Missing Land Markets, Misallocation, Insurance, and Redistribution*

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Abstract

In this paper, I study the extent to which insurance and redistribution benefits from communal land systems in low income countries offset their misallocation costs. I do this by introducing heterogeneity in agricultural and non-agricultural productivity, occupation choice and communal land into a standard model with uninsurable risk. I match the model to panel microdata from Malawi. I use the model to study the implications of converting the communal land system into a rental market. In the policy experiment, farmers at the time of the reform gain rental rights on the land they occupy. Before the reform, Incomplete markets and use or lose it principle make it costly for productive farmers to leave agriculture. The reform induces some of them to leave agriculture and earn a return on their land. This raises productivity in non-agriculture by 41% and in agriculture by 18%. Because land is very scarce and reallocations happen seldomly, the insurance and redistribution benefits of communal land in Malawi are small. Welfare increases by 7% through decreased inequality.

JEL Classification Codes: O11, E02, H11

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1 Introduction

Increasing evidence suggests missing land markets generate large productivity costs by preventing the reallocation of land to more productive farmers. Under communal land systems in developing countries, farmers have few opportunities to grow their operation through market transactions. Rather, the task of allocating most agricultural land is delegated to local leaders. In Africa for instance, it is estimated that 90% of land on the continent is under customary designation (Deininger et al., 2003). Under customary rules, local traditional authorities restrict private transfers and reallocate unused land to landless farmers. Studies using microdata from China and Malawi argue these practices have a disproportionate impact on high-ability farmers – driving them either to operate small farms or to leave agriculture altogether (Adamopoulos, Brandt, Leight, and Restuccia, 2017; Chen, 2017). They estimate that replacing these policies with land markets would raise agricultural productivity by a factor of 2 to 3 in China and Malawi.

Despite these productivity costs, rural institutions have long acted as a source of informal insurance in developing countries (Townsend, 1994; Udry, 1994; Morten, 2019). Under communal land systems, restrictions on private transfers ensure the land remains under the purview of local leaders for reallocation. Aware of this, households move to villages where land is available in times of economic stress. In low-income countries where the formal government plays a minor role in social insurance or redistribution, this provides an alternative avenue for poor households to access productive resources and smooth consumption. This suggests misallocation may emerge in part, while fulfilling a redistribution and insurance objective.

In this paper, I ask to what extent do welfare benefits through insurance and redistribution offset the misallocation costs associated with communal land. I do this by building a model that features uninsurable risk, a farm sector, occupation choice, and land access through communal land.[1] In the model, households face risk in non-agriculture and differ along their permanent productivity in each sector. After observing their productivities and whether they have access to communal land, households choose in which sector they will work. Landless households choosing to work in agriculture may be allocated land by a local leader. Those who are allocated land produce in agriculture as smallholder farmers. Those who are not allocated land supply their labor in agriculture as farm workers. When choosing to work in non-agriculture, households face income risk. Once allocated

[1]The model has the core features of a standard model of incomplete markets following a long tradition as in Imrohoroğlu (1989), Bewley (1986), Huggett (1993), Aiyagari (1994)

land, households have to work in agriculture to keep their land.

I use panel microdata from Malawi to discipline the parameters of my model. I exploit the longetudinal nature of the microdata and estimate for each household, a permanent fixed effect measure of household productivity in each sector. I use the estimated fixed effect and patterns of occupational mobility to discipline the dispersion and interdependence of permanent sectoral productivities. I extract the idiosincratic transitory component of income and use it to discipline the degree of risk in non-agriculture. At last, I use information on households accessing land through local leaders to discipline the degree of land availability. The model matches well patterns of employment, risk and mobility across sectors. The main insight of my paper is that the degree of uninsurable risk in non-agriculture makes leaving agriculture more costly when land is more scarce. As land becomes more scarce, fewer plots become available for reallocation and it takes longer for households to access land. It adds a new risk component to leaving agriculture: if opportunities in non-agriculture fail, regaining access to land may entail long spells in low-paid agricultural work. These dynamic incentives lead households to forgo static income gains in non-agriculture to keep their land. Since productive farmers produce more with their endowment of communal land, the principle of use or lose it imposed by local leaders make it more costly for them to leave agriculture.

In the main quantitative exercise, I conduct a policy counterfactual where the communal land system is converted into a rental market. I do this by assigning property rights to households on the land at the time of the reform. After the reform, local leaders no longer play a role in the allocation of agricultural land. The new landowners can now earn an income on their land and can allocate their labor to where they can earn higher income. Land gets reallocated as households rent land in and out until a rental price clear markets.

The policy raises aggregate output by reducing the extent of misallocation within and across sectors. Labor productivity rises by 18% in agriculture and 41% in non-agriculture. Since output is equal to worker productivity in non-agriculture, productivity gains in the sector come entirely from entry and exit of workers. Since the degree of land scarcity made it very costly for smallholders to leave agriculture, they were willing to forego significant income gains in non-agriculture to keep their land. The reforms allows them to rent out their land and realize these income gains – resulting in large productivity growth in non-agriculture. Labor productivity in agriculture rises through improved allocation of land across farmers and patterns of selection across sectors. The allocation of farmers in agriculture improves as productive farmers scale up their operations and unproductive ones scale down and earn higher wage income in a more productive sector. This increases productivity by improving the allocation of land across farmers. Selection further affects agricultural productivity by driving relatively unproductive farmers out of agriculture and productive ones into agriculture. I find that about 90% of the labor productivity gains in agriculture are realized through improved allocation of land across farmers and only 10% through selection.

My model implies worker selection plays a different role in shaping the effects of communal land compared to the previous literature. The use or lose it feature of communal land interacts with uninsurable risk in non-agriculture to induce productive farmers to remain in agriculture. By contrast, previous work that abstract from incomplete markets find that the restrictions on farm size tend to lead productive farmers to exit the agricultural sector. For instance, in Adamopoulos, Brandt, Leight, and Restuccia (2017) and Chen (2017), selection amplifies the productivity gains in agriculture by three to four fold and reduces productivity in non-agriculture. In my paper, restrictions on private transfers also function as a tax that affect productive farmers. However, because productive farmers generate more income from communal land, they have more to lose by leaving agriculture. These countervailing forces have significant implications for the extent to which the reform raises sectoral productivity.

After documenting the potential efficiency gains from privatizing land, I turn to other welfare implications through insurance and redistribution. I use methods developed by Benabou (2002) and Floden (2001) in order to disentangle these welfare impacts. Efficiency gains reduce inequality by ensuring unproductive farmers earn a return on their land. The degree of land availability in Malawi implies land is seldomly reallocated and its insurance value of is quite low. As a result, the land reform has little impact on insurance. Under the current calibration, I find that privatizing land increases utilitarian welfare by 21%. The higher welfare however comes from a 23% gain through efficiency, a 7% gain through lower inequality and negligible losses in insurance.

The key departure in my paper come from the addition of uninsurable risk into an otherwise standard model of selection and farm-level distortions. My model includes the standard selection framework from Adamopoulos, Brandt, Leight, and Restuccia (2017), but also adds land access rules that are common in communal land systems. My paper highlights an important interaction between the degree of land availability and uninsurable risk. So far, virtually all papers related to land misallocation and communal land abstract from incomplete insurance, and as a result, can only speak to welfare costs through efficiency gains (Adamopoulos, Brandt, Leight, and Restuccia, 2017; Restuccia and Santaeulalia-Llopis, 2017; Chen, 2017; Gottlieb and Grobovšek, 2019; Chen, Restuccia, and Santaeulàlia-Llopis, 2021).

I join a growing literature in macroeconomics trying to understand the implications of incomplete insurance to development (Donovan, 2020; Brooks and Donovan, 2020; Lagakos et al., 2018). Like these papers, the core of my model is a standard incomplete markets model in the tradition of Imrohoroğlu (1989), Bewley (1986), Huggett (1993), and Aiyagari (1994). In my paper, communal land access rules interact with incomplete markets, making it more costly for productive farmers to leave agriculture. In my paper, those who farm do so not only because of higher comparative advantage in agriculture, but also because they need to in order to keep their land. As a result, the degree of land availability and incomplete markets determine how much households are willing to give up in order to keep their land. This has significant implications for the extent to which agricultural productivity can be improved by reallocating land across farmers.

2 Context

Communal land systems are prevalent in the developing world through customary arrangements of access to land. It covers an estimated 90% of land in Africa, some indigenous regions of Latin America as well as some countries in Asia (Deininger et al., 2003). Under these systems, rights on land for individual cultivation are secured through membership in the lineage that cleared the land. Althouth property rights on land fall outside the purview of formal law, land rights provided by these systems are often secure, long-term, and in most cases inheritable (Feder and Noronha, 1987). Once the family has control over the land, they pass it down to their children as they marry and form their own families.

In the quantitative exercise, I focus on the particular case of Malawi. Malawi is typical of low-income countries in that it is primarily rural and agricultural. The particular advantage of Malawi is that it has detailed panel microdata that speaks to households' income from farm and non-farm activities and how frequently they switch between them. Further it includes information on how households acquire the land they use in agriculture. Malawi is one of the poorest and most densely populated countries in Africa. About 82% of the population live in rural areas, only down from 91% in 1977 (Peters and

Kambewa, 2007). This makes Malawi particularly relevant as issues of land availability may be increasingly relevant in the absence of markets. Further, its system of customary tenure shares many similarities with other countries in Africa, hence insights on their welfare costs and benefits may have broader implications.

Formally, there are three types of land ownership delineated in the Malawian constitution: customary, public, and leasehold. Under leasehold, the government grants long term leases and collects royalties from private individuals who run what is commonly known as estate farms. Leasehold titles were originally granted to Malawi nationals from land previously owned by colonial powers. Since independence, the government issues new titles by converting customary land into leasehold land. This however happens infrequently as it requires permission from local leadership who is expected to only grant such permissions for unused land that the village no longer needs. In Malawi, estate farms are the main cultivators of the country's cash crops: tobacco and tea.

I focus on customary land which represents the primary land tenure system and where a majority of the population in Malawi live. Customary land is an official designation of indigenous land that function much in the way of other communal land systems. The village chief (or headman) manages customary land by upholding lineage based inheritance rules and allocating unused land to local landless households. White (1989) sums up best the role of village chiefs regarding land in his book on village life in Malawi.

> The land belonged to the village, not to the lineage. It was the headman who was responsible for its distribution. Land which had once been allocated could not be taken back by the headman unless it had been left uncultivated, but the headman remained responsible for finding land for fresh settlers and for arbitrating boundary disputes. (p. 164)

This description illustrates the incentives facing poor households in Malawi where few sources of social safety net exist from the formal government. In a country where nearly all of rural land is managed in this way, moving to villages where land is available is a common practice for overcoming negative shocks.

