Land Property Rights, Financial Frictions, and Resource Allocation in Developing Countries*

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Abstract

What effect do weak land property rights and limited access to finance have on aggregate productivity and the allocation of resources, and what is the role of their interaction? To answer these questions, I develop a dynamic general equilibrium model and use it to quantify the aggregate and distributional impacts of land and financial market imperfections connected via the collateral channel. I discipline the model with longitudinal micro data from Tanzania and show that substantial frictions in land and financial markets affect resource allocation and economic efficiency in agriculture. In the model, these distortions reduce aggregate productivity by allocating land and capital to less efficient producers, and by preventing households from moving out of agriculture and limiting entrepreneurship. An economy-wide land reform that improves land property rights leads to increases in agricultural and non-agricultural output by 7.4% and 8.2%, respectively, as well as a decline in agricultural employment by 8.6%. A land reform also results in higher financial inclusion, especially among the poorest, as land market frictions amplify the effects of financial markets imperfections. While a financial reform can deliver comparable aggregate effects, land reform is more pro-poor and reduces consumption inequality.

Keywords: Misallocation, productivity, entrepreneurship, financial frictions, land, Africa
JEL Classification: O11, E02, Q12, O55.

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1 Introduction

One of the leading explanations for persistent economic disparities between advanced and developing countries is that low-income countries are less effective in allocating their resources to their most productive use. Widespread market imperfections, including incomplete land and financial markets, are recognized as a potential reason for such misallocation.[1] Many developing countries are characterized not only by a low level of financial development (King and Levine, 1993; Banerjee and Duflo, 2005) but also by limited land markets and insecure land property rights (Adamopoulos and Restuccia, 2014). There are two main reasons for such land market imperfections in low-income countries. First, a large share of land does not have any documentation. Second, the land tenure system in many developing countries is ruled by customary law, particularly in Sub-Saharan Africa (Pande and Udry, 2005). Such customary tenure is a set of rules and norms that govern the allocation, use, access, and transfer of land within communities. These rules include the common "use it or lose it" principle, which means that whoever farms the land can continue using it, but if they do not cultivate the land in a given year, they can lose their rights, and land will be reallocated to someone else.[2]

In this paper, I study the interaction between weak land property rights and limited access to credit and their effect on aggregate productivity and allocation of resources. My paper has two main contributions. First, I develop a heterogeneous-agent dynamic macro model to quantify the aggregate and distributional impact of land and financial market imperfections. The framework incorporates both financial and land market frictions that are connected via the collateral channel. This novel feature of my model enables me to study the interaction of these two markets in a general equilibrium setting. Moreover, accounting for such interaction is particularly important in the context of low-income country, where a large share of households doesn't have much of financial wealth, but has some land holdings. This implies that a substantial portion of the wealth that can be used for collateral might be locked away as a result of insecurity in land property, amplifying the effect of financial market imperfections. Second, I use household-level data from Tanzania to discipline the model and to show that substantial frictions in both the land and credit markets affect resource allocation and economic efficiency in agriculture in Tanzania. I argue that these imperfections reduce aggregate productivity in the economy by affecting two critical margins: the allocation of factors of productions across households and sectors, and the allocation of households across different occupations.

[1] See Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Restuccia and Rogerson (2013) and Hopenhayn (2014) for the review of the expanding literature on misallocation.

[2] Up to 70 percent of land in some low-income countries has no formal or informal documentation (Figure A1). The percent of communal land in Africa varies from 2 in Rwanda to 97 in Somalia. The statistically significant correlation between land security and level of traditional land suggests that countries with a higher level of communal land feature lower land security (Figure A3).

Empirically, I exploit longitudinal micro data from the Tanzania National Panel Survey (2008-2015), which has a special focus on agricultural production. I use a dynamic panel approach to estimate an agricultural production function. My results imply that agriculture in Tanzania is still mainly labor- and land-intensive and exhibits decreasing returns to scale. I then use these estimates to obtain farmer-level TFP measures. Combining these productivity measures with the variation in land property rights and access to credit both across households and across time, I test for the efficiency of resource allocation. In this setting, efficient land allocation is proportional to the farmer's productivity. Moreover, efficient allocation requires that the relationship between farm size and farmer's TFP is identical across farmers. Consistent with the theory, I find that the amount of land cultivated by the farmer is proportional to his productivity in the data. However, the relationship between land size and productivity is heterogeneous across farmers, and depends on the land property rights regime of cultivated land and access to credit by the farmer. Such results suggest that land is not allocated efficiently, and land misallocation is associated with insecure land property rights and limited access to credit. In addition, I find that households that have titled land are more likely to use credit for agricultural purposes and enjoy a larger loan size conditional on being given one. Finally, there is a link between land property rights and occupational choice. Households with titled land are less likely to stay in agriculture and more likely to operate a non-farm enterprise.

I use these empirical findings to discipline a heterogeneous agent incomplete-markets model that incorporates endogenous saving decisions, occupational choice, and communal land evolution. Agents are heterogeneous in their wealth, productivity levels in agriculture and entrepreneurship, and land holdings under either private or communal property rights. Following the main channels of how property rights affect economic activity described in Besley and Ghatak (2010), I incorporate three distinct land market imperfections for communal land: i) it cannot be rented out, ii) it is subject to expropriation risk if it is not used, and iii) it cannot be used as collateral. On the financial side, borrowing is subject to a limit, which is a function of a household's financial wealth, land holdings, and land property rights. The presence of financial market frictions and the inability to use communal land as collateral prevents households without legal land titles that are poor in terms of financial assets from obtaining a loan.

To quantify the effects of potential improvement in land property rights and access to credit, I calibrate the model to Tanzania and perform three sets of counterfactual exercises. First, I show that an economy-wide land reform that converts communal into private land has a positive effect on agricultural and non-agricultural output as well as total consumption. As a result of the reform, agricultural output increases by 7.4%, driven mainly by higher land utilization and more efficient land allocation across households. Non-agricultural output increases by 8.2% due to higher access to credit and a more efficient allocation of households across occupations.

Land reform leads to changes in labor composition in favor of non-agricultural employment (entrepreneurs and workers), with agricultural employment declining by 8.6%.

I also find that despite substantial welfare gains of land reform for the economy, these gains are not evenly distributed. Welfare gains, measured in consumption equivalent changes, are the highest for those living under weak land property rights regime before the reform. These welfare gains are particularly high for those with a low level of financial assets, significant land holdings, and a high level of entrepreneurial skills. Substantial welfare gains are driven by higher financial inclusion as a result of the reform, especially among the poorest households with limited assets but positive land holdings. On the other hand, large private landholders are the main losers of the reform, suggesting that political economy barriers might prevent or slow the progress of land reform in many low-income countries, despite its potential benefits.

In my second counterfactual, I perform a decomposition analysis of the role played by the three communal land market imperfections. To do that, I look at the general equilibrium impact of a policy change that eliminates only one communal land friction at a time.[3] Each channel has a distinct impact on equilibrium prices and average productivity in each sector. I find that the increase in agricultural output is driven mainly by the ability of communal landholders to rent out their unused land. This increase happens as land is reallocated from less to more productive farmers leading to higher agricultural productivity. In addition, the ability to rent out communal land increases land utilization and therefore results in larger land input in agricultural production. By contrast, the increase in non-agricultural production results from eliminating expropriation risk and the ability to use the land as collateral. Such growth is driven by a larger number of entrepreneurs, as well as by the higher labor and capital inputs of these entrepreneurs.

Third, I compare the aggregate and distributional consequences of land reform with the effects of financial reform. To compute the impact of financial reform, I relax the financial constraint so that the loan to collateral value is equal to the level of an advanced economy. I find that the qualitative impact of financial reform on economic outcomes is the same as the impact of the collateral channel of land reform but differs from land reform as a whole. Moreover, distributional consequences are different. In the case of financial reform, marginal entrepreneurs and large asset owners benefit the most. In contrast, those operating communal land do not benefit as much as in the case of land reform. Finally, land reform leads to a lower level of consumption inequality compared to financial reform. This happens as a large share of welfare winners of land reform is among the poorest part of the population before the reform.

I conclude my quantitative analysis by studying the transitional dynamic triggered by a

[3] Recall, that communal land i) cannot be rented out, ii) is subject to expropriation risk if it is not used iii) cannot be used as collateral.

sudden unexpected land reform that removes all land market frictions. I find that most changes happen in the first ten years after the reform, with a substantial initial increase in agricultural and non-agricultural output. Additional adjustment occurs later in transition driven by changes in prices and level of asset accumulation.

Related Literature. This paper contributes to two main strands of literature. First, I relate to the literature quantifying the importance of misallocation for aggregate outcomes (e.g. Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Bartelsman et al., 2013; Restuccia and Rogerson, 2013; Baqaee and Farhi, 2020), especially in the context of developing countries (e.g. Guner et al., 2008; Banerjee and Moll, 2010; Asker et al., 2011; Oberfield, 2013; Kalemli-Ozcan and Sorensen, 2012; Restuccia and Rogerson, 2017, Bau and Matray (2020)) and with a focus on productivity in the agricultural sector (e.g. Chen, 2017; Adamopoulos et al., 2017; Restuccia and Santaeulalia-Llopis, 2017). Second, it contributes to the literature in macroeconomics using micro data to study macro development issues such as Gollin et al. (2014), Buera et al. (2014), Bick et al. (2016), Santaeulàlia-Llopis and Zheng (2016), Adamopoulos and Restuccia (2020), Buera et al. (2021b) among others.

A large share of the misallocation literature focuses on measuring the effect of all sources of misallocation on aggregate output by exploiting cross-sectional dispersion in marginal revenue products without identifying the underlying sources of the distortions. The contribution of my paper is that I not only show the presence of resource misallocation but also link it to specific market distortions. I also measure misallocation under weaker assumptions than some earlier work. Specifically, I estimate the production function instead of assuming that the U.S. parameters can be applied to an African economy. Additionally, I show that my results are robust to alternative production function specifications.

My findings are consistent with the literature that links land property rights to economic outcomes. de Janvry et al. (2015) document that formal land titling enabled a market-based reallocation through sales and rentals to more productive farmers. Beg (2021) provide the evidence that computerized rural land records in Pakistan result in landowning households being more likely to rent out land and to shift into non-agricultural occupations. Consistent with quantitative results of my paper, Chari et al. (2017) find that a land reform in rural China that allowed farmers to lease out their land resulted in a redistribution of land toward more productive farmers and an increase in agricultural output by 8%.[4]

My paper is most closely related to the growing literature that uses micro data and macro models to study the role of different institutions and policies in structural transformation,

[4]Similarly, Acampora et al. (2022) using results from RCT in Kenya show that induced rentals reallocate land to more entrepreneurial farmers. Other work on land property rights and economic outcomes includes Field (2007), Di Tella et al. (2007), Bromley (2010), Macours et al. (2010), and de Brauw and Mueller (2012).

particularly that focusing on land market institutions. Chen (2017), Adamopoulos et al. (2017), and Restuccia and Santaeulalia-Llopis (2017) use micro data to back out farm-specific TFP and wedges in Ethiopia, China and Malawi, respectively. In all these papers, removing wedges to shift land to more productive farmers brings large gains in aggregate agricultural productivity. Gottlieb and Grobovsek (2019) measure the distortionary impact of land expropriation risk under communal land tenure using dynamic general equilibrium model calibrated to Ethiopia, and find that lifting communal land tenure increases GDP by 9%.[5]

I add to this literature in several ways. First, land market imperfections in my model affect economic outcomes through multiple channels. This allows to perform quantitative analysis of economy-wide land reform that improves property rights and study the implications of different channels of such reform, focusing on each land market friction in isolation. Following the previous literature, I include in the model both the inability to rent out communal land (Chen, 2017) and presence of expropriation risk (Gottlieb and Grobovsek, 2019; Ngai et al., 2019).[6] I also add the third market imperfection – the inability to use land as collateral. Second, this paper includes both financial and land market frictions connected via the collateral channel in a macroeconomic model of growth and development. I show that land market frictions amplify the negative impact of limited access to credit, especially for the poorest part of the population.

At the same time, the presence of financial market imperfections might limit the benefits of land market reform. Indeed, there is mixed empirical evidence on the impact of land titling programs on access to formal credit (Deininger and Chamorro, 2004; Galiani and Schargrodsky, 2010; Zegarra et al., 2011; Piza and de Moura, 2016; Agyei-Holmes et al., 2020). Taken together, the findings of these studies suggest that the efficiency of financial markets should be taken into account when the effects of improvements in land property rights are being quantified, as I do in this paper.

My model also allows studying how land property rights affect entrepreneurship. The majority of the entrepreneurship literature on developing countries explores the effect of only financial frictions and does not take land markets into account.[7] I find that improvement in land property rights leads to higher entrepreneurial activity as a lower risk of expropriation makes moving away from agriculture less costly, while the collateral channel provides access to finance to start or expand a business.

[5]Adamopoulos et al. (2017) find that misallocation of land leads to misallocation of workers across different sectors. Adamopoulos and Restuccia (2020) study land reform in the Philippines and find that imposed ceiling on land holdings reduced agricultural productivity by 17 percent.

[6]Chen (2017) build a two-sector general equilibrium model to quantify the impact of untitled land, which cannot be rented in the market. Gottlieb and Grobovsek (2019) use a general equilibrium selection model with communal land that is subject to expropriation and reallocation as a result of such expropriation. Ngai et al. (2019) incorporate reallocation risk of land in a model of migration.

[7]See Buera et al. (2015) for the literature survey.

2 Empirical Evidence: How Do Land and Financial Markets Affect Economic Outcomes?

In this section, I empirically revisit the evidence that insecure land property rights and limited access to finance directly link to resource misallocation, which in turn affects sectoral and aggregate TFP. I start by estimating production functions and farmer-level TFP measures for the agricultural sector in an East African country, Tanzania. I then show that land market and credit market imperfections generate resource misallocation across and within sectors. These facts guide subsequent modeling choices and are used to inform the quantitative exercise.

2.1 Conceptual Framework

To fix ideas, consider an efficient static allocation in a simple model of farm size and input choice. As in Gollin and Udry (2021), there are n heterogenous farmers producing a single homogeneous good according to the production function:

$$Y_i = e_i A L_i^{\alpha_L} \prod_k X_{k,i}^{\alpha_{X_k}}, \quad \text{with} \quad (\alpha_L + \sum_k \alpha_{X_k}) < 1,$$

where L_i is the amount of land used by a farmer i and the $X_{k,i}$ are other inputs like labor and capital used by this farmer. Individual total factor productivity is equal to $e_i A$, with A being common productivity and e_i is individual farming ability.

In this framework, we can characterize efficient static allocation of land across farmers given a fixed land supply. The efficient allocation maximizes aggregate output and solves the following social planner's problem:

$$\max_{\{L_i, X_{k,i}\}} \sum_i e_i A L_i^{\alpha_L} \prod_k X_{k,i}^{\alpha_{X_k}},$$

$$\text{subject to} \sum_i L_i = L, \ \sum_i X_{k,i} = X_k \quad \forall k.$$

The Pareto efficient allocation requires the marginal product of land to be the same across farmers. The efficient land allocation to farmer i is proportional to his productivity e_i:

$$L_i^* = \frac{e_i^{\frac{1}{1-\alpha_L - \sum \alpha_{X_n}}}}{\sum e_i^{\frac{1}{1-\alpha_L - \sum \alpha_{X_n}}}} L,$$

Hence, $\ln(L_i)^* \propto \ln(e_i)$, implying that farmers with higher farmer ability should operate a farm of larger size. In addition, factor intensity ratios should be identical across farmers. I use this framework to analyze micro data from Tanzania and motivate my empirical exercise.

2.2 Data

I use data from the Tanzania National Panel Survey, which represents panel data gathered in waves from the same households. The first wave was surveyed in 2008-09, the second wave in 2010-11, and the last two waves in 2012-13 and 2014-15. The fourth wave uses a new set of households together with a subsample of households from previous waves. The data were collected with support from the World Bank as a part of the LSMS-ISA project. The survey has regionally representative data for all regions on mainland Tanzania and Zanzibar and covers both rural and urban areas (Figure A4). In addition to demographic and social characteristics of households, the survey includes detailed information on durable goods and financial assets; agricultural production, including land characteristics; and operations of non-farm household enterprises.

I focus on agricultural production at the household level, so the observation unit is a household i in period t. One farmer may operate one or several plots of land. I, therefore, aggregate information available at the plot level to the household level. The dataset contains a panel of about 4,000 households and approximately 3,500 households that were added in the last round of the survey. The share of households involved in farming is around 65 percent.

Output and inputs In my analysis, I focus on the long rainy season. For each household, I construct a measure of agricultural output in a given year. My baseline measure is real agricultural output aggregated at the household level using actual quantities of each crop harvested by the time of interview and proxies of prices in 2012-13 as weights. The prevalence of intercropping, when several crops are cultivated simultaneously on a given piece of land, makes it impossible to measure output in physical quantities. Moreover, households report harvest in different units even for the same type of crop, which requires making some unit-price conversion to make the data comparable across farmers. To construct proxies of prices, I obtain the median price of different units for each crop at the national level, conditional on the crop being sold to someone outside the household.

There are four inputs for which quantitative data are available: land, labor, capital, and usage of chemicals such as fertilizers and pesticides. All plot areas are reported in acres, and I use farmer estimates for plots that were never measured by GPS.[8] In terms of land input, both the size of available land and the size of the land that was cultivated are available. I am using the latter in my empirical analysis. The measure of labor inputs is the total number of person-days used by the household. The survey distinguishes between work done by household members and by hired workers. The measure of capital input includes both chemical inputs, such as fertilizers and pesticides, as well as farm implements and machinery, such as hand hoe

[8]As a default, I use GPS measure of a plot. 63% of all plots in the sample were measured with GPS.

and plough. All types of capital inputs are aggregated at the household level and weighted by the median price of each type of input at the national level in 2012-13. I only use those purchased without a voucher and/or subsidy to compute the median price of chemical inputs. Moreover, some types of chemicals are reported in different units, and in this case, unit-price conversion is used. Capital includes both owned and rented machinery.[9]

Land property rights Several indicators on land tenure are available in the survey. For each plot that the household owns or uses, the following information is available: i) whether a household has any legal document for this plot, and – if the answer is "yes" – what type of document; ii) whether a household has the right to sell it or to use it as collateral; iii) whether a household feels comfortable leaving this plot fallow without the worry of losing it; iv) whether the plot is used or obtained free of charge. Using this information for each plot, I construct four measures of land property rights at the household level as a share of total land that satisfies the respective criterion. Later, I use those measures of land property rights to assess the role of land market frictions in the allocation of resources.

Other variables The survey asks farmers about their agricultural practices, such as the use of other water sources and additional organic inputs, the number of trees on the plot, and whether specific tools are used at different stages of the agricultural process. The survey also provides information on other soil characteristics, including various soil type attributes and soil quality. In addition, I have information on land improvements and investments made by households in the recent past.

Household characteristics The survey data include a detailed description of households and individuals. Data are available on household composition and the age, education, literacy, and health characteristics of each household member; the relationship of each member to the household head; occupational choice of adults within households. In addition, for each household, there are data on different types of assets owned by a household – durable goods; live animals; agricultural tools, and equipment; as well as the outstanding amount of any loans both borrowed and/or lent within one year period from/to any source.

Table A1 in the Appendix presents summary statistics of the main variables used in the analysis. The statistics show that farmers operate small plots, with an average cultivated area of 1.2 hectares. Also, farmers mostly rely on domestic labor – only half of the households hire any workers, and the average share of household labor is more than 90 percent. Finally,

[9]I am using the same price weight for both owned and rented machinery, depending on the type of machinery or tool and not on the ownership status.

agricultural practices are labor-intensive, with almost no capital used and little chemical inputs (e.g., fertilizers, pesticides).

2.3 Agricultural Production Function and Measure of Productivity

To obtain a measure of household productivity, I first estimate the agricultural production function. The main challenge in such an estimation is that input choices are not exogenous to productivity, which is unobserved. While an extensive literature addresses this issue in the context of firms, application to agriculture is more limited.[10] Moreover, the literature on firm production function estimation often makes assumptions that are not appropriate to use in an agricultural setting, especially for a low-income country, such as Tanzania. Many approaches require one or several inputs to be monotonic in productivity, which is not a realistic assumption in a developing country due to the presence of numerous frictions and extensive subsidization of inputs such as fertilizers and seeds. Alternatively, imposing a fixed effect on the law of motion for productivity might lead to attenuation bias, especially in the context of small farmers, where most of the labor consists of household members. In this paper, I use the dynamic panel approach as a preferred method to deal with endogeneity issues making assumptions that are more appropriate in the context of small farmers in a developing country.

