ELSEVIER

Agricultural Economics 20 (1999) 37–49

AGRICULTURAL ECONOMICS

Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia

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Received 23 July 1996; received in revised form 6 May 1998; accepted 20 May 1998

Abstract

In this paper, we test the hypothesis that land held under varying configurations of property rights will be farmed at different levels of production efficiency. Production data were collected from 477 plots in a fairly productive, mixed farming system in the Ethiopian highlands. Interspatial measures of total factor productivity, based on the Divisia index, were used to measure the relative production efficiency of three informal and less secure land contracts (rented, share-cropped and borrowed) relative to lands held under formal contract with the Ethiopian government. Although the informally-contracted lands are farmed 10–16% less efficiently, the analysis indicates that farmers of such lands actually apply inputs more, rather than less, intensively (i.e., more inputs per unit of land). The gap in total factor productivity thus results from the inferior quality of inputs (or lack of skills in applying them) rather than a lack of incentive to allocate inputs to mixed crop-livestock farming. For this reason we find no empirical basis to support the hypothesis that land tenure is a constraint to agricultural productivity.

1. Introduction

Many agricultural policy decisions in sub-Saharan Africa (SSA) are affected by the belief that land must be privatized or that people should have exclusive and secure rights on their lands (e.g., titled lands). An important argument in favor of land reforms is that farmlands held under exclusive and secure land rights are more productive than farmlands held under other forms of rights. If true, then reforms to title lands or individualize land rights should improve production efficiency. The hypothesized greater production efficiency of privatized lands, however, may be an illusion if other public policies such as provision of rural infrastructure, promotion of market efficiency, dissemination of information about new technologies and access to credit are not in place (Atwood, 1990). From a public policy view point, better information on the relative efficiency of farm lands under different tenure contracts would provide a better indication of how land tenure systems affect resource use and thereby the overall productivity of farming operations. If we can measure the relative production efficiency of alternative land tenure systems, we can then determine the productivity gains possible through land reforms. If land tenure arrangements are major sources of productivity differences, then efforts to develop technologies will be secondary to land reform policies.

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0169-5150/99/$ – see front matter
PII: S0169-5150(98)00067-X

Although the question of relative production efficiency of indigenous land rights is central to a discussion of land reform in SSA, there is relatively little rigorous empirical research due to lack of adequate disaggregated data. With the exception of few studies (Place and Hazell, 1993; Besley, 1994; Bruce et al., 1994; Gavian and Fafchamps, 1996; Hayes et al., 1997) the subject has not benefitted from rigorous empirical analysis. Further, most studies have covered only areas of rain-fed agriculture. Questions remain about the suitability of indigenous land rights for irrigated farming, extensive pastoral and livestock-based systems and communal forestry areas (Place and Hazell, 1993).

The objective of this paper is to examine the relative production efficiency of alternative land tenure arrangements and the sources of differences in productivity levels in Ethiopia as a case study. In 1974, the country nationalized rural lands, redistributing land use rights 'to the tillers' but maintaining land ownership in the hands of the state. Land sales were outlawed. Tenancy relations, such as sharecropping and renting were prohibited. In recent years, the restrictions on informal land transactions have been lifted and there are currently an array of formal and informal means by which farmers can obtain land. The varying degrees of security and rights associated with these arrangements make Ethiopia appropriate for case study of differences in productivity with land tenure.

The current study differs in several ways from similar studies by Place and Hazell (1993), Besley (1994), Gavian and Fafchamps (1996) and Hayes et al. (1997). First, it focuses on a farming system in which livestock contribute not only 40% of the country's agricultural gross domestic product, and provide most of the power for plowing and threshing. Second, the data used for the analysis were highly detailed, based on short-term (3-day) recall and actual measured yields, rather than end-of-season recall and qualitative measures. Unlike most other studies, labor hours per plot were collected. Finally, where most studies have attempted to gauge efficiency from econometric estimation of reduced-form production functions, this analysis relies on the concept of interspatial total factor productivity (TFP) as defined by (Denny and Fuss, 1980 and Denny and Fuss, 1983). The TFP method is well suited to the complexity and diversity of smallholder farming because it summarizes across fields with varying inputs and outputs. The use of the TFP method permits comparisons across systems with multiple outputs. Thus, while controlling for differences in input levels, we can examine differences in the output of land under different tenure arrangements. The TFP method does not isolate the impact of long term investment. It rather focuses on allocation of variable input levels.

2. Land tenure issues in Sub-Saharan Africa

Despite the large body of literature, the degree to which prevailing land tenure contracts constrain agricultural productivity in SSA is unresolved. Some authors argue that informal contractual tenure arrangements (e.g., tenancy or sharecropping) and other forms of indigenous land tenure rights result in an inefficient allocation of resources as well as reduced incentives to improve agricultural lands (Hayami and Otsuka, 1993). The argument is that land tenure arrangements that assign land rights to the community or to a landlord rather than to the principal land user, discourage long-term investment in land improvements. Individual farmers without secure private rights may not be able to claim fully the returns on their investments in, or attached to, land. Informal contractual tenure arrangements may fail to promote investments required for conservation. Accordingly, reforms such as the privatization or individualized land rights, the abolition of sharecropping and land redistribution are viewed as policy instruments that can improve agricultural productivity (Dorner, 1977; Ip and Stahl, 1978; Harrison, 1987; Hayes et al., 1997).