3 Empirical Evidence

My model deals with the interaction of sector-specific productivity, sectoral risk, and occupational choice. In this section, I show some key results about the empirical counterparts of these that motivate my analysis and discipline central parameters. I use the longetudinal nature of the data to separate the permanent from risk components of productivity across sectors. There are three main takeaways:

- Permanent income dispersion is larger in non-agriculture
- Non-agriculture is riskier than agriculture

3.1 Data

I use data from the Malawi's Integrated Household Survey (IHS) which starting from 2010, also include the World Bank's Integrated Surveys of Agriculture (LSMS-ISA). ISA added detailed information on agricultural production to Malawi's main household survey. I use both the cross sectional data from 2010-2011 and 2015-2016 and the panel subsamples from 2010-2011 to 2012-2013.

The cross sectional samples are nationally representative and contains detailed information and all sources of household income and production. The 2010-2011 sample includes 12,271 households (56,397 individuals), and the 2015-2016 includes 12,447 households. In the data, I observe income generating activities of each household memeber: agricultural production, labor income, capital income, business income, assets, and transfers. Further, the 2015-2016 sample include questions about when and how the household acquired each agricultural plot they employ in agriculture.

The panel subsample has the same information as that of the cross section and includes both original and split-off households. In the panel data, the attrition rate was small. Only about 6% of eligible individuals from the baseline could not be traced back for a follow up in 2013. The 2012-2013 panel wave grew to 4,000 households as some were lost due to tracking issues or death while others were created by splitting off from baseline households.

3.2 Income

At the farm level, I observe all aspects of production: output, sales, intermediate expenditures, household hours, hired hours, and operated land size. This allows me to compute value added in agriculture at the household level. I follow Gollin, Lagakos, and Waugh (2014) and measure value added from all activities in agriculture including non-permanent crops, permanent crops, livestock, and livestock products. For each product, I measure value added as the sum across seasons of household revenues from sales, the market value of unsold product, minus the associated costs. In order to measure the value of unsold products, I use local prices whenever available. If the most local price is not available, I broaden the region category and use prices at a wider regional level (De Magalhães and Santaeulàlia-Llopis, 2018).

Outside of the farm, income is comprised of formal and informal labor, and business income. The household module of the survey contains detailed information on enterprises run by the household; including their revenues, input costs, and labor hours. Formal labor income is recorded for the primary occupation and secondary occupation while informal labor (ganyu) income is reported separately. Rural workers earning primarily ganyu and having no land are the poorest among Malawi's society.

This allows me to write household income as the sum of three categories of income: $y_i = y_{a,i} + y_{b,i} + y_{l,i}$, where $y_{a,i}$ is the value added measure of agricultural output, $y_{b,i}$ is business income, and $y_{l,i}$ is labor income. However, I want to use the income information in order to extract a measure of ability in each sector. However, ganyu is a large share of labor income for the poor and the data does not classify the sector associated with this income. Therefore, I classify as agricultural labor income any income deriving from informal work in rural areas. This allows me to further decompose labor income so that $y_{l,i} = y_{l,i,rural} + y_{l,i,urban}$. Before turning to how I separate permanent from transitory income I need a method for assigning households to occupations. In order to do this, I classify as a farm owner, those with more than 50% of their annual income coming from agricultural production. For other households, I label them as farm workers those earning more than 50% of their income from informal labor in rural areas. All other households are non-ag households. Table 1 summarizes income differences across these groups. Appendix C has more detail on the data construction of incomes in different sectors.

Table 1: Summary of Household Income, IHS 2010-11

	Mean	Dispersion	p20	p40	p60	p80	p90
Farm worker	26.8	37.7	4.2	12.3	21.9	39.0	56.0
Smallholder	51.1	126.1	15.4	27.2	41.7	68.1	97.6
Non-farm	161.2	484.8	26.8	48.6	84.0	157.6	286.3

Notes: Dispesion of income is measured by the standard deviation. All income is measured in thousands of March (2010) Kwachas.

Table 1 provides initial evidence of the degree of risk and heterogeneity in non-agriculture relative to agriculture. The share of households that are classified as farm owners is 63.3%, as farm workers is 9.3% and as non-farm workers is 27.3%. In 2010, Malawi's GDP per capita was 72 thousands of 2010 Kwachas. That is just below the 60th percentile of the non-farm income, above the 80th percentile of the income of farm owners and above the 90th percentile of farm workers.

3.3 Productivity and Risk

My model deals with occupational choice due to productivity differences and risk in non-agriculture. In this section, I use the longetudinal nature of the data to separate permanent versus transitory sources of priductivity. To this end, I use the classification of households as smallholders, farm workers, and non-farm workers as described above. To measure agricultural productivity, I use income from agricultural production $y_{a,i}$. To measure non-agricultural productivity I only keep the business, labor income, and informal labor income in the city $y_{b,i} + y_{l,i,urban}$ as income in non-agriculture. I can then exploit the panel dimension of the data to estimate the permanent and risk components of income in the two sectors.

To get the permanent component of output, I follow Adamopoulos, Brandt, Leight, and Restuccia (2017) and estimate the following equation

$$y_{i,v,t} = \mu_t + \mu_i + \varepsilon_{i,v,t} \tag{1}$$

where μ_t is the year fixed effect that captures time varying shocks to productivity that are common to all farmers; μ_i is the farm specific component that does not vary over time; and $\varepsilon_{i,v,t}$ captures idiosyncratic shocks specific to the household in a given year. In a second step, I follow their procedure to remove village specific effects that may not differ over time but differ across individuals. I remove these village specific effects by regressing the household fixed effect on village dummies and extracting the residual,

$$\mu_i = \mu_v + \eta_i \tag{2}$$

where η_i is a fixed farm component that captures a farm's permanent output that is constant across years and purged of village level factors. I then gather the residuals from equation 2 and they become the permanent measures of ability (I do this for income in each sector). My measure of risk comes from the idiosyncratic residual component of income $\varepsilon_{i,v,t}$ in equation 1.

Table 2: Productivity Variance

	Permanent	Transitory
Farm	0.71	1.20
Non-farm	1.12	2.19

Notes: Dispersion is measured by the variance.

The analysis above uncovers large differences in terms of heterogeneity and risk in agriculture versus non-agriculture. The high relative risk in non-agriculture motivates to model risk in non-agriculture.

3.4 Productivity and Land Access

I now investigate the extent to which households gain access to agricultural land through the village chief and its relationship to farm productivity. I first report patterns of agricultural land access in the cross sectoin. I then use the panel subsample to tie how households acquired their land to the estimated productivity fixed effect. The survey asks the household how each plot they employ in agriculture was acquired.

Table 3: Land Tenure in Malawi

	Family	Village chief	Rent/Own
Agricultural plots (%)	67	17	11

LSMS (2010/2011)

Table 3 displays the patterns of access to agricultural land in Malawi. Households are asked how each one of the plots they use in agriculture were acquired. Each column represents the percentage of agricultural plots acquired by mode of acquisition. Plots acquired either through allocation by traditional authorities or by family make up about 90% of agricultural plots. These represent the households living under customary land. The first column illustrates the dominance of the family based system of land allocation where land that was once allocated by traditional authorities continually gets passed down through the lineage. The chief (traditional authority) still dominates a large share of allocated land (17%). The rest is composed of short term rentals and long-term leases. Under the rent/own category, I include both short term rentals and land that is owned (or on leasehold). Short-term rentals are generally illegal by customary practices but they happen anyway. Of the 11% in this category, 3% is reported to be on leasehold. These are regulated leases managed by the formal government and discussed in section 2.

I now turn to the relationship between farm productivity and land access through the village chief. I first separate households by whether their current land holdings come entirely from the village chief (306 households). I use land size divided by household size and the estimated farm-level productivity fixed effect. Table 4 displays the difference in levels for land size and productivity when households acquire their plot through the chief versus otherwise. It shows that households with chief allocated land (who are likely to be veterans in the village), have bigger farms and higher productivity.

Table 4: Land Access and Productivity

	Land size	Productivity
Allocated by chief	0.36	1.31
Non-allocated	0.47	1.42

To further investigate the role of the chief, I regress the log of land size on the log of the estimated farm productivity fixed effect and a dummy for whether the households' land is acquired entirely from the chief versus those whose land have no chief allocated land. The coefficient on productivity is 0.48 while the coefficient on the dummy is 0.12. While the coefficient on productivity significant, the one on the dummy is only significant at the 0.05 level. To put this in context, the correlation of farm size and productivity in U.S. data is 0.90 (?). By selecting on households whose land is primarily allocated by the chief, they are likely to have been recently allocated. This is because the share of chief allocated land is likely to go down as households acquire more plots through the lineage based system. Figures ?? and ?? in the appendix C displays these the distribution of land sizes and the correlations estimated in a scatter plot.

3.5 Sector Switching

I now investigate the extent to which households switch across sectors and the productivity patterns. Since I classify the occupation of the household based on the primary income earned, not all switchers into the farm sector are new land allocations.

In table 5 I take households in each occupation in 2010-2011 (be row) and see where they end up in 2012-2013. I then take the percentage by occupation of households in 2010-2011 that ends up in each of the occupations in 2012-2013.

Table 5: Occupational Mobility

	Farm workers	Smallholders	Non-farm workers
Farm workers	16	57	26
Smallholders	4	71	24
Non-farm workers	2	30	67

Notes: Percentages add up to 100 by row.

Table 6 shows the level and dispersion of farm productivity for different occupations in 2012-2013 for those who were smallholders in 2010-2011. It shows the mean of farm productivity for those who stayed in agriculture is similar to those who left agriculture. However, the variance of farm productivity for those who left agriculture was much larger.

Table 6: Farm Productivity of 2010-2011 Smallholders

	Mean	Variance
Farm in 2012-2013	0.016	0.54
Non-farm in 2012-2013	0.015	0.80

4 Dynamic Model of Communal Land

In this section, I formalize the details of the model of communal land. There are two sectors: agriculture and non-agriculture. Households choose which sector to work in and face income risk in non-agriculture. Landless households can gain access to communal land by working in agriculture. If they gain use rights on land, they combine land and labor to produce agricultural output. At any time, they can run a non-farm business in non-agriculture. Households with use rights on land can either continue to produce on their farm or walk away from their land to run a non-farm business in non-agriculture. If they walk out of their land, it gets reallocated to a landless household in agriculture. Households have access to a risk free asset they can accumulate for self insurance (Bewley, 1986; Huggett, 1993; Aiyagari, 1994). In this section I describe in detail the choices faced by households in the model.

Demographics. There is a unit measure of dynastic households who discount utility at rate β and a village leader who has control over agricultural land, appropriates unused land and grants use rights to landless agricultural households in the economy.