Consider the Cobb-Douglas production function

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_n n_{it} + \beta_k k_{it} + \omega_{it} + \varepsilon_{it},$$

where the unit of observation is household i involved in agricultural activity in period t. l, n, and k stand for (log) land, labor and capital inputs, while y is (log) output. There are two terms, ω_{it} and ε_{it}, that are unobserved to the econometrician. However, ω_{it} is known to the farmer when he makes his inputs choices and, therefore, inputs are a function of ω_{it}. Estimating the above equation via OLS leads to biased estimates since more productive farms will use more inputs given that the marginal product of an input is increasing in productivity.

I employ three approaches to production function estimation for comparison purposes. First, I start with simple OLS to estimate the agricultural production function. Second, to account for constant unobserved productivity over time, I add household fixed effects to my OLS regression. In this case, ω_{it} can be thought of as the agricultural ability of a household. This approach relies on the assumption that productivity is constant over time, i.e.:

$$\omega_{it} = \omega_{i,t-1} = \omega_i.$$

[10]Firm level production function estimation literature includes Olley and Pakes (1996), Levinsohn and Petrin (2000), De Loecker (2011), Ackerberg et al. (2015), among others

Moreover, in practice, this approach often results in attenuation in inputs like land that does not change much from year to year. To address these concerns, I use a dynamic panel approach as my third and preferred method. This approach relies on the timing of input choices to estimate coefficients.

Assume ε_{it} is i.i.d. over time and uncorrelated with information set at time t, $\mathcal{I}_{it}$, and ω_{it} is following an AR(1) process:

$$\omega_{it} = \rho\omega_{it-1} + \xi_{it}.$$

Given the law of motion for productivity, we can quasi-difference the production function equation to get the estimating equation:

$$y_{it} - \rho u_{it-1} = (1-\rho)\beta_0 + \beta_l(l_{it} - \rho l_{it-1}) + \beta_n(n_{it} - \rho n_{it-1}) + \beta_k(k_{it} - \rho k_{it-1}) + \xi_{it} + \nu_{it},$$

where $\nu_{it} \equiv \varepsilon_{it} - \rho\varepsilon_{it-1}$. Assuming that ξ_{it} is uncorrelated with $\mathcal{I}_{it-1}$, we can estimate the model using the moment conditions:

$$\mathbb{E}[\xi_{it} + \nu_{it}|\mathcal{I}_{it-1}] = \mathbb{E}\left[(\xi_{it} + \nu_{it}) \cdot \begin{pmatrix} l_{it-1} \\ n_{it-1} \\ k_{it-1} \end{pmatrix}\right] = 0.$$

There are two main issues with the dynamic panel approach. First, the estimation relies on the assumption that changes in land, labor, and capital are correlated with their lagged levels. This assumption fails in a world with perfect markets and without adjustment costs, as inputs are determined by the productivity level irrespectively of their past values. Second, it assumes that farmers have the same information set when they choose each input. Under perfect markets, this implies perfect collinearity between the level of each factor of production. I argue that in a low-income country like Tanzania, various market imperfections allow solving both problems. For example, a limited land market might not allow a farmer to increase land input in case of a positive productivity shock. As a result, the farmer is not able to adjust labor perfectly following his productivity. This implies that the current period labor input will correlate with past labor values and not be perfectly collinear with other inputs. However, such market imperfections rule out a class of structural methods that are often used in the literature in the context of advanced economies.[11]

In addition, unanticipated productivity shocks might change farmers' marginal products after choosing their factors and make the allocation look inefficient even when markets are perfect. To account for possible misspecification, I include indicators for illness, death in

[11] The main assumption of such structural methods is that inputs change monotonically with changes in productivity. Imperfect markets and the inability to freely choose the level of inputs violate this main assumption.

the family, flooding, problems with crop-eating pests, poor rainfall, and low/high prices for agricultural inputs/outputs in the year of farming activity in my estimation of the agricultural production function.

Table 1 presents estimates of the Cobb-Douglas production function at the household level.[12] I show estimates using simple OLS, OLS with household fixed effects, and dynamic panel estimation. In the latter case, I use a minimal distance procedure to estimate restricted coefficients. In all three specifications, I find decreasing returns to scale. This is plausible as farming in low-income countries is labor-intensive, and a large farm and workforce are harder to manage.

Table 1: Production Function Estimates

	OLS	OLS FE	DP
	(1)	(2)	(3)
log(Land)	0.343	0.264	0.299
	(0.015)	(0.026)	(0.071)
log(Labor)	0.404	0.366	0.368
	(0.017)	(0.025)	(0.161)
log(Capital)	0.111	0.051	0.035
	(0.006)	(0.009)	(0.025)
β_l			0.294
β_n			0.412
β_k			0.050
ρ			0.533
Return to scale	0.85	0.68	0.76
Test on common factor restrictions			0.835
# obs.	8,949	6,073	3,641
Unexpected shocks	✓	✓	✓

Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household levels. Regressions include year FE, OLS regressions - district-year FE.

2.4 Market Distortions and Resource Allocation

Around 70 percent of the land in Tanzania is under customary land rights, and 80 percent of the population in rural areas depends on subsistence farming. One of the weaknesses of customary rights is that they are not formally documented. Only a small share of all land in Tanzania has a title or a certificate, which results in a higher risk of land expropriation and the inability

[12]Estimates of the production function without shocks are in Table A6. Results are almost identical to the benchmark specification, suggesting that indeed included shocks were not anticipated. Moreover, the results are statistically identical to the inclusion of district-year fixed effects in all specifications.

to sell the land and use it as collateral. Moreover, historically the overriding principle in many communities is that the land belonged to the tiller. In other words, the land is subject to the principle "use it or lose it."[13]

Limited land markets result in around 15 percent of all plots not being fully utilized. i.e., part or all of the plot is being left fallow. Although leaving land fallow occasionally is required not to exhaust the soil and keep it fertile, most households are not able to cultivate the entire plot due to a lack of other inputs rather than soil considerations. If there was a well-functioning land market, those plots would be sold or rented out. Consistent with this theory, Acampora et al. (2022) find that induced rentals lead to land reallocation towards farmers that use more non-labor inputs relative to land owners.

As a proxy of land property rights, I use four different measures that are related to the existence of formal proof of ownership, perception of expropriation risk in case land is unused, *perceived* ability to sell the land and/or use it as collateral, and whether the land was used/obtained free of charge. Figure 1 displays the distribution of each measure in the sample. While all measures are positively correlated, they reflect different aspects of the land tenure system and are complementary in the analysis. I use all of them to test the presence of incomplete markets and the efficiency of resource allocation.[14]

As discussed in Section 2.1, in the efficient static allocation, the amount of land used by the farmer should be positively correlated with farmer's productivity. Moreover, the relationship between these two variables should be the same for all farmers in an economy with no frictions. In the case when the land market is limited under the customary tenure system, an additional constraint might be present. For example, if households are unable to rent land, they can face

$$L_i \leq \bar{L}.$$

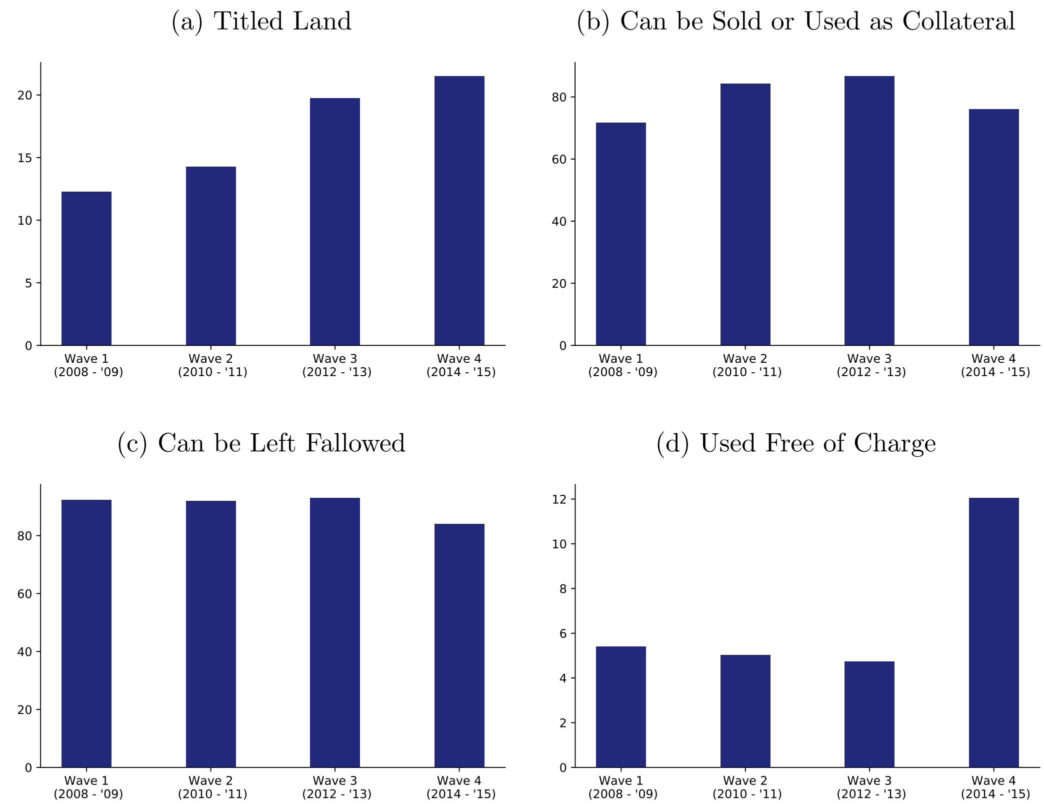
In this case, some households will be constrained with $L^* = \bar{L}$, which is independent of productivity. Hence, the relationship between land and productivity would differ for farmers operating under different property rights regimes. It is also straightforward to show that the relationship is not the same for financially constrained and unconstrained households.

To test the presence of resource misallocation that is associated with insecure land property

[13] More details on the land tenure system in Tanzania can be found in the Appendix B.

[14] Tables A2, A3, A4, A5 in the Appendix present summary statistics for plots under different land property rights for each measure. Statistics are computed for plot and land characteristics, as well as for agricultural practices employed by households on a given plot. For most characteristics, there is no systematic difference between plots under different property rights regimes that is consistent across all measures. The only exception is plot size and whether the soil type is loam. Plots that are under stronger property rights regime are on average larger and are less likely to have loam soil.

Figure 1: Measures of Land Property Rights



Notes: Each plot depicts the share of land that is owned and/or used by a household and (a) the household has a legal document for this land, (b) the owner *thinks* that he has the right to sell land and/or use as collateral, (c) the household feels comfortable leaving this land fallow without the worry of losing it, (d) this land is used/obtained free of charge.

rights and limited access to credit, I use the following baseline regression specification:

$$l_{it} = \phi_0 \ln e_{it} + \phi_1 \left(\ln e_{it} \times Land\_rights_{it}\right) + \phi_2 \left(\ln e_{it} \times Credit_{it}\right) + \delta_{st} + \epsilon_{it},$$

where l_{it} is log of the amount of land used by the farmer i in agricultural production in year t, $\ln e_{it}$ is log of farmer's productivity obtained by computing residual using estimated parameters of the production function, δ_{st} denotes district-year fixed effects to control for things like common weather shocks, and ϵ_{it} denotes the error term. The interaction terms include a measure of land property rights, $Land\_rights_{it}$, which is computed as a share of land belonging to a specified category (e.g., has a title) to the total amount of household's land in a given period t. Additionally, I include an interaction term of productivity and a dummy variable $Credit_{it}$, which is an indicator of whether the household borrowed for agricultural purposes in the past 12 months from any sources.

Table 2 displays the results. The main observation is that there is a positive relationship between the size of land used and productivity. However, this relationship is different for farmers depending on whether cultivated land has strong property rights. Similarly, the relationship is different for farmers who borrowed some resources for agricultural purposes compared to those who did not. Moreover, for some land property rights measures, there is a positive and statistically significant relationship between land size and productivity only in the case of strong land property rights.

Table 2: Land Misallocation

	ln(land)								
		leave fallow		right to sell		title		obtain free	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
HH productivity	0.050	0.014	0.011	0.014	0.011	0.047	0.044	0.057	0.056
	(0.013)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
HH productivity × land_rights		0.044	0.044	0.056	0.056	0.023	0.023	-0.060	-0.059
		(0.004)	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)
HH productivity × credit			0.052		0.050		0.051		0.050
			(0.009)		(0.009)		(0.010)		(0.010)
# obs.	8,939	8,939	8,939	8,939	8,939	8,939	8,939	8,939	8,939
# households	5,095	5,095	5,095	5,095	5,095	5,095	5,095	5,095	5,095
Wave#District FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.290	0.301	0.304	0.319	0.322	0.292	0.295	0.305	0.307

Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household levels. The second row indicates which measure of land property rights is used in the regression analysis.

2.5 Robustness

In this section, I test some of the assumptions that could affect my main empirical findings.

CES production function A possible explanation for the observed misallocation could be that the unity substitution elasticity assumption in the Cobb-Douglas production function is invalid. Although the assumption of a Cobb-Douglas production function is standard in the literature on misallocation, I show that using CES production function also leads to the conclusion that there exists market incompleteness associated with land property rights and access to credit.

Suppose

$$Y_i = e_i \left[\alpha L_i^{-\rho} + \beta N_i^{-\rho} + (1-\alpha-\beta) K_i^{-\rho}\right]^{-\frac{\sigma}{\rho}} ,$$

where σ denotes the return to scale and $\epsilon = \frac{1}{1-\rho}$ is the elasticity of substitution between factors. I assume that e_i is the product of household productivity and time and region fixed effects. Table A9 in the Appendix reports the results of estimation with nonlinear least squares.[15]

In an efficient static allocation, the marginal product of land should be equalized across farmers. I examine whether land property rights and access to credit are sources of variation in MPL across farmers to test whether there exists market incompleteness related to these factors. As evidenced from Table 3, the marginal product of land is higher for farmers that are subject to insecure land property rights and lower for those who did not have a loan. The relationship between the marginal product of the land and land property rights can reflect the fact that in the areas with relatively weak property rights, both rental and final markets for land are absent. At the same time, credit for agricultural purposes is used to buy capital and inputs like fertilizers, and, hence, we observe a positive relationship between credit and MPL.

Table 3: Marginal product of land and market frictions

	ln(MPL)			
	leave fallow (1)	right to sell (2)	title (3)	obtain free (4)
land_rights	-0.196 (0.035)	-0.184 (0.029)	-0.034 (0.045)	0.216 (0.042)
credit	0.403 (0.093)	0.414 (0.092)	0.404 (0.093)	0.410 (0.092)
# obs.	8,925	8,925	8,925	8,925
Wave#District FE	✓	✓	✓	✓

Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household levels.

Variation across time In my baseline analysis, I explore the efficiency of resource allocation using a variation of land property rights both across time and space. By adding household fixed effects to my baseline specification, I exploit whether a positive relationship between land and productivity is present in the data for the transitory part of productivity. In other words, I test whether households adjust the amount of land used in agricultural production when they experience transitory productivity shock and whether there exists any difference in this adjustment depending on the strength of land property rights and access to credit.

Table A10 in the Appendix displays the results. I find a positive relationship between

[15] The ideal estimator is the nonlinear equivalent of the dynamic panel, which applies GMM to the first-difference equation using lagged factors as instruments. Unfortunately, this estimator does not converge.

productivity and land usage only for households who operate land under more secure property rights. These results are consistent with the prediction that inability to rent out or sell the land that is not formally registered or subject to expropriation risk prevents households from making adjustments in the amount of land inputs when they experience productivity shocks.

Factor ratios Finally, in the case of complete markets, variation across farmers in factor ratios would reflect misallocation.[16] Tables A7 and A8 in the Appendix present evidence of different ratios of inputs, first, for households that are subject to different property rights regimes, and, second, for those households that were able and/or willing to obtain a loan for agricultural purposes compared to those that were not. These empirical results suggest that markets are not complete and that market incompleteness is linked to land property rights and access to credit.

3 A Model with Incomplete Land and Financial Markets

In this section, I develop a model that links access to finance, occupational choice, and land ownership. It is a standard occupational choice model with financial frictions but enriched with an additional feature – land ownership, either private or communal.

Time is discrete in the economy. The economy is populated by a continuum of infinitely lived households of measure one indexed by $i \in [0, 1]$. In each time period, a household's state consist of five elements: i) productive skill in the agricultural sector, $z_a > 0$; ii) productive skill in entrepreneurship, $z_e > 0$; iii) endowment of land, $l \geq 0$; iv) property rights regime, $pr = c, p$, either communal or private; v) level of assets, $a \geq 0$. Skills are exogenous and the evolution process is known to a household. Assets evolve endogenously by forward-looking saving behavior.

The total land endowment of land in the economy is L, with a fraction $\lambda_l \in [0, 1]$ being communal (weak land property rights), while the rest is private (strong land property rights). The total and individual levels of private land are fixed and can be used for agricultural production and also can be used as collateral. The total amount of communal land is fixed. However, individual communal land holdings evolve endogenously due to the presence of expropriation risk, and communal land is neither allowed to be rented out nor used as collateral.

[16] This statement generalizes to any homothetic production function.

3.1 Setup

Preferences Individual preferences are described by the following expected utility function over sequences of consumption, c_t:

$$U(c) = \mathbb{E}_t \left[\sum_{t=0}^{\infty} \beta^t u(c_t) \right], \text{ where } u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma},$$

where β is the discount factor, and σ is the coefficient of relative risk aversion.

Occupational Choice At the beginning of each period, a household chooses whether to operate their own business, become a worker, or cultivate a farm. Firms and the agricultural sector produce a single final good. Each firm is run by one entrepreneur, who produces the good using as inputs his entrepreneurial ability, labor, and capital. Each farm is run by one farmer, who produces the good using his productivity in the agricultural sector, land, and capital as inputs.[17] All occupational choices are mutually exclusive within a period t. There is no cost of switching between occupational choices across periods.[18]

Land and Financial Markets Agents have access to a perfectly competitive financial intermediary who receives deposits from households and makes loans to farmers and entrepreneurs. The deposit rate r_t is determined endogenously by the capital market clearing condition at period t. Households use loans to finance capital. Competitive financial intermediation implies that loan contracts are paid at the gross interest rate, $r_t^k = r_t + \delta$, where δ denotes the depreciation rate of capital. Also, there is a competitive intermediary that collects all leased land and then rents it out at rate r_t^l.[19]

Financial markets are incomplete in several dimensions. First, no state-contingent bonds can be purchased. Hence, there is no opportunity to insure against productivity risk. Second, I do not allow borrowing for consumption smoothing across periods by imposing $a_t \geq 0$, therefore entrepreneurs and farmers only can borrow within periods to finance production. Third, similar to Jermann and Quadrini (2012) and Mendoza (2010), I assume that there is a cash flow

[17] I abstract from hired labor input and assume that labor input is embedded in agricultural household productivity, z_a. This is not a strong assumption, given that household members supply the majority of agricultural hours in Tanzania as is shown in Table A1 in the Appendix.

[18] This assumption allows to avoid carrying additional state variable and is common in literature on entrepreneurship and development (For a summary see Buera et al., 2015).

[19] In the benchmark version of the model, land holdings are fixed for each household. Households are able to adjust the amount of land used in the production only by renting. In terms of allocation of land across farmers, the rental market is equivalent to the ability of households to buy or sell land. At the same time, the introduction of the market for land purchases will incentivize households to use the land as a saving tool. This additional mechanism would complicate the model substantially, and it is outside of the scope of this paper. In addition, the model is consistent with the limited land market in Tanzania, with most land being rented.

mismatch, such that the amount of capital that exceeds the current level of assets owned by the household must be financed in advance of production. Thus, households need to borrow intraperiod to finance capital. However, the total amount of borrowing is limited by a collateral constraint due to the limited enforceability of debt contracts. A novel ingredient in my model is that in addition to assets, titled land can also be used as part of the collateral.