Other authors, however, argue that the form of land tenure has little bearing upon allocative efficiency and attribute the poverty of the agricultural sector in SSA to agricultural factor endowments and public policies rather than to the prevailing tenure arrangements. This second school of thought cites evidence that indigenous tenure arrangements are dynamic and evolve in response to population pressure and factor price changes. They argue that privatization of land rights, whereby farm households acquire a complete set of transfer and exclusive rights over land, occurs with increases in population pressures and agricultural

commercialization (Cohen, 1980; Boserup, 1981; Noronha, 1985; Feder and Noronha, 1987; Pinckney and Kimuyu, 1994; Platteau, 1996). Place and Hazell (1993) found that land rights were not significantly related to yields in Ghana, Kenya and Rwanda, thus undermining the common view that land rights constrain agricultural productivity. They further concluded that lack of access to credit, insufficient human capital, and labor shortages adversely affect investment decisions more than insecurity of tenure. Gavian and Fafchamps (1996) tested whether traditional land tenure systems allocate land efficiently and whether insecurity affects the manner in which households allocate manure (a short-to-medium run land improvement strategy) among their fields. They found evidence that tenure insecurity incites farmers to divert soil-enhancing resources to more secure fields whenever possible. The ability to sell land, however, does not effect the allocation of these resources.

3. The conceptual framework

Most productivity analyses are based on partial productivity measures such as yield per hectare (land productivity) or output per person (labor productivity). Such productivity measures can be misleading if considerable input substitution occurs as a result of widely differing input prices due to market imperfections. Although partial productivity measures provide insights into the efficiency of a single input in the production process, they mask many of the factors accounting for observed productivity differentials.

A conceptually superior way to estimate productivity – and therefore production efficiency – is to measure total factor productivity (TFP) defined as the ratio of aggregate outputs to aggregate inputs used in the agricultural production process. There are two basic approaches to the measurement of productivity: the growth accounting approach, which is based on index numbers, and the parametric approach, which is based on an econometric estimation of production, cost or profit functions. In this paper we use the index number approach for three reasons. First, with the index number approach, detailed data with many input and output categories can be used regardless of the number of observations over time. There are, therefore, no problems of degrees of freedom or statistical reliability in working with small samples. Second, there is no need to aggregate outputs into a single index, thus avoiding input–output separability assumptions. Finally, under certain technical and market conditions, the econometric and index number approaches are equivalent. Recent advances in growth accounting theory have shown that non-parametric methods do indeed impose an implicit structure on the aggregate production technology (Ohta, 1974; Diewert, 1976; Diewert, 1981; Denny et al., 1981).

The major difficulty with the index number approach is to derive aggregate output and input measures that represent the numerous outputs and inputs involved in most production processes. Earlier approaches to TFP used a Laspeyres or Paasch weighting system where base period prices were used as aggregation weights. However, the Laspeyres or Paasch indexing procedure is inexact except when the production function is linear and all inputs are perfect substitutes in the relevant range (Christensen, 1975; Diewert, 1976). The most popular indexing procedure is the Divisia index which is exact for the case of homogenous translog functions (Capalbo and Antle, 1988). The translog function does not require inputs to be perfect substitutes, but rather permits all marginal productivities to adjust proportionally to changing prices. Hence the prices from both production systems being compared enter the Divisia index to represent the differing marginal productivities. There have been relatively few applications of this approach in the context of farming systems. Ehui and Spencer (1993) have used the Divisia approach to TFP to measure the sustainability and economic viability of alternative farming systems in Nigeria.

Assume that the agricultural process in land held under tenure system i at time t can be represented by the production function:

$$Q_{it} = F(X_{it}, T_{it}, D_i) \tag{1}$$

where Q_{it} is the output level, X_{it} is a vector of factor inputs, T_{it} is an index of technology, and D_i is a vector of dummy variables for every tenure system other than the reference base system.[1] T_{it} and D_i denote also intertemporal and interspatial efficiency difference

[1]This section is based on Denny and Fuss (1980, 1983).

indicators. Eq. (1) assumes that the production function in each tenure system has common elements as well as differences resulting from the tenure arrangement, which are maintained by the additional argument D. Suppose that we wanted to know the difference between the level of output on land held under tenure system i at time s, and land held under tenure system o at time t. Application of Diewert's (Diewert, 1976) quadratic lemma[2] to a logarithmic approximation of Eq. (1) gives:

$$\begin{aligned}\Delta\ln Q = \ln Q_{is} - \ln Q_{ot} = \frac{1}{2}\sum_k \left[\left.\frac{\partial \ln F}{\partial \ln X_k}\right|_{X_k=X_{kis}} + \left.\frac{\partial \ln F}{\partial \ln X_k}\right|_{X_k=X_{kot}}\right][\ln X_{kis} - \ln X_{kot}] \\ + \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial D_i}\right|_i + \left.\frac{\partial \ln F}{\partial D_i}\right|_o\right][D_i - D_o] \\ + \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{is}} + \left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{ot}}\right] \\ \times [\ln T_{is} - \ln T_{ot}]\end{aligned}$$

