporter own plot = 0	-0.159 (0.141)

a. *, **, *** indicate statistical significance at the 10%, 5% and 1% levels respectively.
b. Variables used to predict ln(labor use/ha) and ln(oxen use/ha) include the same explanatory variables used in the fixed effects regressions reported in Table 6.

5. CONCLUSIONS AND IMPLICATIONS

Our empirical findings are inconsistent with both the "Marshallian" perspective and the transaction costs theory presented in this paper. We do not find empirical support for the Marshallian prediction of inefficient sharecropping, since factor intensity and output value are not significantly different on tenants' own vs. sharecropped fields. Nor do we find that factor intensity or output value differs significantly between cropland importers and exporters, or that cropland area operated is a function of area owned, as predicted by the transaction costs theory. Consistent with the "New School" perspective, our results indicate that land lease markets were operating relatively efficiently in the villages studied when the survey was conducted in 1993/94.

As argued by Otsuka, et al. (1992), it is likely that in the absence of institutional restrictions on contract choice, the selection of tenancy contracts will tend to minimize inefficiency. Thus, landlords who do not know prospective tenants well or for whom monitoring the tenant may be costly will tend to prefer a cash rental contract to a sharecropping contract. Where sharecropping is preferred, transaction costs are lower and hence the inefficiency is limited. Furthermore, landlords who do participate in sharecropping contracts reduce the incentive problems by sharing some of the costs.

Although we find that land lease markets function relatively efficiently in the study villages, our data were collected prior to adoption of restrictions on land leasing by the Oromia Regional Government in 1995. These restrictions allow farmers to lease out no more than half of their land for a maximum of three years. Such restrictions may well have reduced the efficiency of lease markets in the region. Investigation of the impacts of these restrictions would be useful.

We do find evidence supporting the hypothesis of imperfect labor or oxen lease markets. Efforts to improve the functioning of these markets are thus more likely to improve agricultural efficiency than efforts focused on improving land lease markets. Promoting development of competitive tractor hire services, for example, might help to address the constraint that oxen endowment appears to pose for efficiency, while reducing grazing pressure on pastures and croplands.

Another implication of our empirical results is that village level factors are important determinants of input use and productivity. It may be that differences in productivity across the study villages resulted from local variations in rainfall or other idiosyncratic factors in 1993/94, so too much should not be made of this result. However, if such village level differences persist over time, they suggest that factor markets do not function efficiently to equalize marginal returns to productive factors across villages. For example, the absence of a land sales market in Ethiopia may have a more important bearing upon the ability of people to migrate to villages where the returns to their labor and capital are higher, than upon the efficiency of factor allocation within any given village. More research on this issue at a broader scale, enabling identification of which village-level factors are causing differences in input use and productivity, would be valuable.

Appendix 1--Derivation of First Order Conditions:

The tenant's optimization constraints (4) and 5)) are satisfied if the landlord solves the less-constrained maximization problem excluding these two equations, and taking L^t and M^t as choice variables. We can therefore solve this less-constrained problem, since the solution will be the same.

The lagrangian for maximization of 8) with respect to L^t, M^t, L^l, M^l, H^s, L^s, K^s, α, and β subject to 9) is given by:

A1)
$$\begin{aligned} V = & Eu^l\{\theta F^l(\underline{H}^l - H^s, L^l, \underline{K}^l) + (1-\alpha)\theta F^s(H^s, L^s, K^s) \\ & + \beta H^s - w^*(L^l + M^l - \underline{L}^l) - cl^l(L^l + M^l - \underline{L}^l) - ch(H^s, L^s, K^s, \alpha) + g(z^l), M^l\} \\ & + \lambda[Eu^t\{\theta F^t(\underline{H}^t, L^t, \underline{K}^t - K^s) + \alpha\theta F^s(H^s, L^s, K^s) \\ & - \beta H^s - w^*(L^t + L^s + M^t - \underline{L}^t) - cl^t(L^t + L^s + M^t - \underline{L}^t) + g(z^t), M^t\} - \underline{U}^t] \end{aligned}$$

Differentiating V with respect to L^t and M^t we obtain:

A2) $$\frac{\partial V}{\partial L^t} = \lambda[Eu_Q^t \theta F_L^t - Eu_Q^t(w + cl_L^t)] = 0$$

A3) $$\frac{\partial V}{\partial M^t} = \lambda[Eu_M^t - Eu_Q^t(w + cl_L^t)] = 0$$

Equations A2) and A3) simplify to equations 4) and 5) since the tenant's participation constraint is binding ($\lambda > 0$).