Consider a household with wealth a_t and land holding l_t that is asking for a loan x_t from a financial intermediary at rate r_t^k. Once a loan is obtained, the household transforms it costlessly together with assets (but not land, which is used as an input in farmer's production) into capital $k_t = a_t + x_t$. Together with land holdings, the capital is then used as collateral to secure the loan x_t. The household is free to default and walk away with his income and wealth at any time. In this case, collateral will be seized. I assume that the liquidation value of capital is uncertain at the time of contracting, similar to Jermann and Quadrini (2012). With probability $(1 - \frac{1}{\lambda_k})$, where $\lambda_k \geq 1$, intermediary recovers the full value of collateral, $k_t + q_t^l l_t$, where q_t is the shadow price of land. However, it recovers nothing with probability $\frac{1}{\lambda_k}$. Hence, the amount of loan x_t that intermediary is willing to provide is limited to $x_t \leq (1 - \frac{1}{\lambda_k})(k_t + q_t^l l_t)$.[20] The household's capital constraint in terms of his wealth and land holdings is then:

$$k_t \leq \lambda_k(a_t + q_t^l l_t) - q_t^l l_t$$

The parameter λ_k measures the degree of credit frictions, with $\lambda_{k,l} = +\infty$ corresponding to a perfect credit market and $\lambda_k = 1$ to financial autarky where all capital is self-financed. This captures the common prediction from models with limited contract enforcement: credit is limited by an individual's wealth.

The land market is incomplete in the part of the economy with weak property rights. Land under customary tenure regime cannot be rented out and used as collateral. Land market imperfections amplify financial market frictions by making collateral constraint tighter:

$$k_t \leq \lambda_k(a_t + q_t^l l_{t,\mathbb{I}\{land=private\}}) - q_t^l l_{t,\mathbb{I}\{land=private\}}$$

That is, the collateral value of land only appears if land is private.

Evolution of communal land I assume that the communal land that belongs to the household brings zero value if not used. Moreover, communal land that is not used in the current period is subject to expropriation risk with some positive probability, π_E. This means, that

[20] q_t^l is the shadow price of land in consumption units, and is defined as the present value of its expected future income flows in terms of the consumption numeraire. This means that there is endogenous general equilibrium effect on the tightness of collateral constraint, as q_t^l is directly linked to the rental rate of land, r_t^l.

$\pi_E > 0$, if $l_{i,\mathbb{I}\{land=communal\}} - l_i^d > 0$, where l_i^d is farmer's land input. In addition, I assume that expropriation probability is independent of any other household characteristics.

Expropriated communal land is reallocated to other households via a lump-sum transfer η_t, which is endogenous. I assume that the reallocation probability π_R is positive for households that engage in farming in the current period and zero otherwise. Similar to π_E, I assume that reallocation probability and the value of a lump-sum transfer η_t are independent of any other household characteristics.[21]

3.2 Household Problem

The state vector consists of level of wealth, amount of land owned, property rights regime, entrepreneurial ability, and agricultural productivity, $s_{it} \equiv (a_{it}, l_{it}, z_{it}^a, z_{it}^e, pr_i)$. I proceed in two steps to characterize the household problem. First, I write the household value function as the maximum across the value function conditional on occupational choice,

$$V_t(s_{it}) = \max \left\{ V_t^{Worker}(s_{it}), V_t^{Entrepreneur}(s_{it}), V_t^{Farmer}(s_{it}) \right\}.$$

Second, I consider the value function for different occupational choices, conditional on the property rights regime.

Households under private property rights regime Let $x_{it} \equiv (a_{it}, l_i, z_{it}^a, z_{it}^e)$,[22] then the problem of households is the following:

$$V_t(x_{it}) = \max_{c_{it}, a_{it+1}, k_{it}^{o\in\{E,F\}}, n_{it}^{o\in\{E\}}, l_{it,d}^{o\in\{F\}}} \frac{c_{it}^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_t[V_{t+1}(x_{it+1}|x_{it})]$$

subject to the budget constraint

$$c_{it} + a_{it+1} \leq y_{it}^o + r_t^l l_i + (1 + r_t) a_{it},$$

the within period capital borrowing constraint (collateral)

$$k_{it} \leq \lambda_k a_{it} + (\lambda_k - 1) q_t^l l_i, \quad o \in \{Entrep, Farmer\},$$

[21] I assume that π_R is constant across time, and η_t depends on the amount of expropriated land and households' occupational choice. Alternately, η can be fixed as in Ngai et al. (2019), implying $\pi_{t,R}$ to equalize expropriated and reallocated land. In their paper, Gottlieb and Grobovsek (2019) focus on the expropriation risk of communal land and model both η and π_R as state dependent variables.

[22] The amount of private land that household owns is fixed. In the model, I focus on the rental market as sale and purchase of land remain rare in Tanzania, with most land being inherited or allocated by local authorities.

and the across periods borrowing constraint

$$a_{it+1} \geq 0.$$

y_{it}^{o} for each occupational choice is given by

$$\begin{aligned} y_{it}^{Entrep} &= z_{it}^{e} k_{it}^{\alpha_e} n_{it}^{\gamma_e} - w_t n_{it} - r_t^k k_{it}, \\ y_{it}^{Worker} &= w_t, \\ y_{it}^{Farmer} &= z_{it}^{a} k_{it}^{\alpha_a} (l_{it}^{d})^{\gamma_a} - r_t^k k_{it} - r_t^l l_{it}^{d}. \end{aligned}$$

Farmer under communal land property rights regime For households living in the communal part of the economy, the amount of land endogenously evolves across periods. Given that communal land cannot be rented out and production function is increasing in land, farmers in the communal part of the economy would never use less land in production than their land holdings or leave some land fallow. Therefore, for farmers communal land is never subject to expropriation risk.

Letting $x'_{it} \equiv (a_{it}, l_{it}, z_{it}^{a}, z_{it}^{e})$, the household problem for a farmer is:

$$\begin{aligned} V_t^{Farmer}(x'_{it}) = & \max_{c_{it}, a_{it+1}, k_{it}, l_{it}^{d}} \frac{c_{it}^{1-\sigma}}{1-\sigma} + \\ & + \beta \left\{ \pi_R \mathbb{E}_t[V_{t+1}(x'_{it+1}, l_{it+1} = (l_{it} + \eta) | x'_{it})] + (1 - \pi_R) \mathbb{E}_t[V_{t+1}(x'_{it+1}, l_{it+1} = l_{it} | x'_{it})] \right\} \end{aligned}$$

subject to the budget constraint

$$c_{it} + a_{it+1} \leq y_{it} + (1 + r_t) a_{it},$$

the within period capital borrowing constraint (collateral)

$$k_{it} \leq \lambda_k a_{it},$$

and the across periods borrowing constraint

$$a_{it+1} \geq 0.$$

y_{it} for the farmer is:

$$y_{it}^{Farmer} = z_{it}^{a} k_{it}^{\alpha_a} (l_{it}^{d})^{\gamma_a} - r_t^k k_{it} - r_t^l (l_{it}^{d} - l_{it}) \mathbb{I}_{\{l_{it}^{d} \geq l_{it}\}}.$$

Entrepreneur and worker under communal land property rights regime Workers and entrepreneurs in the communal part of the economy do not use land in production. Therefore, their entire land holdings are subject to expropriation risk. Their problem is:

$$V_t^{o\in\{Entrep,Worker\}}(x'_{it}) = \max_{c_{it},a_{it+1},k_{it}^{o\in E},n_{it}^{o\in E}} \frac{c_{it}^{1-\sigma}}{1-\sigma} \quad + \\ + \beta\left\{\pi_E \mathbb{E}_t[V_{t+1}(x'_{it+1}, l_{it+1}=0|x'_{it})] + (1-\pi_E)\mathbb{E}_t[V_{t+1}(x'_{it+1}, l_{it+1}=l_{it}|x'_{it})]\right\}$$

subject to the budget constraint

$$c_{it} + a_{it+1} \leq y_{it}^o + (1+r_t)a_{it},$$

the within period capital borrowing constraint (collateral)

$$k_{it} \leq \lambda_k a_{it} \quad o \in \{Entrepreneur\},$$

and the across-period borrowing constraint

$$a_{it+1} \geq 0.$$

y_{it}^o for each occupational choice is

$$y_{it}^{Entrep} = z_{it}^e k_{it}^{\alpha_e} n_{it}^{\gamma_e} - w_t n_{it} - r_t^k k_{it},$$
$$y_{it}^{Worker} = w_t.$$

3.3 Market Clearing

Let $\mathcal{F}_t(a, l, z^a, z^e, pr)$ denote the joint distribution of wealth, land ownership, property rights regime, and agricultural and entrepreneurial productivity at time t over all households.

The labor market clearing condition is:

$$\int_{e=entrep} n_t d\mathcal{F}_t(a, l, z^a, z^e, pr) = \int \mathbb{I}\{e = worker\} d\mathcal{F}_t(a, l, z^a, z^e, pr).$$

That is, labor demand by entrepreneurs should be equal to the labor supply of workers to a wage job.

The land market clearing condition is:

$$\int l_{\mathbb{I}\{land=rent\_out\}} d\mathcal{F}_t(a, l, z^a, z^e, pr = private) = \int_{e=farmer} l_{\mathbb{I}\{land=rent\_in\}} d\mathcal{F}_t(a, l, z^a, z^e, pr)$$

The total amount of private land that is rented out should be equal to the amount of land rented in by farmers.

Also the amount of communal land that is reallocated should be equal to the amount of land that is expropriated:

$$\int l d\mathcal{F}_t(a, l, z^a, z^e, pr = communal) = \lambda_l L.$$

The capital market clearing condition is:

$$\int a_t d\mathcal{F}_t(a, l, z^a, z^e) = \int_{e=entrepreneur,farmer} k_t d\mathcal{F}_t(a, l, z^a, z^e).$$

The total supply of assets should be equal to the capital demand by entrepreneurs and farmers.

3.4 Competitive Equilibrium

Given an initial distribution of state variables $\mathcal{F}_t(a, l, z^a, z^e, pr)$ and a sequence of wages, interest rate of capital and land, and communal land reallocation $\{w_t, r_t^k, r_t^l, \eta_t\}_{t=0}^{\infty}$, a competitive equilibrium is given by a sequence of allocations $\{c_t(s), a_t(s), k_t(s), n_t(s), l_t^d(s)\}_{t=0}^{\infty}$ and occupational choices $\{e_t(s) = \{Worker, Entrepreneur, Farmer\}\}_{t=0}^{\infty}$ such that (i) households maximize utility by solving value function maximization problem subject to budget constraint, within and across periods borrowing constraints, (ii) the financial intermediary sector makes zero profits, $r_t^k = r_t + \delta$ and (iii) there is market clearing in the labor market, capital market, and land market.

Stationary competitive equilibrium In addition, a stationary competitive equilibrium requires that the joint distribution of state space is a fixed point of the equilibrium mapping and that prices are constant over time.

$$\mathcal{F}(a, l, z^a, z^e, pr) = \mathcal{F}_t(a, l, z^a, z^e, pr) = \mathcal{F}_{t+1}(a, l, z^a, z^e, pr)$$

and

$$w_t = w, \quad r_t^k = r^k, \quad r_t^l = r^l, \quad \eta_t = \eta$$

I focus on a stationary competitive equilibrium when performing counterfactual exercises.

Computational Algorithm For a given set of parameter values, the solution algorithm involves first guessing a steady state prices, w, r^k, r^l, η. Given the prices, solve the policy functions for each set of state variables by value function iteration. Given the policy functions, find the stationary distribution. Check whether market clearing conditions are satisfied and update the guess of prices if needed. More details in the Section C in the Appendix.[23]

4 Model Calibration and Underlying Mechanism

In this section, I present results from numerical exercises with the model. I start my analysis by calibrating the model to the economy of Tanzania. Then, I show how a household's wealth, land ownership, and productivity determine their occupational choices and land usage decisions under different property rights regimes. This helps to illustrate how land property rights affect different people in different ways.

I use the calibrated model to conduct experiments to assess the effect of improvement in land property rights by moving from the economy with a positive share of land under the customary tenure system to the economy with only modern private land property rights. I first document the impact of such policy on a number of aggregate variables, like productivity and prices. Then, I decompose the effect of full-fledged land reform on the various channel by removing only one land market friction at a time and exploring the general equilibrium impact of such an experiment. In my third exercise, I use the model to compare the aggregate effect of financial reform relative to land reform by setting the parameter that governs the degree of financial friction to the level of an advanced economy. Finally, to analyze the short-run implication of land reform, I look at the transition path of the model economy from the initial steady state to a steady state after land reform took place.

4.1 Calibrating the Model to the Tanzanian Economy

The model has 15 parameters for which I need to specify values. Some of the parameters are standard in the literature, others recovered from the analysis of the data available for Tanzania. The remaining set of parameters is calibrated to match aggregate moments jointly. In addition to Household Panel Survey, I use the World Bank's Enterprise Survey and World Development Indicators to discipline the financial part of the model. All the data are for the period 2012-13.

Access to finance The use of bank financing by firms in Tanzania is still limited by international standards. According to the World Bank's enterprise survey, only 18% of firms used

[23] Given the dimensionality of state space and occasionally binding constraints, I use the computational resources provided for the Quest high-performance computing facility at Northwestern University.

banks to finance investment, and around 17% of firms had a loan or a line of credit from a bank. From a list of fifteen items proposed in the same survey, respondents were asked to rank the most significant obstacle faced by the firm for its day-to-day operations. 38% of firms reported access to finance to be the biggest obstacle.

Excessive reliance on internal funds is a sign of potentially inefficient financial intermediation. Such inefficiencies are often reflected in a high value of collateral needed for a loan relative to the loan's value. According to the World Bank's enterprise survey, the level of this parameter in Tanzania is almost 250%, which is higher than the average value in low-income countries and Sub-Saharan Africa. Such a high collateral value accompanied by a low level of assets among households results in very limited access to finance. According to the model, private landholders can still get access to credit even when their financial assets are low by using land as collateral. This model feature is supported by the data on the land titling program in Tanzania. Based on information on one of the largest titling projects, Mkurabita, at least US$2.2 million had been loaned to some of the 110,000 villagers who obtained occupancy certificates under Mkurabita (Schreiber, 2017). Data from another project also suggests that households used their documented land to get credit.

Productivity Productive skills of households are exogenous, independent from each other, and the evolution process is known to a household. Specifically, the logarithm of productive skills for each sector $s \in \{a, e\}$ follows a first-order autoregressive process

$$z_{s,t} = \rho z_{s,t-1} + \varepsilon_{s,t},$$

where $|\rho| < 1$ is the persistence in productivity and $\varepsilon_{s,t}$ is a white noise process with variance $\sigma^2_{\varepsilon,s}$, which represents idiosyncratic risk component.

Technology Entrepreneurs produce with a production function that combines entrepreneurial productive skill z^e, capital, and labor. The production function is increasing in all the arguments, strictly concave in capital and labor, and has a decreasing return to scale. In particular,

$$f(z^e, k, n)^e = \exp(z^e)(k^{\alpha_e} n^{1-\alpha_e})^{1-\nu},$$

where $0 < 1 - \nu < 1$ is the span of control as in Lucas (1978). Similarly, the agricultural production function combines agricultural productivity skill z^a, capital and land with coefficient α_a and γ_a obtained from the agricultural production function estimation.[24]

[24] Labor input is not explicitly modeled but instead embedded in z^a as almost all agricultural labor is coming within the household in the data. The production function is described by $f(z^a, k, l)^a = \exp(z^a) k^{\alpha_a} l^{\gamma_a}$.

Communal Land Evolution I use simple functional forms for π_R and π_E. $\pi_E \in (0, 1)$ if the fraction of land used by the household is smaller than land holdings,[25] and zero otherwise. $\pi_R \in (0, 1)$ if household decides to stay in agriculture in the current period,[26] and zero otherwise.

Parameters invariant over time and across economies The model is calibrated to a period of one year. I set the risk-aversion parameter $\sigma = 1.5$, and the one-year depreciation rate δ is set to 0.06 following Buera et al. (2021a). The aggregate income share of capital for entrepreneur α_e is set to 0.33.

Parameters derived from the data Agricultural productivity is following AR(1) process in logs with persistence ρ_a and normal innovations with variance σ_a^2. Using the results from agricultural production function estimation, the autocorrelation coefficient, ρ_a, is set to be 0.533. I make a similar assumption about the productivity process for entrepreneurs, which is independent of the agricultural productivity process. To measure the autocorrelation coefficient, $\rho_e = 0.262$, I use values for net average monthly profit during the months when a non-farm enterprise is operating from the Household Panel Survey.

I set the share of communal land to be $\lambda_l = 80.7$ percent of total land, which is the share of households' land that does not have any official document that can prove ownership in years 2012-2013. I assume that the probability of land expropriation is constant for those households that decide to leave their land uncultivated. The share of land under weak property rights that cannot be left fallow without risk of expropriation identifies parameter $\pi_E = 9\%$.

Parameters calibrated by matching moments I have six remaining parameters, which are calibrated to match relevant moments shown in Table 4: the annual real interest rate; the share of hired workers, farmers, and entrepreneurs; and the distribution of land across households. The key parameter that captures financial frictions, $\lambda_k = 1.416$, is calibrated to match the average value of collateral needed for a loan as a percent of the loan amount, which is equal to 240.2% in Tanzania. Based on the data from Enterprise Survey, 96.2% of loans are collateralized, which is consistent with the model that assumes that all loans require collateral.

Untargeted Moments I also look at whether the model matches non-targeted measure of consumption inequality. Although consumption inequality in the model is slightly lower compared to the data, the overall pattern is similar (Figure A6). In addition, the model

[25]This means that only households that choose to be workers or entrepreneurs are subject to positive expropriation risk of land as those who are farmers would never decide to use less land than land holdings in equilibrium (production function is increasing in land; communal land can not be rented out).

[26]I also assume that for the households with $l_i = \max(l_i)$, reallocation probability is equal to zero, or $\pi_R = 0$. This assumption is made for computational reasons.

Table 4: Calibration

Target Moment	Data	Model	Parameter	Description
Real interest rate (%)	3.8%	3.75%	$\beta = 0.813$	Discount factor
Share of hired workers (% of empl.)	20.5%	20.5%	$\nu = 0.535$	Span of control
Share of farmers (% of empl.)	61.0%	61.1%	$\sigma_a = 0.09$	S.d. of prod. shock (agriculture)
Share of entrepreneurs (% of empl.)	18.5%	18.4%	$\sigma_e = 0.75$	S.d. of prod. shock (entrepreneurship)
Land distribution		Figure A5	$\pi_R = 0.13$	Probability of reallocation
Collateral/loan value	240.2%	240.4%	$\lambda_k = 1.416$	Tightness of collateral constraint

matches well the level of land utilization, which is 88% in the data, and in the model it is 92%. Finally, I provide additional evidence that model predictions are consistent with the data when discuss mechanics of the model in the next section.

4.2 Discussion on the Mechanics of the Model

Using the baseline calibrated model, I compare household choices for the part of the economy that operates under customary land property rights with the part that operates under the modern property rights regime. Specifically, I describe how customary land tenure affects the economy through two channels: land misallocation and distortions in occupational choice.[27] I then compare the predictions of my model with the outcomes I observe in the data.

Land property rights and land misallocation Efficient allocation requires that the amount of land that the farmer uses is proportional to his productivity. However, the presence of markets distortions leads to the misallocation of inputs of production. First, financial frictions result in inefficient land usage for farmers both under modern and customary land tenure for financially constrained farmers. The reason for such inefficiency is that farmers are not able to obtain an efficient amount of capital and, hence, use the efficient amount of land.

Second, the presence of land market frictions leads to either over-usage or under-usage of land by farmers subject to these frictions. Figure 2 documents the ratio of farmer's operational land in the part of the economy without land frictions and the part of the economy with land frictions given different households characteristics. Under-usage of land is driven by the inability to use the land as collateral to finance the optimal amount of capital, which leads to a lower amount of both capital and land used by the farmer. This effect is the most pronounced for households with high agricultural productivity, low level of financial assets, and an amount of land holding that is positive but smaller than the efficient amount of land.