Let us define the interspatial (i.e., tenure) effect as:

$$\theta_{io} = \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial D_i}\right|_i + \left.\frac{\partial \ln F}{\partial D_i}\right|_o\right][D_i - D_o] \tag{3}$$

and the intertemporal effect as

$$\mu_{st} = \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{is}} + \left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{ot}}\right][\ln T_{is} - \ln T_{ot}] \tag{4}$$

Constant returns to scale and perfect competition in input and output markets imply that $(\partial \ln F/\partial \ln X_k) = s_k$, where the term s_k represents the cost share for the kth input. Using these assumptions, we can rewrite Eq. (2) as

$$\Delta\ln Q = \frac{1}{2}\sum_k [s_{kis} + s_{kot}][\ln X_{kis} - \ln X_{kot}] + \theta_{io} + \mu_{st} \tag{5}$$

From Eq. (5) the output differential across tenure systems and time periods may be broken down into an input effect, a tenure system effect and an intertemporal effect.

Let A denote the land input. Eq. (5) can be rewritten as

$$\Delta\ln\left(\frac{Q}{A}\right) = \frac{1}{2}\sum_{k\neq A}[s_{kis} + s_{kot}]\left[\ln\left(\frac{X_{kis}}{A_{is}}\right) - \ln\left(\frac{X_{kot}}{A_{ot}}\right)\right] + \theta_{io} + \mu_{st} \tag{6}$$

where $\Delta\ln(Q/A)$ denotes the change in land productivity levels[3]. The first expression on the right-hand side of Eq. (6) denotes the weighted sum of differences in factor intensities. Let us define this expression as

$$\rho_{io} = \frac{1}{2}\sum_{k\neq A}[s_{kis} + s_{kot}]\left[\ln\left(\frac{X_{kis}}{A_{is}}\right) - \ln\left(\frac{X_{kot}}{A_{ot}}\right)\right] \tag{7}$$

The difference in land productivity can therefore be decomposed into three effects: (i) a factor intensity effect ρ_{io}; (ii) a tenure system effect (θ_{io}), and (iii) an intertemporal effect (μ_{st}). If we want to measure the production efficiency levels across tenure systems at a given point in time (where $t=s$), we rearrange the terms to isolate the tenure effect:

$$\theta_{io} = \left[\ln\left(\frac{Q}{A}\right)_i - \ln\left(\frac{Q}{A}\right)_o\right] - \frac{1}{2}\sum_{k\neq A}[s_{ki} + s_{ko}] \times \left[\ln\left(\frac{X_{ki}}{A_i}\right) - \ln\left(\frac{X_{ko}}{A_o}\right)\right] \tag{8}$$

The expression θ_{io} is the Tornqvist–Theil approximation (Tornqvist, 1996; Capalbo and Antle, 1988) to the change in productivity levels due to the type of tenure contract at a particular point in time. The difference in the TFP of two systems is a function of the differences in land productivities and factor intensities. Factor intensities are the weighted sum of

[2]Diewert (1976) quadratic lemma basically states that if a function is quadratic, the difference between the function's values evaluated at two points is equal to the average of the gradient evaluated at both points multiplied by the difference between the points: $F(Z^1 - F(Z^0) = \frac{1}{2}[F(Z^1) + F(Z^0)]^{\mathrm{T}}(Z^1 - Z^0)$ where $F(Z^r)$ is the gradient vector of F evaluated at Z^r, r=0,1.

[3]Dividing by A is the equivalent of presenting agricultural data on a per unit area basis (e.g., per hectare or acre). The final TFP figures are the same whether or not land is used as a numeraire, but the interpretation of the components does not correspond to those described in Eq. (8).

differences in the level of variable inputs applied per unit of land.[4]

In the case of multiple outputs, the Tornqvist–Theil quantity index can also be used to aggregate the various outputs into a single index:

$$\left[\ln\left(\frac{Q}{A}\right)_i - \ln\left(\frac{Q}{A}\right)_o\right] = \frac{1}{2}\sum_j [r_{ji} + r_{jo}] \times \left[\ln\left(\frac{Q_j}{A_i}\right)_i - \ln\left(\frac{Q_j}{A_j}\right)_o\right] \quad (9)$$

where r_{ij} and r_{jo} denote the jth output revenue share in systems i and o, respectively. Q_j denotes the jth output level.

