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Communal Land and Agricultural Productivity ☆

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Abstract

Communal land tenure is prevalent across many developing countries. It implements a "use it or lose it" principle that allows owners to farm their land but restricts their right to transfer it away. This paper measures the distortionary impact of communal land in a dynamic general equilibrium model of occupational selection, calibrated to Ethiopia. We find that lifting communal land tenure increases GDP by 9% and lowers agricultural employment by 18 percentage points. While agricultural productivity increases, that of non-agriculture drops. Communal land tenure helps rationalizing about one-half of the relative agricultural productivity gap in the poorest economies. Its impact on aggregate productivity, though, is comparatively minor.

Keywords: Agricultural productivity, Growth and development, Misallocation, Land, Africa, Ethiopia.

JEL: O10, O13, O40, O55, Q15.

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1. Introduction

The labor productivity gap between rich and poor countries is larger in the agricultural sector than in the rest of the economy (Caselli, 2005; Restuccia et al., 2008). Are there particular policies or institutions in developing countries that depress relative agricultural productivity? If yes, do they also entail large losses in *aggregate* productivity? The aim of this paper is to evaluate one such institution, the communal land tenure system. It is prevalent across the developing world and most notably in Sub-Saharan Africa, the focus of our analysis. As we will elaborate further below, the term "communal" is a catch-all for many characteristics. A defining one is that land property rights are not complete because the allocative control is vested in either the community or the state. More precisely, land user rights are subject to *limited transferability*. Individuals cannot freely sell and/or rent out their land. If they do, they risk expropriation, following a "use it or lose it" principle.

We analyze this particular land tenure system in a general equilibrium selection model where individuals make an occupational choice between agriculture and non-agriculture. In agriculture, they run their own farm and choose the scale of their land operations. Individuals hold user rights over communal land that are renewed every period unless expropriation occurs. The sale of communal land is prohibited, while rentals are allowed, but risky. Specifically, the risk of expropriation rises in the fraction of the land that is rented out: individuals who do not rent out their land face no expropriation risk while individuals who rent out all of their land (i.e., those who work in non-agriculture) face the highest risk. Finally, expropriated land is reallocated to farmers only and follows a probabilistic rule that favors those who are land-poor.

Our main contribution is to measure the impact on the aggregate economy of a reform that removes communal land tenure. The model is calibrated to Ethiopia, an ideal benchmark economy because typical features of communal land tenure are codified in law.[3] The key result is then the comparison of the calibrated economy to

[3]This formalization allows for a clean mapping from the data to the model. In particular, we exploit

a counterfactual one where communal land is no longer subject to expropriation and reallocation.

Such a reform generates an aggregate productivity (GDP) increase of 9%. This is driven mostly by a rise in non-agricultural output of 16% while agricultural output remains almost flat, up by 3%. Communal land tenure therefore has a non-negligible negative impact on GDP, but that effect is an order of magnitude away from explaining the wealth of nations. The reform also induces a sizable decrease in agricultural employment of 18 percentage points, or 25%. While real agricultural labor productivity rises substantially, by 37%, the reform also generates a large fall in real non-agricultural labor productivity of 29%. It follows that the ratio of real productivity in non-agriculture relative to agriculture drops by 49%. To put this number in context, that productivity ratio – henceforth referred to as the real agricultural productivity gap (real AGP) – is roughly 7.9 times higher in the poorest relative to the richest decile of countries.[4] We find that communal land tenure helps explaining this enormous factor difference. Thinking of Ethiopia as a representative economy of the poorest decile of countries, the elimination of land transfer restrictions halves the real APG vis-à-vis the richest countries to $7.9 \times (1 - 0.49) = 4$.

The reform removes two types of misallocation. The first one is that of occupational choice. Under communal tenure, many individuals with a comparative advantage in non-agriculture decide to work as farmers in order to mitigate the risk of losing their accumulated communal land and, to a lesser extent, because they expect to receive additional land grants in the future. Our key message is that these occupationally constrained farmers are typically endowed with low skills in *both* agricultural and non-agricultural activities. The intuition is as follows. Comparative advantage in non-agriculture is a relative concept that is traded off against the expected discounted flow

the fact that all land in Ethiopia has limits on transferability, that any land sales are prohibited, and that land ownership is tied to continuous nearby residence.

[4]That number is based on our estimates using data around 2005. See Appendix A for details. Caselli (2005) and Restuccia et al. (2008) estimate it to be roughly a factor of 10 around the year 1985. In any case, the real APG in poor countries is large, which is also confirmed by Gollin et al. (2014a) who focus on the most important staple crops.

value of holding communal land. High-skilled individuals will cherish the comparative skill advantage more and locate in non-agriculture. Low-skilled individuals, on the other hand, may find that their comparative advantage does not outweigh the asset value of the communal land holdings.

Securing complete property right will thus lead to large shift of disproportionately unskilled workers from agriculture into non-agriculture. The change in the skill composition generates a drop in non-agricultural productivity. Conversely, the occupational shift also accounts for roughly 80% of the increase in agricultural productivity. This works through two channels. The main one is the composition effect as the average skill of the remaining farmers rises. The other channel is the mechanical negative relationship between the total number of farmers and agricultural labor productivity due to the fixed supply of land.

The other type of misallocation pertains to the scale of operation across farmers. Under communal tenure, distortions arise because relatively land-rich farmers restrict the amount of land that they rent out to shield themselves from the risk of expropriation. As a result, relatively high-skilled and land-poor farmers face high rental rates and thus operate relatively little land. Removing this misallocation accounts for roughly one-fifth of the agricultural productivity increase.

Since occupational misallocation is the key driving force, the aggregate productivity gain from fully securing communal land rights is muted. The productivity gains in one sector are, to a large extent, offset by productivity losses in non-agriculture.

Section 2 positions our contribution within the literature. Section 3 describes the institutional characteristics of communal land. Section 4 lays out the model. Section 5 characterizes the equilibrium. In Section 6 we discuss the calibration of the model. Section 7 presents the main findings and counterfactuals. Section 8 concludes.

2. Literature

This paper connects with several strands of the literature. The first is the classic dual-economy literature that stipulates *occupational barriers* that keep inefficiently many workers in the agricultural sector and prevent the equalization of the two sectors' marginal products (Lewis, 1954; Harris and Todaro, 1970). Communal land tenure acts precisely as such a barrier: holding everything else constant, individuals prefer working in agriculture to secure and accumulate communal land. The upshot is that the relative nominal value-added per worker in agriculture is depressed.[5] We find that a land reform that allows communal land to be transferred freely would lead to a decrease in the *nominal* productivity in non-agriculture relative to agriculture of 53%. Communal land thus rationalizes much of the nominal APG (i.e., the real APG adjusted for the relative sectoral price), which is roughly 3.5 times higher in the poorest compared to the richest decile of countries.[6]

Second, we connect with a recent literature that finds that in developing countries, the relative skill and work intensity of agricultural workers is low. This implies that relatively low agricultural wages (and by extension also relatively low real and nominal agricultural productivity) simply reflect selection. Gollin et al. (2014b) find that adjustments to observable hours worked and human capital reduce the cross-country APG factor difference by up to a half.[7] Lagakos and Waugh (2013) rationalize such a pattern as an efficient outcome. In their sorting model the skill distribution implies that high agricultural employment is accompanied by a fall in the average skill of agricultural workers relative to that of non-agricultural workers.[8] This mechanism is also present in our framework, though part of the selection is inefficient. Communal land tenure acts an occupational barrier for all workers, but in particular the unskilled ones.

This paper follows in the footsteps of a growing macro development literature that

[5]See Vollrath (2009) and McMillan and Rodrik (2011) regarding possible GDP gains from equalizing sectoral value-added.

[6]See Appendix A for the computation of this factor.

[7]Also, longitudinal data on Brazil (Alvarez, 2018) as well as Indonesia and Kenya (Hicks et al., 2017) reveal that workers switching from non-agriculture to non-agriculture typically experience small wage gains, which is not consistent with large occupational barriers.

[8]Similarly, Young (2013) finds that much of the urban-rural gap in real consumption across countries can be explained by differences in unobserved sector-specific skills. According to Herrendorf and Schoellman (2018) the wage gap in agriculture relative to non-agriculture in several developing countries (excluding Sub-Saharan Africa) is in fact explained away by observable years of education once cross-sectoral differences in returns to human capital are taken into account.

explains the APG in developing countries as a consequence of distortions to land allocation.[9] Adamopoulos and Restuccia (2014) are among the first to study misallocation in agriculture through the lens of a model where farmer-operators are heterogeneous in skills. They find that matching typical features of the farm size distribution in developing countries - a low mean and low dispersion in farm size - via generic wedges can account for an important fraction of the real APG. Restuccia and Santaeulàlia-Llopis (2017), Adamopoulos et al. (2017) and Chen et al. (2017) go a step further by using micro data to back out farm-specific TFP as well as wedges in Malawi, China and Ethiopia, respectively. In all cases, the authors compute huge gains in aggregate agricultural productivity from removing wedges in order to shift land from skilled to unskilled farmers.[10] In addition, Adamopoulos et al. (2017) also find that misallocation of land within agriculture generates misallocation of workers across sectors. Note that in all three countries some of the underlying distortions are likely to be caused by restrictions that limit transferability of land across users. Chen et al. (2017) also show that the misallocation of land is lower in Ethiopian regions with more rental activity.

Relative to the above contributions, our paper provides a micro foundation based on an explicit policy that explains such distortions. The most related paper is Chen (2017) who uses a similar modeling framework to investigate the impact of non-transferable land on the misallocation of land across farmers, and workers across sectors. His quantification on Malawian data yields similar qualitative predictions to ours on most variables of interest, though quantitatively we find that communal land has a somewhat weaker impact on agricultural employment and GDP. Our paper differs in two aspects. The first is that we set up a dynamic environment in which individuals make forward-looking decisions. The stationary distribution that maps communal holdings to individual skills hence arises endogenously. The second aspect in which this pa-

[9]The APG has also been addressed by distortions encouraging home work in the rural sector (Gollin et al., 2004), distortions to intermediate input use in agriculture (Restuccia et al., 2008), transportation costs (Gollin and Rogerson, 2014), incomplete financial markets (Donovan, 2016).

[10]Gollin and Udry (2017) also find gains from reallocation of land across farmers in Ghana and Uganda but caution that these gains are substantially smaller after correcting for potential measurement error.

per differs relative to the baseline results presented in Chen (2017) is that farmers in our setup can rent out their communal land, albeit at the risk of expropriation. This implies that there is relatively less operational misallocation.[11]

Another contribution that focuses on a specific policy is Adamopoulos and Restuccia (2015). They provide a detailed case study of misallocation due to a sudden land reform and farm size caps in the Philippines. They precisely quantify a one-off event, but their underlying institutional arrangement is very distinct. We study a process of continuous land reallocation where agents take actions to fend off the threat of expropriation. Also, the policy analyzed in Adamopoulos and Restuccia (2015) directly constrains high-skilled farmers, while in our setting high-skilled farmers are affected by the policy only through the high equilibrium rental rate of land. Our results are hence very complementary to theirs.

We also touch base with the microeconomic literature on tenure insecurity and agricultural productivity. A limited number of these papers focus on misallocation across users. The contributions in Holden et al. (2009), for example, provide evidence that land security boosts allocative gains in several Sub-Saharan African countries. In the Ethiopian context de Brauw and Mueller (2012) find that perceptions of land tenure security foster increased rural-urban migration. A study on the Dominican Republic by Macours et al. (2010) finds that insecure land rights prompt owners to limit land rentals to close kin only, thus preventing allocation to more efficient users. In the case of Mexico, de Janvry et al. (2015) document that formal land titling enabled a market-based reallocation (through sales and rentals) to more productive land-poor from less productive land-rich farmers, and a stronger outmigration of the latter. These papers measure misallocation in a partial equilibrium setting while our paper stresses equilibrium adjustments, which turn out to be crucial. Specifically, we find that communal land tenure substantially increases the rental rate of land. This is because it induces a larger number of farmers and because these farmer run excessive land operations, thus

[11] We allow for land rental market activity, in accordance with recent evidence from Sub-Saharan Africa (Holden et al., 2009).

stifling the rental market.