Preferences. Dynastic households maximize expected discounted utility.

$$U = \sum_{t=s}^{\infty} \beta^{t-s} u(c_t) \tag{3}$$

where we can abstract from sectoral differences in consumption goods as we assume they are perfectly substitutible. The utility function is CRRA with risk aversion parameter σ so per period utility can be written as: $u(c) = \frac{c_t^{1-\sigma}}{1-\sigma}$

Household endowments. Households are endowed with one unit of labor which they supply inelastically. Their permanent productivities $\bar{z}_a$ in agriculture and $\bar{z}_n$ in non-agriculture are drawn from a joint log-normal distribution. Households face idiosyncratic persistent shocks $z_{n,t}$ in non-agriculture. When working in agriculture, households can be either landless or landholders. Agricultural households who are landholders are endowed with a common endowment of land ℓ_c and are called smallholder farmers while those who are landless are called farm workers.

Technology. Smallholder farmers have access to farming technology based on their permanent and transitory productivities and produce $\bar{z}_a f_a(\ell_c, n_{a,t})$ by combining ℓ_c with hired labor. They earn profits and the return on their own labor $w_{a,t}$. At any point, the household can choose to work in non-agriculture and access a technology to produce according to $f_n(\bar{z}_n, z_{n,t}) = \bar{z}_n z_{n,t}$ where $z_{n,t}$ is drawn from an AR1 process that can be written as follows:

$$\log z_{n,t+1} = \rho_z \log z_{n,t} + \sigma_z \epsilon_t \tag{4}$$

where ϵ_t is an i.i.d random variable drawn from a standard normal distribution.

Household decisions. Households make dynamic decisions according to five individual states: landholding status, permanent productivity in each sector, persistent shocks in non-agriculture and assets. These individual states can be summarized according to $x \in \mathcal{L} \times \mathcal{B} \times \mathcal{Z}_n \times \bar{\mathcal{Z}}_n \times \bar{\mathcal{Z}}_a$ such that $\mathcal{L}$ is binary indicator that represents access to land while other states are continuous. Given its endowment and realizations of shocks, households first decide whether to work in agriculture or non-agriculture. Let W and V

denote the value functions of landless and landholding households respectively. Then

$$W(b, z_n, \bar{z}_n, \bar{z}_a) = \max\{\pi_a V^a(b, z_n, \bar{z}_a) + (1-\pi_a) W^a(b, z_n), W^n(b, z_n, \bar{z}_n)\} \tag{5}$$

$$V(b, z_n, \bar{z}_n, \bar{z}_a) = \max\{V^a(b, z_n, \bar{z}_a), W^n(b, z_n, \bar{z}_n)\} \tag{6}$$

where π_a is the probability of land allocations by the village chief; V^a is the value function of being a landholder and working in agriculture as a smallholder; W^a is the value function of being landless and working in agriculture as farm worker; and W^n is the value function of working in non-agriculture. Note that the allocation of the village chief is directed towards landless households.

I now explain each of the underlying value functions in turn. Landless households choosing agriculture can either become a farm worker or a smallholder. Those choosing agriculture but not allocated a plot of land become landless farm workers. They earn the wage in agriculture and divide their assets between consumption and savings but are subject to a borrowing constraint. Let W^a be the value function of landless farm workers, their problem can be written as:

$$W^a(b, z_n, \bar{z}_n, \bar{z}_a) = \max_{c, b'} \quad u(c) + \beta \mathbb{E}_{z'_n|z_n}\left[W(b', z'_n, \bar{z}_n, \bar{z}_a)\right] \tag{7}$$

$$c + b' = w_a + Rb, \quad b' \geq -\phi \tag{8}$$

With probability π_a, the household is allocated a plot by the village chief and produce using the farm technology. Households face constraints on their borrowing which is limited to ϕ. Those who become smallholders now earn profits along with the return on their labor. Let V^a be the value function when being allocated a plot of land. Then, the consumption-savings problem of the household can be written as:

$$V^a(b, z_n, \bar{z}_n, \bar{z}_a) = \max_{c, b', n_a} \quad u(c) + \beta \mathbb{E}_{z'_n|z_n}\left[V(b', z'_n, \bar{z}_n, \bar{z}_a)\right] \tag{9}$$

$$c + b' = \bar{z}_a f_a(\ell_c, n_a) - (n_a - 1) w_a + Rb, \quad b' \geq -\phi \tag{10}$$

When choosing to work in non-agriculture, the household faces income risk. There is no possibility of being allocated land when choosing to work in non-agriculture. Let W^n denote the value of non-farm work. These households now divided their risky income into consumption and savings according to:

$$W^n(b, z_n, \bar{z}_n, \bar{z}_a) = \max_{c,b'} \quad u(c) + \beta \mathbb{E}_{z'_n|z_n}[W(b', z'_n, \bar{z}_n, \bar{z}_a)] \tag{11}$$

$$c + b' = f_n(\bar{z}_n, z_n) + Rb, \quad b' \geq -\phi \tag{12}$$

where summarizes the value functions of the three occupations in the economy.

Like the landless households, landholders choose whether to work in agriculture or non-agriculture. If they choose agriculture, they are smallholder farmers, have value function V^a and face the consumption savings problem described in equations 9 and 10. Households choosing to work in non-agriculture have value function W^n and face the consumption savings problems described in equations 11 and 12. A key feature of my model is that when landholders choose to work in non-agriculture, they lose their rights on the land and walk into next period with the value function of a landless household W. Having described the decision problems facing all agents in the economy, I now describe the equilibrium concept I rely on for my analysis.

Equilibrium. I focus on a stationary equilibrium where the distribution of states in the economy are constant. A stationary equilibrium in this economy is an agricultural wage (w_a), a land allocation probability (π_a), and value functions $V(b, z_n, \bar{z}_n, \bar{z}_a)$, $W(b, z_n, \bar{z}_n, \bar{z}_a)$ such that:

- Landless and landholding households solve their individual problems
- Agricultural labor markets clear:

$$\begin{aligned}&(n_a(w_a) - 1)\left(\int_V \mathbb{I}_{(occ=a)}(x)dF(x) + \pi_a \int_W \mathbb{I}_{(occ=a)}(x)dF(x)\right)\\ &= (1-\pi_a)\int_W \mathbb{I}_{(occ=a)}(x)dF(x)\end{aligned}$$

- Communal land used in agriculture production cannot exceed supply

$$\ell_c \int_V dF(x) = \ell_c N_c \leq L$$

- Stationarity implies flow of new communal households equal the flow of new landless

$$\pi_a \int_W \mathbb{I}_{(occ=a)}(x)dF(x) = \int_V \mathbb{I}_{(occ=n)}(x)dF(x)$$

5 Discussion of Model Mechanisms

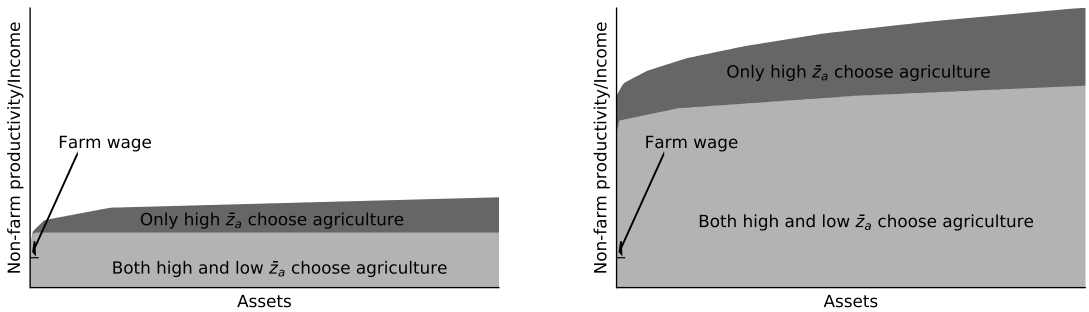
In this section, I demonstrate the ways in which my model captures the incentives households face under communal land and their implications for resource allocation, insurance and redistribution. In particular, I highlight the interaction between use or lose it rules of communal land and uninsurable risk. First I show how this interaction affects the distribution of farmers who end up on communal land. I then show how access to communal land affects the distribution and volatility of consumption in the economy. I start in partial equilibrium where w_a and π_a are given.

5.1 Occupation Choice and Agricultural Productivity

I begin by showing how occupation choices shape the distributions of farm productivities operating in agriculture. In the model the only households who are eligible to access communal land are landless agricultural workers. However land is scarce and there may not be available land for all those who want it. Further, if a household stops farming their land, it is taken away from them and given to someone willing to farm it. This creates rather different incentives for agricultural work for those with land versus those without. While those with no land see agricultural work as an investment into gaining access to land, landholders see it as an avenue for keeping an important source of insurance.

In the first exercise, I demonstrate how incentives related to risk and land access affect the household's occupation choice. To this end, I fix both permanent productivities and instead focus on transitory shocks in non-agriculture and land access. In figure 5a, the shaded region represents the transitory productivity levels in non-agriculture and assets where the household goes into agriculture. However, when choosing agriculture, they can end up as a farm worker or immediately gain access to communal land and become a smallholder farmer. As a farm worker, the household earns the prevailing wage in agriculture. As smallholder, they earn both the wage and the profits from their land holding. To put this into perspective, a farmer whose $\bar{z}_a = 0$ could still choose to go into agriculture and earn the wage w_a. The curvature on assets illustrates the role of borrowing constraints in limiting the amount of time the household spends in agricultural work waiting for land until they run out of assets. The solid line represents the level of non-agricultural productivity such that $\bar{z}_n z_n = w_a =$ farm worker income. If the landless household gains access to land, they earn in the current period $y_a = \pi + w_a =$ smallholder income where π are the farm profits. When becoming a landholder, the household faces different incentives. It takes a much large non-agricultural productivity shock to induce them to leave agriculture. Because they lose the land if they leave it, they are willing to forego high earnings in non-agriculture in order to keep their land. They do this because the land not only come with static income gains, but carries future value in the event that their non-agricultural productivity drops.

Figure 1: Occupational Choice and Agricultural Productivity



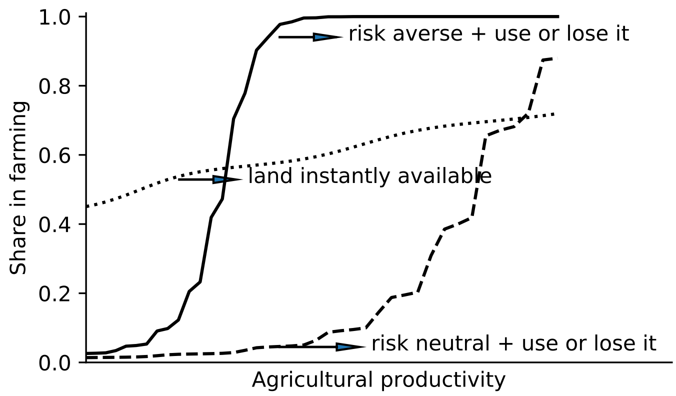
(a) Landless

(b) Landholder

Notes: While $\bar{z}_n$ is fixed, non-farm productivity includes both components of productivity $\bar{z}_n z_n$. Since this also coincides with non-farm earnings when choosing non-farm, the y-axis has the same scale as earnings.