Eq. (8) indicates that there are two components that contribute to any observed differences in TFP. First are changes in the level of land productivity. This is the major component underlying TFP differentials. Second are changes in factor intensities. TFP is therefore the residual, or the portion of change in output levels not explicitly explained by changes in input levels. However, increases in factor intensities may occur without any increase in TFP. Changes in TFP levels and factor intensities are not independent but they are of different significance. Increases in TFP will occur if land productivity increases proportionally more than increases in factor intensity levels. But increases in land productivity that are due to increases in factor intensities are qualitatively (although not quantitatively) less significant than changes in TFP. Indeed land productivity will increase if a farmer applies more purchased inputs. Unless there are improvements in the use of these inputs, this will be a change in factor intensity and not TFP. It is clear that with TFP changes, in contrast with factor intensity differentials, the farmer's capability to produce more with the same resources has improved.

[4]Although this study focuses on only one time period, the general expression shown in Eq. (6) can be specialized to provide a comparison of the rate of growth of productivity due to technical change for a particular system over time (D_i=D_o and s=t+1).

$$\mu_{t+1,t} = \left[\ln\left(\frac{Q}{A}\right)_{t+1} - \ln\left(\frac{Q}{A}\right)_t\right] - \frac{1}{2}\sum_{k\neq A}[s_{k,t+1} + s_{kt}] \times \left[\ln\left(\frac{X_{k,t+1}}{A_{t+1}}\right) - \ln\left(\frac{X_{kt}}{A_t}\right)\right]$$

μ_{t+1} measures the intertemporal TFP of a production system over two periods. It is the Tornqvist–Theil approximation to the change in productivity levels due to technical change.

4. Study area and data collection

For the last two decades in Ethiopia, all rural lands have been owned by the government in the name of the people. Lands were nationalized in a country-wide campaign in 1975, expropriated from both large landlords and small peasant farmers alike. Control over this resource was given to the representatives of lowest level of government, the Peasant Association (PA). PA officials periodically redistributed land between households based primarily on family size. To be eligible for land at the time of the next distribution, a farmer was required to register with the Peasant Association at age 18 or when he married.[5] When the Transitional Government of Ethiopia took power in 1991, it imposed a moratorium on land distributions until such time as a new land policy was formulated. Although the Constitution of 1994 re-iterated the inability of private citizens to own or sell land, it remained vague on the question of land distribution. To this day, this policy has yet to be clarified, although some regions of the country have undertaken or are planning rural land redistributions.[6] The International Livestock Research Institute (ILRI) conducted a study in 1994 to present evidence on ways farmers in the Ethiopian highlands gain access to land and the production and management strategies they use to cultivate and maintain that resource.

4.1. Study area

The study area was selected from one of the most productive regions of the country, the Arsi Zone of Oromia Region. Four peasant associations in the Tiyo *woreda* (district) – Abichu, Bilalo, Ketar Genet and Mekro Chebote – were selected for their varying altitudes and thus mix of crop and livestock activities. A census carried out in March 1994 provided a sampling frame for classifying households based on their official access to state lands. Households classified as peasant association members (PA) were those

[5]The original law does not distinguish between men and women. In practice, however, women are usually registered as independent PA members and allocated land in their names when, for some reason, they cannot depend on their spouse for land, as with widows, divorcees and wives in polygamous marriages.

[6]For a more thorough description of the recent evolution of land tenure legislation in Ethopia, see Girma and Zegeye (1995)

which had received at least one crop or pasture field from the government. The second tenure class was made up of households which had not yet acquired either crop or pasture land from the government (NPA) but were farming land acquired from their PA neighbors through various informal contracts. The census indicated that in the total farming population of 1671 households, 83% were PA members and the other 17% were not. To determine the appropriate sample size for both the PA and NPA samples, the Weyman procedure (Cochrane, 1963) was applied to gauge the variability of the key agricultural variables in the census data by tenure class. Based on these results, a random sample of 161 households was selected from the census list, composed of 115 PA and 46 NPA households.

These households controlled 510 crop fields from which a final sample of 317 crop fields was selected. Each of the sampled crop fields was sub-divided where necessary into plots, where a plot was defined as a distinct management unit due to the farmer's choice to plant a unique crop or intercrop there. Not only were crops such as barley, wheat, teff (*Eragrostis tef*), etc., distinguished from one another, but so too were the sub-varieties within these categories. Some fields were made up of only one plot, while others had as many as 10 plots. The sampled crop fields contained 477 separate plots for which the following data were collected:

- *Input* data on all inputs used on each plot during the main 1994 growing season (from April to December 1994). These were collected twice weekly by asking the farmer to recall his activities on that particular plot during the past three days. Data included labor time (by source, gender, age, and field operation), as well as the quantities of traction (oxen and tractors), seed, fertilizers, pesticides, and herbicides employed. The prices of all purchased inputs were likewise recorded at this time.
- *Output* data on all the quantity of all cereals, pulses and residues harvested from each plot on the field. The full amount of offtake was weighed by enumerators after threshing and winnowing operations.
- Area measures, i.e., the area of plots.

In a separate survey, the prices of all crops and residues were collected in each of the two major rural markets frequented by farmers from these PAs: Asella and Ketar Genet markets. Twice monthly, enumerators recorded prices from three samples of each crop species and sub-variety found on the sampled plots.