One aspect that we abstract from are productive investment incentives in the face of tenure insecurity. This is beyond the scope of the present paper, but we do note that our framework is well-suited for such an extension. Suffice it to say that the empirical literature on the effect of increasing tenure security on investment in Sub-Saharan Africa has been very active, identifying several pathways. First, investment can increase as the likelihood of recouping its returns is higher, as shown by Besley (1995) and Goldstein and Udry (2008) in studies on Ghana, by Ali et al. (2011) in Ethiopia, and by Fenske (2011) in several countries in West Africa. Second, land investment may also decrease as individuals with weak titles feel more compelled to secure their user rights via intensive outlays - see for instance Place and Otsuka (2002) and Deininger and Jin (2006). Third, securing land rights may raise collateral to be used for credit and investment (Feder, 1985), though there is little evidence of such a channel in Africa (Brasselle et al., 2002).

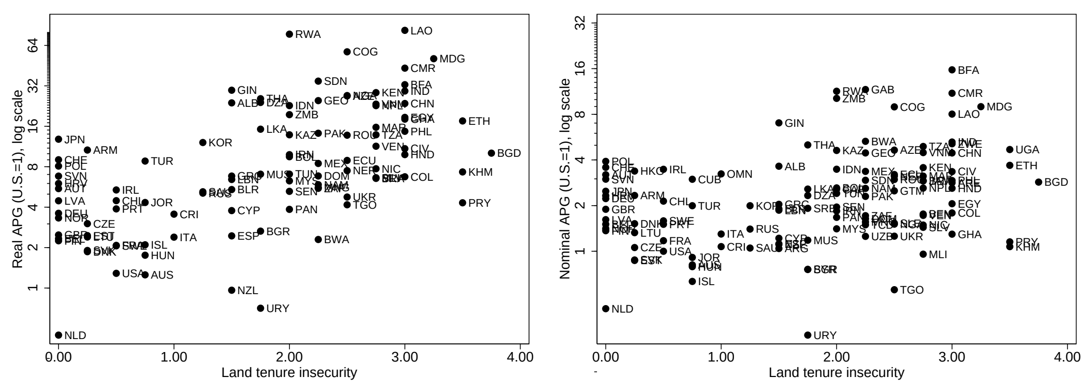
3. Institutional environment

3.1. Communal land across countries

Communal land tenure systems are present in many developing countries, in particular in Sub-Saharan Africa. There, land tenure is often prescribed by customary law that varies across as well as within countries (Pande and Udry, 2005). Its features, however, can be summed up by the principle of "use it or lose it" whereby *rights to land can be claimed only through the use of land, and only for the duration of that use* (Sjaastad and Bromley, 1997).[12] This principle restricts the commercialisation of land, whether that be through sales or rentals. Land sales require the consent of extended family members, clan leaders, or chiefs; they may block them on the notion that one cannot sell something that one had been granted by the community (Atwood, 1990;

[12]Some communal land tenure systems also feature collective ownership, for example with regards to pastures. The resulting classical incentive problems are not addressed here as our framework focuses on exclusive user rights.

Bruce and Migot-Adholla, 1994). Also, farmers are reluctant to rent out their land to tenants who, by virtue of working it, can stake a claim to ownership.[13] Such a threat is particularly likely for landlords who migrate; owners in effect invest "guard labor" to prevent expropriation (Field, 2007). If expropriated, the user rights to the land are tacitly or explicitly reallocated by local authorities. One particular concern in the reallocation process is to prevent the emergence of a large landless class of farmers. This is reflected in the comparatively low inequality in land ownership in most Sub-Saharan African countries (Place, 2009). In some countries, all land belongs to the state and the principles of customary land tenure apply formally (e.g. in Ethiopia and Tanzania). Beyond Sub-Saharan Africa, formal or informal rules can be found across other parts of the world, prominent examples being the *ejidos* in Mexico (de Janvry et al., 2015) or public land in China (Jacoby et al., 2002; Deininger and Jin, 2009) and Vietnam (Do and Iyer, 2008).



(a) Real (b) Nominal

Figure 1: Relative agricultural productivity and land tenure insecurity.

Measuring the extent of limited land transferability is not straightforward. As it is enforced via expropriation, one proxy is tenure insecurity. Figure 1 shows the cross-country relationship between a tenure insecurity index and productivity in non-

[13] Bomuhangi et al. (2011) show that land rentals are especially risky for disadvantaged owners such as women.

agriculture relative to agriculture (both real and nominal).[14] The statistically significant correlation suggests that countries with higher tenure insecurity feature a larger APG, both in real and nominal terms, which serves as a motivation for our analysis.[15]

3.2. Land tenure in Ethiopia

Our quantification is based on Ethiopia, an ideal benchmark economy for our purposes. It is a large country that is representative of the poorer economies of Sub-Saharan Africa.[16] With respect to measurement, customary law poses the difficulty of being informal as well as diverse across areas and ethnicities within the same country. Ethiopia's communal land tenure regime, by contrast, is codified in law. While some details of the legal architecture vary across federal regions, its main features are identical. These properties facilitate the mapping from the model to the data.

Up until 1975 Ethiopia's land tenure system had feudal characteristics. The majority of land was granted by the emperor to absentee landlords and worked by tenant sharecroppers (Rahmato, 1984). Following the socialist revolution, farms were nationalized and collectivized. After the departure of the Derg regime in 1991, farms were de-collectivized and households were granted permanent use rights. Renting land and hiring of labor were legalized again, and major land redistributions stopped, except in Amhara where one last large scale land redistribution occurred in 1997 (Benin and Pender, 2009). The fundamental principles governing land tenure have remained intact since 1991, codified in the 1997 Constitution.

The existing legal framework has three *de jure* prescriptions regarding land transfer-

[14]The land tenure insecurity index is computed by CEPII and is a composite measure of several factors. See Appendix A for details on the index and the regression.

[15]The tenure insecurity index, besides accounting for land expropriation, also accounts for formal land titling. In Sub-Saharan Africa only about 10 percent of agricultural land is registered (Byamugisha, 2013). The absence of official titles, however, does not necessarily imply low transferability, nor does their presence guarantee free transactions. This is well documented for tenure regimes in Côte d'Ivoire and Ghana by Pande and Udry (2005).

[16]According to World Bank data for 2012, Ethiopia's GDP per capita in PPP is 1,256 USD, its agricultural employment share is 73%, and it disposes of 0.16 hectares of arable land per capita. The corresponding figures for the average of Sub-Saharan Africa are 3,241 USD, 57%, and 0.22 hectares per capita. Also, relative to U.S., Ethiopia's real and nominal APG is 14.3 and 3.7, respectively. The unweighted country average for Sub-Saharan Africa is 8.3 and 2.6, respectively.

ability that guide our modeling choice. First, according to the *Constitution of Ethiopia* "Land is a common property of the Nations, Nationalities and Peoples of Ethiopia and shall not be subject to sale or to other means of exchange." This declares all attempts of land sales and mortgages as illegal, and circumscribes land rental activities. Second, the *Regional Land Proclamations (2007)* set limits on the duration and amount of land that can be rented out. Under "traditional technology" these vary between three years everywhere except for Amhara where it is twenty-five years, and between 50% of land holdings in Oromia and Tigray to 100% in Amhara and in Southern Nations, Nationalities, and Peoples' Region. Third, the *Federal Land Proclamation (2005)* defines an additional restriction on land transferability: land can be leased, but only without causing displacement, i.e. migration (Deininger et al., 2008).

The legal framework of land expropriation coincides with the *de facto* perceptions of the law by households. The Ethiopian Rural Household Survey (ERHS), a panel dataset of six rounds collected between 1994 and 2004, contains questions on the perception of different dimensions of land rights. Based on that dataset, Deininger and Jin (2006) and Dercon and Krishnan (2010) show that expropriation threatens those that do not make continuous and productive use of their land. In particular, Dercon and Krishnan (2010) show that the perceived tenure security is weaker on rented as opposed to non-rented plots. This evidence strengthens the argument that communal land expropriation is more likely to occur on land that is not operated by its owner. Moreover, Deininger et al. (2003) estimate that the household's expectation of losing land, controlling for regional variation, increases by 10 percent if the household head has an off-farm employment. This shows that continued enjoyment of land user rights is contingent on physical residence in the village (Rahmato, 2003).

The Ethiopian legal framework further prescribes how land user rights are acquired. The Constitution of Ethiopia states that "Ethiopian peasants have right to obtain land without payment." Also, one of the guiding principles of the *Poverty Reduction Strategy Paper* issued by the Federal Government is to grant access to land to every individual who wants to make a livelihood from farming (Rahmato, 2004). In contrast to this *de jure* evidence, there is relatively little research on *de facto* outcomes. Based on the ERHS dataset, Deininger et al. (2003) provide evidence that land reallocations among farmers have been driven mainly by political concerns rather than economic ones.[17]

4. A model of communal land

4.1. Individuals and stand-in household

The economy is populated by a unit measure of infinitely lived individuals. In each time period, the individual's state consists of three elements: (i) his productive skill in the agricultural sector, $z_a > 0$; (ii) his productive skill in the non-agricultural sector, $z_n > 0$; and (iii) his endowment of communal land, $l_c \geq 0$. Individual skills are exogenous and drawn from a joint cumulative distribution, $\{z_a, z_n\} \sim \Psi(z_a, z_n)$. With probability $\zeta \in [0, 1]$ the individual's skills are redrawn jointly in the following period, and otherwise remain unchanged.[18] Communal land holdings l_c, on the other hand, evolve endogenously. To simplify the exposition, let $x \equiv \{z_a, z_n, l_c\}$ denote the individual's state, defined over the Cartesian product of the three sets $Z_a \times Z_n \times L_c = \{(z_a, z_n, l_c) | z_a \in Z_a, z_n \in Z_n, l_c \in L_c\}$. Let $H(x)$ denote the associated (endogenous) cumulative distribution function.

Individuals maximize expected value $\mathbb{E} \sum_{t=0}^{\infty} \beta^t b(x_t)$ where $\beta \in (0, 1)$ is the time discount factor and period utility is linear in revenue b. In each time period an individual of type x is endowed with a unit of labor and chooses his current occupation: agriculture ($\mathbb{1}_a = 1$) or non-agriculture ($\mathbb{1}_a = 0$). The production of non-agricultural goods is linear in efficiency labor so that the non-agricultural wage simply equals $w_n(z_n) = (1 - \theta) z_n$. The parameter $\theta < 1$ represents a wedge or tax on non-agricultural labor income; its only role here is to improve the empirical fit of the model. In agriculture, by contrast, each individual runs an own farm. The farm's output, y_a, depends on the individid-

[17] Additional evidence by Ege (1997) further emphasizes the political dimensions associated with land reallocation in Ethiopia.

[18] The variation of skills through time is not an essential feature of the model. We use it for two reasons. First, it adds an additional realistic notion at no cost to tractability. Second, as will become clear further on, it rules out degenerate stationary equilibria with zero expropriation and reallocation.

ual's agricultural skill, z_a, as well as the choice of the scale of land operations, $l \geq 0$, according to the following production technology:

$$y_a(z_a, l) = z_a^{1-\gamma} l^{\gamma}.$$

The production technology is kept deliberately simple to single out the interplay between fixed farmer skills and land operations.[19] The rental rate of land r and the price of agricultural output is p. The farmer's implied labor income (or equivalently profits) equals $w_a(z_a, l) = p y_a(z_a, l) - rl$.

The individual's period revenue is

$$b(x) = \begin{cases} w_n(z_n) + rl_c = (1-\theta)z_n + rl_c & \text{if } \mathbb{1}_a = 0, \\ w_a(z_a, l) + rl_c = p z_a^{1-\gamma} l^{\gamma} + r\left(l_c - l\right) & \text{otherwise.} \end{cases}$$

Beyond labor income individuals earn rental income from communal land holdings l_c. Observe that non-agricultural workers ($\mathbb{1}_a = 0$) rent out all of their communal holdings while agricultural workers ($\mathbb{1}_a = 1$) either receive rental payments on land holdings that they do not operate ($l_c - l > 0$) or else rent in land over and above their holdings ($l_c - l \leq 0$).

4.2. Communal land

The economy's aggregate endowment of land is L. A fraction $\lambda \in [0, 1]$ of it is communal, $L_c = \lambda L$, while the rest is private, $L_p = (1-\lambda)L$. All communal land is held individually in the form of l_c, requiring $L_c = \int l_c(x) \mathrm{d}H(x)$. Within a time period, an individual has exclusive user rights over l_c, whether that be for the purpose of operation or out-rental. The sale of communal land, on the other hand, is not permitted. The key aspect of the model is the *dynamic* evolution of communal land

[19] In particular, we abstract from variable labor input. This is not a critical assumption given that the majority of agricultural hours worked across the world, both in developed and developing countries, are supplied by family members (Adamopoulos and Restuccia, 2014). High monitoring costs are typically advanced as the reason why farms rarely expand in labor.

holdings through public interventions via expropriation and reallocation.