These occupation choices have important implications for the distribution of farmers in agriculture. In order to illustrate this, I now continue with the same fixed permanent productivity in non-agriculture but now look at the patterns of farmers that emerge along the entire distribution of agricultural productivities. In this exercise, I continue in partial equilibrium with w_a and π_a fixed. I then solve for the optimal decisions of households given w_a and π_a and simulate a panel of households who make optimal decisions until a stationary distribution is reached. A stationary distribution is reached when the mass of those leaving their land behind is equal to that of those gaining access to land. I then compute the mass of households with land for each level of permanent productivity in agriculture. These are the operating farmers in the economy. For a household with no land in non-agriculture I call landless risk, the uncertainty about whether a household gets the land when going into agriculture. As $\pi_a \to 0.0$, this risk is higher. In order to illustrate the role of landless risk and uninsurable risk, in figure 2, I plot the share of households at each level of permanent productivity in agriculture who end up on land in the stationary distribution. In a standard Roy model with permanent productivity differences and no transitory shocks, this will be 1 or 0. My model nests this case by removing transitory shocks and making $\pi_a = 1$. In that case, there is a cutoff $\bar{z}_a^*$ such that all households with $\bar{z}_a > \bar{z}_a^*$ go into agriculture and all those with $\bar{z}_a < \bar{z}_a^*$ go into non-agriculture.[2] I add each new feature I introduce in my paper to illustrate their impact on the distribution of operating farmers in the economy.

Figure 2: Distribution of Farm productivity, Uninsurable Risk and Land Availability



To illustrate the implications of income and landless risk, in this exercise, I introduce each of these items in turn. When I add transitory shocks and there is no sense of land scarcity ($\pi_a = 1$), more productive farmers are more likely to go into agriculture. They compare incomes in each sector and go to where they are paid more. The dotted line illustrates the pattern of farm productivities that end up in agriculture in the stationary distribution. The dashed line represents the possibility of gaining access to communal land in agriculture but the households are risk neutral. In this case, there is no insurance concerns but the household is going to be more willing to go into agriculture and enjoy the higher lifetime value of agricultural work. This value now includes the possibility of gaining access to land. When markets are incomplete and households face uninsurable income risk in non-agriculture, they are less willing to give up their land.

5.2 Insurance and Redistribution

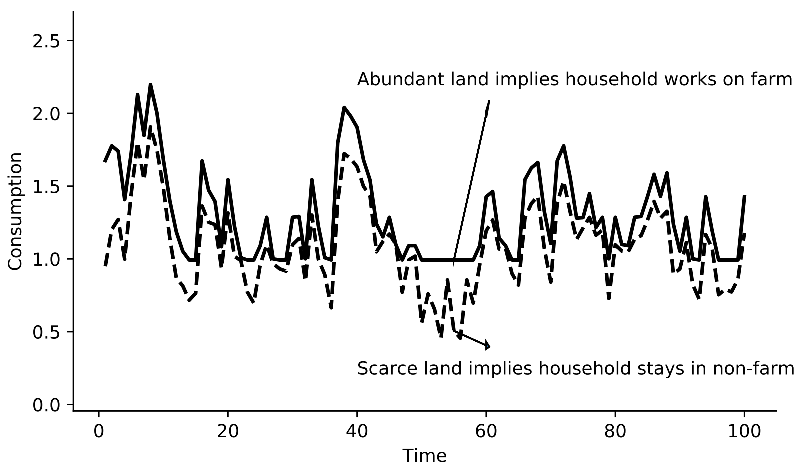
In this section I focus on the redistribution and insurance properties of communal land. To this end, I vary π_a and study occupation and consumption patterns across time and in the cross section. In this exercise, households are still taking π_a and w_a

[2] My model nests the standard framework used to study misallocation in from communal land systems. Without transitory shocks or any sense of land scarcity ($\pi_a = 1$), it is a simplified version of Chen (2017) and without heterogeneity in non-agriculture, it's a simplified version of Chen, Restuccia, and Santaeulàlia-Llopis (2021)

as given. I start from a path of non-agricultural productivity shocks that households experience under a low π_a and under high π_a. I first compute optimal individual decisions taking both the π_a levels as given and the same wage $w_a = 0.1$. I then simulate these households until a stationary equilibrium is reached. From the stationary distribution, I simulate the household over 100 periods. The patterns I illustrate here are similar across permanent productivity levels, therefore I hold them fixed. The non-agricultural income is a combination of their permanent and transitory components and move over time. The household's farm income if they access land is $y_a = \pi + w_a$

Consider first the consumption path for a household when $\pi_a = 1$ represented by the solid line. The consumption level of this household never drops below their income from smallholder farming. They move in and out of agriculture several times, experiences higher levels of consumption as a result and also avoid states of the world that would bring their income below the farm income. This demonstrates how higher levels of π_a allows the household to enjoy higher consumption levels. The effect on volatility is less clear. For landless households, a higher π_a allows them to avoid low levels of income, while for smallholders, it allows them to go out and take advantage of higher productivity in non-agriculture more often. In other words, while the redistribution effect of higher π_a is obvious by allowing households to enjoy higher levels of consumption, its effect on consumption volatility is less clear.

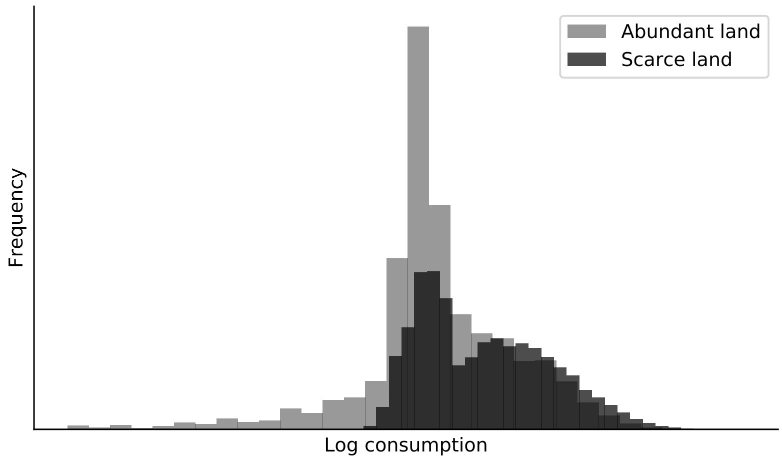
Figure 3: Consumption Path of Household under Scarce vs Abundant Communal Land



Notes: Households in this simulation experience the same sequence of transitory shocks in non-agriculture

Finally, to understand the cross sectional implications of higher access to communal land, I plot the distribution of consumption in the stationary distribution under the same π_a regimes. The patterns of consumption across a household's lifetime have significant implications for observed patterns in the cross section. Figure 4 illustrates this point as a higher π_a shifts the distribution of consumption to the right by allowing households access to land when their transitory productivity drops. Further, this has a disproportionate impact on low ability farmers whose threshold for leaving agriculture is lower.

Figure 4: Distribution of Log Consumption of Landless Households



6 Calibration

I use simulated method of moments in order to parametrize the model and study its quantitative implications. To this end, I use a mix of both micro and macro moments estimated in section 3. I calibrate the baseline model of Malawi with data from the Living Standards and Measurement Survey (LSMS). I use the survey years of 2010 and 2013. With moments from the data in hand, the calibration works as follows: I begin from a guess of parameters, solve the model, simulate a panel of households, compute moments from the model, and iterate on parameters until model and moments are matched. Table 7 has the list of parameters that I calibrate along with their values. Below I describe how they were chosen in detail.

Parameters set exogenously. There are 5 parameters to set exogenously, 4 of which are set to standard values in the literature. I set $\beta = 0.96$ since the model is in yearly frequency and $\sigma = 2$ as in Lagakos et al. (2018). I have three technology parameters

Table 7: Calibration Parameters

	Expression	Value
Predetedermined Parameters		
Interest rate	R	0.90
Discount Factor	β	0.96
Risk Aversion	σ	2.00
Land share	α	0.50
Span of control of farmer	ζ	0.50
Elasticity of substitution between land and labor	γ	1.10
Calibrated Parameters		
Mean of permanent non-agricultural productivity	μ_n	-1.33
Variance of permanent non-agricultural productivity	σ_n	1.45
Variance of permanent agricultural productivity	σ_a	0.68
Covariance of agricultural and non-agricultural productivity	$\sigma_{n,a}$	-0.24
Probability of land allocation	π_a	0.04
Persistence of non-agricultural productivity process	ρ_z	0.40
Variance of non-agricultural productivity process	σ_z	1.00

to set: ζ determines the span of control of the farmer, γ is the elasticity of substitution between land and labor and α determines the land share. I set the land share to $\alpha = 0.5$, the span of control parameter to $\zeta = 0.5$ and the elasticity of substitution to $\gamma = 1.1$. Since asset markets are in partial equilibrium as in Lagakos et al. (2018), I also set the interest on assets exogenously. Since my model is set in annual frequency, I set it to $R = 0.90$.

Parameters chosen jointly. There are 7 parameters to target. I leave the supply of land L to be consistent with an equilibrium where all of the land is being used, ℓ_c, and μ_a to be normalized. Therefore, I am left to calibrate the probability of gaining access to communal land π_a, the variance and the persistence of the the non-agricultural productivity process, σ_z and ρ_z, the variance of the distribution of productivity in agriculture, σ_a, the mean and variance of the distribution of permanent productivity in non-agriculture, μ_n and σ_n and the covariance of permanent agricultural and non-agricultural productivity $\sigma_{a,n}$. In order to pick these parameters, I match them to moments from the LSMS. These targeted moments include the share of the population in smallholder farming, the share of the population working as a landless farm worker, the share of workers in agriculture in 2010 transitioning to non-agriculture in 2013, the variance of the log permanent non-agricultural income in 2010, the variance of the log transitory non-agricultural income, the variance of output in agriculture and the covariance of permanent agricultural and non-agricultural income. While the parameters are chosen to match parameters jointly, each one of them are informative about particular moments. In this section I go through each parameter and associated moment in detail.

To match employment shares I use the mean of the non-agricultural productivity distribution μ_n and the probability of accessing communal land π_a. I use these parameters to match the share of households that engage in smallholder farming and the share of households engaged in landless farm work. In the data, I first classify households that earn income primarily from agricultural production as a smallholder farmer. I take this number for the larger cross section data from 2010. Next I need a measure of landless farm workers. In order to get this share, I classify anyone in the data whose income is earned primarily in rural informal work as landless farm workers. I also take this number from the larger cross sectional data from 2010.