4.2. *Description of land contracts in the survey region*

There are many arrangements under which farmers gain access to crop lands in Ethiopia. As stated above, the only official contract is with the government, through the PA. There are also numerous informal contracts, made unofficially between farmers without involving the PA. Whereas patterns of land transactions vary greatly between regions of the country, results our census indicated that in 1994 in Tiyo *woreda*, 76% of all fields were allocated directly by the PA to the current farmer. The remaining 24%, originally allocated to PA members, had been informally subcontracted to other farmers.

NPA farmers rely solely on informal contracts whereas PA farmers rely on both formal contracts with the government and informal contracts between themselves. The census indicated that over one-fifth of the PA households exported, or contracted out, one of their fields and about the same proportion imported, or contracted in, at least one field. A very small proportion (2%) both imported and exported land, perhaps to lessen the distances they had to walk to their fields. Over half of the PA households farmed uniquely the lands they had been allocated by the PA.

Based on differences in the nature of these contracts – in terms of duration, rights and costs – we have grouped all fields into one of four categories: PA-allocated, rented, sharecropped and borrowed.

PA fields are those which are allocated directly to the farmer by PA officials. Because no farmer has a permanent, legally defensible claim to land, even the duration of PA contracts are fairly short-term. However, PA-allocated fields are held longer and have a greater range of rights than the informally-contracted fields. The average PA-allocated field had been used by the current farmer two and a half to four times longer than the average contracted field. Furthermore, the duration of the current contract on PA-allocated fields is indefinite, whereas most contracted fields have only one year contracts (Table 1).

Most farmers on PA-allocated fields felt able to exercise most of the usufruct rights shown in Table 1. About one-fifth felt they could not build wells, stone

Table 1
Frequency and nature of land contracts in the Arsi region in Ethiopia

	PA-allocated	Informally contracted		
		Rented	Shared	Borrowed
Share of contracts for cropped fields users	83	5	4	7
PA-member households	100	18	76	64
Landless households	0	83	24	36
No. years field used by current farmer	8	2	3	3
Duration of current contract (%)	100	100	100	100
One year	0	91	63	16
Two years	0	6	7	2
Three or more years	0	0	7	0
Permanent/indefinite	100	3	23	81
Proof of contract (*% fields*)	100	100	100	100
None required	0	27	77	96
Witnesses required	100	8	0	0
Written contract	0	65	23	4
Share of fields for which user holds the following right (%):				
Unrestricted crop choice	100	100	100	97
Fallow for 1 year	96	87	33	16
Fallow for more than 1 year	95	64	8	13
Plant trees	92	75	12	19
Install a well or pump	77	75	12	19
Build stone bunds	79	82	37	35
Build fence from natural materials	93	89	34	55
Build fence from stone/metal	79	68	14	32
Share out	98	64	53	6
Rent out	97	62	44	6
Lend out	96	61	45	6
Bequeath	99	68	34	6

Source: ILRI Field Management Survey; Rights Survey.
Notes: 'Permanent', in the case of contract duration means that the two parties will honor the agreement until the government intervenes with another distribution.

bunds or permanent fences of metal or stone but these responses may reflect more their desire rather than their right (the distinction is difficult to make to farmers, the concept of rights being rather abstract). In contrast, farmers on the informally contracted fields feel substantially more restricted in all activities except the right to choose the crop they plant. Structural changes, fallowing and subcontracting out the land were usually not possible for farmers with informal land contracts.

Although PA members are required to pay taxes, that tax is unrelated to amount of crop or pasture land they receive. In 1994, PA members were taxed 22 Ethiopian Birr (EB) per household, which, at an average holding of about 2.9 ha, equals about 7.5 EB per hectare (or US$ 1.20/ha). Essentially, therefore, PA-allocated lands are free.

Rented fields are those for which a fixed cash sum is paid – usually in advance – by the tenant to the landholder. The renter-tenant pays for all inputs and reaps all benefits (or losses) of his cropping activities. Of the informally-contracted fields, rented fields have the shortest leases. The average renter operated under a one-year agreement that was less often extended than agreements established by borrowers or sharecroppers (as indicated by the number of years the field had actually been used in Table 1. As on all informally-contracted fields, the range of use and modification rights is more restricted on rented fields than it is on PA-allocated fields. As compared with the other

contracted fields, however, renters have the broadest range of rights (Table 1). They also are the most likely to have a written contract. The average cost for renting a field in the survey area was 352 EB per hectare in 1994 (US$ 56/ha). Rented fields made up about 8% of all cropped lands in Tiyo woreda in 1994 and 33% of the area's contracted fields.