[27] Recall, that there are three main differences between the two property rights regimes: i) customary land is subject to expropriation risk in case it is not used, ii) customary land cannot be rented out, and iii) customary land is not allowed to be used as collateral to finance capital.

Proposition 1. *Denote optimal choices of land used by farmers who own the land under communal and private property rights regimes as* l_c^* *and* l_p^**, respectively. Then, if optimal land usage is larger than household land holding,* $l_p^* > l_p$*, and farmers' initial conditions in private and communal sectors of the economy are the same (i.e., the same amount of land, skills, and assets):*

$$l_c^* \leq l_p^*,$$

and for assets holdings $a_{small} < a_{large}$*, given everything else the same, the following is true*

$$l_p^*(a_{small}) - l_c^*(a_{small}) \geq l_p^*(a_{large}) - l_c^*(a_{large}),$$

and for levels of agricultural productivity $z_{small} < z_{large}$*, given everything else the same, we have*

$$l_p^*(z_{small}) - l_c^*(z_{small}) \leq l_p^*(z_{large}) - l_c^*(z_{large}),$$

and for levels of land holdings $l_{small} < l_{large}$*, given everything else the same, we get:*

$$l_p^*(l_{small}) - l_c^*(l_{small}) \leq l_p^*(l_{large}) - l_c^*(l_{large}).$$

Proof See Appendix D.

While under-usage is mainly driven by the inability to use the land as collateral, over-usage results from the inability to rent out land under customary tenure. Given that households that operate customary land do not receive any income if they decide not to use the land and the agricultural production function is increasing in land, they always prefer to operate the entire land holding. The effect will be the most pronounced for households with low agricultural productivity and large land holdings.

Proposition 2. *Denote optimal choices of land used by farmers who own the land under communal and private property rights regimes as* l_c^* *and* l_p^**, respectively. Then, if optimal land usage is lower than household land holding,* $l_p^* < l_p$*, and farmers' initial conditions in private and communal sectors of the economy are the same (i.e., the same amount of land, skills, and assets):*

$$l_c^* \geq l_p^*,$$

and for the levels of agricultural productivity $z_{small} < z_{large}$*, given everything else the same*

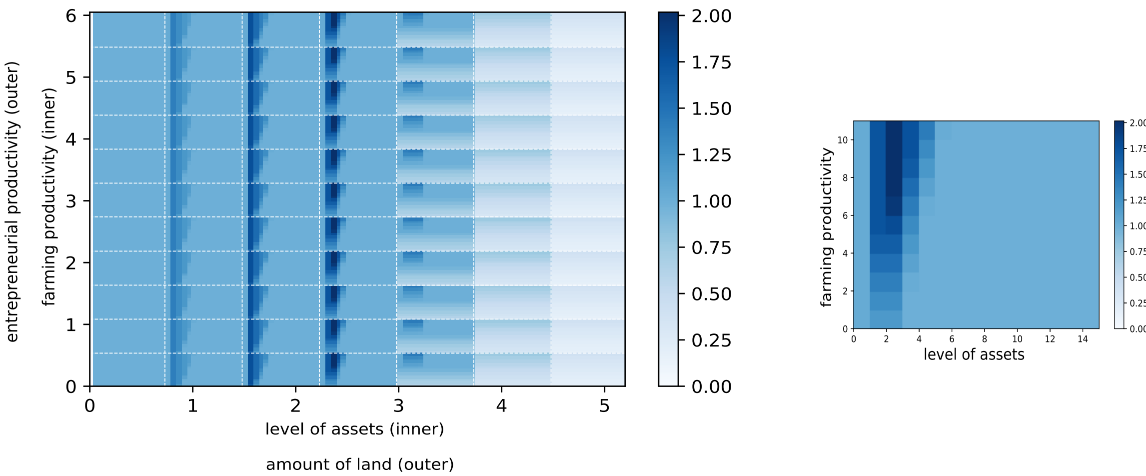
$$l_c^*(z_{small}) - l_p^*(z_{small}) \geq l_c^*(z_{large}) - l_p^*(z_{large}),$$

and for the levels of land holdings $l_{small} < l_{large}$, given everything else the same, we get:

$$l_c^*(l_{small}) - l_p^*(l_{small}) \leq l_c^*(l_{large}) - l_p^*(l_{large}),$$

Proof See Appendix D.

Figure 2: Land Misallocation: Ratio of Land Usage by Farmers with Private Land Relative to Farmers with Communal Land



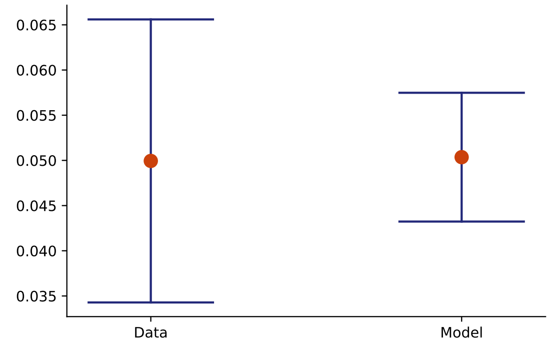
Notes: The right panel is a zoomed-in inner cell on the left (white dashed lines separate cells).

To verify that model predictions are consistent with the data, I replicate empirical analysis in Section 2.4 with simulated model data. Figure 3 compares the relationship between the amount of land operated by the farmer and his productivity observed in the data and reported in Column (1) of Table 2 and the one obtained using the simulated data from the model. As shown in the picture, points estimates of regression coefficients are almost identical. Moreover, consistent with empirical results in Column (6) of Table 2, coefficient is 48.8% higher for farmers with titled land when use simulated model data.[28]

Land property rights and occupational choice Figure 4 documents occupational choices in parts of the economy under different land property rights regimes. In a frictionless world, households will choose their occupation based on the level of productivity in each sector. Similar to land misallocation, the presence of financial frictions distorts occupational choices for those households that are financially constrained irrespective of their land property rights regime. When the level of assets limits capital financing, those with high agricultural productivity might choose to become workers, and those with high entrepreneurial productivity might either stay in farming, which is less capital intensive, or become workers.

[28] I remove from the sample the large land owners as outliers.

Figure 3: Land and Productivity Relationship: Data vs Model



Notes: Model regression includes the level of assets, land holdings, and entrepreneurial productivity as controls and is conditional on household decide to choose agriculture for employment. The vertical lines show 95% confidence intervals.

Land market imperfections would also lead to distortions in occupational choice in favor of farming, mainly through collateral and expropriation risk channels. The presence of expropriation risk prevents households from moving from farming to other sectors of the economy. The threshold of agricultural productivity when a household decides to move from agriculture to another occupation is much lower for those living under customary tenure relative to private tenure for all levels of assets and land. The risk of losing land in the next period and the probability of receiving the lump-sum land transfer incentivize households with relatively low agricultural productivity to remain in farming. Moreover, the agricultural productivity threshold goes down as the size of the owned land increases and, hence, potential land loss in case of expropriation. In the modern part of the economy, the agricultural productivity threshold is independent of the size of land owned by the household when their financial constraint does not bind.

Moving from worker or farmer to entrepreneur is limited by the collateral channel. Households with a low level of financial assets but sizable land holdings can finance their capital using land as collateral if their land is under a modern tenure system. This allows them to start their own business and switch to entrepreneurship. This option is not available for households whose land is under the customary system, so they are forced to stay in agriculture or become workers.

Finally, the inability to rent out your land leads to lower non-occupational income compared to the modern property rights regime, making non-agricultural occupations less attractive.

To further validate model predictions, I examine empirically whether there exists any association between land property rights and different household characteristics. Table 5 reports the results of this exercise. Consistent with the main model mechanism, I find that households with titled land are more likely to rent out the land, potentially due to lower expropriation risk. Households that have an official document for their land are not only more likely to obtain

Figure 4: Occupational Choices

credit in the last 12 months but also enjoy a larger loan size conditional on being given one. Since in every regression I include household fixed effects, such a relationship can be explained by the collateral channel. Suggestive evidence that supports this theory is the fact that in the year 2014/2015 around 49.2 billion shillings had been issued as loans by various financial institutions, using Certificates of Customary Rights as collateral (URT (2016)).

Table 5: Land property rights and other household characteristics

	Dependent variable					
	rent out land (1)	obtained credit (2)	size of a loan (3)	operate a business (4)	head of HH in agriculture (5)	hours in agriculture (6)
land_rights	0.015	0.028	0.574	0.023	-0.037	-0.033
	(0.006)	(0.011)	(0.214)	(0.014)	(0.017)	(0.009)
# obs.	7,874	11,752	448	11,752	11,752	11,752
Household FE	✓	✓	✓	✓	✓	✓

Notes: Robust standard errors (in parentheses) are two-way clustered at the household and district levels. Logarithm of loan size is used as dependent variable in Column (3), share of household's working hours spent for farming used in Column (6), and respective dummy variables are used for all other regressions. I use the share of titled land owned by the household as a main regressor, *land_rights*. Regressions with dependent variable on occupation or presence of business also include dummy variable indicating whether HH owns a plot.

Finally, I test whether the same patterns are observed in the data and in the model in terms of occupational choices of households. As in the model, households with titled land are less likely to stay in agriculture (as an occupation of the head and as a share of household's total working hours) and more likely to operate a business. In addition, model predicts that, everything else equal, household with larger land is more likely to remain in agriculture due to larger losses in case of land expropriation. As shown in Table A11 in the Appendix, similar to the model, I observe in the data that households with larger land holdings are more likely to stay in agriculture but only in the case when land is untitled.

5 The Effect of Policy Interventions in Estimated Model

I now present a quantitative exploration of the aggregate and distributional impact of improvements in land property rights by moving from the economy with different tenure regimes, customary and modern, to an economy with only private land. In the model, customary land differs from private land in three different ways: i) it cannot be rented out, ii) it cannot be used as collateral, and iii) it is subject to expropriation risk. To better understand the impact of each channel on the economy, I conduct a set of experiments, where I remove only one type of friction at a time and explore the general equilibrium effects. I also compare the impact of land reform and financial reform, and finally, I look at the transition path of the model economy from the initial steady state to a steady state after land reform took place.

5.1 General Equilibrium Impact of Land Reform

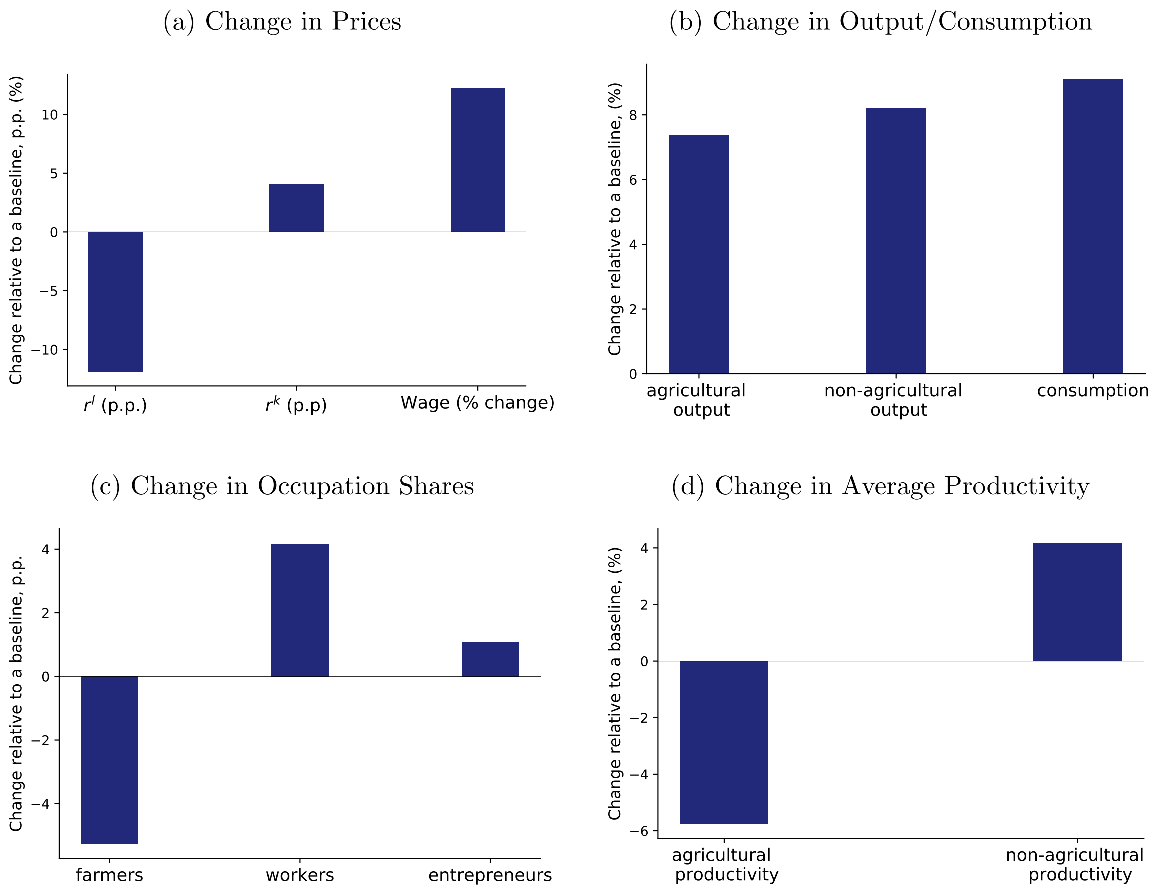
Figure 5 presents the long-run general equilibrium effect of a land reform that transforms all communal land to private land. The four panels compare economic outcomes of the baseline calibrated economy with 80 percent of communal land and the economy after land reform. The impact of land reform is positive for both agricultural and non-agricultural output, as well as welfare, measured by real consumption. Moreover, it leads to a smaller share of labor remaining in agriculture and more entrepreneurs.

The top left panel documents changes in prices. An increase in the real interest rate is due to increased demand for capital as the budget constraint is relaxed for land owners under customary tenure before the reform. At the same time, the ability to rent out land results in higher land utilization and a drop in the rental rate of land. Finally, a wage increase is driven by increased demand for labor from entrepreneurs due to the higher amount of capital used as well as higher levels of entrepreneurship. At the same time, both farming and entrepreneurship become more attractive, putting pressure on the supply of workers and, hence, pressure on wages.

The left bottom panel presents the impact of land reform on labor shares for each occupation. Despite lower input price of land and, hence, higher attractiveness of agriculture, farmers' share in the economy decreases by 8.6%. A substantial increase in wage and absence of expropriation risk leads to an increase in the share of workers, while more relaxed collateral constraints increase entrepreneurship by 5.8%.

Output, both agricultural and non-agricultural, increases, as well as consumption. An increase in agricultural output by 7.4% is driven by higher land utilization and more efficient land allocation across farmers. Although the average agricultural skill of a farmer decreases, aggregate agricultural productivity measured by output per farmer increases by 17.5%.[29] Non-agricultural output increases by 8.2% due to both higher levels of inputs, labor and capital, and level of average entrepreneurial skill. Moreover, consumption increase is more significant than the increase in total output due to a lower level of households' savings driven by higher financial inclusion and better allocation of capital across households.

Figure 5: The Effects of Land Reform



(a) Change in Prices

(b) Change in Output/Consumption

(c) Change in Occupation Shares

(d) Change in Average Productivity

Notes: Plot (d) depicts the change in average productivity of employed farmers and entrepreneurs.

Partial vs General Equilibrium The importance of general equilibrium forces for aggregate effects of land reform is illustrated in the Figure A7 in the Appendix. Agricultural output and employment decline substantially in partial equilibrium as households move to higher-income

[29] Average agricultural skill of farmers decreases as households with both high agricultural and non-agricultural skills living in a communal part of the economy move from farming to entrepreneurship.

sectors. However, in general equilibrium, an increase in the interest rate of capital and wage encourage households with relatively high agricultural productivity to remain in agriculture. Moreover, a substantial decline in the rental rate of land makes agriculture more profitable, preventing the outflow of farmers to other sectors in general equilibrium setting.

Distributional impact While land reform leads to a higher level of consumption and welfare, these gains are not evenly distributed. Figure 6 shows the distribution of welfare gains and losses across households that were under customary and private land property rights before the reform. The gains are measured in equivalent consumption units. The figure shows that a majority of households under the communal tenure system gain from land reform. There is empirical evidence that a significant fraction of households does realize economic gains of titled land. According to the last wave of the Household Survey, the majority of households that do not have any land certificate said that they would like to obtain one and are willing to pay for it (90.3% and 75.1%, respectively).

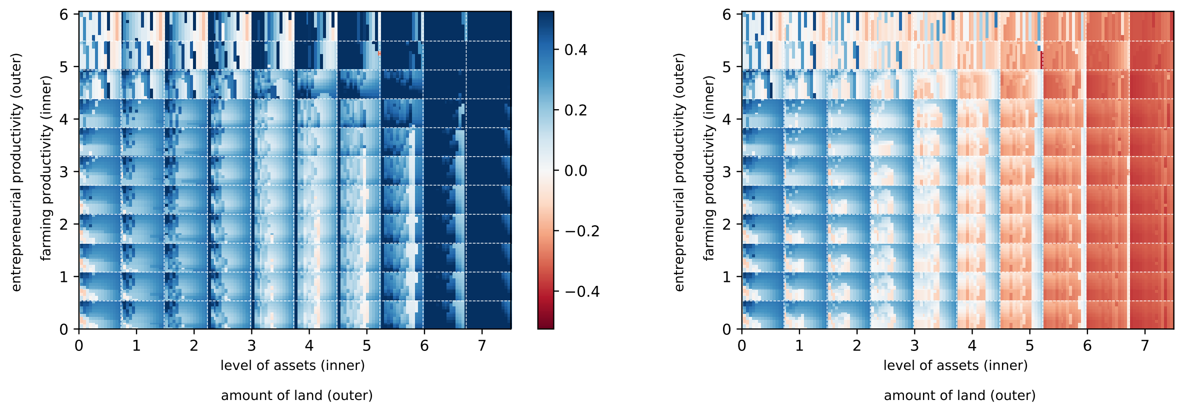
In the communal part of the economy, the gains are the largest for those with large land holdings. Now, they can use the land as collateral, receive rental income from unused land, and move to the occupation, where they are the most productive. Moreover, those gains are increasing in entrepreneurial productivity and decreasing in the level of financial assets. Those with a low level of assets gain relatively more as they face a tighter financial constraint. Those with relatively large land holdings and high entrepreneurial productivity gain more than low productivity entrepreneurs, as now they switch from farming to entrepreneurship due to the absence of expropriation risk.

Precisely the opposite situation obtains for the initially private land holders: those with large land holdings experience welfare losses due to a drop in the land rental rate. For the originally private land holders, the most gains are observed for households with relatively little own land who stay in farming and need to rent in some land due to a decrease in the rental rate for land. The gain is higher for those with higher agricultural productivity.

In sum, I find substantial welfare gains, especially for those in the communal part of the economy with a low level of assets. In addition, those with a high level of assets benefit from a higher rental rate of capital, while those with large holdings of private land experience losses. Moreover, consumption increases for many households due to higher levels of financial inclusion, and, hence, lower level of savings. Given that welfare gains are the largest among households initially belonging to the communal part of the economy, and consumption changes are favorable for the poorest households in terms of assets and land holdings, overall consumption inequality slightly decreases, with the Gini index declining from 30.9 to 29.6 for consumption.

Figure 6: Changes in Welfare Distribution

(a) Communal Land Holders (b) Private Land Holders



5.2 Decomposing Impact of Land Reform

Given that there are three main differences between customary and modern land tenure regimes, I explore the effects of each channel separately. I perform a decomposition analysis of different channels of land reform by looking at the impact of removing only one friction at a time. Such a decomposition is important in the context of low-income countries as reform implementation often faces numerous challenges due to the presence of imperfections in other markets.[30] Three channels that are studied: i) expropriation risk, ii) inability to use land as collateral, and iii) inability to rent out land.

Figure 7 presents the general equilibrium effect of each channel of land reform on economic outcomes. Lower expropriation risk pushes households from agriculture to other occupations, leading to a higher rental rate of capital and lower wages. The increase in demand for workers, driven by households joining entrepreneurship, is smaller than the increase in the supply of labor driven by higher attractiveness to be a worker. A decrease in the number of farmers and lower average agricultural skills of farmers lead to a decline in agricultural output. An increase in average entrepreneurial productivity, and reduction of agricultural productivity, are driven by marginal entrepreneurs who have both relatively high agricultural and entrepreneurial productivity but remain in farming due to expropriation risk.