4.2.1. Expropriation

We assume that individual expropriation is governed by an exogenous institutional policy with the following key ingredients features. Expropriation is defined as the loss of all current-period communal land holdings, l_c, at the start of the next time period. Its occurrence is stochastic and endogenous since the expropriation probability depends on an individual's current-period actions. In particular, we model the "use it or lose it" principle as follows. First, farmers face no expropriation risk tomorrow as long as they operate at least the equivalent of their communal land holding, $l \geq l_c$.[20] Second, whenever operations fall short of that level, $l < l_c$, the probability of expropriation is positive and increasing in the fraction of communal land that is rented out, $(l_c - l)/l_c$. By renting out communal land, the individual runs the risk of losing it. The higher the fraction of rented out land, the stronger is the signal that the household does not require land for productive purposes. This enhances the motivation of the land authority to seize the farmer's holdings. The expropriation probability is highest in the case of zero operations ($l = 0$), which coincides with the choice of employment in the non-agricultural sector.[21]

Formally, the function that defines the expropriation probability π_E reads as follows

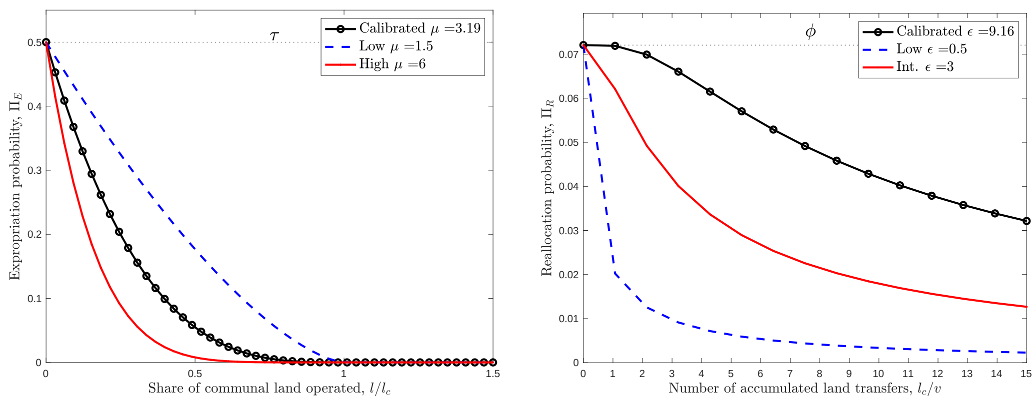
$$\pi_E(l_c, l) = \begin{cases} \tau \left(\frac{l_c - l}{l_c}\right)^{\mu} & \text{if } l_c - l > 0, \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

The parameter $\tau \in [0, 1]$ represents the highest possible expropriation probability, which applies when $l = 0$. The parameter $\mu \geq 0$ governs the curvature of the function

[20] Agents are assumed to operate their own holding l_c before renting in any additional land.

[21] We take a short-cut by assuming that non-operated land is invariably rented out. Strictly speaking, the expropriation probability is thought to increase in non-operated land so that renting it out rather than leaving it idle is always a dominant strategy. In Sub-Saharan Africa it is common practice for migrating farmers to leave their land for free in the hands of extended family members. In the context of our model, this is akin to expropriation as no rental payments are received.

with regard to the fraction of rented out land. The expropriation probability is thus decreasing and convex in l/l_c, as illustrated in the left panel of Figure 2. The parameter μ spans various scenarios. When $\mu = 1$ the expropriation probability is linear in the fraction of rented-out land. On the opposite end of the spectrum, when $\mu \to \infty$ the probability tends to zero as long as the individual's operations are strictly positive, $l > 0$. In that case, farmers are completely shielded from expropriation, and the risk only applies to those leaving the agricultural sector.



(a) Expropriation probability

(b) Reallocation probability

Figure 2: Illustration of expropriation and reallocation functions

4.2.2. Reallocation

Expropriated communal land is reallocated to farmers via a lump-sum transfer v. A farmer can receive one such transfer per period where v is endogenous to ensure that the total of reallocated land equals the amount of expropriated land. Also, reallocation is stochastic, which is a suitable assumption: some individuals receive a better ex-post treatment by the local authorities than others. Finally, the probability of receiving a transfer in the upcoming period is endogenous in the individual's current-period action and state. First, we assume that only current-period farmers are entitled to the transfer. Second, we assume that reallocation is progressive: the probability of an additional communal land transfer depends negatively on the amount of current communal land holdings l_c.

Formally, the function that defines the reallocation probability π_R is defined as

$$\pi_R(l_c, \mathbb{1}_a) = \begin{cases} \phi \left[1 - \left(\frac{l_c/v}{1+l_c/v}\right)^{\epsilon}\right] & \text{if } \mathbb{1}_a = 1; \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

The parameter $\phi \in (0, 1]$ represents the highest possible probability of transfer receipt, which applies to landless farmers ($l_c = 0$). The degree of progressivity of the function, meanwhile, is governed by $\epsilon > 0$, as illustrated in the right panel of Figure 2. The lower is ϵ, the lower is the likelihood of an additional transfer for any given strictly positive level of $l_c > 0$. At $\epsilon \to 0$ only landless farmers can expect a transfer with probability ϕ while farmers with $l_c > 0$ receive no additional land. Conversely, as $\epsilon \to \infty$ the transfer probability equals ϕ for everyone and becomes independent of current holdings.[22]

4.3. Recursive formulation

The individual's value function in recursive form is given by:

$$\begin{aligned} V(z_a, z_n, l_c) = \max_{\mathbb{1}_a, l} \Big\{ & \mathbb{1}_a \left(p z_a^{1-\gamma} l^{\gamma} - rl\right) + (1 - \mathbb{1}_a)(1 - \theta) z_n + r l_c \\ & + \beta \Big([1 - \pi_E(l_c, l)] \pi_R(l_c, \mathbb{1}_a) \mathbb{E}_{z'|z} V(z'_a, z'_n, l_c + v) \\ & + [1 - \pi_E(l_c, l)][1 - \pi_R(l_c, \mathbb{1}_a)] \mathbb{E}_{z'|z} V(z'_a, z'_n, l_c) \\ & + \pi_E(l_c, l) \pi_R(l_c, \mathbb{1}_a) \mathbb{E}_{z'|z} V(z'_a, z'_n, v) \\ & + \pi_E(l_c, l)[1 - \pi_R(l_c, \mathbb{1}_a)] \mathbb{E}_{z'|z} V(z'_a, z'_n, 0) \Big) \Big\} \end{aligned} \tag{3}$$

where $\mathbb{E}_{z'|z} V(z'_a, z'_n, l'_c) = (1 - \zeta) V(z_a, z_n, l'_c) + \zeta \int V(z'_a, z'_n, l'_c) \mathrm{d}\Psi(z'_a, z'_n)$.

4.4. Consumption and market clearing

Consumption decisions occur at the level of the aggregate economy by means of a stand-in household. The household has non-homothetic preferences over the consump-

[22] In the stationary equilibrium, the lump-sum transfer is identical across periods. Equilibrium holdings of communal land can then be expressed on a discrete grid $l_c = nv$, where $n \in \mathbb{N}$ is the individual's history of the number of accumulated transfers uninterrupted by expropriation.

tion of agricultural (Y_a) and non-agricultural goods (Y_n),

$$U(Y_a, Y_n) = \eta \log(Y_a - \overline{a}) + (1-\eta)\log Y_n$$

with $\eta \in (0,1)$ and the subsistence requirement $\overline{a} > 0$. The stand-in household's budget is given by

$$pY_a + Y_n = \int b(x)\mathrm{d}H(x) + rL_p + \theta Y_n.$$

The household collects individual revenue b, income from renting out private land L_p at the rate r as well as collects the tax non-agricultural output. The price of agricultural goods is p while that of non-agricultural goods is normalized to unity. The resulting optimality condition $\eta/(Y_a - \overline{a}) = p(1-\eta)/Y_n$ is the standard driving force of structural transformation.[23]

The agricultural and non-agricultural goods market clear as follows:

$$Y_a = \int y_a(x)\mathrm{d}H(x) \tag{4}$$

and

$$Y_n = \int [1 - \mathbb{1}_a(x)]z_n(x)\mathrm{d}H(x). \tag{5}$$

The land market clears according to

$$\int l(x)\mathrm{d}H(x) = L. \tag{6}$$

Finally, the amount of reallocated must be consistent with the amount that is expropriated so that

$$\int l_c(x)\mathrm{d}H(x) = \lambda L. \tag{7}$$

[23] If the utility function applied directly to individuals, its curvature would imply a consumption-smoothing motive for individuals facing variations in skills. We would like to abstract from such concerns here, which is why individual utility is assumed to be linear. The trade-off between agricultural and non-agricultural goods, on the other hand, is preserved by the use of the stand-in household. Our framework, however, is not suited to analyze individual welfare.

5. Characterization of the equilibrium

From now on we focus on stationary equilibria as defined in Appendix B. Note that besides the stationary distribution H, there are three equilibrium objects: p, r and v.

5.1. Equilibrium without expropriation and reallocation

First, consider individual choices in absence of expropriation risk, $\tau = 0$. In this case, communal land is analogous to private land; since it is not expropriated, $\pi_E = 0$, it is also not reallocated, $v = 0$ and $\pi_R = 0$. Observe from the value function (3) that occupational and land operation choices, then, only maximize current income.[24] Farmers equalize the marginal revenue of land operations to the rental rate,

$$l^\star(z_a; p, r) = \left(\frac{\gamma p}{r}\right)^{\frac{1}{1-\gamma}} z_a, \tag{8}$$

which gives the following profit or implied agricultural wage income:

$$w_a^\star(z_a; p, r) = \frac{1-\gamma}{\gamma} \left(\frac{\gamma p}{r}\right)^{\frac{1}{1-\gamma}} r z_a. \tag{9}$$

It is convenient to define two thresholds in the space of z_a. The first one, $T^\star$, is the threshold at which farming is an optimal choice ($\mathbb{1}_a = 1$), namely if and only if $w_a^\star(z_a; p, r) \geq (1-\theta) z_n$. Using equation (9) this condition is

$$z_a \geq \frac{\gamma(1-\theta)}{1-\gamma} \left(\frac{r}{\gamma p}\right)^{\frac{1}{1-\gamma}} \frac{z_n}{r} \equiv T^\star(z_n; p, r). \tag{10}$$

The second threshold of interest, $K^\star$, is that at which farmers' operations weakly exceed their communal land holdings, $l^\star(z_a; p, r) \geq l_c$. Using equation (8) this condition is

$$z_a \geq \left(\frac{r}{\gamma p}\right)^{\frac{1}{1-\gamma}} l_c \equiv K^\star(l_c; p, r). \tag{11}$$

[24] In particular, the rental market in this case allocates land efficiently. The economy's only source of inefficiency is the standard occupational wedge, $\theta \neq 0$.

Thus, in the absence of land expropriation and reallocation, individuals become farmers if and only if $z_a \geq T^\star(z_n; p, r)$. Moreover, conditional on farming, they operate more than their holdings by *renting in* additional land if and only if $z_a > K^\star(l_c; p, r)$. Conversely, farmers strictly *rent out* some of their communal land holdings if and only if $z_a < K^\star(l_c; p, r)$.

5.2. Equilibrium with expropriation and reallocation

Consider now an economy that features expropriation risk, $\tau > 0$, and therefore also reallocation of communal land, $v \geq 0$. Observe from the value function (3) that individuals' choices are now intertemporal as they affect expected future communal land holdings. Our analysis distinguishes farmers based on whether their choices of occupation and the size of operations is distorted by the communal land tenure system.