Sharecropped fields involve a commitment by both partners to share the costs of the inputs and the benefits of the outputs.[7] Sharecropped fields are held somewhat longer than rented fields, with 23% under long-term agreements and an average holding time of three years (Table 1). The reverse is true in terms of rights; the considerably more restricted range of rights on sharecropped than rented fields reflects the lack of autonomy for the share-tenant in this partnership. In the survey year, the cost of the sharecropped contract was two and a half times greater than that for rented fields. After deducting the landholder's share of all labor and inputs from his share of the outputs, the average cost of a sharecropped contract was 935 EB per hectare (US$ 148/ha).[8] Sharecropped fields made up 4% of all cropped lands in Tiyo woreda in 1994 and 17% of the area's contracted fields.

Borrowed and gift fields are those given by the landholder to the user free of charge. Borrowed fields are given for a defined period, whereas gift fields are usually given for a longer, but indefinite period (i.e., until the next land distribution). Both types of fields are almost always given by relatives, usually by parents who give out part of their holdings to their newly-married family members. As offspring or relatives of the landholder, many of these farmers contributed labor to the landholders' fields. These contributions were difficult to monitor and have not been valued here. Because the basic attributes of gift and borrowed fields are very similar, they have been combined under the same rubric in this analysis (borrowed/gift). The duration of the average borrowed/gift contract comes closest of all the three informal contracts to the PA-allocated fields, with fully 81% of users operating under a long-term arrangement (Table 1). Borrowed/gift fields had an average holding time of three years and as relatives, the two parties rarely require a written document. The range of rights, however, is quite restricted, roughly the same as sharecropped fields, more restricted than rented fields and much more restricted than PA-allocated fields. As with shared fields, these restrictions represent the partnership underlying the borrowing arrangement, in this case between family members. Borrowed/gift arrangements are fairly common, making up 12% of all cropped lands and half of all contracted fields in 1994.

4.3. *Defining security*

Theory suggests farmers will be reluctant to invest in insecure fields. But the concept of security is complex and elusive, depending in great measure on the farmer's subjective assessment of the political and legal climate. Bruce et al. (1994) describe security in terms of the formal duration of rights, the protection of rights and the robustness of rights. The analysis by Place and Hazell (1993) employs qualitative variables to represent tenure security in terms of bundles of transfer rights: limited (cannot be permanently transferred), preferential (can be bequeathed or given) and complete (can be sold). Besley (1994) measures land tenure security in terms two variables: the number of transfer rights the farmer can exercise without approval from the family members and the number of transfer rights for which such approval is needed.

In this study, we define land tenure security as a combination of the expected longevity of the contract and the breadth of rights to carry out a range of field-related activities. Because none of the tenure contracts is long-term or alienable and nearly all farm lands are under exclusive control only for the duration of the growing season (becoming open to grazing animals in the dry season), the definition of security is necessarily relative. The four tenure arrangements described above have been ranked from 1 to 4 based on the information presented in Table 2 in terms of (a) duration (a combination of past holding and current contract length), (b) use rights (planting, fallowing),

[7] *Equl* and *Siso* are local names of the two most common contracts, meaning equal sharing and two-third share, respectively (from the tenant's point of view). Under either contract, most labor is provided by the share-tenant. In spite of these simplified names, there are numerous permutations on these arrangements, based on the specific endowments of the two contracting partners.

[8] Note that 1994 was a good crop year in the Arsi Region and, therefore, the cost of the average share contract was higher than usual.

Table 2
Relative ranking of the security of land tenure arrangements in the Arsi region in Ethiopia

	PA-allocated	Informally contracted		
		Rented	Shared	Borrowed
Duration	4	1	2	2
Use rights	4	3	2	2
Modification rights	4	3	2	2
Transfer rights	4	3	2	1
Total	16	10	7	6

Based on the data on contract duration and rights displayed in Table 1, the land contracts have been order from 1 (least) to 4 (most). The sum of these rankings is given in the row entitled 'Total', and represents a qualitative measure of tenure security.

(c) modification rights (trees, wells, fences, bunds) and (d) transfer rights (share, rent, lend, bequeath). A ranking of 4 indicates the given tenure arrangement was superior to all the other arrangements on the particular measure; conversely a ranking of 1 indicates that tenure arrangement ranked lowest. Where there was no notable difference between the two categories, an equal score has been granted (Table 2).

This ranking procedure permits us to order the land tenure arrangements in terms of declining security: PA, rented, shared and borrowed. Although PA-allocated lands are not 'secure' in a truly long-term sense, the security offered by the government is necessarily greater than what farmers can offer each other under renting, sharecropping and borrowing contracts. Furthermore, most farmers on PA-allocated lands claim to the right to undertake important investments (modifications to the field) or transfers, whereas farmers on informally-contracted fields feel unable to undertake major improvements to fields. Generally, renters have less security but a wider range of rights than either sharecroppers or borrowers. What distinguishes the latter two groups is the stiff price tag paid by sharecroppers in kind to the landholder.

4.4. *Transforming the production data*

For the purposes of this analysis, the different types of land contracts are hypothesized to have different effects on the structure of production in the region. We have conducted pair-wise comparisons between those lands allocated by the government (i.e., PA-allocated) and each type of land received under an informal farmer-to-farmer arrangement (i.e., rented, share-cropped or borrowed lands).