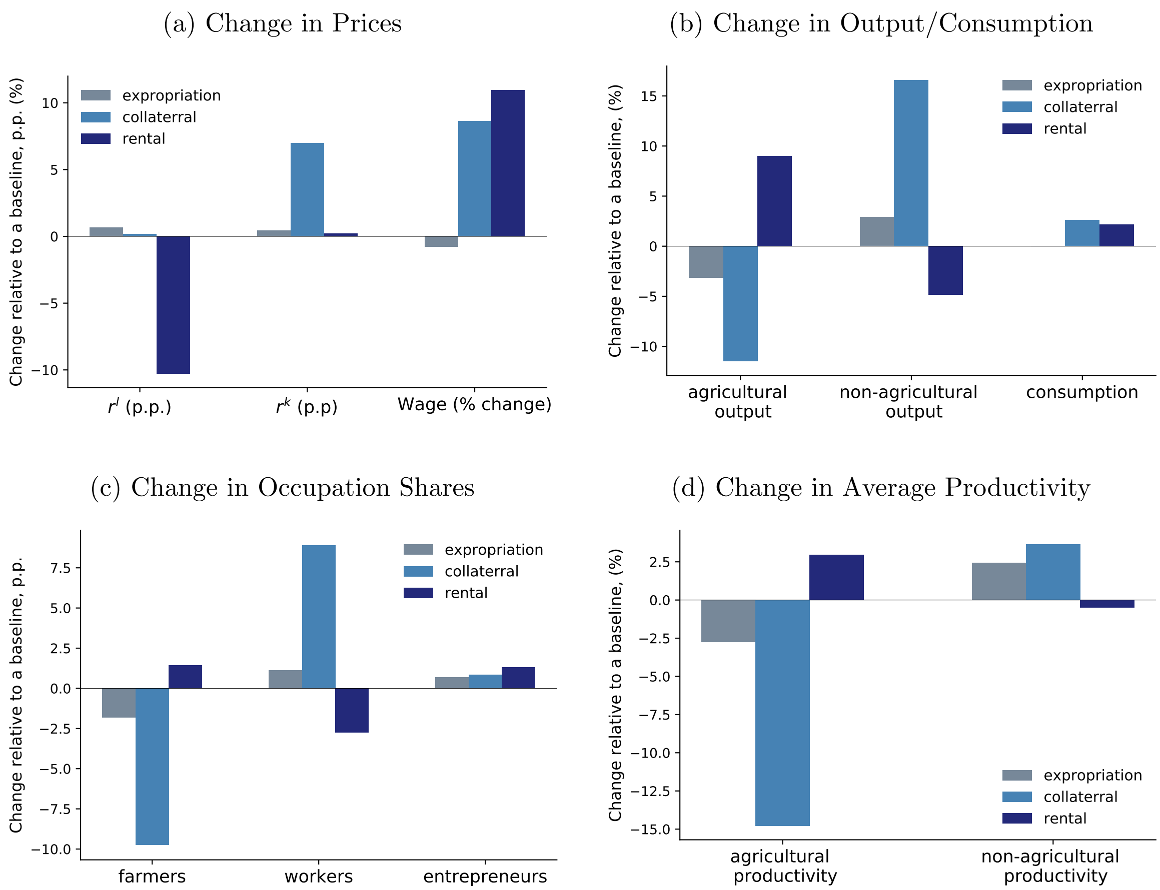
The ability to use the land as collateral creates demand for capital from farmers and entrepreneurs. As a result, the rental rate of capital increases, which pushes away some people from agriculture and business. Therefore, the supply of workers increases, but by a smaller amount than the demand for workers driven by larger capital inputs of entrepreneurs. To clear

[30] For example, the collateral channel might not work because banks would not be willing to accept land as collateral due to the limited land market. I address some of these issues in Section 5.5.

the labor market, the wage increases. The effects on output and average productive skills are similar to the expropriation channel but larger in magnitude as the collateral channel has a more significant impact on capital and labor inputs.

Allowing households under customary tenure to rent out land increases land supply and land utilization. As a result of the larger supply, the rental rate of land drops, which attracts more households to agriculture. Higher land utilization also creates demand for capital, and the rental rate of capital slightly increases. To prevent the outflow of workers, the wage increases. The average productive skills of farmers increases as land is reallocated from less productive to more productive households. Higher inputs and average productivity increase agricultural output.

Figure 7: Decomposition of Land Reform



(a) Change in Prices

(b) Change in Output/Consumption

(c) Change in Occupation Shares

(d) Change in Average Productivity

5.3 Land Reform vs Financial Reform

One of the channels through which land reform affects the economy is by allowing the use of private land as collateral. As a result, land reform also facilitates financial inclusion among poor households who own some land. Given the interaction between land property rights and the financial sector, I compare a land reform's impact on the economy with the effects of financial reform. To compute the effect of financial reform, I relax financial constraints in a way so that the loan to collateral value is equal to the level of the advanced economy – Sweden (83.9%).[31]

Figure A8 compares the effects of land reform and financial reform. Given that it is impossible to perform two numerically equivalent reforms in different sectors, I cannot compare the magnitudes of economic outcomes changes. But it is worth exploring the direction of changes. In terms of prices, financial reform has a minor effect on land rental rate as land supply does not change. The small drop in r^l is driven by lower demand for land as some households move from agriculture to other sectors. Both consumption and non-agricultural output increase in the case of both reforms as households move from farming towards entrepreneurship and use more capital due to more relaxed financial constraints. However, financial reform leads to lower agricultural output as a lower share of households remains in agriculture, and average productivity in this sector decreases.

To sum up, the qualitative impact of financial reform on economic outcomes is the same as the impact of the collateral channel of land reform but differs from land reform as a whole. Moreover, distributional impacts are different (Figure A9). In the case of financial reform, those who are marginal entrepreneurs and existing entrepreneurs with positive assets who are financially constraint benefit the most. In contrast, those operating communal land do not benefit significantly more than those operating private land, as we observe in the case of land reform.

5.4 Postreform Transition Dynamics

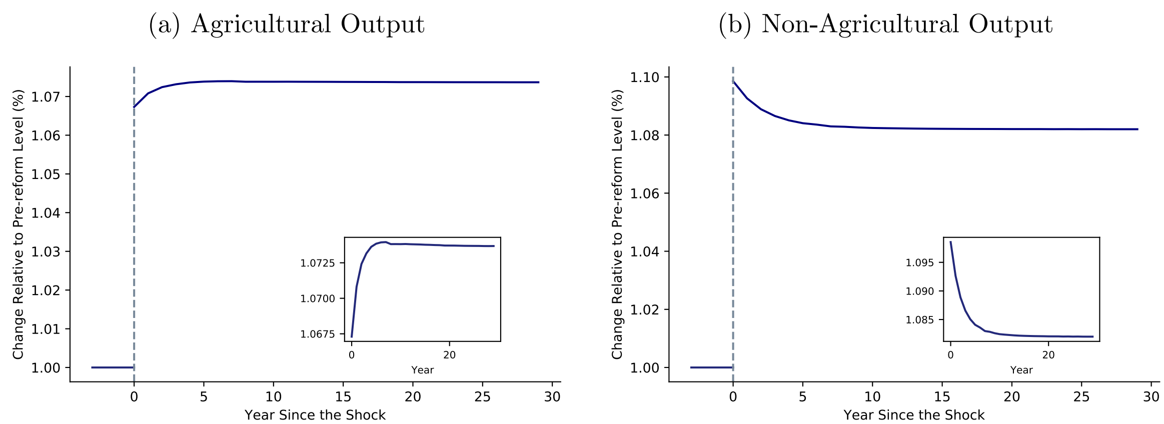
In this exercise, I study the transitional dynamics triggered by a sudden unexpected land reform that removes all land market frictions. I assume that financial frictions remains the same throughout the transition period.

Figure 8 shows the evolution of agricultural and non-agricultural output along with the transition to the new postreform steady state. The economy moves into the neighborhood of the new steady state in 20-25 years. However, the majority of changes happen in the first ten years after the reform. We observe a substantial initial increase in agricultural and non-agricultural output due to higher land utilization and relaxation of financial constraints, leading to more capital used in the production. While agricultural output continues to increase in the following years, non-agricultural output experiences some decline compared to the initial jump. The removal of land market frictions explains such dynamics that move labor from

[31] I use Sweden to be consistent with the parameter I use for λ_k in the baseline model, given that Sweden is the only advanced country that is present in the World Bank's enterprise survey.

agriculture to other occupations, accompanied by a slow increase in prices of production for the non-agricultural sector, wage, and capital interest rate (Figure A10).

Figure 8: Postreform Transition Dynamics for Output



Notes: The output series are normalized by their respective prereform values.

5.5 Discussion and Model Extensions

In this section, I discuss the relevance of some model extensions and mechanisms that can be implemented into my baseline model. More specifically, I provide discussion on the model mechanism when i) agricultural and entrepreneurial productivity of a household are correlated, ii) change in land property rights lead to change in agricultural technology, iii) land reform endogenously facilitates financial reform, iv) additional financial market imperfections arise due to high cost of seizing small parcels of land in case of default, and v) communal land redistribution used as insurance against negative shock.[32]

Correlated productivity In my baseline model I assume that agricultural and entrepreneurial productivity of a household are independent. In reality, however, they might be positively or negatively correlated.[33] In case of positive correlation, the effect of land reform is expected to be smaller to some extent on agricultural output. Smaller output in agriculture would arise due to sorting as a result of land reform of more productive farmers into entrepreneurship, which is delivers higher income. The opposite result is expected in case of negative correlation.

[32]One can come up with additional model extension that can be incorporated to the model. I limit discussion in this section to the extensions that have some empirical support.

[33]For example, Alvarez-Cuadrado et al. (2020) using data from four African countries – Ethiopia, Malawi, Nigeria, and Uganda, find that more productive farming households are more likely to pursue entrepreneurship, allocate more hours to it, and are more likely to enter into entrepreneurship over time.

Agricultural technology Agricultural activity in many developing countries is labor-intensive and is characterized by a low level of mechanization compared to advanced economies. As Tanzanian data evidence, households with land under stronger property rights are also more likely to obtain credit for agriculture and conditional on having the loan, the size is larger. Hence, households with more secure land might also have a higher level of mechanization through higher access to credit and, as a result, a larger amount of capital used in agriculture. Based on the statistics reported in Table A2 in the Appendix, households with titled land are also more likely to hire external labor. In addition, returns to scale might differ.

Such differences in production function and technology in agriculture would not only affect the assessment of misallocation, but also the magnitude of output gains from the land reform, and importance of different channels. Specifically, higher returns to scale in case of strong property rights regime would imply a larger effect for the output in agricultural sector.[34] Additionally, the collateral channel would play a more important role when land reform takes place, as it would lead to higher demand for credit to finance more capital intensive agriculture (relative to the benchmark model), and hired labor before the revenue from harvest realized.

Land and financial reform interaction In the benchmark model I assume that coefficients on the land and financial wealth in collateral constraint are the same. However, given that immobile nature of land, the liquidation value might be higher for land than for financial wealth. In this case, land reform would also facilitate financial reform by endogenously relaxing financial constraint. As a result, effect on non-agricultural sector will be higher.

Property size and access to credit In their recent work, Agyei-Holmes et al. (2020) find that land registration does not translate into increased credit taking. In addition, despite evidence that many households in Tanzania have used land with Certificate Rights of Occupancy as collateral (URT, 2016), there is evidence that banks often impose additional conditions on the loans. Sanga (2009) conducted face-to-face interviews in nine villages in the Mbozi district in Tanzania, and the study reveals that farmers apply for loans using land as collateral, and banks are willing to provide them. However, additional conditions often apply, and the main reason for rejection is low value of the land.[35] As a result, the collateral channel would play a less important role, and the impact on financial inclusion would be less pronounced, especially for the poorest households with small land holdings.

[34] Aragon et al. (2022) illustrate how different estimates of agricultural production function might affect the gains from more efficient land allocation.

[35] To account for this in the model, collateral constraint such can be changed so that the land, even in the private sector of the economy, can be used as collateral only if it is large enough, i.e.
$k_t \leq \lambda_k a_t + (\lambda_k - 1) q_t^l l_{t,\mathbb{I}\{land=private\}\mathbb{I}\{l \geq \underline{l}\}}$.

Communal land as insurance Despite productivity costs that arise from the presence of a customary land tenure system, rural institutions have long acted as a source of informal insurance in low-income countries (Udry, 1994). In the absence of formal insurance, communal land often operates as a source of social insurance to households undergoing temporary adverse shocks. In this case, land reform might move poorest households experiencing negative shock to the level way below poverty line.[36]

6 Concluding Remarks

The prevalence of communal land tenure system in low-income countries is of first-order importance for the macroeconomic development of these economies. Such a system leads to both misallocation of factors of production and distortions in households occupational choices. Moreover, since communal land could not be used as collateral, such a tenure system amplifies financial market frictions widespread in developing countries. In this paper, I study the effect of land property rights on aggregate productivity and allocation of resources, and the impact of financial and land market frictions on the economic development of low-income countries.

To assess the aggregate and distributional impacts of economy-wide land reform, which eliminates the customary tenure system, I develop a general equilibrium model that features frictions of both land and financial markets. I leverage detailed panel household data from Tanzania in two ways: i) to discipline the model and ii) to show that the presence of insecure land property rights and limited access to credit is associated with resource misallocation in agriculture. Using a quantitative model, I find that land reform has positive effects on agricultural and non-agricultural output and leads to occupational shifts of households away from agriculture. Moreover, land reform increases the level of financial inclusion, especially among the poorest households with limited financial assets.

To sum up, this paper points to the significant potential gains from land reform that improves land property rights. Not only do stronger land property rights lead to higher welfare and more efficient allocation of resources, but they also help to create a more financially inclusive society. However, welfare gains of land reform, measured in consumption equivalent changes, are not evenly distributed, and some households experience losses. The main losers of such reform are large private landholders, suggesting that political economy barriers might prevent or slow the progress of land reform, despite its potential benefits.

[36] Such extension can be easily incorporated into benchmark model by allowing the reallocation of communal land to be state-dependent. Specifically, the probability of reallocation can depend on the level of productive skills in entrepreneurship, i.e. $\pi_{it}^{R} = f_R\left(l_{\mathbb{I}\{land=communal\}}, z_{it}^{e}\right)$.

References

Acampora, M., L. Casaburi, and J. Willis (2022): "Land Rental Markets: Experimental Evidence from Kenya," *mimeo*.

Ackerberg, D., K. Caves, and G. Frazer (2015): "Identification Properties of Recent Production Function Estimators," *Econometrica*, 83, 2411–2451.

Adamopoulos, T., L. Brandt, J. Leight, and D. Restuccia (2017): "Misallocation, Selection and Productivity: A Quantitative Analysis with Panel Data from China," Working papers, University of Toronto, Department of Economics.

Adamopoulos, T. and D. Restuccia (2014): "The Size Distribution of Farms and International Productivity Differences," *American Economic Review*, 104, 1667–97.

——— (2020): "Land Reform and Productivity: A Quantitative Analysis with Micro Data," *American Economic Journal: Macroeconomics*, 12, 1–39.

Agyei-Holmes, A., N. Buehren, M. P. Goldstein, R. D. Osei, I. Osei-Akoto, and C. Udry (2020): "The Effects of Land Title Registration on Tenure Security, Investment and the Allocation of Productive Resources: Evidence from Ghana," Policy Research Working Paper Series 9376, The World Bank.

Alvarez-Cuadrado, F., F. Amodio, and M. Poschke (2020): "Selection and Absolute Advantage in Farming and Entrepreneurship," CEPR Discussion Papers 14269, C.E.P.R. Discussion Papers.

Aragon, F., D. Restuccia, and J. P. Rud (2022): "Assessing Misallocation in Agriculture: Plots versus Farms," NBER Working Papers 29749, National Bureau of Economic Research, Inc.

Asker, J., A. Collard-Wexler, and J. De Loecker (2011): "Productivity volatility and the misallocation of resources in developing economies," CEPR Discussion Papers 8469, C.E.P.R. Discussion Papers.

Banerjee, A. and B. Moll (2010): "Why Does Misallocation Persist?" *American Economic Journal: Macroeconomics*, 2, 189–206.

Banerjee, A. V. and E. Duflo (2005): "Growth Theory through the Lens of Development Economics," in *Handbook of Economic Growth*, ed. by P. Aghion and S. Durlauf, Elsevier, vol. 1, Part A, chap. 07, 473–552, 1 ed.

Baqaee, D. and E. Farhi (2020): "Productivity and Misallocation in General Equilibrium*," *The Quarterly Journal of Economics*, 135, 105–163.

Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2013): "Cross-Country Differences in Productivity: The Role of Allocation and Selection," *American Economic Review*, 103, 305–34.

Bau, N. and A. Matray (2020): "Misallocation and Capital Market Integration: Evidence From India," NBER Working Papers 27955, National Bureau of Economic Research, Inc.

Beg, S. (2021): "Digitization and Development: Formalizing Property Rights and its Impact on Land and Labor Allocation," Mpra paper, University Library of Munich, Germany.

Besley, T. and M. Ghatak (2010): "Property Rights and Economic Development," Elsevier, vol. 5, chap. Chapter 68, 4525–4595.

Bick, A., F.-S. Nicola, and D. Lagakos (2016): "How do Average Hours Worked Vary with Development? Cross-Country Evidence and Implications," CEPR Discussion Papers 11092, C.E.P.R. Discussion Papers.

Bromley, D. (2010): "The Emergence of Land Markets in Africa: Impacts on Poverty, Equity, and Efficiency, edited by Stein T. Holden, Keijiro Otsuka, and Frank M. Place," *Journal of Regional Science*, 50, 1006–1008.

Buera, F., J. Kaboski, and Y. Shin (2014): "Macro-perspective on Asset Grants Programs: Occupational and Wealth Mobility," *American Economic Review*, 104, 159–64.

——— (2021a): "The Macroeconomics of Microfinance," *Review of Economic Studies*, 88, 126–161.

Buera, F., J. Kaboski, and R. Townsend (2021b): "From Micro to Macro Development," NBER Working Papers 28423, National Bureau of Economic Research, Inc.

Buera, F. J., J. Kaboski, and Y. Shin (2015): "Entrepreneurship and Financial Frictions: A Macrodevelopment Perspective," *Annual Review of Economics*, 7, 409–436.

Chari, A., E. Liu, S.-Y. Wang, and Y. Wang (2017): "Property Rights, Land Misallocation and Agricultural Efficiency in China," NBER Working Papers 24099, National Bureau of Economic Research, Inc.

Chen, C. (2017): "Untitled Land, Occupational Choice, and Agricultural Productivity," *American Economic Journal: Macroeconomics*, 9, 91–121.

de Brauw, A. and V. Mueller (2012): "Do Limitations in Land Rights Transferability Influence Mobility Rates in Ethiopia?" *Journal of African Economies*, 21, 548–579.

de Janvry, A., K. Emerick, M. Gonzalez-Navarro, and E. Sadoulet (2015): "Delinking Land Rights from Land Use: Certification and Migration in Mexico," *American Economic Review*, 105, 3125–49.

De Loecker, J. (2011): "Product Differentiation, Multiproduct Firms, and Estimating the Impact of Trade Liberalization on Productivity," *Econometrica*, 79, 1407–1451.

Deininger, K. and J. S. Chamorro (2004): "Investment and equity effects of land regularisation: the case of Nicaragua," *Agricultural Economics*, 30, 101–116.

Di Tella, R., S. Galiant, and E. Schargrodsky (2007): "The Formation of Beliefs: Evidence from the Allocation of Land Titles to Squatters," *The Quarterly Journal of Economics*, 122, 209–241.

Field, E. (2007): "Entitled to Work: Urban Property Rights and Labor Supply in Peru," *The Quarterly Journal of Economics*, 122, 1561–1602.

Galiani, S. and E. Schargrodsky (2010): "Property rights for the poor: Effects of land titling," *Journal of Public Economics*, 94, 700–729.

Gollin, D., D. Lagakos, and M. Waugh (2014): "Agricultural Productivity Differences across Countries," *American Economic Review*, 104, 165–70.