Proposition 1. *There exists a threshold $\overline{T}(z_n, l_c; p, r, v)$ such that individuals with agricultural skill $z_a \geq \overline{T}(z_n, l_c; p, r, v)$ choose the agricultural occupation. Moreover, the threshold is such that $\overline{T}(z_n, l_c; p, r, v) < T^\star(z_n; p, r)$.*

Proof. See Appendix B. □

Under communal land tenure system there exist farmers such that $\overline{T}(z_n, l_c; p, r, v) < z_a \leq T^\star(z_n; p, r)$ as defined in Proposition 1. We define these individuals as *occupationally* constrained: they choose farming despite the fact that they can achieve a higher current income by working in non-agriculture. As such, they are *relatively unskilled* farmers because their comparative advantage lies in non-agriculture. Their choice to work in farming is motivated by two factors. First, the risk of expropriation: the higher is the agent's communal holding, l_c, the more he risks losing by choosing non-agriculture. The second motivation is the promise of an additional land transfer v tomorrow. The higher is the transfer probability π_R, the more profitable is the agricultural activity. In contrast, farmers of type $z_a \geq T^\star(z_n; p, r)$ are *relatively skilled* because for them, agricultural employment dominates even in absence of communal land considerations.

Proposition 2. *Farmers of type $z_a \geq K^\star(l_c; p, r)$ choose non-distorted land operations $l = l^\star(z_a; p, r)$. Conversely, farmers of type $z_a < K^\star(l_c; p, r)$ choose land operations such that $l \in (l^\star(z_a; p, r), l_c)$.*

Proof. See Appendix B. □

Farmers of type $z_a \geq K^\star(l_c; p, r)$ are *relatively land-poor* because the threshold $K^\star$ in equation (11) is increasing in l_c. Their choice of land operations does not affect their continuation value: they do not fear expropriation as they do not rent out land, and the probability of receiving land transfers is independent of operations l. Conversely, farmers of type $z_a < K^\star(l_c; p, r)$ are *relatively land-rich* as they rent out land. Doing so, however, raises the specter of expropriation. To protect themselves against such an outcome, they rent out strictly less land than dictated by marginal productivity and hence operate inefficiently large farms. We define these farmers as *operationally* constrained because their scale of operation is larger than that which maximizes current income, $l > l^\star(z_a; p, r)$.

	$z_a \geq K^\star(l_c; p, r)$	$z_a < K^\star(l_c; p, r)$
$z_a \geq T^\star(z_n; p, r)$	Farmer type (A) Occupation: unconstrained Operation: unconstrained $l = l^\star(z_a; p, r) \geq l_c$	Farmer type (B) Occupation: unconstrained Operation: constrained $l \in (l^\star(z_a; p, r), l_c)$
$\overline{T}(z_n, l_c; p, r, v) \leq z_a < T^\star(z_n; p, r)$	Farmer type (C) Occupation: constrained Operation: unconstrained $l = l^\star(z_a; p, r) \geq l_c$	Farmer type (D) Occupation: constrained Operation: constrained $l \in (l^\star(z_a; p, r), l_c)$

Table 1: Characterization of farmer types.

Table 1 summarizes the resulting four types of farmers, A-D. In particular, it clarifies the impact of the communal land tenure system in a partial equilibrium setting. At given prices p and r, the policy unambiguously bolsters the demand for land, both by encouraging relatively skilled farmers to run relatively large operations (type B) and by encouraging unskilled farmers to farm at all (types C and D). These channels, moreover, stimulate the supply of agricultural output, Y_a, while dampening that of non-agricultural goods, Y_n. The general equilibrium impact, however, is more involved because market clearing implies upward pressure on the rental rate, r, and downward pressure on the price of agricultural output, p. Such price distortions create countervailing forces that lower the demand for land while discouraging (encouraging) the supply of agricultural (non-agricultural) output. The relative strength of these forces depends crucially on the stationary distribution $H(x)$ that maps the relative mass of skills z_a and z_n to the amount of communal holdings l_c.

6. Calibration

We calibrate the model to Ethiopia around the year 2012. As discussed in subsection 3.2, the land tenure system in Ethiopia lends itself well to mapping the model to data. First, Ethiopia has explicit laws that are captured by our expropriation and reallocation functions. Second, the tenure regime has remained stable for about three decades prior to 2012, which implies a time frame that is sufficiently long to compare empirical outcomes to a stationary distribution. Third, because land sales are forbidden, the current land distribution can be rationalized as a result of the proposed policies. Fourth, since all land is communal, we do not need to worry about any potential co-variation between the distributions of communal and private land.

Before proceeding, we would like to clarify that the quantification is relevant for all poor economies where the spirit of the "use it lose it" principle underlies land tenure. While in Ethiopia the expropriation and reallocation of land are guided by explicit policies, in many other Sub-Saharan African economies such rules are implicit under customary tenure and enforced by local leaders or elders. "Expropriation" therefore need not be a unilateral act by a central authority. It can just as well be understood as a cultural norm by which individuals who are perceived to require less land (e.g. the young who migrate to cities or the elderly farmers detaining large holdings) are obliged to share it with others. The crucial element is that individuals cannot easily transfer away land for economic gain.

6.1. Set parameters

Since all land in Ethiopia is communal we set $\lambda = 1$. Based on the legal provisions outlined in subsection 3.2, we posit that the entire land holding can be rented out following migration, but that expropriation kicks in on average after two years. This strikes a balance between the principle that non-farmers cannot rent out land at all, and the fact that in practice land rentals are not immediately detected. We thus fix the *maximum* expropriation probability τ to 0.5.

The land endowment L is normalized to unity. As the model is calibrated to annual frequency, we fix the discount factor β to the standrad value 0.96. We also fix the probability of skill change ζ to 0.02. This implies that the entire set of individual-specific skills changes on average once in 50 years, or roughly once in a generation. The land intensity parameter γ is set to 0.33. In absence of frictions, this parameter is equivalent to the agricultural land share. Historically, share-cropping arrangements have assigned by rule-of-thumb a value of between 1/3 and 1/2 to landowners as reported e.g. in Mundlak (2005). We settle for the more conservative lower bound in the light of evidence that the land share in modern agriculture may be somewhat lower than one-third.[25]

Following Lagakos and Waugh (2013), we assume that the skill distribution $\Psi(z_a, z_n)$ is a Frank copula with interdependence parameter ρ of the individual Fréchet distributions $\Psi_a(z_a) = \exp\left(z_a^{-\psi_a}\right)$ and $\Psi_n(z_n) = \exp\left(z_n^{-\psi_n}\right)$. Determining the interdependence parameter ρ is beyond the scope of this paper and we set $\rho = 3.5$ as in Lagakos and Waugh (2013), implying a correlation coefficient of 0.44 between $\log z_a$ and $\log z_n$. The correlation is positive and hence in line with the intuition that skills in the two activities are in part driven by a common component such as cognitive and

[25]For the U.S. Valentinyi and Herrendorf (2008) find that the income share accruing to land in agricultural value-added is a fraction $0.18/(0.18{+}0.64) = 0.28$ of the combined labor and land shares. Such a relatively low land share results from the imputation of the *indirect* contribution of land from non-agricultural intermediate inputs for which land is negligible. However, the nominal agricultural intermediate input share in Sub-Saharan Africa is low relative to developed economies (Donovan, 2016), suggesting that more weight should be attached to the direct contribution of land. Setting $\gamma = 0.33$ therefore appears to be a reasonable middle ground.

Parameter	Value	Moment	Target
Set parameters			
Share of communal land (λ)	1.00	Share of communal land	
Max. expropriation probability (τ)	0.50	Ethiopian law	
Endowment of land (L)	1.00	Normalization	
Discount factor (β)	0.96	Annual frequency	
Probability to draw new skill set (ζ)	0.02	Frequency of talent draw	
Span of control (γ)	0.33	Land share	
Interdependence (ρ)	3.50	Lagakos & Waugh (2013)	
Calibrated parameters			
Talent distribution non-agriculture (ψ_n)	1.64	Variance of non-ag. wages (log)	0.831
Talent distribution agriculture (ψ_a)	1.61	Variance of land to labor ratio (log)	0.630
Occupational wedge (θ)	0.42	Value-added ratio ag. vs non-ag.	0.523
Subsistence requirement ($\bar{a}$)	0.98	Agricultural employment share	0.727
Relative preference for ag. goods (η)	0.28	GDP share of subsistence cons.	0.330
Curvature of expropriation function (μ)	3.19	Share of land rented in	0.195
Probability to obtain a land transfer (ϕ)	0.07	Fraction of landless farmers	0.069
Progressivity of land redistribution (ϵ)	9.16	Expropriation rate	0.006

Table 2: Calibration

physical ability. At the same time, the correlation is sufficiently moderate to reflect that the two activities value different types of knowledge and experience profiles. In particular the correlation coefficient is comprised between two values obtained from calibrations that directly target moments on occupational switchers. Whereas Alvarez (2018) infers a high positive correlation of 0.83 in Brazil using an identical distribution to ours, Adamopoulos et al. (2017) find a negative correlation of -0.34 in China using a multi-variate log-normal distribution. In Appendix D we show that the main results are robust to an alternative calibration assuming independent draws, $\rho = 0$.

6.2. Jointly calibrated parameters

The parameters $\psi_a \geq 0$ and $\psi_n \geq 0$ determine the mean and the dispersion of skill in both sectors. The empirical data moment chosen to discipline ψ_n is the variance of the permanent component of (log) earnings in the non-agricultural sector. We compute this to be 0.831 from the LSMS-ISA panel dataset for Ethiopia. The associated calibrated value of ψ_n is 1.638. For agriculture, we set ψ_a so that our model matches the empirical variance of the permanent component of the (log) ratio between operated land and labor at the household level. In particular, we focus on a restricted sample of GPS measured pure-stand fields on which staple crops are planted for the two waves of the LSMS-ISA survey. We estimate the permanent component of the agricultural land to labor ratio by regressing our measure on household and time fixed effects. The empirical variance is 0.63 and the associated calibrated value of ψ_a equals 1.614. Please see Appendix C for further details.

The subsistence requirement $\overline{a}$ is calibrated to 0.98 in order to match a share of aggregate income spent on subsistence consumption $\frac{p_a \overline{a}}{p_a Y_a + Y_n}$ of 0.33. This is an estimate from Rosenzweig and Wolpin (1993) on a sample of Indian rural households in 1984. We use it based on the fact that GDP per capita in India in 1984 is comparable to that of Ethiopia in 2012.[26] Ethiopia's fraction of agricultural employment, $N_a = 0.727$, is then targeted by preference parameter $\eta = 0.283$. Our procedure results in a substantially higher preference for agricultural goods than methods that target the long-run share of agricultural employment shares in currently rich countries. As a robustness check we propose an alternative calibration in Appendix D where η is set to 0.01. The main results are largely unaffected.

Next, the wedge on non-agricultural labor income $\theta = 0.419$ is strongly identified by matching the nominal value-added share of agriculture, $\frac{p_a Y_a}{p_a Y_a + Y_n}$. We compute Ethiopia's empirical equivalent in 2012 to be 0.522 based on World Bank data on the sectoral nominal value-added shares, $VA_a = 0.449$ and $VA_n = 0.551$, adjusted for physical capital income.[27]

This leaves us with three remaining policy parameters. The first moment is the fraction of rented-in communal land, $(\int \max\{l_c(x) - l(x), 0\}\mathrm{d}x)/L_c$. We compute this to be 19.5% as a simple average between the 2011-2012 and 2013-2014 LSMS-ISA rounds. The rental market in Ethiopia is active as reflected in the calibrated value of the parameter μ that governs the curvature of the function that governs the individual

[26]Following World Bank data, GDP per capita in constant 2005 dollars (the only comparable data series) amounts to 325 USD for India in 1984 and 272 USD for Ethiopia in 2012.

[27]In absence of precise data on aggregate data on sectoral income shares, we fix the non-agricultural capital share to the standard 0.33 and that of agriculture to 0.1. It follows that $p_n Y_n = 0.67 \times VA_n$ and $Y_a = 0.9 \times VA_a$.

expropriation probabilities. At 3.191 the quantification suggests that while farmers who rent out land are not shielded from expropriation (as $\mu << \infty$), they do run a considerably lower risk than migrants (as $\mu > 1$). For instance, whereas the expropriation probability is 50 percent ($\Pi_E = \tau$) when all land holdings are rented out, it is only about 5 percent when half of their holding are rented out. Another data moment that we obtain from the LSMS-ISA is the fraction of landless farming households, which is 6.9% (computed as the fraction of farmers who rent in their entire land operations). The parameter that exerts the strongest influence on that outcome is ϕ, the probability faced by landless farmers of being allocated communal land, calibrated to 0.072. This implies that a landless farming household needs to wait on average about 14 years to be allocated a plot of communal land.