To have an adequate number of observations in each field tenure class, the analysis has been restricted to wheat, barley and legume plots which constitute 82% of the plots surveyed.

Within each generic crop category (i.e., wheat, barley and legume) farmers distinguished numerous sub-varieties.[9] Because not all sub-varieties were found in each tenure system, grains were aggregated into three categories – wheat, barley and legumes – and all residues were grouped together. Likewise, because not all inputs were used in each of the four tenure systems, more generic input categories have been formed: human labor, power (oxen and tractor), chemicals (fertilizer and herbicides) and seed.

Given that the different tenure arrangements had multiple and dissimilar crop outputs and inputs, it was necessary to aggregate the varying input and outputs into meaningful categories to permit application of the Tornqvist–Theil indexing procedure, as shown in Eqs. (8) and (9). Implicit output indices of wheat, barley and legumes were calculated by dividing the total value of all output by the price index obtained by weighing the individual output prices by the revenue share of each crop. A corresponding input quantity index for labor, power, chemicals and seed was computed as the ratio of total expenditures in each input category to the weighted price index of that input. The latter was measured as an index of all prices of individual input prices weighed by the cost share of each input.

All inputs and outputs enter the calculations on a per hectare basis; land enters the model with a quantity value of one along with the associated per hectare price for each tenure category. This method of including land as a numeraire permits the output and input components to be interpreted as land productivity and factor intensity, respectively, as shown in Eq. (8).

The prices used for these models were derived from several sources. Output and seed prices were drawn from the twice-monthly survey of retail prices in the two major markets in the area. Based on the observation that most farmers market their crops in the three months following harvest, the December through

[9]Because these distinctions were not made by trained agronomists, we refrain from calling these cultivars.

Table 3
Comparisons of total factor productivity, land productivity and factor intensities by tenure arrangements in the Arsi region in Ethiopia

	PA-allocated	Informally contracted fields		
		Rented	Shared	Borrowed
Total Factor Productivity	1.00	0.90	0.87	0.84
Land Productivity	1.00	0.96	0.91	0.92
Wheat	1.00	1.12	1.21	0.95
Barley	1.00	0.88	0.78	0.95
Legumes	1.00	0.96	0.98	1.03
Residues	1.00	1.01	0.99	0.99
Factor Intensity	1.00	1.06	1.05	1.10
Labour	1.00	1.00	0.99	0.98
Power	1.00	1.01	0.99	1.01
Chemicals	1.00	1.04	1.06	1.10
Seed	1.00	1.01	1.01	1.01

February price average was used to represent output prices; based on the similar observation that seeding is carried out in May and June, the average of the market prices for these months was used to represent the value of seed, whether purchased or reserved from last year's stock. Prices for purchased inputs such as fertilizers, herbicides, pesticides, and tractor power were derived from averages cited by farmers in the course of the production survey. Pricing unpurchased inputs such as human and animal labor was more difficult. Although there is a labor market, hired labor made up only 7% of total labor time. For the purposes of the TFP computations, all labor was valued at the market rate, disaggregated by activity where there were significant differences in daily wages by activity. Assuming the opportunity cost of most household labor is not as high throughout the growing season as the wage rate for labor hired at peak periods, this method most likely overstates labor component of total input costs. (Analyses to test the sensitivity of the results to this method indicated that using the hired labor rate did not distort the final results). As the market for animal labor is even thinner than that for human labor[10], it was impossible to gather good data for this input. The final prices used were derived from key informant interviews.

[10]When farmers need additional animal power, they tend to swap between themselves.

5. Productivity estimates

Table 3 shows the average total factor productivity levels for each of the three informal contracts (rented, shared and borrowed lands) relative to the PA-allocated land tenure type. Land and total factor productivity levels are lower for these contracts relative to the PA-allocated arrangement. Borrowed lands have the lowest TFP levels producing 16% less output than the PA-allocated lands using the same input bundle. The shared lands are 11% less efficient than the PA-allocated lands, whereas rented lands are only 7% less efficient.

The overall land productivity levels for informally-contracted fields are also lower than for PA-allocated fields. However, the gap is smaller than the gap in TFP levels due to the relatively high levels of factor intensity on informally-contracted fields. The higher level of total inputs (labor, power, chemicals and seeds) applied to informally-contracted fields increases the level of land productivity but not the level of TFP. For example, the factor intensity level on borrowed land is 10% higher than the PA-allocated lands but the TFP level is 16% lower.