Differentiating with respect to β yields:

A4) $$\frac{\partial V}{\partial \beta} = Eu_Q^l H^s - \lambda Eu_Q^t H^s = 0$$

Equation A4) implies that

A5) $$\lambda = \frac{Eu_Q^l}{Eu_Q^t}$$

Differentiating with respect to α yields:

A6) $$\frac{\partial V}{\partial \alpha} = -Eu_Q^l \theta F^s - Eu_Q^l ch_\alpha + \lambda Eu_Q^t \theta F^s = 0$$

Substituting A5) into A6) and simplifying, we obtain equation 12).

Differentiating with respect to L^l and M^l yields:

A7) $$\frac{\partial V}{\partial L^l} = Eu_Q^l \theta F_L^l - Eu_Q^l (w + cl_L^l) = 0$$

A8) $$\frac{\partial V}{\partial M^l} = Eu_M^l - Eu_Q^l (w + cl_L^l) = 0$$

Equation A7) and A8) can be rewritten as equations 11) and 10).

Differentiating with respect to L^s, K^s, and H^s yields:

A9) $$\frac{\partial V}{\partial L^s} = Eu_Q^l (1-\alpha)\theta F_L^s - Eu_Q^l ch_L^l + \lambda[Eu_Q^t \alpha\theta F_L^s - Eu_Q^t (w + cl_L^t)] = 0$$

A10) $$\frac{\partial V}{\partial K^s} = Eu_Q^l (1-\alpha)\theta F_K^s - Eu_Q^l ch_K^l + \lambda[-Eu_Q^t \theta F_K^t + Eu_Q^t \alpha\theta F_K^s] = 0$$

A11) $$\frac{\partial V}{\partial H^s} = -Eu_Q^l \theta F_H^l + Eu_Q^l (1-\alpha)\theta F_H^s + Eu_Q^l (\beta - ch_H^l) + \lambda[Eu_Q^t \alpha\theta F_H^s - Eu_Q^t \beta] = 0$$

Substituting A5) and 12) into A9), A10) and A11) and simplifying, we obtain equations 13)-15).

Proof that $d(Eu^t_Q\theta/Eu^t_Q)/d\alpha < 0$ if $u^t()$ exhibits constant or increasing absolute risk aversion:

A12) $$\frac{\partial[\frac{Eu_Q^t \theta}{Eu_Q^t}]}{\partial \alpha} = F^s \frac{Eu_Q^t E(u_{QQ}^t \theta^2) - E(u_Q^t \theta) E(u_{QQ}^t \theta)}{(Eu_Q^t)^2}$$

Case 1. Constant absolute risk aversion

In this case, u^t_{QQ} = constant < 0. Thus

A13) $$sign\{\frac{\partial[\frac{Eu_Q^t\theta}{Eu_Q^t}]}{\partial\alpha}\} = sign\{E(u_Q^t\theta)E(\theta) - E(u_Q^t)E(\theta^2)\}$$

Since

A14) $$\frac{\partial u_Q^t}{\partial\theta} = (F^t + \alpha F^s)u_{QQ}^t < 0$$

Then

A15) $$Cov(u_Q^t, \theta) < 0$$

A15) implies that

A16) $$E(u_Q^t\theta) < E(u_Q^t)E(\theta) = E(u_Q^t)$$

since E(θ) = 1.

Jensen's inequality implies that

A17) $$E(\theta^2) > (E\theta)^2 = 1$$

Using relations A16) and A17) in equation A13), we find that

A18) $$sign\{\frac{\partial[\frac{Eu_Q^t\theta}{Eu_Q^t}]}{\partial\alpha}\} < 0$$

Case 2. Increasing absolute risk aversion

With increasing absolute risk aversion, $u^t_{QQQ} < 0$. Therefore

A19) $$\frac{\partial u_{QQ}^t\theta}{\partial\theta} = u_{QQ}^t + \theta(F^t + \alpha F^s)u_{QQQ}^t < 0$$

This implies that

A20) $$Cov(u_{QQ}^t\theta, \theta) < 0$$

Thus

A21) $E(u_{QQ}^{t}\theta^{2}) < E(u_{QQ}^{t}\theta)E(\theta) = E(u_{QQ}^{t}\theta) < 0$

Using relations A21) and A16) (which holds also with increasing absolute risk aversion) in equation A12) proves the result.

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