For the distribution of permanent productivity in the two sectors, I have four parameters; the variance of agricultural income σ_a, the variance of non-agricultural income σ_n, the mean of non-agricultural income μ_n, and the covariance of agricultural and non-agricultural incomes $\sigma_{a,n}$. The variance of permanent agricultural productivity σ_a determines the degree of misallocation in the baseline economy. In order to pick this parameter I use the permanent measure of agricultural output that I estimate using panel data methods described in section 3. I then use the variance of the estimated farmer fixed effect component of agricultural output as a target. The variance of permanent non-agricultural productivity σ_n governs the degree of permanent non-farm abilities in the economy. I take the analogous measure of permanent income for non-agriculture described in section 3 and use the variance as a target. For the mean μ_n, I target the share of households staying in agriculture. For the covariance, I use occupation switchers. I take someone in agriculture in 2010 who has moved to non-agriculture in 2013 and I compute the covariance of their permanent abilities.

The variance of the non-agricultural income process σ_z determines the degree of risk in non-agriculture. I use the variance of the idiosyncratic component of income dispersion derived in section 3. I classified households as non-agricultural households those who are not smallholder farmers or farm workers. In order to arrive at a measure of income volatility for this group, I only consider households transitioning from agriculture. I then use the variance of the idiosyncratic component of income for households who transition from agriculture to non-agriculture. This will include both households transitioning from the landless status as well as those transitioning form the communal land sector.

Table 8: Data and Model Moments

Targeted Moments	Model	Data
Share of smallholders farmers (2010)	0.69	0.64
Share of farm workers (2010)	0.06	0.09
Share in farming in 2010 in non-agriculture in 2013	0.06	0.25
Variance of transitory non-farm income of switchers	0.96	2.10
Variance of permanent non-farm productivity in 2010	0.84	1.20
Variance of permanent farm productivity in 2010	0.78	0.71
Covariance of farm and non-farm productivity of switchers	0.18	0.09

7 Quantitative Analysis

I now use the model to understand the impacts of creating a market for land. I start with a policy experiment that is standard in the misallocation literature. The analogy is to "remove distortions" and allow farmers to rent in and out their labor and land endowments. In my model, this means giving ownership rights to landholders in the stationary equilibrium and allow them to rent land and adjust their operation size optimally. I conduct two exercises. First, I compute a counterfactual economy where landholders in the stationary equilibrium become owners of the land and are able to engage in a rental market. Second I decompose the welfare changes into its contribution to growing the pie (efficiency), inequality (redistribution), and income volatility (insurance) both in the aggregate and the cross section in the population.

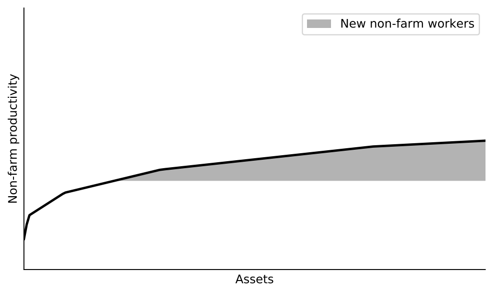
7.1 A Land Rental Market

In the primary policy experiment in the paper, I convert the communal land system into a private rental market. This policy experiment is useful in two ways. First, many of the land titling reforms taking place throughout Africa (See XX) give ownership rights to current holders of the land. One of the primary goals of these reforms are to generate an active rental market. Second, this is a common exercise in the literature on static land misallocation which so far has been the primary tool used to quantify the benefits of market oriented land policies in low income countries.

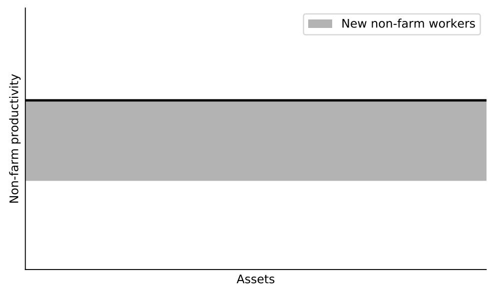
In practice, the rental market allows farmers to choose their operation size $\ell \neq \ell_c$ and earn rents $q\ell_c$ if they become landowners. Further, because the village chief no longer allocates agricultural land, π_a is no longer operative. The details of the economy after the reform are described in appendix A. The counterfactual I perform takes households who are currently on the land (holding the value function V^a) and gives them rights to rent their land endowment ℓ_c. Households with low productivity in non-agriculture without land can now join the agricultural sector by renting in land from landowners. Landowners who had "too much" land based on their productivity rents land out and allocate their labor to the sector with higher earnings. Productive farmers who were constrained before the reform grow their operations.

The occupation choice is no longer dependent on the ownership of land and rather, it is solely a function of labor earnings in the two sectors. Further, because households do not use assets in production or incur adjustment costs when switching sectors, occupation choice is also independent of asset position. As a result, at any time, and for any combination of $\bar{z}_a$ and $\bar{z}_n$, there is a cutoff point $z_n^*(\bar{z}_a, \bar{z}_n)$ such that households go into non-agriculture if transitory shocks fall above this point and into agriculture if it falls below. Below I plot the old and new occupation choices of households following the reform. The shaded area represents the levels of assets and non-farm productivity of households leaving agriculture after the reform. The similar levels of non-farm productivity illustrates how land ownership no longer matter for occupation choices once land can be rented.

Figure 5: Sector Choice and Household Earnings



(a) Landless



(b) Landholder

Notes: While $\bar{z}_n$ is fixed, non-farm productivity includes both components of productivity $\bar{z}_n z_n$

In this section, I will first report the aggregate changes from the reform. I will then explain in detail how misallocation in agriculture in reduced. I will then move towards the welfare implications of the reform both in the aggregate and along the distribution of permanent ability differences.

7.1.1 Aggregate Implications

The aggregate impacts of a rental market in terms of efficiency are sizable with several caveats. Efficiency rises in both sectors from improvements in the allocation of labor across sectors and land across farmers. Misallocation of land across farmers is reduced with a rental market by productive farmers growing their operations and unproductive ones reducing their farm size and earning rental income from their land instead. Patterns of entry and exit into each sector determine the ultimate impact of the policy on sectoral productivity. The land reform delivers efficiency gains both in agriculture and non-agriculture with those in non-agriculture significantly higher. This however does not reduce the gap between agricultural and non-agricultural productivity. Since farmers under communal land are giving up higher transitory income in non-agriculture in order to keep their land, non-agricultural productivity gains from the reform are sizable.

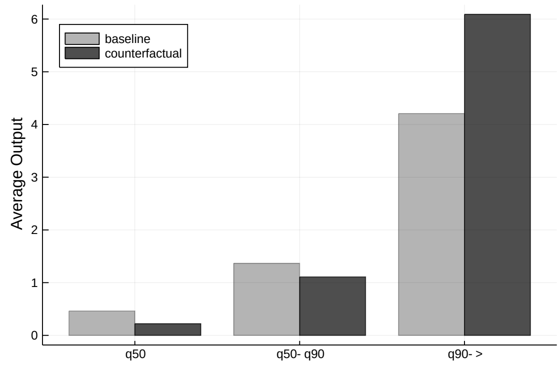
Table 9: Aggregate Impacts

Statistic	Baseline	Reform
Y_a	1.00	1.10
N_a	0.77	0.72
Y_a/N_a	1.00	1.18
Y_n	1.00	1.65
N_n	0.23	0.28
Y_n/N_n	1.00	1.41
w_a	1.00	1.13
q		0.45

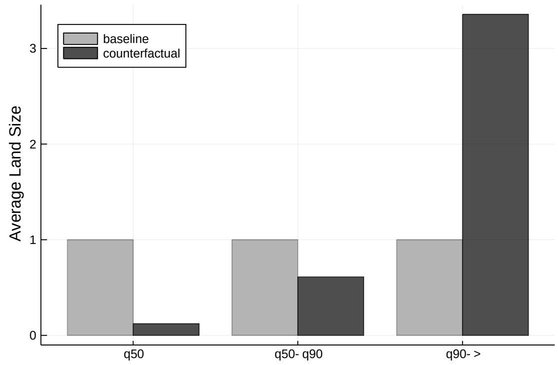
7.1.2 Agricultural Productivity

I now explore how agricultural productivity rises. There are two important changes that take place after the reform. First, land becomes better allocated across those in agriculture. This is a key feature of many studies of land misallocation and is also operative here. Second, patterns of exit and entry changes the distribution of abilities in each sector and shape productivity effects of the reform. The first plot displays the new distribution of both land and output. Figure 6a displays the average output by output over the distribution of productivities. It shows that unproductive farmers produce less and less of the total output while productive produce more. Figure 6b illustrates how the patterns of output changes are driven by productive farmers scaling up their operation by increasing their land size while unproductive ones scale down.

Figure 6: Post Reform Allocation of Land and Ouput



(a) Average Output by Productivity Quintile

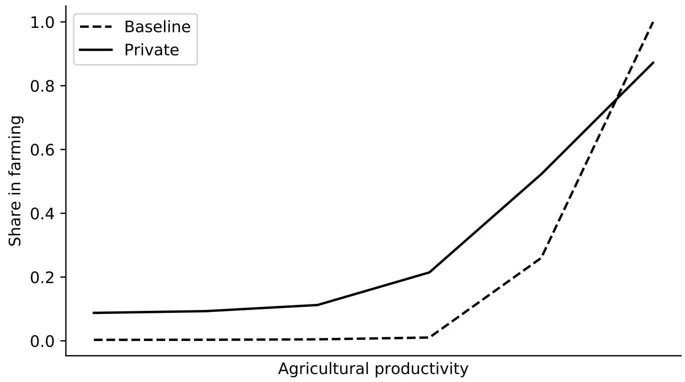


(b) Average Size by Productivity Quintile

One caveat in my paper is that households are willing to give up static income gains in order keep their land. This effect is especially pronounced for productive farmers. For households with low productivity in non-agriculture, they select themselves into agriculture before the reform and since their labor is more productive after the reform, they are better off and largely stay in agriculture. In order to demonstrate the new mechanism, I focus on the high non-agricultural ability households. These are the households that through the new mechanism would have been giving up the most to keep their land. In particular, take those with the highest non-agricultural productivity $\bar{z}_n = \bar{z}^h$ in my quantitative exercise. I plot below the share of households in farming along the agricultural productivity before and after the reform. It illustrates how uninsurable risk interacts with selection to dampen the productivity gains from a rental market. In the upper right corner of figure 7, the reform induces some high ability farmers to leave agriculture, as they were forgoing too much income to keep their land. The higher wage in agriculture induces some low ability farmers undergoing negative shocks to join the farm sector. These patterns take place along the entire distribution and rationalize agricultural productivity gains that are similar to the static one sector case.