Gollin, D. and C. Udry (2021): "Heterogeneity, Measurement Error, and Misallocation: Evidence from African Agriculture," *Journal of Political Economy*, 129, 1 – 80.

Gottlieb, C. and J. Grobovsek (2019): "Communal land and agricultural productivity," *Journal of Development Economics*, 138, 135–152.

Guner, N., G. Ventura, and Y. Xu (2008): "Macroeconomic Implications of Size-Dependent Policies," *Review of Economic Dynamics*, 11, 721–744.

Hopenhayn, H. A. (2014): "Firms, Misallocation, and Aggregate Productivity: A Review," *Annual Review of Economics*, 6, 735–770.

Hsieh, C.-T. and P. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 124, 1403–1448.

Jermann, U. and V. Quadrini (2012): "Macroeconomic Effects of Financial Shocks," *American Economic Review*, 102, 238–71.

Kalemli-Ozcan, S. and B. Sorensen (2012): "Misallocation, Property Rights, and Access to Finance: Evidence from Within and Across Africa," NBER Working Papers 18030, National Bureau of Economic Research, Inc.

King, R. and R. Levine (1993): "Finance, entrepreneurship and growth: Theory and evidence," *Journal of Monetary Economics*, 32, 513–542.

Levinsohn, J. and A. Petrin (2000): "Estimating Production Functions Using Inputs to Control for Unobservables," NBER Working Papers 7819, National Bureau of Economic Research, Inc.

Macours, K., A. de Janvry, and E. Sadoulet (2010): "Insecurity of property rights and social matching in the tenancy market," *European Economic Review*, 54, 880–899.

Mendoza, E. (2010): "Sudden Stops, Financial Crises, and Leverage," *American Economic Review*, 100, 1941–66.

Ngai, L. R., C. Pissarides, and J. Wang (2019): "China's Mobility Barriers and Employment Allocations," *Journal of the European Economic Association*, 17, 1617–1653.

Oberfield, E. (2013): "Productivity and Misallocation During a Crisis: Evidence from the Chilean Crisis of 1982," *Review of Economic Dynamics*, 16, 100–119.

Olley, G. S. and A. Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64, 1263–97.

Pande, R. and C. Udry (2005): "Institutions and Development:A View from Below," Working papers, Economic Growth Center, Yale University.

Piza, C. and M. J. S. B. de Moura (2016): "The effect of a land titling programme on households' access to credit," *Journal of Development Effectiveness*, 8, 129–155.

Restuccia, D. and R. Rogerson (2008): "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics*, 11, 707–720.

——— (2013): "Misallocation and productivity," *Review of Economic Dynamics*, 16, 1–10.

——— (2017): "The Causes and Costs of Misallocation," *Journal of Economic Perspectives*, 31, 151–74.

Restuccia, D. and R. Santaeulalia-Llopis (2017): "Land Misallocation and Productivity," NBER Working Papers 23128, National Bureau of Economic Research, Inc.

Sanga, R. T. (2009): “Assessing the Impact of Customary Land Rights Registration on Credit Access by Farmers in Tanzania: a Case Study in Mbozi District,” mimeo, International Institute for Geo-Information Science and Earth Observation, Enschede, the Netherlands.

Santaeulàlia-Llopis, R. and Y. m. o. r. a. c. u. i. a. l. e. f. e. d. a. c. H. Zheng (2016): “The Price of Growth: Consumption Insurance in China 1989-2009,” Economics Working Papers ECO2016/13, European University Institute.

Schreiber, L. A. (2017): “Registering Rural Rights: Village Land Titling in Tanzania, 2008-2017,” *Innovations for Successful Societies; Princeton University.*

Udry, C. (1994): “Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria,” *Review of Economic Studies*, 61, 495–526.

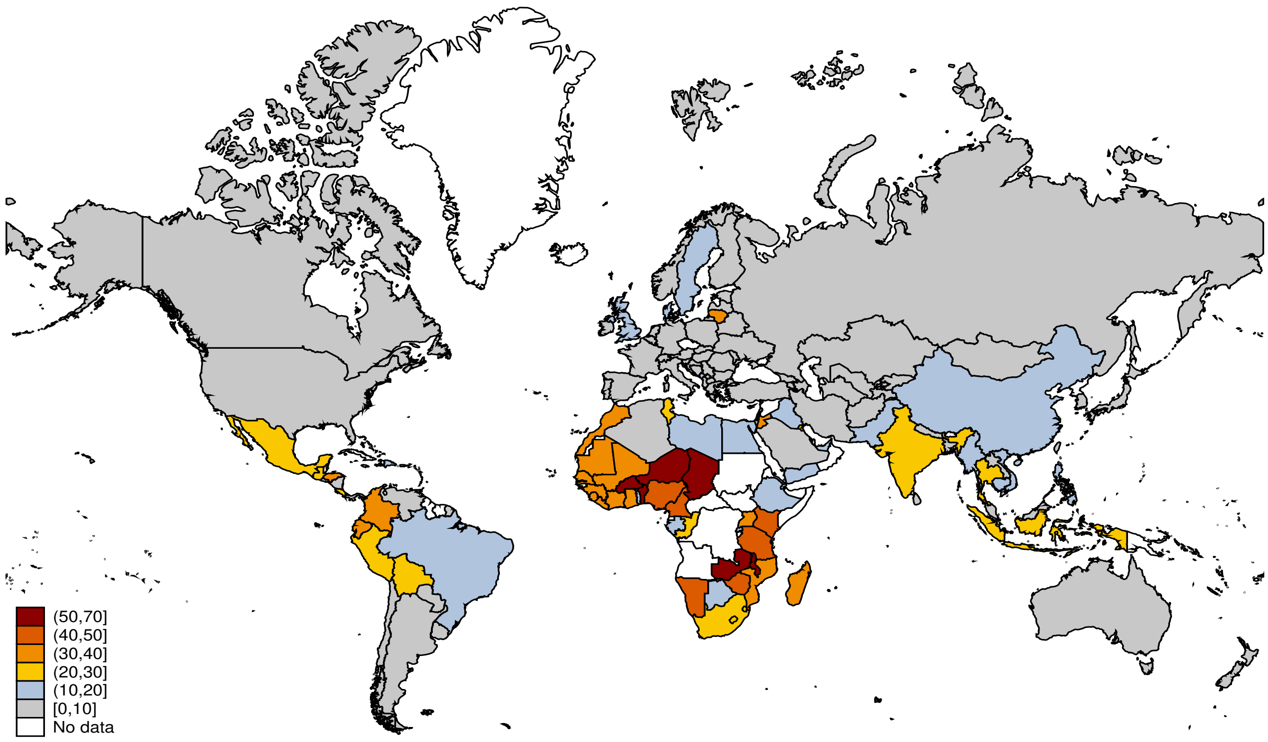
URT (2016): “Draft National Land Policy 2016,” *United Republic of Tanzania, Ministry of Lands, Housing and Human Settlements Development, Dar es Salaam.*

Zegarra, E., J. Escobal, and U. Aldana (2011): “Titling, Credit Constraints and Rental Markets in Rural Peru: Exploring Channels and Conditioned Impacts,” IDB Publications (Working Papers) 3707, Inter-American Development Bank.

Online Appendix

A Additional Tables and Figures

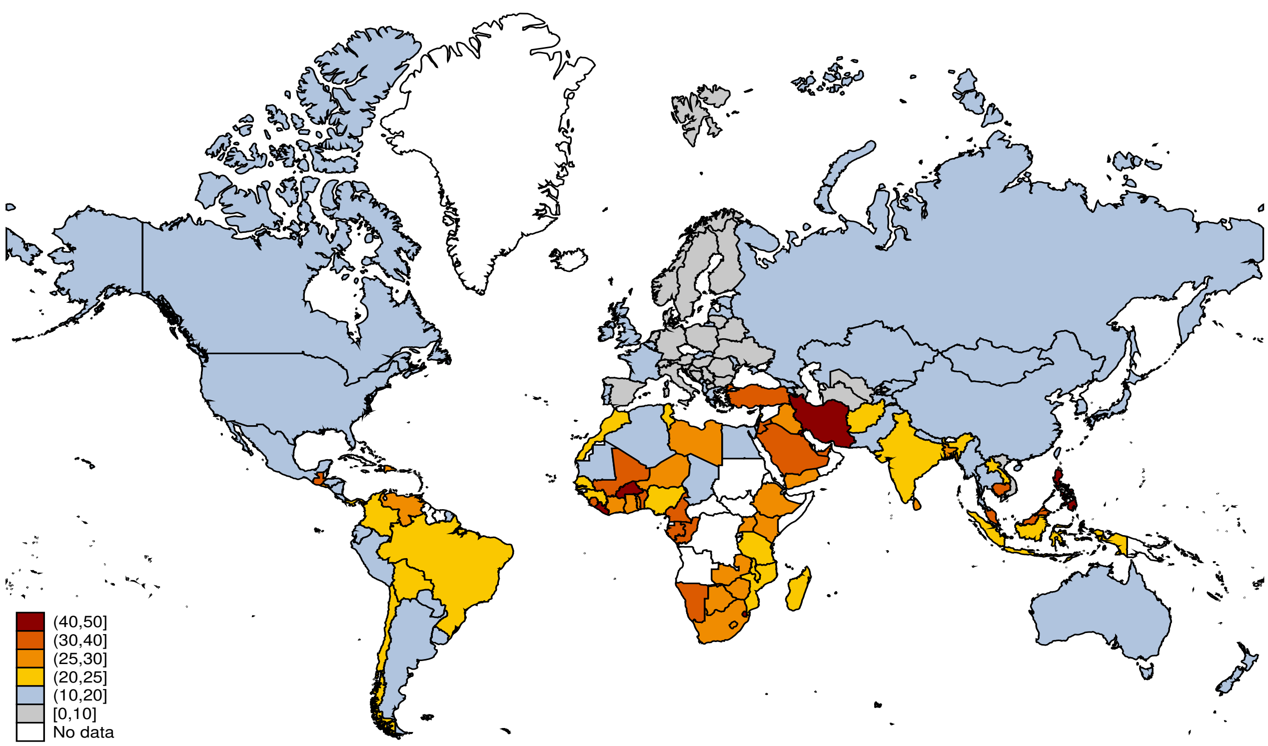
Figure A1: Share of Land with No Official or Unofficial Document (2020)



Data Source: Prindex.

Notes: Legend reflects the share of land with no documentation.

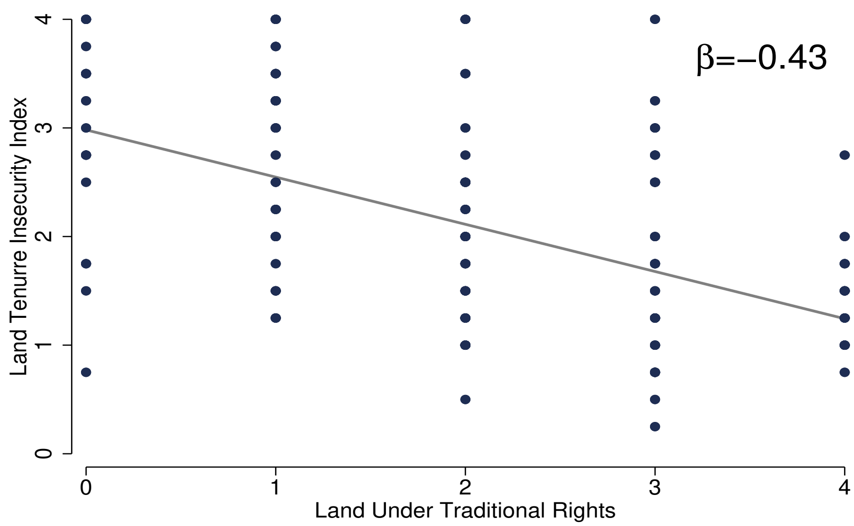
Figure A2: Share of Adults that Feel Insecure about Their Property (2020)



Data Source: Prindex.

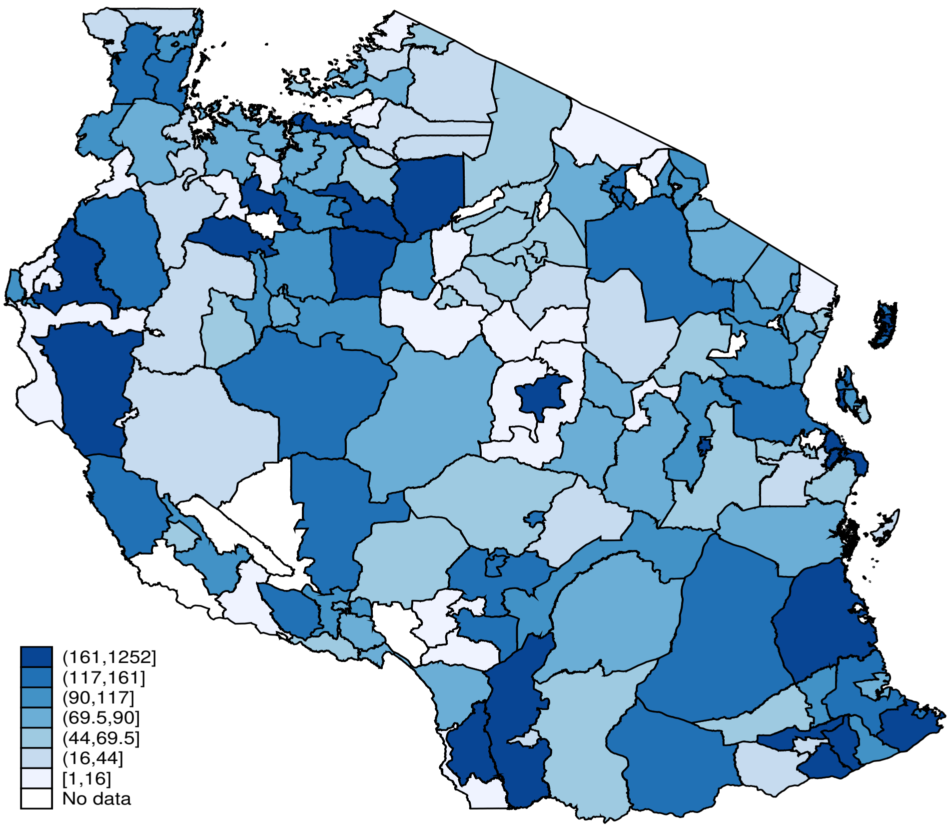
Notes: Legend reflects the share of surveyed adults that feel insecure about their property.

Figure A3: Share of Traditional Land and Land Tenure Insecurity



Notes: The land tenure insecurity index ranges from 0 to 4, with 0 being the highest level of land insecurity. Land under traditional system measures the share of rural land under the traditional rights system, and ranges from 0 to 4, with 0 indicating that there is no land under traditional system. Both indicators are obtained from The Institutional Profiles Database (IPD) of the Centre d'Etudes Prospectives et d'Informations (CEPII), and are a composite measures of several factors.

Figure A4: Sample coverage



Notes: Legend reflects the number of households surveyed in a given district.

Table A1: Summary statistics (TPNS 2008-2015)

Variable	Mean	Median	Std. Dev.
Total harvest (ths TZS)	722.9	164.4	25,460
Yield (ths TZS/acre)	163.3	62.5	2,288
Land cultivated (acres)	5.5	2.8	12.3
Land available (acres)	6.2	3.0	14.9
Total labor (per-day)	172.9	116.0	185.7
HH labor (per-day)	158.6	104.0	178.2
Hired labor (per-day)	14.3	0	37.9
Daily wage (ths TZS)	3.8	2.5	4.7
Capital (ths TZS)	1,887.9	13.5	7,850.4
Chemicals (ths TZS)	2.5	0	7.6
Variable	**% of obs**		
HH own/cultivate plot	65.4	-	-
Plots cultivated	85.0	-	-
Land utilization	85.2	-	-
Hire workers	43.1	-	-
Use chemicals	35.5	-	-
Can leave plot	86.5	-	-
Right sell/coll	68.4	-	-
Title/certificate	12.5	-	-
Took loan (1 yr)	10.5	-	-
Took loan (ag) (1 yr)	1.3	-	-
Took loan (bus) (1 yr)	2.7	-	-

Notes: Average exchange rate in 2013 was ≈ 1,600 TZS per 1 USD.

Table A2: Descriptive Statistics for Plots Based on Title

	Title		No Title		*Differences*	
	Mean	SD	Mean	SD	Diff.	p-value
			Panel A: Land Characteristics			
Soil quality	1.19	0.75	0.19	0.75	0.00	0.98
% Slope flat bottom	0.51	0.50	0.52	0.50	0.00	0.69
% Slope flat top	0.07	0.25	0.06	0.23	0.01	<0.01
% Slightly sloped	0.24	0.43	0.25	0.43	-0.01	0.11
% Slope steep	0.03	0.16	0.03	0.18	-0.01	0.05
% Soil clay	0.15	0.36	0.15	0.36	0.01	0.43
% Soil loam	0.50	0.50	0.53	0.50	-0.02	0.01
% Soil sandy	0.17	0.37	0.16	0.37	0.01	0.21
			Panel B: Plot Characteristics			
Plot area (acres)	3.77	17.7	2.73	6.36	1.04	<0.01
Distance to home (km)	7.26	35.8	4.93	25.4	2.33	<0.01
Distance to market (km)	10.0	14.5	9.72	13.5	0.30	0.27
Distance to road (km)	2.17	4.61	2.32	5.09	-0.15	0.14
% Erosion control	0.1	0.3	0.09	0.29	0.01	0.10
% Irrigation system	0.02	0.14	0.02	0.12	0.00	0.10
			Panel C: Agricultural Practices			
% Use inorganic fertilizer	0.10	0.30	0.09	0.29	0.01	0.26
% Use organic fertilizer	0.13	0.35	0.09	0.29	0.05	<0.01
% Hire labor (outside HH)	0.29	0.45	0.25	0.43	0.04	<0.01
% Use input on credit	0.01	0.10	0.01	0.10	0.00	0.71
% Use pesticides	0.07	0.26	0.08	0.27	0.01	0.17
% Use animal traction	0.22	0.42	0.28	0.45	-0.05	<0.01
% Use mechanization	0.06	0.23	0.05	0.21	0.01	0.25
Labor per acre (person-days)	102.9	388.9	101.3	503.2	1.54	0.87
% Use credit for agriculture	0.04	0.19	0.02	0.13	0.02	<0.01
Land utilization (%)	0.93	0.18	0.93	0.19	0.00	0.50
	N=3,030		N=19,808			

Table A3: Descriptive Statistics for Plots Based on the Right to Sell/Use as Collateral

	Has Right to Sell		Does Not Have		*Differences*	
	Mean	SD	Mean	SD	Diff.	p-value
			Panel A: Land Characteristics			
Soil quality	1.19	0.76	1.19	0.71	0.00	0.76
% Slope flat bottom	0.50	0.50	0.55	0.50	-0.04	<0.01
% Slope flat top	0.06	0.23	0.06	0.24	0.00	0.25
% Slightly sloped	0.25	0.43	0.25	0.43	-0.01	0.39
% Slope steep	0.04	0.19	0.03	0.16	0.01	<0.01
% Soil clay	0.15	0.36	0.14	0.34	0.01	<0.01
% Soil loam	0.51	0.50	0.55	0.50	-0.04	<0.01
% Soil sandy	0.16	0.36	0.17	0.37	-0.01	0.06
			Panel B: Plot Characteristics			
Plot area (acres)	3.20	8.7	1.99	8.9	1.20	<0.01
Distance to home (km)	5.36	27.5	4.93	25.5	0.43	0.28
Distance to market (km)	10.0	13.7	9.01	13.3	0.93	<0.01
Distance to road (km)	2.43	5.39	1.95	3.09	0.48	<0.01
% Erosion control	0.09	0.29	0.09	0.28	0.01	0.13
% Irrigation system	0.02	0.12	0.02	0.13	0.00	0.07
			Panel C: Agricultural Practices			
% Use inorganic fertilizer	0.10	0.30	0.08	0.27	0.02	<0.01
% Use organic fertilizer	0.10	0.30	0.10	0.29	0.00	0.56
% Hire labor (outside HH)	0.25	0.43	0.29	0.45	-0.04	<0.01
% Use input on credit	0.01	0.10	0.01	0.08	0.01	<0.01
% Use pesticides	0.09	0.28	0.06	0.23	0.03	<0.01
% Use animal traction	0.28	0.45	0.24	0.43	0.04	<0.01
% Use mechanization	0.05	0.21	0.05	0.31	-0.01	0.26
Labor per acre (person-days)	91.1	497.7	129.2	466.3	-38.1	<0.01
% Use credit for agriculture	0.02	0.15	0.01	0.12	0.01	<0.01
Land utilization (%)	0.93	0.19	0.94	0.17	-0.02	<0.01
	N=16,590		N=6,246			