Parameter ϵ determines the progressivity of the function that governs the individual reallocation probabilities. It is tightly linked to other matched moments described above, such as the variability of operations and the fraction of land rented in. At the same time it also generates the allocation of communal holdings and therefore governs the degree of potential mismatch between individual holdings and marginal productivities. As such it is indirectly related to the equilibrium expropriation rate, namely the fraction of individuals that in a given period experience expropriation. Because there are no recent comprehensive data on expropriation, we rely on our own small-scale household questionnaire administered in several distinct locations in Ethiopia (please see Appendix C for details). In particular, we inquired whether the household or the parents of the household's head have ever been subject to land expropriation. From this we compute an expropriation rate of 0.55%. Put into perspective, this implies that each year one in two hundred households experiences expropriation.[28] The calibrated

[28] Admittedly, this figure is imprecisely estimated as our sample of 44 households is small. At the same time, it is likely to be a conservative lower bound. Based on a nationally representative survey of farm households, Deininger and Jin (2006) find that 9 percent of farmers were affected by land redistribution in the period between 1991 and 1998. Also, the dataset used in Dercon and Krishnan (2010) confirms that about 7 percent of household lost land during the redistribution between 1994 and 1999. These frequent expropriations, however, also include episodes of land redistributions in the 1990s that differ from the expropriation mechanism proposed in our model. For this reason we settle on a relatively low rate of expropriation.

value of the parameter ϵ is 9.157, which is high. It suggests that the probability of being allocated communal land (conditional on farming) is almost independent of the size of existing land holdings.[29] This is consistent with the empirical evidence presented in subsection 3.2 that suggests that the reallocation of land was motivated by political rather than economic considerations.

6.3. Non-targeted moments

We evaluate the performance of our model by highlighting a number of important non-targeted moments. First, the model generates a variance of (log) agricultural skills z_a of 0.76 among individuals employed in agriculture. Chen et al. (2017) infer farm TFP in Ethiopia and find a standard deviation of (log) farm TFP of 0.91, implying a variance of 0.83. Our model outcome is therefore very close. Second, the model predicts a variance of (log) communal land holdings, l_c, of 0.48. In comparison, the empirical measure is 0.61. While the model understates the dispersion of operations and holdings relative to the data, the discrepancy is not large. In addition, we note that the model matches the empirics qualitatively by producing a slightly lower dispersion in holdings than in operations. Third, the correlation between land holdings and operations in the model is 0.79. In the data that correlation amounts to 0.75 on average across the two LSMS-ISA waves. This last moment gives us particular confidence that our model captures well the frictions that produce a high correlation between holdings and operations.

7. Results

We now present the main results: the quantitative impact of removing communal land tenure on aggregate statistics. The key comparison of interest is between our benchmark economy ($\lambda = 1$) and a counterfactual economy where communal land is

[29]For example, if the probability of passing from no land to a first transfer is ϕ, the probability of passing from nine to ten transfers is $0.62 \times \phi$.

fully transferable ($\lambda = 0$).[30]

7.1. Main results

Y_a	Y_n	N_a (p.p.)	p	r/p
2.6	16.4	-18.1	8.5	-42.0

GDP	Y_a/N_a	Y_n/N_n	Real APG	Nom. APG
9.3	37.2	-29.3	-48.5	-52.5

Table 3: Aggregate effects of communal land reform. The table documents the effects on the benchmark economy of abandoning communal land ($\lambda = 0$). All numbers are percent changes except agricultural employment, which gives the percentage point change.

Table 3 presents the main results of this paper. Removing the communal land tenure system generates a slight increase in agricultural output, Y_a, of 2.6%, and a large increase in non-agricultural output, Y_n, of 16.4%. We also find that land liberalization is associated with a sizable drop in the share of farmers of 18.1 percentage points, from 72.0 to 53.9 percentage points (i.e., a 25% reduction in agricultural employment and a 65% increase in non-agricultural employment). These movements are accompanied by a 8.5% increase in the relative price of agricultural goods, p, and a steep decline of 42% in the relative rental rate of land, r/p.

Next, we turn to aggregate and sectoral productivity. Removing communal land tenure increases GDP by 9.3%.[31] This is quite large. Yet it also indicates that the misallocation caused by communal land is unlikely to be the major cause of low aggregate productivity in developing countries. Communal land tenure does, however, offer a key explanation for the agricultural productivity puzzle in developing countries. Lifting communal tenure generates a 37.2% increase in agricultural productivity, Y_a/N_a, and a 29.3% drop in non-agricultural productivity, Y_n/N_n. Altogether, the real agricultural productivity gap, $\frac{Y_n/N_n}{Y_a/N_a}$, plummets by 48.5% as a result of full land liberalization.

[30]Recall that an economy with no communal land, $\lambda = 0$, is equivalent to one with communal land yet no threat of expropriation, $\tau = 0$.

[31]GDP is evaluated in constant prices of the calibrated economy, $Y_n + p_{\lambda=1} Y_a$. The resulting change would be almost identical if, instead, we used the constant price of the non-distorted one ($p_{\lambda=0}$).

Given the movements in the real APG and the price p, the nominal APG, $\frac{Y_n/N_n}{pY_a/N_a}$, drops even further, by 52.5%. Communal land tenure therefore accounts for about one half of the real and nominal APG puzzle in an economy such as Ethiopia.

7.2. Decomposition of agricultural productivity gains

Agricultural productivity can be rewritten as follows:

$$\frac{Y_a}{N_a} = \bar{q}\bar{z}_a^{1-\gamma}\left(\frac{L}{N_a}\right)^{\gamma} \tag{12}$$

where $\bar{z}_a$ is the average agricultural skill of farmers and where the term $\bar{q} \in (0, 1]$ captures operational misallocation. In absence of operational misallocation, $\bar{q} = 1$.[32] The real agricultural productivity gain from lifting communal land tenure can be decomposed as follows:

$$\underbrace{\frac{Y_a'/N_a'}{Y_a/N_a}}_{1.372} = \underbrace{\frac{1}{q}}_{1.078} \times \underbrace{\left(\frac{\bar{z}_a'}{\bar{z}_a}\right)^{1-\gamma}}_{1.157} \times \underbrace{\left(\frac{N_a}{N_a'}\right)^{\gamma}}_{1.100}$$

The first term captures operational misallocation. For example, consider an announced reform that allowed communal land to be fully transferable yet imposed prohibitive costs of switching sectors. Agricultural productivity would increase by 7.8% as a result of optimizing the use of land while leaving the number and average skill of farmers unchanged. A complete liberalization, on the other hand, also removes occupational misallocation. This raises agricultural productivity through two channels. One is a 15.7% increase due to higher average quality of farmers. The other is a mechanical 10% increase resulting from a reduction in the number of farmers. This last effect is simply a consequence of decreasing aggregate returns to scale in agriculture as land is in fixed supply. This suggests that only about 20% (=7.8/37.2) of the impact of land tenure on agricultural productivity is due to operational misallocation. The primary channel of misallocation is occupational.

[32] Formally, $\bar{q} = \frac{\int z_a(x)q(x)^{1-\gamma}h(x)\mathrm{d}x}{[\int z_a(x)q(x)h(x)\mathrm{d}x]^{\gamma}[z_a(x)h(x)\mathrm{d}x]^{1-\gamma}}$ where $q(x) \equiv \frac{l(x)}{l^\star(z_a)} \geq 1$ denotes departures from optimal land use. To find this, integrate over the land use $l(x) = q(x)l^\star(z_a) = q(x)\left(\frac{\gamma p}{r}\right)^{\frac{1}{1-\gamma}} z_a$ to find

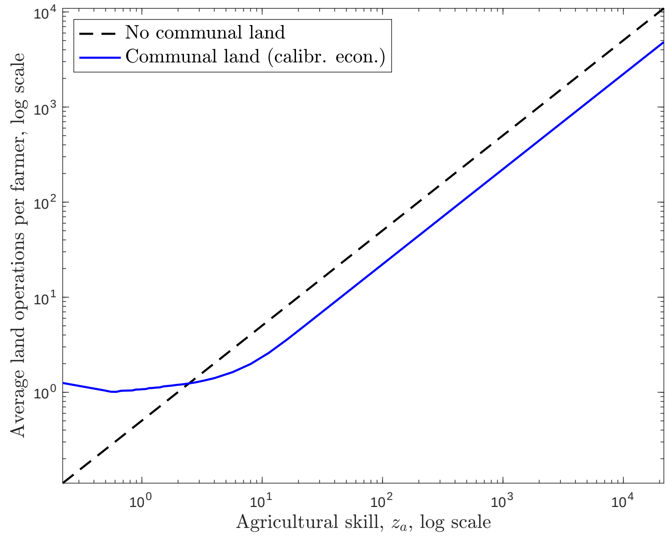


Figure 3: Average size of operations conditional on agr. skills.

We would like to emphasize that while the aggregate impact of operational misallocation may be rather small, its signature features are very much present in the benchmark economy. For this, consider Figure 3 that plots the average scale of operation of farmers as a function of agricultural skill.[33] In the non-distorted economy individual farmer operations are log-linear in agricultural skills. In the distorted economy, that is also approximately true for the very high skilled farmers since their own communal holdings typically are lower than the desired scale of operations. For low-skilled agricultural workers, on the other hand, the relationship between average land operations and skills is flat. Because much of the mass of farmers is on the flat section, the correlation between the agricultural skill of farmers, $\log z_a$, and the size of operations, $\log l$, is relatively low, 0.47, instead of being perfect as in the economy without communal land. Moreover, we note from Figure 3 that lifting communal land tenure leads to reallocation of land towards higher skilled farmers. In particular, this increases the variance of (log) operations from 0.63 to 0.79, in line with Adamopoulos and Restuccia (2014)

the land clearing price r/p, and then replace that expression after integrating over $y(x) = z_a^{1-\gamma} l(x)^\gamma$.

[33]That is, for each z_a, the expected value $\frac{\int\int l(x)\mathbb{I}(x)h(x)\mathrm{d}z_n\mathrm{d}l_c}{\int\int \mathbb{I}(x)h(x)\mathrm{d}z_n\mathrm{d}l_c}$.

who hypothesize that distortionary policies may be responsible for the low dispersion in farm size in developing countries.

Restuccia and Santaeulàlia-Llopis (2017), for Malawi, and Chen et al. (2017), for Ethiopia, compute that the scale of operations is by and large uncorrelated with inferred farm productivity. The flat section of the graph is therefore consistent with their findings. The increasing section, however, is not. This is because in our framework high-skilled farmers rent in land optimally at the prevailing rental rate. It also drives our conclusion that operational misallocation resulting from the communal land policy is relatively weak. Note that this does not imply that the operational misallocation in general is low. It simply means that it is likely not a consequence of communal land tenure systems that usually do not set an upper limit on the size of farms. Our interest here is restricted to the impact of a particular and widespread policy, while in the data, land may otherwise be misallocated for a variety of reasons such as financial frictions, distorted input markets or agency frictions between landlord and tenants. In addition, measuring the true extent of operational misallocation across farms is challenging. Gollin and Udry (2017) find that standard procedures imply large misallocation across plots operated by the same farmer, which is likely to indicate measurement error. Correcting for it yields gains from optimal factor reallocation across farmers that are substantially smaller.

7.3. Communal land liberalization and occupational switch

The overall GDP gain from lifting communal land tenure is moderate because the two sectoral productivities move in opposite directions. The sectoral composition of the workforce is key to understand this result: it is the only driver of the drop in non-agricultural productivity and, as argued above, the main cause of the agricultural productivity increase. To see how the two are interconnected, we turn to Table 4. The upper half summarizes the shares and average characteristics of different types of workers in the benchmark economy broken down by occupation and, conditional on farming, whether they are constrained in the choice of occupational and/or size of operations (corresponding to Table 1). The lower half quantifies the shares and average characteristics of the subset of workers who choose to switch occupation following an unannounced reform that permanently secures property rights by suspending the threat of expropriation (i.e., by setting $\tau = 0$).[34]

Occupation, $\overline{T}$	Farmers					Non-farmers
Occ. constraint, $T^\star$	No	No	Yes	Yes		
Oper. constraint, $K^\star$	No	Yes	No	Yes		
Farmer type	(A)	(B)	(C)	(D)	(A)+(B)+(C)+(D)	
Mass, initial	12.2	20.9	4.4	34.5	72.0	28.0
Average z_a	9.4	2.5	1.5	1.2	3.0	1.7
Average z_n	2.0	1.1	1.3	1.4	1.4	5.5
Average l_c	0.6	1.7	0.1	1.6	1.4	0.0
Mass, switch	0.0	0.0	0.7	18.6	19.3	1.2
Average z_a	-	-	0.8	1.1	1.0	4.1
Average z_n	-	-	0.9	1.6	1.5	4.0
Average l_c	-	-	0.1	1.8	1.7	0.0

Table 4: Shares of individuals by types.