In a final exercise, I follow Adamopoulos, Brandt, Leight, and Restuccia (2017) and Chen (2017) and decompose the changes in agricultural productivity coming from selection versus those coming from improved allocation of land across farmers. In this exercise, I fix the occupation choice of farmers in the baseline and let them rent land at the prices of the counterfactual policy. This yields an increase in productivity of 16% and no increase in non-agricultural productivity. This implies that although selection amplifies the effect market restrictions on agricultural productivity by 2 percentage points, it amplifies its effect on aggregate labor productivity by significantly more. However,

Figure 7: Share of households with $\bar{z}_n = \bar{z}^h$ in farming by $\bar{z}_a$



this takes place through substantial increases in non-agricultural productivity by allowing those undergoing positive shocks in non-agriculture to take advantage of the income gains without fear of losing their land. This illustrates how the channels I introduce in my paper change the amplifying effect of selection that is present in models that abstract from incomplete markets and the actions households take to access communal land.

7.1.3 Welfare Implications

As the previous section highlighted, the reform leads to significant efficiency gains. In section 5, I also highlighted how communal land can deliver higher insurance and lower inequality by preventing the persistence of low consumption in landless agricultural work. However, the π_a that was calibrated using micro data implies the redistribution and insurance value of Malawi's communal land system may be low. This may in part reflect the lack of opportunities outside of agriculture which perpetuates high employment in agriculture. This implies the efficiency gains have widespread benefits in the economy. In this section, I decompose the benefits into its various components both in the aggregate and in the cross section.

In this section I focus on the distributional aspects of these welfare gains. I use methods developed by Benabou (2002) and Floden (2001) in order to decompose the welfare gains into its efficiency (consumption levels), insurance (consumption volatility), and redistribution (inequality). The exercise under this section comes from steady state to steady state comparison, therefore, I focus on distributional outcomes along the permanent productivity distribution. The welfare criterium used is an utilitarian social welfare function [3]. The total welfare gains from privatizing land is 20%.

8 Conclusion

In this paper I study the implications of risk and incomplete insurance for privatizing communal land systems in developing countries. Since these communal systems also redistribute resources from the rich to the poor and provide means for households to shield themselves from risk, removing this function and allowing markets to allocate land also carries costs when insurance markets are incomplete. However, I find that the efficiency gains to be quite sizable. In my paper, most of the gains come from allowing households to access temporary, albeit risky, opportunities in non-agriculture without losing their land. I discipline the degree of risk in non-agriculture, land access, and sector mobility using rich panel data from Malawi.

[3] The details of the decomposition are delineated in section **??** of the appendix

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A Counterfactual Private Economy

This section describes the counterfactual economy that I use in order to quantify the insurance and redistribution value of communal land. This economy is analogous to having the share of the population in the stationary equilibrium on communal land with permanent rights on communal land. All functional forms are the same. The bellman equations have the same interpretation, however the binary land state is now permanent.

Individual policies Therefore the occupation choices can be written as:

$$W(b, z_n, \bar{z}_n, \bar{z}_a) = \max \{V^a(b, z_n, \bar{z}_n, \bar{z}_a), W^n(b, z_n, \bar{z}_n, \bar{z}_a)\}$$
$$V(b, z_n, \bar{z}_n, \bar{z}_a) = \max \{V^a(b, z_n, \bar{z}_n, \bar{z}_a), W^n(b, z_n, \bar{z}_n, \bar{z}_a)\}$$

where these value functions for each activity $k \in \{a, n\}$ can be written as follows:

$$V^k(b, z_n, \bar{z}_n, \bar{z}_a) = \max_{c,b'} \quad u(c) + \beta \mathbb{E}_{z'|z} [V(b, z_n, \bar{z}_n, \bar{z}_a)]$$
$$c + b' = y_k(z_n, \bar{z}_n, \bar{z}_a) + q\ell_c + Rb, \quad b' \geq -\phi$$

$$W^k(b, z_n, \bar{z}_n, \bar{z}_a) = \max_{c,b'} \quad u(c) + \beta \mathbb{E}_{z'|z} [W(b, z_n, \bar{z}_n, \bar{z}_a)]$$
$$c + b' = y_k(z_n, \bar{z}_n, \bar{z}_a) + Rb, \quad b' \geq -\phi$$

where $y_k(z) = z$ if $s = n$ and $y_k(z) = w_a$ if $s = a$. Further, q is the rental rate on land.

Equilibrium. A stationary equilibrium in this economy is an agricultural wage (w_a), a rental rate on land (q), and value functions $V((b, z_n, \bar{z}_n, \bar{z}_a), W((b, z_n, \bar{z}_n, \bar{z}_a)$ such that:

- Households solve their individual problems
- Household farms choose labor and land optimally
- Agricultural labor markets clear
- Agricultural land markets clear

B Welfare Decomposition

In this section I describe in detail the decomposition as described in Floden (2001). It's a slightly simplified version of what is in his paper as I don't have leisure in my economy. The goal is to devise a method that allows me to compare the welfare properties of the economy under communal land and one in which communal land is privatized. Undoubtedly, this change in policy will affect levels of consumption, distribution of income and uncertainty households face. We want a method that can capture the relative effects separately. We can start by defining lifetime utility as

Definition 1 *Lifetime utility V can be written as:*

$$V(\{c_s\}_{s=1}^{\infty}) = \sum_{s=t}^{\infty} \beta^{s-t} u(c_s) \tag{13}$$

Definition 2 *Certainty-equivalent consumption bundle $\{\bar{c}\}$ fulfills*

$$V(\{\bar{c}_s\}_{s=1}^{\infty}) = E_t V(\{c_s\}_{s=t}^{\infty}) \tag{14}$$

Now let C be the average consumption, $C = \int c d\lambda$ and let $\bar{C}$ denote the certainty equivalent consumption $C = \int \bar{c} d\lambda$. We are now ready to describe the utilitarian social welfare, U

Definition 3 *The utilitarian social welfare function is defined as:*

$$U = \int E_t V(\{c_s\}_{s=t}^{\infty}) d\lambda \tag{15}$$

And finally we are ready to define the welfare gain of a particular policy compared to a baseline.

Definition 4 *The utilitarian welfare gain of a policy change, ω_U is defined by*

$$\int E_t V(\{(1+\omega_U)c_s\}_{s=t}^{\infty}) d\lambda^A = \int E_t V(\{c_s\}_{s=t}^{\infty}) d\lambda^B \tag{16}$$

We can think of ω_U as the percent of lifetime consumption agents in economy A are prepared to give up to get the policy change. This is the classic measure of consumption equivalence from Lucas's calculations of the costs of business cycles. We can compute this for different groups. For example, I calculate this for different quintiles of the non-ag quintile distribution and of the income distribution. All one would have to do is adjust measures λ^A and λ^B so that it captures the designated groups. Now we are ready to get measures required to isolate effects through insurance versus redistribution. The idea is to first get the certainty equivalent consumption for each individual, the inequality is measured by the distribution of certainty equivalent consumption while uncertainty is measured by comparing differences in actual and certainty-equivalent consumption.

Definition 5 *The cost of uncertainty, p_{unc} is defined as:*

$$V(\{(1+p_{unc})C\}_{s=t}^{\infty}) = V(\{\bar{C}\}_{s=t}^{\infty}) \tag{17}$$

The cost of uncertainty can be intuitively thought of as the percent of average consumption agent is willing to give up in order to just get the certainty equivalent average every period (holding inequality fixed).

Definition 6 *The cost of inequality, p_{ine} is defined as:*

$$V(\{(1+p_{ine})\bar{C}\}_{s=t}^{\infty}) = \int V(\{\bar{c}\}_{s=t}^{\infty})d\lambda \tag{18}$$

Now we are ready to define the welfare gains from these various channels.

Definition 7 *The welfare gains from increased levels ω_{lev}:*

$$\omega_{lev} = \frac{C^B}{C^A} - 1 \tag{19}$$

Definition 8 *The welfare gains from lower uncertainty ω_{unc}:*

$$\omega_{unc} = \frac{1-p_{unc}^B}{1-p_{unc}^A} - 1 \tag{20}$$

Definition 9 *The welfare gains from lower inequality ω_{ine}:*

$$\omega_{ine} = \frac{1-p_{ine}^B}{1-p_{ine}^A} - 1 \tag{21}$$

This implies the total welfare gain ω_U approximately approaches:

$$\omega_U = (1+\omega_{lev})(1+\omega_{unc})(1+\omega_{ine}) - 1 \tag{22}$$

C Data Construction

In order to use the data to inform the parameters of my model I need to compute measures from the data with clear analogues in the model. In this section I describe these measures and how I compute them. First, I need measures of income for the three occupations in the model, i.e. agricultural income of landed farmers, income of landless agricultural cultivators, and non-agricultural income.

Agricultural Income of Smallholders For agricultural income, I only compute earnings from non-permanent crops. Fisheries and livestock income will be capital income from fishing equipment and livestock capital. I consider only income from the rain season as in Restuccia and Santaeulalia-Llopis (2017) where Value added in agriculture can be written as:

$$VA_{a,i} = Rev_{c,i} + P_{c,i}(Output^{z}_{c,i} - Sold_{c,i}) - Cost_{c,i} \tag{23}$$

and represents value added from product c for household i. $Rev_{c,i}$ represents household i's revenues from selling crop c, $Output^{z}_{c,i} - Sold_{c,i}$ represents the fraction of production of crop c that household i keeps for its own consumption and $P_{c,i,r}$ is the price received by household i for crop c (sale value of own consumption), which is replaced by the regional price when such price cannot be inferred for household i (households that report production but no sales). In order to compute this price, I proceed as follows:

1. If household i sold crop c, I use reported sales $Rev_{c,i}$ and quantity sold $Q_{c,i}$ and compute $P_{c,i,r} = Rev_{c,i}/Q_{c,i}$
2. Otherwise I attribute the median price of the crop sold by other households in the same region if available, meaning $P_{c,i} = \bar{P}_{c,j}$ where j lives in the same region as i

Finally, for the production of each crop, the household reports costs associated with various inputs and factors. I aggregate costs across inputs

$$Cost_{c,i} = \sum_{v} Cost^{v}_{c,i} \tag{24}$$

where $v \in \{intermediates, labor, capital, land, transportation\}$ represents the costs associated with production. After computing $VA_{c,i}$ for each crop and household, define household farm earnings as the sum of value added across crops

$$VA_i = \sum_c VA_{c,i} \tag{25}$$

which represents the income of farmers that get their land in Malawi through the customary tenure system.