Table A4: Descriptive Statistics for Plots Based on Ability to Leave Land Fallow without Fear to Lose Land

	Can Leave Fallow		Can Not Leave		*Differences*	
	Mean	SD	Mean	SD	Diff.	p-value
Panel A: Land Characteristics						
Soil quality	1.19	0.75	1.23	0.73	-0.04	<0.01
% Slope flat bottom	0.51	0.50	0.57	0.50	-0.05	<0.01
% Slope flat top	0.06	0.23	0.06	0.24	-0.01	0.09
% Slightly sloped	0.25	0.43	0.24	0.43	0.01	0.26
% Slope steep	0.03	0.18	0.02	0.16	0.01	<0.01
% Soil clay	0.15	0.36	0.18	0.38	-0.03	<0.01
% Soil loam	0.52	0.50	0.55	0.50	-0.03	<0.01
% Soil sandy	0.16	0.37	0.15	0.35	0.01	0.08
Panel B: Plot Characteristics						
Plot area (acres)	2.93	9.1	1.97	3.5	1.20	<0.01
Distance to home (km)	5.19	27.0	8.60	40.1	-3.40	<0.01
Distance to market (km)	9.77	14.1	10.3	16.5	-0.53	0.05
Distance to road (km)	2.31	7.04	2.61	5.96	-0.29	0.02
% Erosion control	0.09	0.29	0.10	0.30	-0.01	0.34
% Irrigation system	0.02	0.12	0.03	0.17	-0.01	<0.01
Panel C: Agricultural Practices						
% Use inorganic fertilizer	0.10	0.29	0.11	0.31	-0.01	0.02
% Use organic fertilizer	0.10	0.30	0.08	0.28	0.01	0.01
% Hire labor (outside HH)	0.25	0.43	0.34	0.47	-0.08	<0.01
% Use input on credit	0.01	0.10	0.01	0.10	0.00	0.62
% Use pesticides	0.08	0.27	0.08	0.28	0.00	0.52
% Use animal traction	0.27	0.44	0.30	0.46	-0.03	0.03
% Use mechanization	0.05	0.21	0.08	0.26	-0.03	<0.01
Labor per acre (person-days)	101.7	506.9	94.6	220.8	7.04	0.43
% Use credit for agriculture	0.02	0.14	0.03	0.16	-0.01	0.07
Land utilization (%)	0.93	0.19	0.96	0.15	-0.03	<0.01
	N=20,960		N=3,283			

Table A5: Descriptive Statistics for Plots Based on Whether Land Was Obtained/Used for Free

	Not free		For Free		*Differences*	
	Mean	SD	Mean	SD	Diff.	p-value
Panel A: Land Characteristics						
Soil quality	1.19	0.75	1.24	0.69	-0.06	<0.01
% Slope flat bottom	0.51	0.50	0.60	0.49	-0.09	<0.01
% Slope flat top	0.06	0.23	0.05	0.22	0.01	0.06
% Slightly sloped	0.25	0.43	0.24	0.42	0.01	0.15
% Slope steep	0.04	0.18	0.02	0.14	0.02	<0.01
% Soil clay	0.15	0.36	0.15	0.35	0.01	0.29
% Soil loam	0.52	0.50	0.56	0.50	-0.04	<0.01
% Soil sandy	0.16	0.36	0.17	0.38	-0.02	0.02
Panel B: Plot Characteristics						
Plot area (acres)	2.99	9.04	1.52	3.0	1.47	<0.01
Distance to home (km)	5.61	29.1	5.91	29.8	-0.29	0.61
Distance to market (km)	9.98	14.5	8.8	14.4	1.19	<0.01
Distance to road (km)	2.11	4.08	2.39	7.21	0.28	0.04
% Erosion control	0.10	0.29	0.06	0.25	0.03	<0.01
% Irrigation system	0.02	0.13	0.02	0.12	0.00	0.45
Panel C: Agricultural Practices						
% Use inorganic fertilizer	0.10	0.30	0.09	0.28	0.01	0.09
% Use organic fertilizer	0.10	0.30	0.06	0.24	0.04	<0.01
% Hire labor (outside HH)	0.26	0.44	0.29	0.45	-0.03	<0.01
% Use input on credit	0.01	0.10	0.01	0.08	0.00	0.02
% Use pesticides	0.09	0.28	0.05	0.22	0.03	<0.01
% Use animal traction	0.29	0.45	0.23	0.42	0.06	<0.01
% Use mechanization	0.05	0.22	0.06	0.24	-0.01	0.41
Labor per acre (person-days)	96.1	486.6	113.4	412.4	-37.2	<0.01
% Use credit for agriculture	0.02	0.15	0.01	0.11	0.01	<0.01
Land utilization (%)	0.93	0.19	0.96	0.15	-0.02	<0.01
	N=21,265		N=2,279			

Table A6: Production function estimates

	OLS (1)	OLS FE (2)	DP (3)
log(Land)	0.347	0.266	0.280
	(0.018)	(0.027)	(0.042)
log(Labor)	0.411	0.348	0.446
	(0.027)	(0.030)	(0.081)
log(Capital)	0.111	0.048	0.036
	(0.008)	(0.010)	(0.020)
β_l			0.268
β_n			0.421
β_k			0.049
ρ			0.371
Return to scale	0.87	0.66	0.74
Test on common factor restrictions			0.832
# obs.	8,949	6,073	3,641

Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household level. Regressions include year FE, OLS regressions - district-year FE.

Table A7: Factor ratios: Capital

	ln(land)				
		leave fallow	right to sell	title	obtain free
	(1)	(2)	(3)	(4)	(5)
ln(Capital)	0.177	0.147	0.145	0.173	0.181
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ln(Capital) × land_rights		0.033	0.043	0.022	-0.048
		(0.003)	(0.002)	(0.004)	(0.003)
ln(Capital) × credit		0.034	0.032	0.033	0.033
		(0.007)	(0.007)	(0.007)	(0.007)
# obs.	10,047	10,047	10,047	10,047	10,047
# households	5,513	5,513	5,513	5,513	5,513
Wave#District FE	✓	✓	✓	✓	✓

Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household levels.

Table A8: Factor ratios: Labor

	ln(land)				
		leave fallow	right to sell	title	obtain free
	(1)	(2)	(3)	(4)	(5)
ln(Labor)	0.586	0.528	0.515	0.576	0.583
	(0.013)	(0.015)	(0.015)	(0.013)	(0.013)
ln(Labor) × land_rights		0.055	0.072	0.042	-0.076
		(0.006)	(0.005)	(0.008)	(0.007)
ln(Labor) × credit		0.054	0.050	0.050	0.051
		(0.014)	(0.014)	(0.014)	(0.014)
# obs.	10,054	10,054	10,054	10,054	10,054
# households	5,515	5,515	5,515	5,515	5,515
Wave#District FE	✓	✓	✓	✓	✓

Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household levels.

Table A9: CES Production Function Estimates

	(1)	(2)
ϵ	1.186	1.186
	(0.041)	(0.042)
σ	0.851	0.841
	(0.015)	(0.015)
α	0.602	0.602
	(0.039)	(0.039)
β	0.364	0.364
	(0.030)	(0.030)
# obs.	8,959	8,959
Unexpected shocks		✓

Notes: Estimated using fixed-effects nonlinear least-squares. Robust standard errors (in parentheses) are two-way clustered at the district and household levels.

Table A10: Land Misallocation: Across Time Variation

	ln(land)			
	leave fallow	right to sell	title	obtain free
	(1)	(2)	(3)	(4)
HH productivity	-0.007	-0.010	-0.006	-0.002
	(0.010)	(0.009)	(0.008)	(0.008)
HH productivity × land_rights	0.002	0.009	0.010	-0.023
	(0.005)	(0.004)	(0.005)	(0.008)
HH productivity × credit	0.024	0.024	0.024	0.025
	(0.010)	(0.010)	(0.010)	(0.010)
# obs.	6,043	6,043	6,043	6,043
# households	2,218	2,218	2,218	2,218
Wave#District FE	✓	✓	✓	✓
HH FE	✓	✓	✓	✓
R^2	0.833	0.833	0.833	0.833

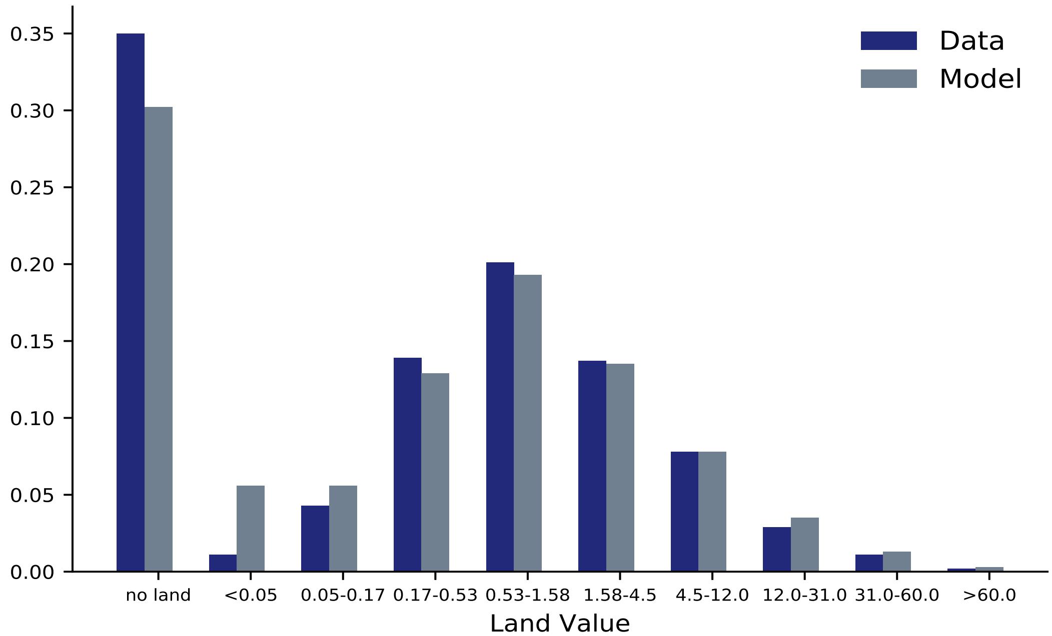
Notes: Robust standard errors (in parentheses) are two-way clustered at the district and household levels.

Table A11: Land property rights and household occupation

	Dependent variable			
	head of HH in agriculture		hours in agriculture	
	(1)	(2)	(3)	(4)
land_size	0.021	0.028	0.015	0.011
	(0.006)	(0.025)	(0.004)	(0.022)
# obs.	6,404	578	6,404	578
Household FE	✓	✓	✓	✓

Notes: Robust standard errors (in parentheses) are two-way clustered at the household and district levels. Logarithm of plot size is used as a main regressor, *land_size*. Columns (1) and (3) report results for households that do not have any titled land, Columns (2) and (4) report results for households that have some land that is titled.

Figure A5: Distribution of Land: Model and Data



Notes: The distribution is based on price of land in mln TZS such that it is equispaced on a log scale.

Figure A6: Lorenz Curve for Consumption

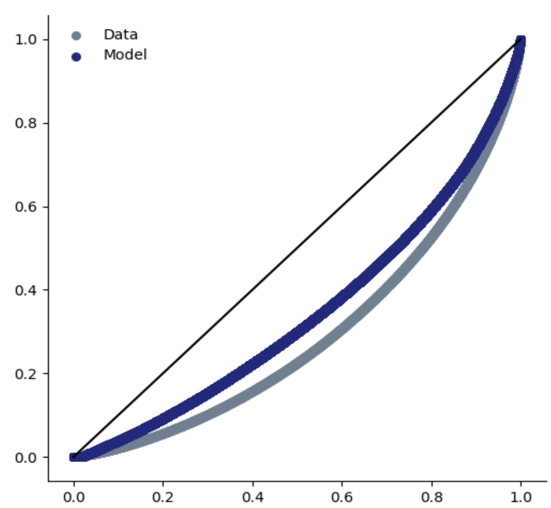
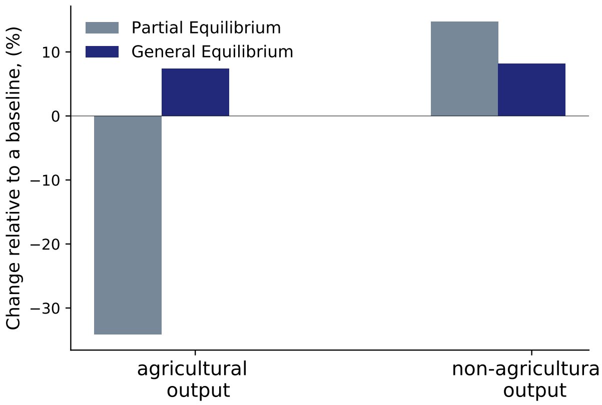
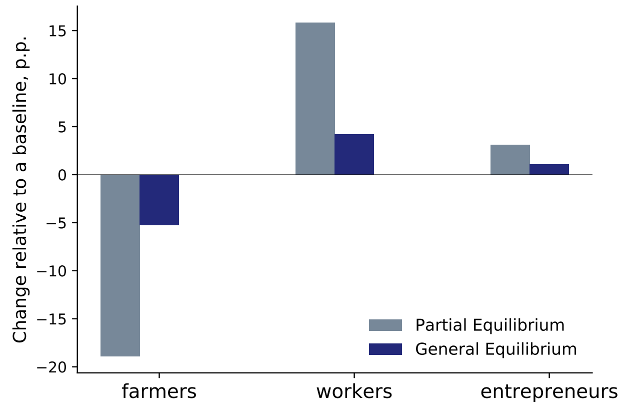


Figure A7: The Effects of Land Reform

(a) Change in Output



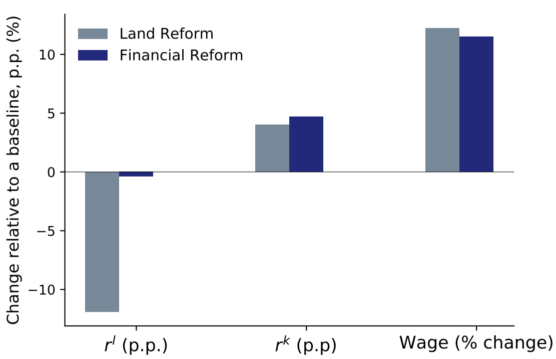
(b) Change in Occupation Shares



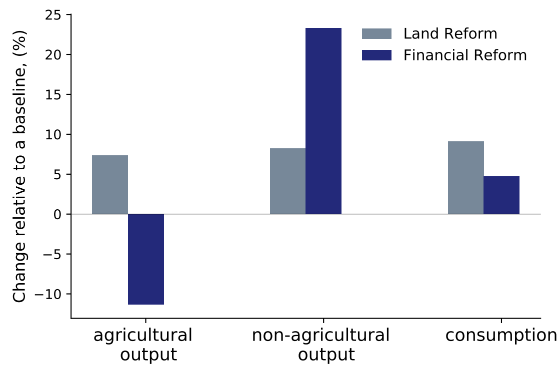
Notes: The effects of land reform in partial equilibrium are estimated keeping all prices fixed.

Figure A8: The Effects of Land and Financial Reforms

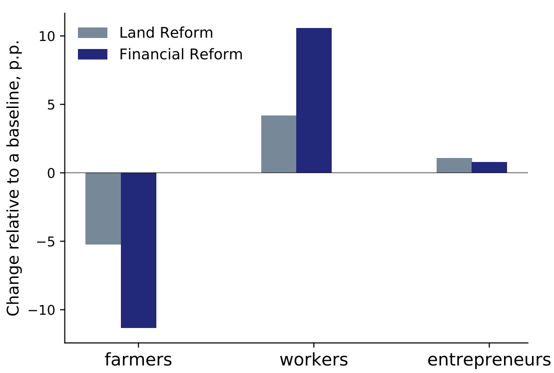
(a) Change in Prices



(b) Change in Output/Consumption



(c) Change in Occupation Shares



(d) Change in Average Productivity

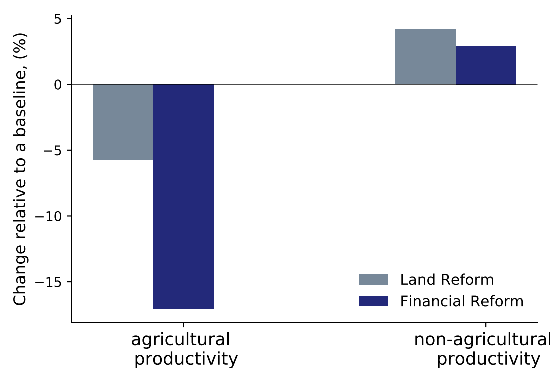


Figure A9: Changes in Welfare Distribution: Financial Reform

(a) Communal Land Holders

(b) Private Land Holders

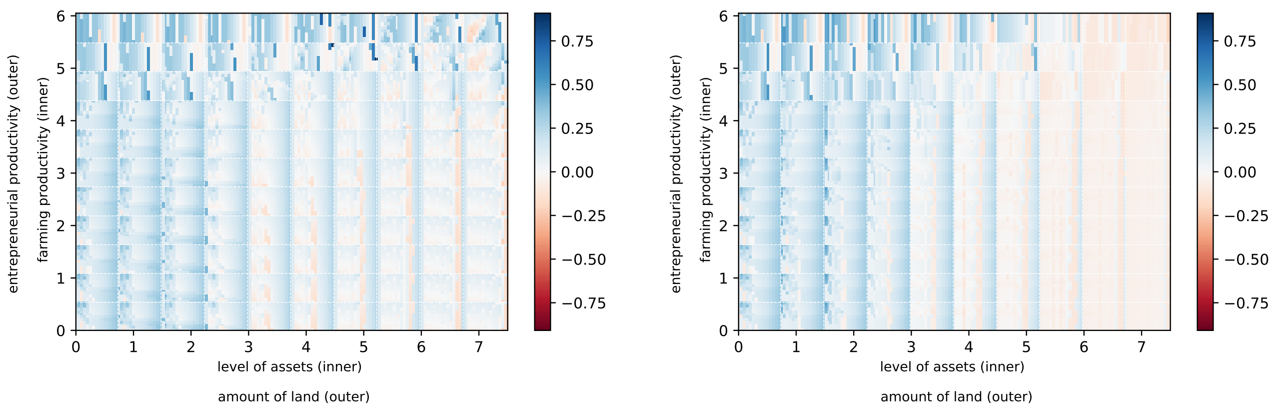
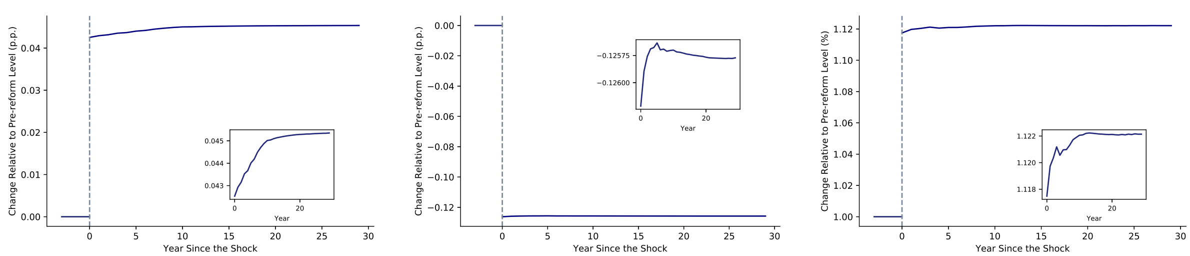


Figure A10: Postreform Transition Dynamics for Prices

(a) Capital Interest Rate

(b) Land Rental Rate

(c) Wage



Notes: Prices are shown as deviations from their respective pre-reform values.