We compute that in the benchmark economy, only 17% of farmers (12.2 percentage points out of 72 percentage points of farmers) are unconstrained by the land policy. The largest group of farmers is constrained on both margins. Relative to the average farmer, the model suggests that they are relatively unskilled in the agricultural activity, z_a/z_n, yet detain relatively large communal land holdings. Note also that only 6% of farmers (4.4 out of 72 percentage point) are occupationally but not operationally constrained. These farmers have little communal land and remain in agriculture solely because they anticipate the receipt of land grants in the future. This suggests that the tenure system's pull effect into agriculture works mainly through the channel of threatening the expropriation of current holdings ("locking in farmers") as opposed to the promise of future transfers.

Limited land transferability is often viewed as a means to prevent massive (and potentially disruptive) migration flows from rural to urban areas. Assuming that the *perception* of this pent-up migration pressure is based on current equilibrium prices p

[34] Note that upon such a reform, the model economy would immediately jump to the new equilibrium. There is no transition period as expropriation and redistribution stop at once.

and r, the model rationalizes why a land reform that secures transfer rights is perceived as causing massive occupational switching. At current prices, more than half (54%) are occupationally constrained and would therefore switch sectors if the land tenure system were removed. Our computations, however, suggest that the resulting relative price changes would undo much of that migration pressure as terms of trade shift in the favor of farmers: the price of agricultural output increases while the cost of renting land drops. We find that in general equilibrium only about half of those would-be movers actually make the switch, 19.3 percentage points. Observe as well that the equilibrium price changes motivate about 1.2 percentage points of non-farmers to switch into agriculture.

Most importantly, consider the average characteristics of farmers switching sectors relative to staying farmers. The reason that they switch into non-agriculture is *not* because their non-agricultural skills, z_n, are significantly higher (1.5 relative to 1.4). They switch because their agricultural skills, z_a, are low (1.0 relative to 3.0) and because they detain higher communal land holdings that kept them in agriculture in the first place (1.7 relative to 1.3). As a result, when they arrive in the non-agricultural sector they pull down the productivity of that sector because they have significantly lower non-agricultural skills, z_n, relative to the incumbents (1.5 relative to 5.5). This is instructive. In a nutshell, the communal land tenure system, by threatening to expropriate holdings that have been accumulated over the past, acts as a device to keep a large mass of individuals in agriculture who have low agricultural and non-agricultural skills. Removing the system generates a large occupational shift that – through composition – increases agricultural productivity and lowers that of non-agriculture.

7.4. Coexistence of communal and private land

Finally, we re-compute the main aggregate statistics for economies with various aggregate shares of communal land, λ, i.e. economies where communal land coexists with private land. This is of interest because Ethiopia can be viewed as representative of many developing countries both in terms of its fundamentals – the intrinsic productivity distribution z_a and z_n – as well as in terms of principles governing communal land tenure. At the same time, other African economies have dual land markets where some land is strictly communal and following traditional customary tenure transferability principles, while the rest is under complete owernship and fully transferable. This can loosely be represented by various values of λ. Similarly, in Appendix E we consider departures from the benchmark economy with respect to other policy parameters governing the expropriation and reallocation function.

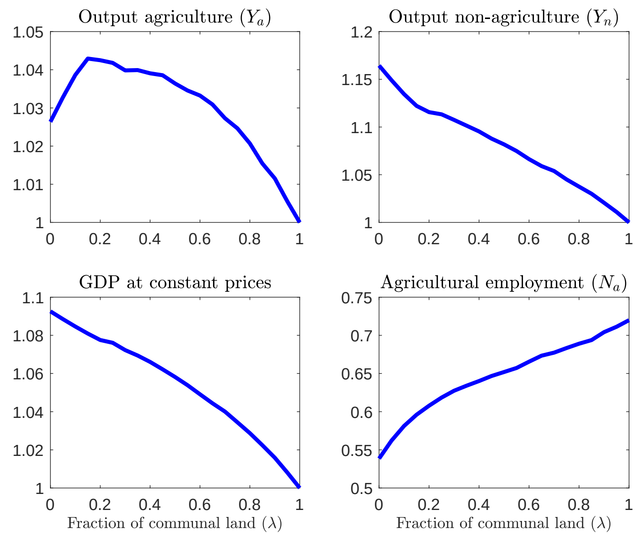


Figure 4: Effects of communal land reform on economic aggregates. The figure documents stationary equilibria for various economies indexed by λ. All variables except agricultural employment are normalized to the calibrated economy ($\lambda = 1$).

The results are depicted in Figures 4 and 5. Most variables are monotonic and quite linear in λ. Notable exceptions are agricultural output, Y_a, and the price of agricultural output, p. This can be understood in conjunction with Figure 6 that depicts the components of agricultural productivity in equation (12). Introducing a little bit of private land in an economy where most land is communal (i.e, lowering λ when λ is close to 1) has a disproportional impact on the reduction of operational misallocation. In this region of λ, occupational misallocation is reduced more slowly. It follows that as agricultural productivity increases while farmers remain put in agriculture, agricultural output grows faster than that of non-agriculture, and the market clearing price p declines. In contrast, in economies with a substantial fraction of private land (say, at λ

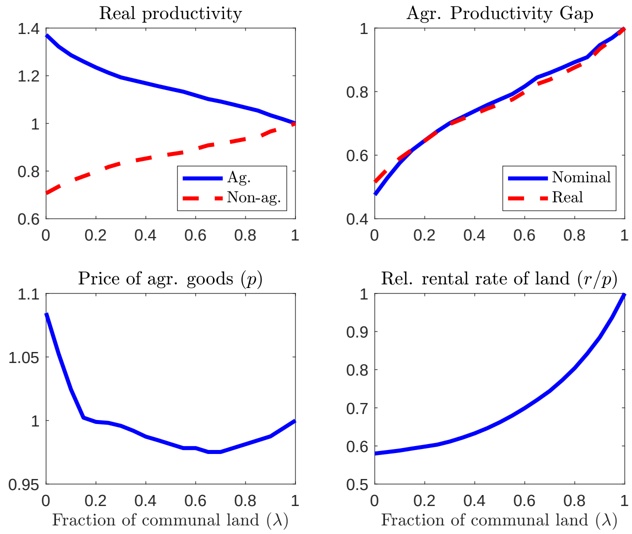


Figure 5: Effects of communal land reform on economic aggregates. The figure documents stationary equilibria for various economies indexed by λ. All variables except agricultural employment are normalized to the calibrated economy ($\lambda = 1$).

close 0.5), a further reduction of communal land produces few productivity gains associated with the reduction in operational misallocation. Instead, a marginal decline in λ will now substantially reduce the attractiveness of the agricultural sector and hence lower occupational misallocation. This means that agricultural output rises by little, and may even fall, while non-agricultural output continues to rise. As a result, price p increases.

8. Conclusion

This paper measures the general equilibrium impact of communal land tenure on productivity and employment. For this we formalize stylized policies that capture key elements of land tenure systems observed across many developing countries. We emphasize the role of limited transferability of land by which individuals are only exposed to the risk of expropriation when they rent out land. By doing that we heed the lessons from the micro development literature which states that *de jure* tenure insecurity (e.g. in the form of no formal land registration) does not necessarily imply *de facto* tenure insecurity, as exemplified in the debate on tenure security and investment

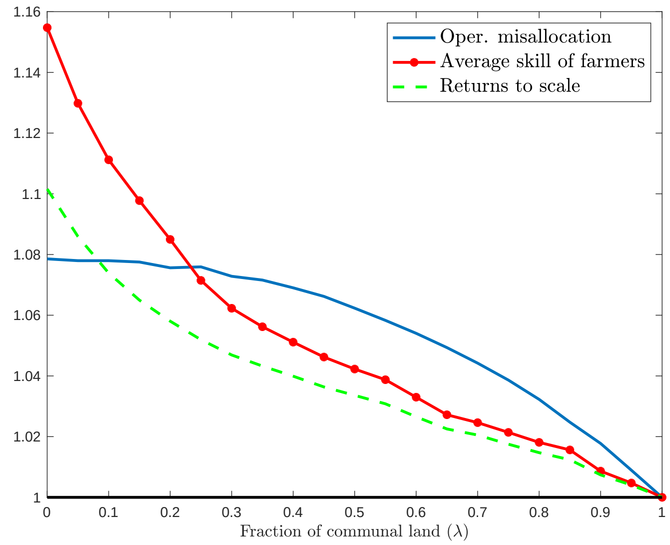


Figure 6: Decomposition of agricultural productivity gains.

(Fenske, 2011). We do, however, take a strong position on the fact that the threat of expropriation has bite when farmers decide to turn user rights into commercial value by renting out land, in particular when they stop farming altogether.

Our principal findings are as follows. Restoring land transferability in an economy where all land is communal results in a GDP increase of 9% and a substantial decrease in agricultural employment of 18 percentage points. The combined effect of a rise in agricultural and fall in non-agricultural productivity generates a drop in the real agricultural productivity gap by a factor of two. These quantifications result from a calibration on Ethiopia. We argue that our results can be applied to other poor agricultural economies with similar tenure regimes, in particular in Sub-Saharan Africa. We also recognize that in most of these economies, contrary to Ethiopia, private land co-exists with communal land tenure. Our results therefore have to be viewed as closer to the upper bound of the potential impact of communal land on the static misallocation of land across users and individuals across occupations.

Our exercise offers the following lessons. First, communal land helps explaining the agricultural productivity gap in the poorest countries. To the extent that selection plays a key role, our results echo the findings of Lagakos and Waugh (2013), though in our case the occupational selection pattern is distorted. We emphasize that the primary impact of communal land tenure is to keep disproportionately unskilled workers in agriculture. Second, the removal of obstacles to land transferability results in aggregate benefits, but it falls short of producing a first-order impact on aggregate productivity. This implies that lowering the real and nominal APG in developing countries does not by itself entail the solution to the development puzzle. To be sure, an extension of our framework to include endogenous investment and other refinements may still produce larger losses associated with communal land. Our framework, however, also rules out by assumption any potential *benefits* of communal land. Since institutions that limit land transferability are prevalent around the world, they certainly exist to correct some undesirable outcomes. They may, for example, address issues such as inequality, myopic behavior or incomplete insurance, in particular in economies with few other public policy instruments. Our results are therefore silent on the ultimate welfare consequences of communal land tenure. We leave it to future research to weigh its distortionary effects against any potential benefits.

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Appendix

Appendix A. Cross-country data

In this subsection we outline our measures of the agricultural productivity gap across countries. We also show that these measures relate to a particular index on tenure insecurity.

Agricultural productivity gaps across countries

To construct a measure of the *nominal* agricultural productivity gap (APG) we use 2005 World Bank data on the ratio of the non-agricultural value-added share, $p_nY_n/(p_aY_a+p_nY_n)$, to the agricultural share, $p_aY_a/(p_aY_a+p_nY_n)$, measured in current USD, and adjusted by levels of employment N_j in each sector $j = \{a, n\}$. The nominal agricultural productivity gap (APG) of country i is hence $APG^i_{nom} = \frac{(p^i_nY^i_n)/N^i_n}{(p^i_aY^i_a)/N^i_a}$. The nominal APG is then normalized to the U.S. to obtain its relative difference (RAPG), i.e. $RAPG^i_{nom} = APG^i_{nom}/APG^{US}_{nom}$.