Although Eq. (8) provides an excellent framework for decomposing the change in TFP into its various components, we can also express the changes in the levels of inputs as a percentage of the change in land productivity. Table 4 indicates that differences in most

Table 4
Sources of productivity differences: informally-contracted fields relative to government (peasant association) -allocated fields in Arsi region in Ethiopia

	Rented	Shared	Borrowed
Differences in TFP (percentage points)	−10	−13	−16
Land productivity (output)	−4	−9	−8
Total factor intensity	6	5	10
Labor	0	−1	−2
Power	1	−1	1
Chemicals	4	6	10
Seed	1	1	1
Differences in TFP as share of difference in land productivity (%)	250	144	200
Total factor intensity	−150	−56	−125
Labor	0	11	25
Power	−25	11	13
Chemicals	−100	−67	−125
Seed	−25	−11	−13

input levels between the informally-contracted lands and PA lands were positive, whereas differences in land productivity were negative thus resulting in a negative change in TFP levels for all lands under informal contracts. Chemical inputs (fertilizers and herbicides) were the major contributor to higher levels of inputs for all the informal contracts, whereas the contribution of animal power, human and seed remain roughly the same. The increase in the level of chemicals was inversely proportional to the degree of land tenure security as defined above. The more insecure the land, the more farmers applied chemical inputs. The largest increase (10%) was for borrowed lands.

The high input intensities, combined with low land productivity ratios and thus low TFP, indicate that the capacity of rented, shared and borrowed lands to produce more output is not hampered by under-investment in variable inputs due to land insecurity. Rather than applying less input, as theory would suggest, farmers on informally-contracted fields applied more inputs, in particular, more chemical fertilizers.

There are several reasons for this high input/low output combination on informally-contracted fields. First, informally-contracted fields may have poor soil quality. Although data on the physical description of these fields failed to show a significant difference in slope or erosion on the informally-contracted fields, there was some evidence of differences in soil type. Borrowed fields in particular were less likely to be found on the rich black soils that characterize much of the Ethiopian Highlands. (More precise assessments of soil quality were not done). Furthermore, borrowers almost always receive their land from their fathers who share a piece of their limited PA-allocated holdings. Dependent on their father's generosity for this free land, borrowers are thus stuck with what they are given, as compared with renters and sharecroppers who have somewhat more bargaining power to search for better land. Many reported not finding land until well into the plowing season. To the extent that landholders may continually contract out the same plot year after year (to different farmers), the inherent quality of those plots may be low. It is thus possible that the quality of all informally-contracted fields, and especially borrowed fields, is lower than PA fields.

Second, land-importing farmers may use labor inefficiently. As young adults, borrowers usually have strong obligations to contribute labor to the family farm. Additionally, they tend not to own the oxen needed to plow their borrowed fields. Although they use the same amount of total human and animal days per hectare as PA farmers, they do so by relying on labor and oxen exchanges, after tending to family fields. This would imply that borrowers were not planting and harvesting at the optimal time. Thus, it appears likely that the TFP efficiency gap is due to youth, poor soil quality and timing rather than tenure insecurity.

6. Conclusions

The reform of land policies in Sub-Saharan Africa has received much attention in recent years. Many authors believe that farm lands held under indigenous or informal land contracts in sub-Saharan Africa are less productive than those held under title or individualized land rights (e.g., owner cultivation). Others argue that the indigenous tenure arrangements have little bearing on crop productivity because they are dynamic and evolve in response to changes in land values. This debate will continue so long as there is insufficient empirical evidence to support the arguments. Using plot-level data and the concept of inter-spatial total factor productivity, this analysis determined the relative production efficiency of four alternative land tenure arrangements prevailing in one region of Ethiopia. Lands allocated by the government are the most secure because farmers have relatively greater duration and a greater range of rights on them compared to the informal tenure arrangements. There are no privately owned lands in Ethiopia to use as a standard, thus we focused on lands formally allocated by the government (PA-allocated lands), as well as those informally exchanged between farmers (rented, shared and borrowed lands).

The results of our study show that although the production efficiency of farming differs by tenure contract, the differences were relatively small and not attributable to the use of fewer variable inputs as a result of insecurity. Informally-contracted lands were relatively less productive than the PA-allocated lands. Borrowed lands were the least efficient, followed by shared and rented lands. With a TFP level of 0.84, borrowed lands were the least productive. These were followed by shared lands (0.87) and rented lands (0.90). As shown in the conceptual framework (Section 2), TFP is a function of both land productivity and factor intensities. The land productivity levels for informally-contracted lands were lower than unity, but the factor intensity levels were greater than unity, indicating that overall lower levels of TFP were due to increases in quantities of factor inputs without a corresponding increase in land productivity (Table 4). Further decomposition of the factor intensity levels identified chemical inputs as the major source of differences. Because of the relatively high use of chemical inputs on less insecure fields, we suggest that other more important factors contribute to the low productivity levels of farming operations than tenure, such as soil quality, farmer endowments and farmer experience. In other words, productivity determines tenure than vice versa. Thus there seems to be little evidence to say that changing tenure arrangements per se will change productivity, unless it can also change soil quality and farmer experience.

Although this study uses a different methodology than appears in most analyses of agricultural productivity and property rights, it supports the conclusions of those who argue that land tenure does not constrain productivity at the current level of development in Sub-Saharan Africa. The results of our study suggest that the government should assess farmers, demand for formalization of informal land tenure contracts.

Acknowledgements

The authors thank Charles F. Nicholson, Mohammad Jabbar, and two anonymous referees for very helpful comments and suggestions. Nega Gebreselassie and Amare Teklu assisted in editing the manuscript.

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