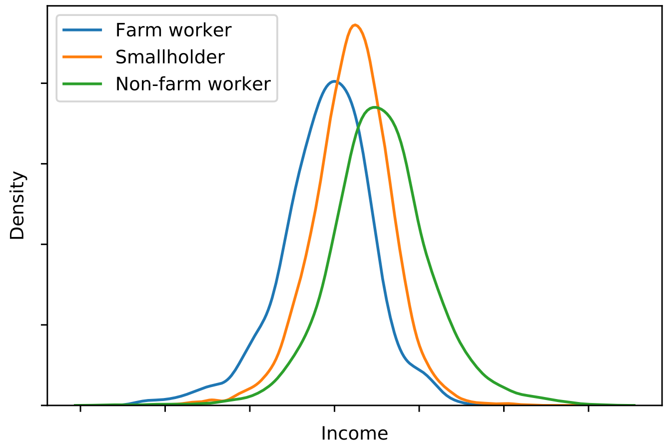
Farm Work Income. There are two ways to compute wages paid to agricultural labor. In the time use side, the only labor income that is tied to agriculture are wages paid in the formal sector. The farms paying these salaries are large and export oriented and highly regulated by the government. These workers are not the ones supplying labor to smallholder farmers who get land through customary tenure. There is another category in the time use portion of the survey that asks for the wage received for informal labor in rural areas. This is the first candidate for w_a. Another way of computing this is by looking at the production side and measuring labor payments made by landed farmers. These can be seen in figure **??** for each one of the years in our panel data. In short this tells us that in 2010, rural wages were reportedly higher than producers reported paying to agricultural labor. This is not surprising as perhaps that year, there were more non-agricultural activities in rural areas that households earned income from - and those paid more than agriculture. In 2013 however, they followed closely one another.
Non-agricultural Income. There are two types of non-agricultural income. Some households run non-agricultural businesses and report in the survey the revenues and costs over the year. Therefore I can write household non-agricultural business income as:

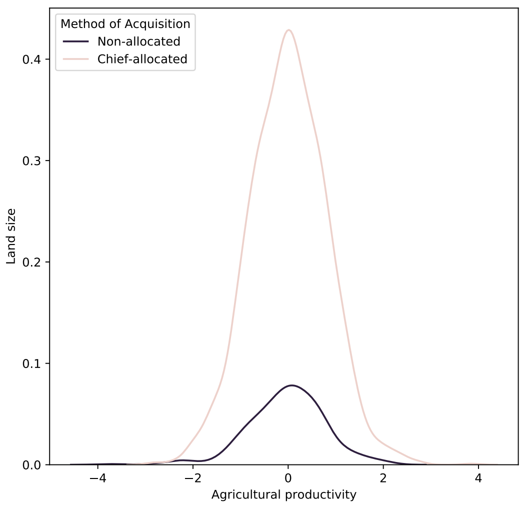
$$VA_{b,i} = Rev_{b,i} - Cost_{b,i} \tag{26}$$

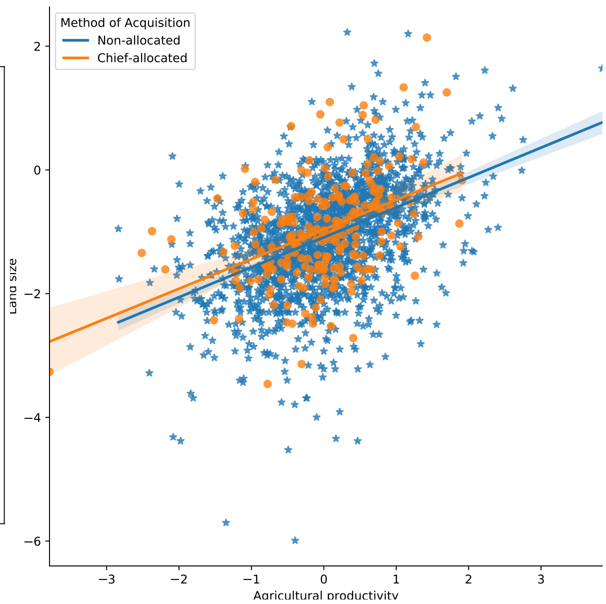
In order to have a comparable measure against other income sources, I compute the non-agricultural business income per hour of household member spent on working at the business. Further, there is also a set of formal workers who earn non-agricultural wages. These are professional workers with education who work in the formal and government sectors of the economy. I also measure their hourly wage.

Summary. In order to assign an occupation to households in our data, I assign them to the occupation (landed agriculture, agricultural labor, non-agriculture) where the household spends most of their time in. After doing this, I can characterize the distribution of income across the three occupations in our economy as seen in figure 8.

Figure 8: Distribution of Sectoral Incomes







D Computational details

Solving models with continuous and discrete choices presents several challenges and this section details the steps I took to overcome such challenges. In order to deal with non-linearities in borrowing constraints and occupational choices as well as a large state space, I used an adaptive sparse grid method as delineated in Brumm and Scheidegger (2017).

In that paper, their adaptive grid is limited to collocation with linear basis functions. I combine their adaptive grid procedure with a finite element method as in McGrattan (1996). This combination allows me to apply their adaptive grid procedure to higher order basis functions. Higher order basis functions are needed to accurately solve for policies, especially around points that are highly nonlinear. Finally, this allows me to solve for the coefficients on the value function using the Newton-Raphson algorithm. Taken together, this improves upon both speed and accuracy over value function iteration methods. I also use extreme value shocks in order smooth out the discrete choices in the model. Below, I explain each step in detail.

D.1 Extreme value shocks

Nondiffereriabilities in the value function due to discrete choices makes calibration very challenging. I add iid extreme value shocks to the discrete choices in order to smooth out this choice and allow the use of derivatives in the calibration. Once I calibrate, I bring the role of these shocks down until it plays no role. This section describes in detail the implementation of these shocks into the finite element framework I use.

Let $\varepsilon_i^W, \varepsilon_i^V$ for $i \in \{a, n\}$ be extreme value preference shocks with common shape parameter σ_ε We can rewrite the individual choices as:

$$W(b, z, \varepsilon^W) = \max\left\{\pi_a V(b, z|a) + (1 - \pi_a) W(b, z|a) + \varepsilon_a^W, W(b, z|n) + \varepsilon_n^W\right\} \tag{27}$$

$$V(b, z, \varepsilon^V) = \max\left\{V^a(b, z|a) + \varepsilon_a^V, W^n(b, z|n) + \varepsilon_n^V\right\} \tag{28}$$

Then the occupation dependent bellman equations can be written as follows:

$$V(b, z|a) = \max_{b' \in \mathcal{B}} u(c, z, b, b', c) + \beta \mathbb{E}_{z'|z}\left[\mathbb{E}_{\varepsilon^V}\left[V(b', z')\right]\right] \tag{29}$$

$$V(b, z|n) = \max_{b' \in \mathcal{B}} u(c, z, b, b', p) + \beta \mathbb{E}_{z'|z}\left[\mathbb{E}_{\varepsilon^W}\left[W(b', z')\right]\right] \tag{30}$$

$$W(b, z|a) = \pi_a \left(\max_{b' \in \mathcal{B}} u(c, z, b, b', c) + \beta \mathbb{E}_{z'|z}\left[\mathbb{E}_{\varepsilon^V}\left[V(b', z')\right]\right]\right) + \tag{31}$$

$$(1 - \pi_a) \left(\max_{b' \in \mathcal{B}} u(c, z, b, b', p) + \beta \mathbb{E}_{z'|z}\left[\mathbb{E}_{\varepsilon^W}\left[W(b', z')\right]\right]\right) \tag{32}$$

$$W(b, z|n) = \max_{b' \in \mathcal{B}} u(c, z, b, b', p) + \beta \mathbb{E}_{z'|z}\left[\mathbb{E}_{\varepsilon^W}\left[W(b', z')\right]\right] \tag{33}$$

Instead of approximating the occupation specific value function, I approximate the expected value with respect to extreme value shocks. Once I have an approximation of this, I can back out the occupation specific value functions, and consequently other policies. Hence, define $\mathbb{E}_a[W(b,z|a)] = \pi_a V^a(b,z) + (1-\pi_a)W^a(b,z)$ I can write the following residual equations

$$R^W(b,z) = \mathbb{E}_{\varepsilon^W}[W(b,z)] - \left(P_a^W \mathbb{E}_a[W(b,z|a)] + P_n^W W(b,z|n)\right) \tag{34}$$

$$R^V(b,z) = \mathbb{E}_{\varepsilon^V}[V(b,z)] - \left(P_a^W V(b,z|a) + P_n^W W(b,z|n)\right) \tag{35}$$

where the probabilities follow the usual expression $P_a^V = \frac{\exp(V(b,z|a)/\sigma_\varepsilon)}{\exp(V(b,z|a)/\sigma_\varepsilon)+\exp(V(b,z|n)/\sigma_\varepsilon)}$ [4]. The goal is to approximate $\hat{W}(b,z) = \mathbb{E}_{\varepsilon^W}[W(b,z)]$ and $\hat{V}(b,z) = \mathbb{E}_{\varepsilon^V}[V(b,z)]$. In order to numerically approximate this, I use finite element methods. Now consider solving the model over the domain $\mathcal{B}$. In finite element analysis, I can define non-overlapping intervals over $\mathcal{B}$ as $\{[b_0,b_1],...,[b_i,b_i+1],...[b_{k-1},b_k]\}$. Then define lagrange basis functions of order n - $\psi^n(b,z)$ - over each interval i with associated coefficient vector $\boldsymbol{\theta}$. Then the task is to find $\boldsymbol{\theta}$ such that

$$\int_{b_i}^{b_{i+1}} \psi_i(b,z)R^J(b,z;\theta)db = 0, \quad i = 0,1,...,k, \quad z \in \mathcal{Z}, \quad J \in \{V,W\} \tag{36}$$

and the approximated value function can be written as:

$$\hat{V}(b,z) = \psi_i(b,z)\theta_i + ... + \psi_{i+n-1}(b,z)\theta_{i+n-1} \quad b \in [b_i, b_{i+1}] \tag{37}$$

So for cubic basis functions, $n=4$. The ability to evaluate the equations in 36 over each element independently makes finite element analysis very amenable to paralellization.