The computation of the *real* APG is less straightforward. It again involves the use of 2005 World Bank data as well as data from the Food and Agricultural Organisation (FAO) for the years 2004-2005. We start from the identity:

$$p^{WB}_aY^i_a + p^{WB}_nY^i_n = p^{WB}Y^i. \tag{A.1}$$

This decomposes country i's real GDP measured in World Bank international dollars $p^{WB}Y^i$ into real sectoral components of value-added evaluated at each sector's respective international price. Since neither $p^{WB}_aY^i_a$ nor $p^{WB}_nY^i_n$ are available we proceed with FAO data and make two critical assumptions. The FAO collects country-specific industry-level prices for agricultural output in order to measure gross output (O) in international FAO dollars, $p^{FAO,O}_aO^i_a$. These are hence cross-country data on real agricultural output, but not real valued-added, since for years other than 1985 the FAO does not collect prices for (non-agricultural) intermediate inputs used in agriculture. In order to obtain real value-added in agriculture we make the assumption that $p_a^{FAO,O}/p_a^{i,O} = p_a^{FAO}/p_a^i$, i.e. the ratio between international and local industry prices equals the ratio between international and local value-added deflators. This gives $p_a^{FAO}Y_a^i = \frac{p_a^{FAO,O}O_a^i}{p_a^{i,O}O_a^i}p_a^iY_a^i$. World Bank data on agricultural value-added in current USD, $p_a^iY_a^i$, coupled with FAO data on gross agricultural output in international and current USD, respectively, $p_a^{FAO,O}O_a^i$ and $p_a^{i,O}O_a^i$, thus translate into the real measure of value-added in agriculture, $p_a^{FAO}Y_a^i$. The second assumption is to translate those into World Bank international prices by a factor of proportionality so that $p_a^{WB}Y_a^{US} = \alpha p_a^{FAO}Y_a^i$. We proceed as in Caselli (2005) by noting that given the size of the U.S. in the construction of international prices one can assume $p_a^{WB}Y_a^{US} = p_a^{US}Y_a^{US}$. From that we have that $\alpha = \frac{p_a^{US,O}O_a^{US}}{p_a^{FAO,O}O_a^{US}}$. With $p_a^{WB}Y_a^i$ in hand we can hence compute $p_n^{WB}Y_n^i$ from (A.1). Finally, the real agricultural gap is hence $APG_{real}^i = \frac{(p_n^{WB}Y_n^i)/N_n^i}{(p_a^{WB}Y_a^i)/N_a^i}$.

Decile	N	Real APG	N	Nominal APG
1	11	22.92	13	6.02
2	11	20.02	13	4.66
3	11	17.16	13	3.52
4	11	11.45	13	2.39
5	11	10.17	13	2.54
6	11	5.37	13	2.08
7	11	4.39	13	2.76
8	11	3.57	13	2.85
9	11	3.15	13	1.64
10	11	2.90	13	1.70
Total	110	10.11	130	2.92

Table A1: Real and nominal relative APG (U.S.=1)

Table A1 ranks both measurements of APG (normalized to the U.S.) in deciles according to real GDP per capita (in PPP) and reports the average APG for each group.[35] Clearly, the APG is decreasing in GDP per capita, and comparing the first and last deciles gives factor differences of $22.92/2.90 = 7.9$ and $6.02/1.70 = 3.5$ for the real and nominal measures, respectively.

[35]We drop countries smaller than 1,000 square kilometers in size. We also drop Burundi, Guyana, Libya, Guyana which are clear outliers in terms of relative nominal agricultural productivity. This does not significantly affect the results.

Agricultural productivity gaps and tenure insecurity

The Institutional Profiles Database (IPD) of the Centre d'Etudes Prospectives et d'Informations (CEPII), provides an index on land tenure insecurity that covers a large number of countries. The indicator ranges between 0 and 4 and is increasing in tenure insecurity. It is constructed on the basis of answers to four aspects of tenure security, namely (1) the importance of land expropriation practices, (2) the importance of land issues in local politics/media, (3) the share of the urban population with tenure rights that are not formally recognized, and (4) the share of the rural population with tenure rights that are not formally recognized. In table A2 we regress our measures of nominal and real APG differences on the IPD indicator. The results suggest a statistically significant relationship whereby high levels of tenure insecurity are systematically positively related to both the real and nominal APG. For comparison we also regress the APG measures on GDP per capita.

	(1) Nom. APG (log)	(2) Real APG (log)	(3) Nom. APG (log)	(4) Real APG (log)
GDP per capita (log)	-0.278***	-0.598***		
	(-5.90)	(-10.07)		
Land tenure insecurity			0.226***	0.540***
			(3.89)	(6.97)
Constant	3.171***	7.027***	0.383**	0.833***
	(7.69)	(13.37)	(3.19)	(5.30)
Observations	130	110	119	102

t statistics in parentheses
Source: CEPII database, WorldBank and FAO (2005). GDP and APG's are in logs.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A2: **Real and nominal agricultural productivity gap (APG) and tenure insecurity.**

Appendix B. Theory

We present the definition of the stationary equilibrium as well as all the proofs.

Definition of the stationary equilibrium

For an equilibrium to exist the economy must be sufficiently productive to ensure that the subsistence requirement in agricultural goods is met, $Y_a > \overline{a}$. The stationary equilibrium is defined as the set of individual allocations $b(x)$, $\mathbb{1}_a(x)$, $l(x)$, $y_a(x)$, $w_a(x)$, $\forall x$; policy outcomes $\pi_E(x)$, $\pi_R(x)$, and $l'_c(x)$, $\forall x$; prices p and r; aggregate allocations Y_a and Y_n; the transfer value v; as well as a stationary distribution $H(x)$, such that:

1. all agents of type x solve their maximization problem (3);
2. the aggregate stand-in household solves its maximization problem;
3. goods and land markets clear according to equations (4), (5), (6) and (7);
4. the stationary distribution $H(x)$ is consistent:

The stationary equilibrium always features positive expropriation and reallocation because skills change through time. A changing skill set implies that at any point there always exists a positive mass of farmers who are sufficiently unskilled so as to rent out land, resulting in positive expropriation. The distribution of communal holdings therefore cannot be static, meaning that it is less likely to depend on initial conditions. Indeed, our numerical simulations around the calibrated economy suggest that distinct initial conditions all lead to the same stationary distribution. We do not, however, provide an analytic prove of its uniqueness.

Proof of Proposition 1

Comparing the value function (3) under the two sectoral choices we have that $\mathbb{1}_a = 1$ if and only if

$$w_a(z_a, l; p, r) + M(l) \geq (1 - \theta) z_n$$

where

$$\begin{aligned} M(l) \equiv \beta \Big\{ & [\tau - \pi_E(l_c, l)] \Big(\mathbb{E}_{z'|z} \big[V(z'_a, z'_n, l_c) - V(z'_a, z'_n, 0) \big] \Big) \\ & + \pi_R(l_c, 1)[1 - \pi_E(l_c, l)] \Big(\mathbb{E}_{z'|z} \big[V(z'_a, z'_n, l_c + v) - V(z'_a, z'_n, l_c) \big] \Big) \\ & + \pi_R(l_c, 1) \pi_E(l_c, l) \Big(\mathbb{E}_{z'|z} \big[V(z'_a, z'_n, v) - V(z'_a, z'_n, 0) \big] \Big) \Big\}. \end{aligned}$$

The continuation difference term under any strictly positive choice of land operations $l > 0$ is strictly positive, $M(l) > 0$. Let $z_a = \overline{T}$ denote the threshold value for which the individual is indifferent between the two activities:

$$w_a(\overline{T}, l; p, r) + M(l) = (1 - \theta)z_n.$$

The indifferent farmer can be of two types, as shown in Proposition 2. Either his land choice is non-distorted, i.e. $l = l^\star$, resulting in $w_a(\overline{T}, l; p, r) = w_a^\star(\overline{T}; p, r)$. In that case we have

$$w_a^\star(\overline{T}; p, r) + M(l^\star) = (1 - \theta)z_n. \tag{B.1}$$

Alternatively, the indifferent farmer's land choice is distorted, i.e. $l > l^\star$. If the indifferent farmer, instead, chose non-distorted land operations $l = l^\star$, agriculture would no longer be the optimal sector:

$$w_a^\star(\overline{T}; p, r) + M(l^\star) < (1 - \theta)z_n. \tag{B.2}$$

Combining equations (9) and (10) results in $w_a^\star(\overline{T}; p, r) = \frac{\overline{T}}{T^\star}(1 - \theta)z_n$. Combining this with (B.1) and (B.2) yields

$$\frac{\overline{T}}{T^\star}(1 - \theta)z_n + M(l^\star) \leq (1 - \theta)z_n.$$

Since $M(l^\star) > 0$, it follows that $\overline{T} < T^\star$. Finally, notice that the threshold value of $\overline{T}$, through $M(l)$, depends on the individual's continuation which is a function of z_n, l_c and v, in addition to p and r: $\overline{T} = \overline{T}(z_n, l_c; p, r, v)$.

Proof of Proposition 2

Conditional on farming ($\mathbb{1}_a = 1$) the first-order condition with respect to l from the value function (3) implies

$$\gamma p z_a^{1-\gamma} l^{\gamma-1} = r + Q(l)$$

where

$$Q(l) \equiv \frac{\partial \pi_E(l_c, l)}{\partial l} \beta \Big(\pi_R(l_c, \mathbb{1}_a) \mathbb{E}_{z'|z} \left[V(z'_a, z'_n, l_c + v) - V(z'_a, z'_n, v) \right] + [1 - \pi_R(l_c, \mathbb{1}_a)] \mathbb{E}_{z'|z} \left[V(z'_a, z'_n, l_c) - V(z'_a, z'_n, 0) \right] \Big).$$

Since V is strictly increasing in l_c, $Q(l) = 0$ if and only if $\frac{\partial \pi_E(l_c,l)}{\partial l} = 0$ (which is the case when $l \geq l_c$). Otherwise it must be that $Q(l) > 0$ when $\frac{\partial \pi_E(l_c,l)}{\partial l} > 0$ (which is the case when $l < l_c$). Two cases are thus possible. First, if $l \geq l_c$ we have $Q(l) = 0$ and the first-order condition results in $l = l^\star$. From the definition of $K^\star$ from (11) this implies that $z_a \geq K^\star$. On the contrary, if $l < l_c$, the first-order condition states that $l > l^\star$. This implies that $l_c > l^\star$. After replacing the expression of $l^\star$ we have that $z_a < K^\star$.

Appendix C. Empirical moments

In this subsection we explain the construction of the moments of the targets used for the calibration in section 6

LSMS-ISA Ethiopia

Most of our empirical moments are computed using the Ethiopian LSMS-ISA panel dataset over the waves 2011-2012 and 2013-2014. We rely on the panel dimension to back out permanent components in order to weed out transitory shocks (in income, farm output) and measurement errors.

Our first moment is the dispersion in non-agricultural wages, w_n. First, we construct a panel of individuals and measure hourly wages for the two waves. We run an OLS regression of (log) wages on a set of individual and time dummies, and then compute the variance of the individual dummies to be 0.831.

The second moment is the dispersion in land operations l. The unit of our model is an individual while its empirical part is a family farm. This is why we target the ratio of land operations relative to farm labor.[36] We construct a panel where land operations

[36] In particular, we posit that the empirical production function is $y = (zn)^{1-\gamma} \tilde{l}^{\gamma} = z^{1-\gamma} l^{\gamma} n$ where $\tilde{l}$

include all the land used, namely the sum of fields on which staple crops are planted. As for labor, we count the number of individuals (household labor, hired labor and free labor) involved in planting and harvesting activities on staple crop fields, and aggregate this measure up to the household level. The resulting ratio is regressed via OLS on a set of individual and time dummies. The variance of the individual dummies, 0.630, represents our target.

Beyond the moments that are used for the purpose of the calibration, we also compute two empirical moments that will allow us to gauge the performance of our model. The first non-targeted moment is the dispersion of land ownership, l_c. To measure land ownership at the household level we focus on a sample of field level measurements for cultivated fields (pure stand and mixed crop). In particular, a household's land ownership comprises two parts. First, its operated parcels that are granted by local leaders and inherited to be owned (excluding parcels that are rented/borrowed for free/moved in without permission, which are considered to be rented in). Second, owned parcels that are rented out. These are directly given in wave 2, while for wave 1 we only have information on how many fields on a particular parcel have been rented out. To infer the size of the land rented out, we assume that the fields within a parcel (on which there is rental-out activity) are of equal size. We then aggregate the parcel level variables at the holder level, before aggregating them to the household level. Finally, we divide by total labor supply as computed above. The resulting ratio is regressed via OLS on a set of individual and time dummies. The variance of the individual dummies, 0.61, represents the dispersion in the permanent component of l_c.

The second non-targeted moment is the correlation between (log) operations per labor supply and (log) ownership per labor supply. It amounts to 0.66 and 0.85, respectively, in the two waves, so 0.75 on average.

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is total operations, n is total hours worked, and l is the ratio of the two.