B Land Tenure System in Tanzania

The current land tenure and administration system in Tanzania has evolved from the Germans and British colonial rules and incorporates the features of pre-colonial, colonial and post-colonial tenures.

B.1 Brief Historical Context

Prior to colonial era all land belonged to different tribes and the general characteristics of land holdings were based on the culture of each tribe. The common principal of most tribes was that land belongs to its user, which means that when the family is no longer using the land, it is reallocated to another family.

Colonial period can be split into two sub-periods – the German Era (1884-1917) and the British Era (1918-1961). The Germans imposed a declaration in 1895 that all land in German East Africa to be unowned Crown Land vested in the German Empire. The only exception was land where proof of ownership could be shown either though documentations, or through effective occupation. The main types of tenures established during the German era were: i) Freeholds granted mainly to European Settlers ii) Leaseholds iii) Crown Land – unowned land determined by the commissions, and iv) Customary Land Tenure for the land occupied by the natives.

Under the British rule, the first land tenure statute was the Land Ordinance of 1923, which declared all land, but freeholds acquired before, as being public land. Under 1928 extension, anyone holding land under customary tenure was declared a legitimate holder of the land. The main types of tenures established during the British era were: i) Freeholds ii) Granted Rights of occupancy (long-term for 33, 66 or 99 years; short term for less than 6 years; and from year to year) iii) Deemed rights of occupancy (in urban areas and rural areas, which was mostly held by native communities) iv) Public land.

B.2 Land Tenure in the Post-Independence Era

The Land Ordinance 1923 continued to be the principal document on land tenure till 1999. In 1995 a National Land Policy was published and two pieces of legislation were introduced in 1999: Village Land Act No 5, which covered rural land, and Land Act No 4, which covered general land, including urban land.

Around 70 percent of land in the Mainland of Tanzania is considered to be Village Land (80 percent of population), 28 percent is Reserved land (i.e. national parks), and 2 percent is general land (mainly urban, 20 percent of the population).

Village land is regulated by the Village Land Act, and divides land into three categories: communal land, occupied land and future (or reserved) land. The Village Land Act empowers village councils to maintain a register of village land. The Acts recognize two forms of tenure: i) the granted right of occupancy, and ii) customary right of occupancy.

As for now, and for the period of study in this paper, Tanzania presents a dynamic land tenure context. All land in Tanzania is owned by the state and held in trust by the president, but individuals residing on or using designated Village Land have the right to obtain formal documentation of their use rights in the form of a Certificate of Customary Right of Occupancy (CCRO). However, insufficient capacity of district land offices that issue CCROs, a lack of funds to pay associated fees, unfamiliarity with formal land laws and other factors have resulted in few villagers obtaining formal documentation for their plots. Furthermore, many villages have not yet completed the village land use management plans that are a prerequisite for CCRO issuance.

The Government of Tanzania and the donor community recognize that improving the security of land rights is essential to protecting the rights of smallholders, reducing disputes and tensions and maximizing the economic potential of the region. The Government, through various programs, often sponsored by the donor community, has made efforts to speed up village land demarcation, village land use planning and village land certification.

Land Tenure Programs A pilot Village Certification project was implemented in Mbozi District from 1999 as an effort to implement Village Land Act. By 2007 village boundaries of all 175 villages in Mbozi had been surveyed and 158 had been issued with Certificates of Village Land, and total of 1,117 CCROs have been issued. This experience was replicated in 10 Districts: Iringa (40 villages); Handeni (6 villages); Kilindi (10 villages); Babati (5 villages); Monduli (49 villages); Kiteto (6 villages); Kilolo (9 villages); Namtumbo; Ngorongoro (1 village); Muleba (2 villages). Countrywide, by 2016, around 400,000 CCROs have been issued in various villages and in the years 2014-15 around 49.2 billion shillings had been issued as loans by financial institutions, using CCROs as collateral URT (2016).

Another example of program that aims to improve situation with land property rights in Tanzania, is Feed the Future Tanzania Land Tenure Assistance (LTA) project. The U.S. Agency for International Development project works with 41 communities in central Tanzania to register land and issue Certificates of Customary Right of Occupancy to individual landholders, with a focus on increasing women's inclusion in property ownership. LTA has worked with villages to demarcate and digitally map and record almost 63,000 parcels. These previously undocumented parcels are now registered in the country's official land registry system, providing secure property tenure to 21,000 Tanzanians. The project is also working with local banks to encourage the acceptance of certificates as collateral and with villages to raise awareness of the new loan opportunities. Farmers have already begun using their land-backed loans to purchase fertilizer, high-quality seeds, tractors, and other agricultural inputs to raise their productivity and their incomes.

C Computational Algorithm

Steady State The solution algorithm starts with guessing steady state level of prices, w, r^k, r^l, η. Given the prices, solve the policy function for each set of state variables using value function iteration. The process yields the optimal occupational choice and policy functions for level of assets, consumption, capital, labor and land inputs. Obtain the stationary distribution of households by finding fixed point using forward iteration. Given the distribution and policy functions, obtain aggregate variables and use them to check whether market clearing conditions for the labor market, capital market, and land market are satisfied. Update the guess for prices and repeat until all market clears.

Transition First, compute the initial and final steady states. Then, choose a length T for the transition, and guess a path for prices $\{w, r^k, r^l\}_{t=1}^{T}$. Solve the household problem along the transition path using backward induction: (a) taking value function in the final steady state, V_{ssf}, the market clearing prices as given, solve for household value functions and optimal occupational choice and policy functions for level of assets, consumption, capital, labor and land inputs; (b) repeat this process until solving back to the first period. Given the distribution and policy functions, obtain aggregate variables and use them to check whether market clearing conditions for the labor market, capital market, and land market are satisfied for each period along the transition path. Update the guess for prices and repeat until all market clears for all periods. Check whether T is large enough by trying a larger T and see if the equilibrium path is robust.

D Proofs of Propositions

Proposition 1. *Denote optimal choices of land used by farmers who owns land under communal and private property right regimes as l_c^* and l_p^*, respectively. Then, if optimal land usage is larger than household land holding, $l_p^* > l_p$, and farmers' initial conditions in private and communal part of the economy are the same (i.e. same amount of land, skills and assets), we get:*

$$l_c^* \leq l_p^*$$

Proof: Let households living under communal and private property rights regime have the same amount of land holdings, have the same productive skills in each sector, and amount of assets. Conditional on farming, also assume that optimal land usage for household in private part of the economy be larger than household land holding, $l_p^* > l_p$. Let μ be the Lagrange multiplier on collateral constraint (with μ_c and μ_p for communal and private part of the economy, respectively). Then, optimal amount of capital used by the farmer is

$$k^* = \left(\exp\left(z_a\right) \left(\frac{\gamma_a}{r^l}\right)^{\gamma_a} \left(\frac{\alpha}{r^k + \mu}\right)^{1-\gamma_a} \right)^{\frac{1}{1-\alpha_a-\gamma_a}}$$

and

$$l^* = \left(\frac{\gamma_a \exp\left(z_a\right) k^{*\alpha_a}}{r^l} \right)^{\frac{1}{1-\gamma_a}}$$

then if $\mu_c = \mu_p = 0$, then $k_p^* = k_c^*$ and $l_p^* = l_c^*$.

If, $\mu_c > 0$ and $\mu_p > 0$, then $k_p^* \geq k_c^*$ and $l_p^* \geq l_c^*$ as $(\lambda_k - 1)q^l l \geq 0$. Moreover, for positive values of land holdings there would occur situation, when $\mu_c > 0$ and $\mu_p = 0$.

and for assets holdings $a_{small} < a_{large}$, given everything else the same, the following true

$$l_p^*(a_{small}) - l_c^*(a_{small}) \geq l_p^*(a_{large}) - l_c^*(a_{large}),$$

Proof: Fix a_{small} and a_{large}, and let households with a_{small} and a_{large} differ only in the amount of assets while all other state variables being the same. Also, let a_c^* and a_p^* denote minimum levels of assets when collateral constraint binds, i.e. $\mu_c > 0$ and $\mu_p > 0$, in case of communal and private land holders, respectively. Then, $a_p^* \leq a_c^*$ as $(\lambda_k - 1)q^l l \geq 0$, and following cases are possible:

i) If $a_{small} \leq a_{large} \leq a_p^* \leq a_c^*$, then both when assets small or large collateral constraint binds. Therefore,

$$l_c^* = \left(\frac{\gamma_a \exp\left(z_a\right) (\lambda_k a)^{\alpha_a}}{r^l} \right)^{\frac{1}{1-\gamma_a}}$$

and

$$l_p^* = \left(\frac{\gamma_a \exp{(z_a)} (\lambda_k a + (\lambda_k - 1) q^l l_p)^{\alpha_a}}{r^l} \right)^{\frac{1}{1-\gamma_a}}$$

Then

$$l_p^*(a_{small}) - l_c^*(a_{small}) \geq l_p^*(a_{large}) - l_c^*(a_{large}) \Leftrightarrow$$

$$(\lambda_k a_{small} + (\lambda_k - 1) q^l l_p)^{\frac{\alpha_a}{1-\gamma_a}} - (\lambda_k a_{small})^{\frac{\alpha_a}{1-\gamma_a}} \geq (\lambda_k a_{large} + (\lambda_k - 1) q^l l_p)^{\frac{\alpha_a}{1-\gamma_a}} - (\lambda_k a_{large})^{\frac{\alpha_a}{1-\gamma_a}}$$

The inequality is true, given that function $f(x) = x^{\frac{\alpha_a}{1-\gamma_a}}$ is concave downward (as $f''(x) = \frac{\alpha_a(\alpha_a+\gamma_a-1)}{(1-\gamma_a)^2} x^{\frac{\alpha_a+2\gamma_a-2}{1-\gamma_a}} < 0$ for production function with decreasing return of scale), and $(\lambda_k - 1) q^l l \geq 0$

ii) If $a_{small} \leq a_p^* \leq a_{large} \leq a_c^*$, then both when assets small or large collateral constraint binds for household living in communal part, while for private part collateral constraint binds only for households with a_{small}. Then, the optimal level of capital for households with a_{large} is

$$k_p^*(a) \leq \lambda_k a_{large} + (\lambda_k - 1) l_p$$

and, hence,

$$l_p^*(a_{small}) - l_c^*(a_{small}) \geq l_p^*(a_{large}) - l_c^*(a_{large}) \Leftrightarrow$$

$$\begin{aligned} (\lambda_k a_{small} + (\lambda_k - 1) q^l l_p)^{\frac{\alpha_a}{1-\gamma_a}} - (\lambda_k a_{small})^{\frac{\alpha_a}{1-\gamma_a}} &\geq \\ \geq (\lambda_k a_{large} + (\lambda_k - 1) q^l l_p)^{\frac{\alpha_a}{1-\gamma_a}} - (\lambda_k a_{large})^{\frac{\alpha_a}{1-\gamma_a}} &\geq \\ \geq (k_p^*(a))^{\frac{\alpha_a}{1-\gamma_a}} - (\lambda_k a_{large})^{\frac{\alpha_a}{1-\gamma_a}} & \end{aligned}$$

iii) If $a_{small} \leq a_p^* \leq a_c^* \leq a_{large}$ then when assets are small collateral constraint binds for all household, while for a_{large} households using the optimal level of capital and land both in communal and private parts of the economy. Hence, $l_p^*(a_{large}) - l_c^*(a_{large}) = 0$ and we have that

$$(\lambda_k a_{small} + (\lambda_k - 1) q^l l_p)^{\frac{\alpha_a}{1-\gamma_a}} - (\lambda_k a_{small})^{\frac{\alpha_a}{1-\gamma_a}} \geq 0$$

iv) If $a_p^* \leq a_{small} \leq a_c^* \leq a_{large}$ is equivalent to iii) with $l_p^*(a_{large}) - l_c^*(a_{large}) = 0$.

v) If $a_p^* \leq a_{small} \leq a_{large} \leq a_c^*$ then households living in private part of the economy use the same amount of land – efficient, and, therefore,

$$l_p^*(a_{small}) - l_c^*(a_{small}) \geq l_p^*(a_{large}) - l_c^*(a_{large}) \Leftrightarrow$$

$$-(\lambda_k a_{small})^{\frac{\alpha_a}{1-\gamma_a}} \geq -(\lambda_k a_{large})^{\frac{\alpha_a}{1-\gamma_a}} \Leftrightarrow$$

$$a_{small} \leq a_{large}$$

vi) Finally, if $a_p^* \leq a_c^* \leq a_{small} \leq a_{large}$ none collateral constraint binding and all households use the same efficient amount of land, and

$$l_p^*(a_{small}) - l_c^*(a_{small}) = 0 \geq l_p^*(a_{large}) - l_c^*(a_{large}) = 0$$

and for the levels of agricultural productivity $z_{small} < z_{large}$, given everything else the same

$$l_p^*(z_{small}) - l_c^*(z_{small}) \leq l_p^*(z_{large}) - l_c^*(z_{large}),$$

Proof: Fix z_{small} and z_{large}, and let households with z_{small} and z_{large} differ only in the level of their agricultural productivity while all other state variables being the same. Also, let k_c^* and k_p^* denote minimum levels of capital when collateral constraint binds, i.e. $\mu_c > 0$ and $\mu_p > 0$, in case of communal and private land holders, respectively. Also, denote k_{small}^* and k_{large}^* to be optimal level of capital used by households with agricultural productivity z_{small} and z_{large}, respectively. Then, following the same six cases, but with level of capital as in previous part, analogous steps provide proof of proposition.

and for the levels of land holdings $l_{small} < l_{large}$, given everything else the same, we get

$$l_p^*(l_{small}) - l_c^*(l_{small}) \leq l_p^*(l_{large}) - l_c^*(l_{large}).$$

Proof: Fix l_{small} and l_{large}, and let households with l_{small} and l_{large} differ only in the level of their land holding while all other state variables being the same. Given that households only differ in the level of land holdings, then optimal levels of capital and land would be same for all households, k^* and l^*:

$$k^* = \left(\exp(z_a) \left(\frac{\gamma_a}{r^l} \right)^{\gamma_a} \left(\frac{\alpha}{r^k + \mu} \right)^{1-\gamma_a} \right)^{\frac{1}{1-\alpha_a-\gamma_a}}$$

and

$$l^* = \left(\frac{\gamma_a \exp(z_a) k^{*\alpha_a}}{r^l} \right)^{\frac{1}{1-\gamma_a}}$$

Hence, household would deviate from optimal levels only when collateral constraint for some of them binds. This leads to the following cases:

i) If no constraints binds, then $l_p^*(l_{small}) - l_c^*(l_{small}) = 0 \leq l_p^*(l_{large}) - l_c^*(l_{large}) = 0$

ii) If collateral constraint binds only for those in the communal part of the economy, then

$l_c^*(l_{small}) = l_c^*(l_{large}) = \lambda_k a$ and $l_p^*(l_{small}) = l_p^*(l_{large}) = l^*$, hence

$$l_p^*(l_{small}) - l_c^*(l_{small}) \leq l_p^*(l_{large}) - l_c^*(l_{large}) \Leftrightarrow$$

$$l_c^*(l_{large}) - l_c^*(l_{small}) \leq l_p^*(l_{large}) - l_p^*(l_{small}) \Leftrightarrow 0 = 0$$

iii) If collateral constraint binds for households living in private part with l_{small} and not l_{large},[37] then it also binds for all households in communal part as $k^* \geq \lambda_k a + (\lambda_k - 1) l_{small} \geq \lambda_k a$. Then,

$$l_p^*(l_{small}) - l_c^*(l_{small}) \leq l_p^*(l_{large}) - l_c^*(l_{large}) \Leftrightarrow$$

$$l_c^*(l_{large}) - l_c^*(l_{small}) \leq l_p^*(l_{large}) - l_p^*(l_{small})$$

with $l_c^*(l_{small}) = l_c^*(l_{large}) = \lambda_k a$ we get

$$l_p^*(l_{large}) - l_p^*(l_{small}) = l_p^*(k^*) - l_p^*(k = \lambda_k a + (\lambda_k - 1) l_{small}) \geq 0$$

as $k^* > \lambda_k a + (\lambda_k - 1) l_{small}$ and land is strictly increasing in capital.

iv) If all constraints bind, then again $l_c^*(l_{small}) = l_c^*(l_{large}) = \lambda_k a$, and,

$$l_p^*(l_{large}) - l_p^*(l_{small}) = l_p^*(\lambda_k a + (\lambda_k - 1) l_{large}) - l_p^*(k = \lambda_k a + (\lambda_k - 1) l_{small}) \geq 0.$$

as $\lambda_k a + (\lambda_k - 1) l_{large} > \lambda_k a + (\lambda_k - 1) l_{small}$ and land is strictly increasing in capital.

Proposition 2. *Denote optimal choices of land used by farmers who owns land under communal and private property right regimes as l_c^* and l_p^*, respectively. Then, if optimal land usage is lower than household land holding, $l_p^* < l_p$, and farmers' initial conditions in private and communal part of the economy are the same (i.e. same amount of land, skills and assets):*

$$l_c^* \geq l_p^*$$

Proof: Let households living under communal and private property rights regime have the same amount of land holdings, have the same productive skills in each sector, and amount of assets. Conditional on farming, also assume that optimal land usage for household in private part of the economy be smaller than household land holding, $l_p^* < l_p$. Then, given that households in communal part of the economy could not rent out their land and agricultural production

[37] The opposite could not be true as $k^* \geq \lambda_k a + (\lambda_k - 1) l_{large}$ implies that $k^* \geq \lambda_k a + (\lambda_k - 1) l_{small}$

function is increasing in land, households in communal part would use all their land for farming, $l_c^* = l_c$. Hence,

$$l_c^* = l_c = l_p > l_p^* \Leftrightarrow l_c^* \geq l_p^*$$

and for the levels of agricultural productivity $z_{small} < z_{large}$, *given everything else the same*

$$l_c^*(z_{small}) - l_p^*(z_{small}) \geq l_c^*(z_{large}) - l_p^*(z_{large})$$

Proof: Again, given that households in communal part are going to use all land holding, $l_c^*(z_{small}) = l_c^*(z_{large}) = l_c$, hence,

$$l_c^*(z_{small}) - l_p^*(z_{small}) \geq l_c^*(z_{large}) - l_p^*(z_{large}) \Leftrightarrow$$

$$l_p^*(z_{small}) \leq l_p^*(z_{large})$$

which holds, as l^* is increasing in both z_a and k^*, that is also is increasing in z_a.

and for the levels of land holdings $l_{small} < l_{large}$, *given everything else the same, we get*

$$l_c^*(l_{small}) - l_p^*(l_{small}) \leq l_c^*(l_{large}) - l_p^*(l_{large})$$

Proof: Following the above,

$$l_c^*(l_{small}) - l_p^*(l_{small}) \leq l_c^*(l_{large}) - l_p^*(l_{large}) \Leftrightarrow$$

$$l_p^*(l_{small}) \leq l_p^*(l_{large})$$

With l^* increasing in k^*, when

i) collateral constraints not binding in neither cases, $l_p^*(l_{small}) = l_p^*(l_{large}) = l^*$.

ii) collateral constraint binding for l_{small} and not for l_{large},[38] we have

$$l_p^*(l_{large}) - l_p^*(l_{small}) = l_p^*(k^*) - l_p^*(k = \lambda_k a + (\lambda_k - 1)l_{small}) \geq 0.$$

as $k^* > \lambda_k a + (\lambda_k - 1)l_{small}$ and land is strictly increasing in capital.

iii) collateral constraint binds for both l_{large} and l_{small}, then again $l_c^*(l_{small}) = l_c^*(l_{large}) = l*c$, and,

$$l_p^*(l_{large}) - l_p^*(l_{small}) = l_p^*(\lambda_k a + (\lambda_k - 1)l_{large}) - l_p^*(k = \lambda_k a + (\lambda_k - 1)l_{small}) \geq 0.$$

as $\lambda_k a + (\lambda_k - 1)l_{large} > \lambda_k a + (\lambda_k - 1)l_{small}$ and land is strictly increasing in capital.

[38]The opposite could not be true as $k^* \geq \lambda_k a + (\lambda_k - 1)l_{large}$ implies that $k^* \geq \lambda_k a + (\lambda_k - 1)l_{small}$