D.2 Solving for Coefficients

Note that solving for the value function requires solving a root finding problem for equations in 36. This implies that having analytical expressions for the jacobian of 36 [5] is an essential step. Unlike the model without extreme value shocks (when the residual

[4] Numerically, this blows up easily, hence we have to make the following transformation in order to make the algorithm more stable. First let $\bar{V}(a,b) = \max\{V(b,z|a), V(b,z|n)\}$. Then we can multiply P_a^V by $\frac{\exp(\bar{V}(a,b)/\sigma_\varepsilon)}{\exp(\bar{V}(a,b)/\sigma_\varepsilon)}$ and get that $P_a^V = \frac{\exp\left((V(b,z|a)-\bar{V}(a,b))/\sigma_\varepsilon\right)}{\exp\left((V(b,z|a)-\bar{V}(a,b))/\sigma_\varepsilon\right)+\exp\left((V(b,z|n)-\bar{V}(a,b))/\sigma_\varepsilon\right)}$

[5] This is the most error prone step in solving for coefficients. In practice, I construct test functions that compute both the numerical and analytical derivatives until they coincide.

equations are linear in $\boldsymbol{\theta}$ like other residual methods like collocation for instance), with extreme value shocks, it takes a bit more work to derive the jacobian since the residual is now nonlinear in the coefficient vector. This is due to the value function appearing in the choice probabilities. This section goes through this process in detail. Let 34 and 35 be the two residual equations that we'll use in order to approximate W and V. Then, these are solely functions of our coefficients and we need the jacobian with respect to coefficients. First, for the current value, it's simple. For any point $b_i \in \mathcal{B}$, if the grid for communal and landless households coincide, then we can write

$$\frac{\partial V(b_i, z)}{\partial \theta_{b_i}} = \frac{\partial W(b_i, z)}{\partial \theta_{b_i}} = \psi(b_i, z)$$

Now note that the maximand on $V^a(b, z), W^a(b, z)$ and $W^n(b, z)$ are $b'_{W,a}, b'_{V,a}$ and $b'_{W,n}$ respectively. Hence, if the order of approximation is k, there will be $k-1$ non-zero values for the expected bellman for each possible $z' \in \mathcal{Z}$ as well. Hence, at each point $(b, z) \in \mathcal{B} \times \mathcal{Z}$, we have derivatives around optimal decisions in ag and non-ag. This says that in the event that I choose agriculture, there is also some probability that I would have chosen non-agriculture. Either way, if I end up in agriculture, I chose savings as if I was in agriculture.

Finally this implies we are ready to compute all derivatives of the RHS with respect to coefficients. There are two sets of non-zero points in the jacobian for each occupation choice. In agriculture, there is a non-zero point associated with choosing agriculture and another associated with choosing agricultural asset choice. Suppose we have land and want the derivative with respect to unknowns surrounding the agricultural savings choice. Then we can write the derivative as:

$$\frac{\partial RHS_V(b, z)}{\partial \theta_{b',z,z',a}} = P_a^V \beta \pi(z, z') \frac{\partial \hat{V}(b', z')}{\partial \theta_{b',z,z',a}} + \frac{\partial P_a^V}{\partial \theta_{b',z,z',a}} V(b, z|a) + \frac{\partial P_n^V}{\partial \theta_{b',z,z',a}} V(b, z|n) \Rightarrow$$

Since the value function of the landless households is a bit different, we'll also derive them here. Suppose we want the derivatives around the optimal asset choice when the agent gets the land (denoted by f). Let $\tilde{W}^a(b,z) = \pi_a V^a(b,z) + (1-\pi_a)W^a(b,z)$

$$
\begin{aligned}
\frac{\partial RHS_W(b,z)}{\partial \theta_{b',z,z',a}} =& P_a^W \pi_a \beta\pi(z,z')\frac{\partial \hat{V}(b',z')}{\partial \theta_{b',z,z',a}} + \frac{\partial P_a^W}{\partial \theta_{b',z,z',a,V}}\pi_a V^a(b,z) + \frac{\partial P_n^V}{\partial \theta_{b',z,z',a,V}} W(b,z|n) \\
\frac{\partial RHS_W(b,z)}{\partial \theta_{b',z,z',a}} =& P_a^W (1-\pi_a)\beta\pi(z,z')\frac{\partial \hat{V}(b',z')}{\partial \theta_{b',z,z',a,W}} + \frac{\partial P_a^W}{\partial \theta_{b',z,z',a,W}}(1-\pi_a) W^a(b,z) + \\
& \frac{\partial P_n^V}{\partial \theta_{b',z,z',a,W}} W(b,z|n)
\end{aligned}
$$

and an analogous scheme can be used in order to solve for other derivatives. We can use this to build the weighted residual and analytically solve for the jacobian as described above. This enables us to use a newton in order to solve the individual problem. Now we can move towards getting the partial derivatives from the choice probabilities.

$$
\begin{aligned}
\frac{\partial P_a^V}{\partial \theta_{b',a}} =& \frac{\exp\left(V(b,z|a)/\sigma_\varepsilon\right)}{\exp\left(V(b,z|a)/\sigma_\varepsilon\right) + \exp\left(V(b,z|n)/\sigma_\varepsilon\right)} \frac{\partial V(b,z|a)}{\partial \theta_{b',a}} / \sigma_\varepsilon - \\
& \frac{\exp\left(V(b,z|a)/\sigma_\varepsilon\right)\exp\left(V(b,z|a)/\sigma_\varepsilon\right)}{\left(\exp\left(V(b,z|a)/\sigma_\varepsilon\right) + \exp\left(V(b,z|n)/\sigma_\varepsilon\right)\right)^2} \frac{\partial V(b,z|a)}{\partial \theta_{b',a}} / \sigma_\varepsilon \\
=& \frac{\partial V(b,z|a)}{\partial \theta_{b',a}} \left(P_a^V/\sigma_\varepsilon - (P_a^V)^2/\sigma_\varepsilon\right) \\
\frac{\partial P_n^V}{\partial \theta_{b',a}} =& - \frac{\exp\left(V(b,z|n)/\sigma_\varepsilon\right)\exp\left(V(b,z|a)/\sigma_\varepsilon\right)}{\left(\exp\left(V(b,z|a)/\sigma_\varepsilon\right) + \exp\left(V(b,z|n)/\sigma_\varepsilon\right)\right)^2} \frac{\partial V(b,z|a)}{\partial \theta_{b',a}} / \sigma_\varepsilon \\
=& -\frac{\partial V(b,z|a)}{\partial \theta_{b',a}} P_n^V P_a^V / \sigma_\varepsilon
\end{aligned}
$$

Further we know that for each z, $\frac{\partial V(b,z|a)}{\partial \theta_{b',a}}$ relates to the future bellman through its local impacts from z' and occupation dependent savings. Consequently, we can expand the expressions above as follows

$$
\begin{aligned}
\frac{\partial P_a^V}{\partial \theta_{b',z,z',a}} &= \beta\pi(z,z')\frac{\partial \hat{V}(b',z')}{\partial \theta_{b',z,z',a}} \left(P_a^V/\sigma_\varepsilon - (P_a^V)^2/\sigma_\varepsilon\right) \\
\frac{\partial P_n^V}{\partial \theta_{b'_{V,a,z,z'}}} &= -P_n^V P_a^V \beta\pi(z,z')\frac{\partial \hat{V}(b',z')}{\partial \theta_{b',z,z',a}} / \sigma_\varepsilon
\end{aligned}
$$

This complete the derivation of the residual equations 36 and the jacobian with respect to coefficient vector $\boldsymbol{\theta}$ and allows me to solve the individual problem.

E Baseline Static Misallocation

As a benchmark, I first highlight the implications of an efficient allocation of resources at the agricultural sector level. Consider a sector where farmers are heterogeneous along their permanent productivity $\bar{z}$ which is drawn from a log-normal distribution. They have access to a technology that uses both land and labor $\bar{z}_i f(\ell_i, n_i)$. Each farmer is endowed with one unit of labor and their individual agricultural productivity $\bar{z}_i$. Suppose that the aggregate endowment of land and labor are L and N, then the planner's problem can be written as:

$$Y^e = \max_{\ell_i, n_i} \sum_i \bar{z}_i f(\ell_i, n_i) \text{ subject to } \sum_i n_i = N \quad \sum_i \ell_i = L$$

Understanding the welfare costs of communal land systems require first that we understand the misallocation that emerges. Consider now an allocation such that individual farmers can only adjust their labor input but cannot adjust their land size. In particular, suppose everyone gets the same endowment of land $\ell = \ell_c = 1$. Now define the following production function

$$y_i = \bar{z} f(\ell, n_a) = \bar{z} \left(\alpha \ell^{\frac{\gamma-1}{\gamma}} + (1-\alpha) n_a^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\zeta\gamma}{\gamma-1}}$$

And suppose that faced with the inability to change the land size and taken the wage as given, farmer i chooses how much labor to hire:

$$\max_{n_i} \bar{z}_a f(\ell_c, n_i) - w_a(n_i - 1)$$

We can then aggregate the outputs such that under an egalitarian distribution of land sizes assigned by the village chief, aggregate production is $Y^c = \sum_i \bar{z}_i f(\ell_c, n_i)$. Using standard values for the parameters of the production function (reported in the appendix), I begin with a numerical demonstration of the operation scales of the farmer who cannot get more land versus what the planner would assign based on the farmer's productivity. It shows that land sizes should be increasing in farmer ability and fairly linearly. This also implies that the dispersion of operation scales should fairly equal to the dispersion of land sizes

the efficiency gains from reallocating land across farmers.

Figure 10: Communal versus Efficient Farm Size

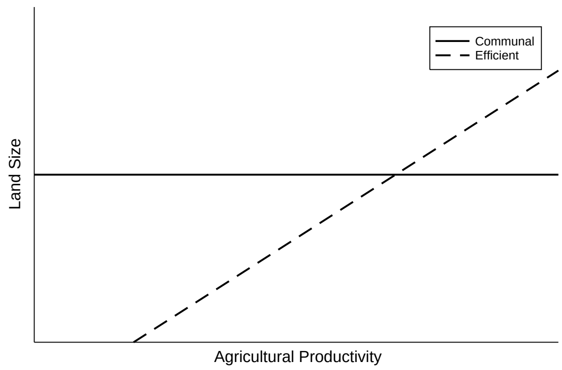
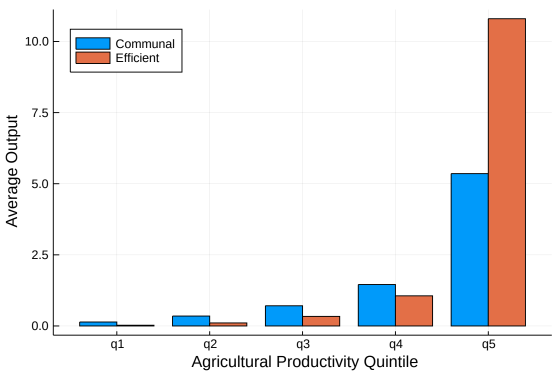
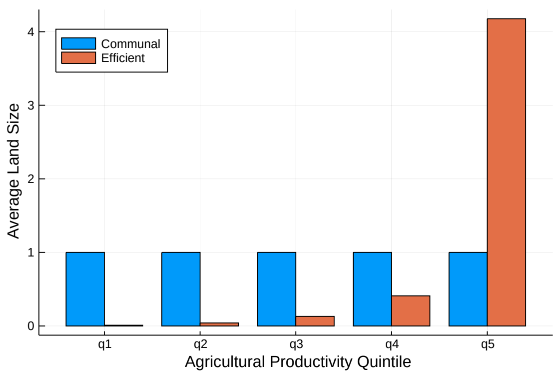


Figure 11: Distribution of Output and Operated Land Size



(a) Average Output



(b) Average Land Size