Own data collection

In December 2014, we interviewed randomly selected households in seven villages (kebele) across four sub-regions (woreda) in Ethiopia's two main regions (Amhara and Oromia). In combination, the chosen locations in South Wollo and Arsi are as close to representativeness of Ethiopian agriculture as one can get in a small sample. In each village, we interviewed six or seven households to obtain a sample of 44 households. In each village, we complemented a formal survey with a large number of semi-structured focus group discussions and key informant interviews (village leaders, land committee members and extension workers).

	Mean	Sample Size
Expropriation	0.068	44
Expropriation parents	0.36	44
Age household head	48.5	44
Age children	21.8	28

Source: Own dataset.

Table A3: Expropriation statistics

A section of the questionnaire is devoted to land expropriation and redistribution. As part of our section on land expropriation and redistribution, household heads were asked whether one of their household members has been subject to land expropriation since household formation - see Table A3. Responses suggest that 6.8% have experienced expropriation in Ethiopia. We consider this number to be rather low in light of the numerous episodes of land expropriation and redistribution that have taken place in Ethiopia over the last four decades. This is confirmed by further evidence from our dataset, which documents that 36% of the parents of the household head (or spouse) experienced expropriation.

Since we calibrate the model to annual frequency we adjust these expropriation rates to annualized values and divide the expropriation rate by the average number of years since household formation, which gives us a lower bound of 0.25%. Doing the same adjustment with the expropriation rate on the parents of the household head, and adjusting it by the average generational length of 43 years (totalling to a life expectancy of 63 years in Ethiopia) gives us an upper bound of 0.85% for the expropriation rate.

We take the mean of the upper and lower bounds and hence target a mean rate of 0.55%.

Appendix D. Robustness

Here, we study the robustness of our main results relative to two alternative calibrations. The first alternative calibration ("Calibration 1") is one where we change the interdependence parameter between agricultural and non-agricultural skills, ρ. In the benchmark, ρ equals 3.5 following Lagakos and Waugh (2013), implying a moderately positively correlation of skills. Given that this parameter is weakly identified, we consider the case $\rho = 0$ so that two skills are independent draws. In the second alternative calibration ("Calibration 2") we consider lowering the preference parameter $\eta = 0.28$ to $\eta = 0.01$, which is more standard in the literature. For this we ignore the data moment on the share of subsistence consumption. As reported in Table A4, the first alternative requires a re-calibration of all parameters, while the second alternative only requires a re-adjustment of the subsistence parameter, $\overline{a}$. Figures A1 and A2 portray the impact of lowering the share of communal land, λ, on the main variables of interest.

Parameter	Main calibration	Calibration 1	Calibration 2
Set parameters			
Share of communal land (λ)	1.00	1.00	1.00
Max. expropriation hazard (τ)	0.50	0.50	0.50
Endowment of land (L)	1.00	1.00	1.00
Discount factor (β)	0.96	0.96	0.96
Probability to draw new skill set (ζ)	0.02	0.02	0.02
Span of control (γ)	0.33	0.33	0.33
Interdependence (ρ)	3.50	0.00	3.50
Calibrated parameters			
Talent distribution non-agriculture (ψ_n)	1.64	1.49	1.64
Talent distribution agriculture (ψ_a)	1.61	1.64	1.61
Generic tax (θ)	0.42	0.37	0.42
Subsistence requirement ($\bar{a}$)	0.98	0.99	1.53
Relative preference for ag. goods (η)	0.28	0.29	0.01
Curvature of expropriation function (μ)	3.19	3.26	3.19
Probability to obtain a land transfer (ϕ)	0.07	0.07	0.07
Progressivity of land redistribution (ϵ)	9.16	16.49	9.16

Table A4: Robustness of calibration.

We see that Calibration 1 yields very similar results to the benchmark calibration.

The only difference relative to the benchmark calibration is that communal land has somewhat smaller effects on most variables of interest. This is because occupational misallocation is somewhat less pronounced as individual choices are more strongly driven by comparative advantage. When skill draws are independent, there are fewer individuals with low skills in *both* sectors who are inefficiently kept in agriculture by communal land.

Calibration 2 also yields qualitatively similar results, while the quantitative impact of communal land tenure now is a bit stronger than in the benchmark calibration. Agricultural consumption here is mostly driven by the subsistence need so that agricultural output hardly changes over the institutional parameter space. As a consequence, the attractiveness of agricultural employment falls faster as λ decreases. Overall, our main results are largely unchallenged. If anything, the described effects are larger when he elasticity of food demand to income is low.

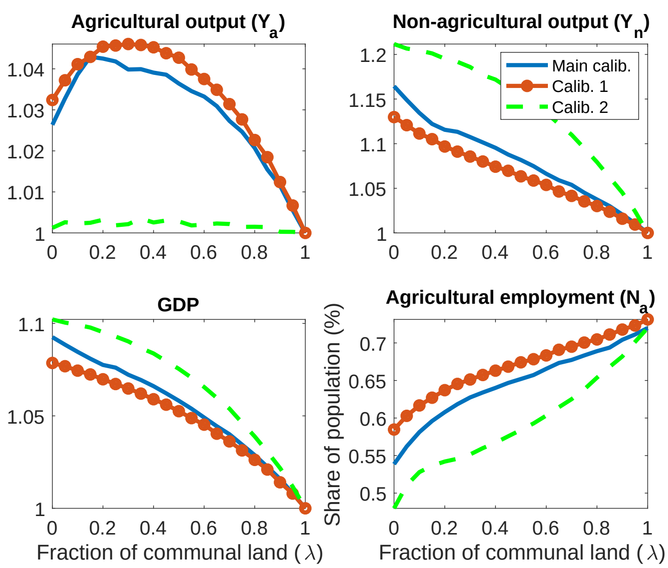

Figure A1: Real aggregates. All variables except agricultural employment are normalized to the calibrated economy ($\lambda = 1$).

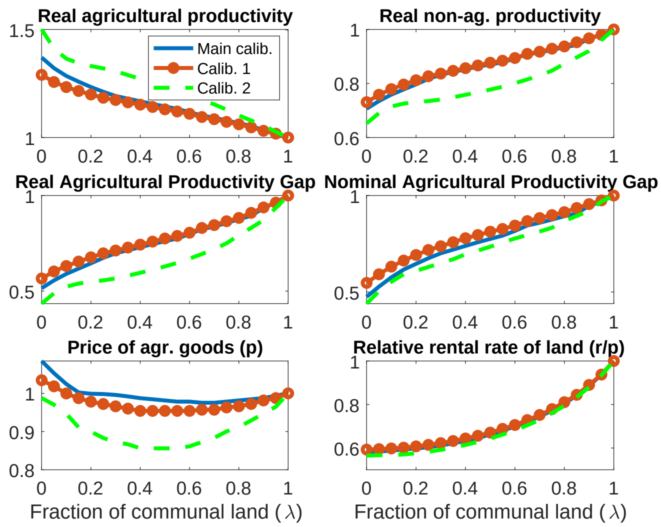

Figure A2: Productivity and prices. All variables are normalized to the calibrated economy ($\lambda = 1$).

Appendix E. Changes in policy parameters

In this section, we study the equilibrium impact of the four communal land tenure policy parameters. This exercise is useful because it provides insight into the role that the various policy parameters play in shaping the equilibrium. Also it illustrates the impact of the communal regime in economies that are similar to Ethiopia yet differ along one of the policy dimensions. We consider the sensitivity of key moments with respect to (i) the maximum expropriation hazard, τ; (ii) the curvature of the expropriation function, μ; (iii) the probability of obtaining communal land transfer, ϕ; and (iv) the progressivity of the land redistribution function, ϵ. We change each parameter and then re-compute equilibrium change relative to the benchmark economy, as reported in Table A5. For comparison we also report again the change associated with removing communal land tenure, $\lambda = 0$.

Maximum expropriation probability, τ. Lowering the maximum expropriation probability, τ, generates qualitatively similar outcomes as removing land tenure. Note, however, that even at a low value of $\tau = 0.1$ relative to the benchmark where $\tau = 0.5$, communal land tenure exercises a strong impact on sectoral and aggregate productivity as well as employment. Conversely, increasing τ to 1, implying that non-agricultural

	Y_a	Y_n	N_a (p.p.)	p	r/p
No comm. land, $\lambda = 0$	2.6	16.4	-18.1	8.5	-42.0
Low $\tau = 0.1$	3.0	4.0	-1.8	-3.8	-21.4
High $\tau = 1$	-1.4	-1.2	0.8	2.4	11.7
Low $\mu = 1$	-11.0	-5.0	4.8	35.9	344.3
High $\mu = \infty$	6.3	3.0	-3.5	-12.0	-39.8
Low $\phi = 0.01$	-3.9	1.6	-3.4	13.5	9.4
High $\phi = 1$	2.5	-0.8	3.1	-7.3	-5.6
Low $\epsilon = 0.01$	4.7	-1.8	5.6	-13.4	-11.4
Med $\epsilon = 1$	1.3	-0.6	2.1	-4.1	-2.8

	GDP	Y_a/N_a	Y_n/N_n	Real APG	Nom. APG
No comm. land, $\lambda = 0$	9.3	37.2	-29.3	-48.5	-52.5
Low $\tau = 0.1$	3.5	5.7	-2.3	-7.5	-3.9
High $\tau = 1$	-1.3	-2.4	1.5	4.0	1.5
Low $\mu = 1$	-8.1	-16.5	14.5	37.1	0.9
High $\mu = \infty$	4.7	11.7	-8.5	-18.1	-6.9
Low $\phi = 0.01$	-1.3	0.9	-9.5	-10.3	-21.0
High $\phi = 1$	0.9	-1.8	11.5	13.5	22.5
Low $\epsilon = 0.01$	1.6	-2.9	23.0	26.7	46.3
Med $\epsilon = 1$	0.4	-1.5	7.4	9.0	13.7

Table A5: Sensitivity to changes in policy parameters.

workers face certain expropriation, has a weak additional quantitative impact. This gives us confidence that the exact value of τ is not critical in understanding the main effects. What matters is that there is *some* risk of expropriation: even a modest maximum expropriation threat of 10 percent results in a sizeable impact.

Convexity of expropriation function, μ. We consider departures from the calibrated value of $\mu = 3.19$, namely to the polar cases $\mu = 1$ and $\mu \to \infty$. A decrease in μ raises the expropriation probability, playing out similarly to an increase in τ. At $\mu = 1$ the expropriation probability becomes linear in the fraction of rented out land. Accordingly, farmers become more reluctant to rent out their holdings, almost no land is rented out, and the rental rate shoots up relative to the benchmark economy. The additional misallocation of farmers' scale of operation leads to a drop in agricultural output, inducing a large increase in its price p. The number of farmers increases somewhat and GDP drops by 7.5 percent relative to the benchmark economy. Essentially, $\mu = 1$ describes an economy where land rentals are almost completely shut down. The resulting efficiency losses associated with communal land, in particular the operational misallocation, are therefore substantially more pronounced. In contrast, when $\mu \to \infty$, individuals can rent out land without any expropriation risk as long as they remain farmers. Operations, therefore, are not distorted. There is still occupational misallocation, however, implying that the GDP gain is smaller than under the complete removal of communal land tenure.

Maximum transfer probability, ϕ. We discuss variations in the maximum transfer probability rate ϕ from the initial value of 0.07: a low value 0.01 followed by the highest possible $\phi = 1$. A decrease in ϕ implies that individuals face a lower probability of receiving a land transfer. The agricultural occupation becomes less attractive, generating fewer farmers, and therefore also an increase in the relative price p. As a result, more of the skilled non-agricultural workers are drawn into farming, implying a drop in non-agricultural productivity. GDP, however, is hardly affected by that change.

Progressivity of transfer function ϵ. The last parameter sensitivity is with respect to ϵ, which governs the progressivity of the communal land reallocation. The calibrated parameter $\epsilon = 9.16$ is high and implies that communal land is slightly progressive. We perform two variations: a medium value of $\epsilon = 1$, and the lowest possible value of $\epsilon \to 0$. A decrease in ϵ plays out similarly to an increase in ϕ. In both cases the dispersion in communal holdings declines. This means two things. On the one hand there are many marginal individuals that prefer the agricultural sector, resulting in a more agricultural employment and a drop in its price, p. In terms of GDP, the least pernicious regime is that where reallocation is highly progressive. Interestingly, it is also the regime that creates the largest APG, both real and nominal.