# Land rights and risk sharing in rural West Africa

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**Abstract**

Despite arduous efforts of advancing land rights in Africa, most of the continent experiences low levels of formally recognized property. I propose a novel contextualisation of formal land titling that motivates a theoretical model to account for land reforms' effects when implemented in weak institutional environments with high risk. Village communities have developed informal mechanisms of risk-sharing to provide households with a safety net, while land allocation is centrally decided by traditional leaders. Therefore, when a land reform, aiming at granting individual property rights, takes place, it operates in a highly antagonistic way to the established customary rules. I build a model of risk-sharing with limited commitment to explain the competing forces developed between statutory land reform and informal mutual insurance at the community level. The model shows that a land reform increases the share of surplus that a villager can extract from a risk-sharing contract among community members and decreases the size of the pie available to the community. Additionally, it shows a non-monotonic relation between land allocation and productivity revealing a trade-off between output efficiency and size of risk-sharing. Subsequently, I use data from Burkina Faso which implemented a land reform in 2009 that did not deliver the desired results in terms of population's participation to validate the theoretical predictions.

Keywords: *Land reforms, property rights, one sided limited commitment, optimal recursive contracts*

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# 1 Introduction

Despite harsh climatic conditions of the West African Sahelian zone, agriculture in Burkina Faso constitutes one of the major economic activities. It contributes almost one third of the Buriknabé GDP while it employs more than 90% of the country's labour force (FAO., 2012). The agricultural sector in Burkina Faso is predominantly small-scale and organized towards subsistence farming. As such, harvest fluctuates due to weather conditions, pests but also various idiosyncratic risks. Village communities in rural West Africa adapting to this high risk environment, have devised mechanisms of mutual insurance. Those informal arrangements are mostly comprised of borrowing and lending and gift-giving in consumption units as to provide a safety net around the community members (Platteau, 1991).

At the same time, land tenure in Burkina Faso is mostly governed by ethnic, cultural and customary rules. Traditional leaders' influence over land is deeply rooted in pre-colonial institutions of Burkina Faso and those figures maintain extensive power despite multiple governmental interventions. Traditional norms of land management depart from the notion of private property. Land is largely considered to be inherited from tribal ancestors and every member of the tribe, clan, lineage is entitled to use it. Land management is coordinated by a land chief, a religious figure who ensures righteous land allocation. Thus, access to land is reassured in the context of the community, but not formally.[1] Household farms perceive their land as their own even without an official certificate of land ownership issued by a state authority. Since agricultural activity in rural West Africa is usually confined within the boarders of the village with production aimed mostly for own consumption, land ownership is adequately recognised at the community level.

Economic literature has long emphasized the critical role of strong property rights in economic growth. The main benefits from individual ownership can be summarized into three broad categories (Bambio and Agha, 2018; Brasselle et al., 2002). The "assurance" effect would provide the necessary incentives to productively invest to land, since land as well as investments' returns are secured by the rights' holder. The "transferability" effect would allow more efficient land allocation through rentals and purchases (Alchian and Demsetz, 1973; Bambio and Agha, 2018).[2] The "collateralization" effect would allow the owner to pledge the plot as collateral and thus gain access to credit (Feder and Nishio, 1998). However, existing theory overlooks potential interactions with traditional land management remotely linked to the western canon of individual ownership. Pre-colonial institutions at an ethnic level strongly live up until today in rural Africa, creating a conflict between institutional, statutory interventions and customary norms.

In this paper I argue that land reforms introduced by governmental authorities constitute an antagonistic mechanism to traditional land arrangements in rural communities. I build on the premise that reforms attempting to render land as privately owned, interact with local mutual insurance networks developed among neighbours, relatives and extended families. Those networks utilise land not only as the main (and often the sole) production factor but also

[1] This is also mirrored in the the vast absence of official ownership documents in Burkina Faso (figure A.1)

[2] A subtly different but linked to the "transferability" effect is the "realisability" effect of property rights Brasselle et al. (2002). This refers to the ease with which property can be converted into liquid assets through sales.

as a major mean of risk-sharing. As a result, when reforms solely focus on the "assurance" effect without granting access to land and/or credit markets, while their application locus is village economies with low level of mechanisation and scarce investment opportunities, state interventions severely disrupt their functioning.

To theoretically account for mutual insurance and land reform as competing forces, I employ a model of constrained optimal risk-sharing under limited commitment. A principal, head of the community and an agent, a farming household, engage into reciprocal state contingent transfers of consumption and land allocation. While the principal is fully committed, the agent can renege the contractual agreement at any point in time. Within this framework, I model the agent as a small agricultural household, which uses land as a production factor. In order to accurately trace the practices of African communities, I allow the fraction of land allocated to the household to be decided by the principal. This feature is consistent with the practice of periodic land redistribution observed in rural Burkinabé villages and renders land as an additional insurance mechanism co-existing with consumption transfers inside the contract.

Agent's outside option is the interaction channel between government's land intervention and community's risk-sharing. In the presence of a land reform and voluntary participation, the outside option of the household is to register the fraction of land that was lastly allocated within the contract. This distorts the incentives of the principal to allocate land according to idiosyncratic productivity in order to sustain the contract. The antagonistic force stemming from the existence of a land reform entails efficiency costs on the functioning of the informal risk-sharing mechanism.

The case of Burkina Faso constitutes an illustrative example of a state that implemented a land reform to establish individual property. The reform was introduced with the enactment of a truly innovative and inclusive rural land law (034/2009), allowing individuals to register their plots and obtain a certificate of ownership. The legislation was followed by an extended effort to disseminate information about the formal procedure to be followed. Government's plan to reform land management was closely assisted by the Millennium Challenge Corporation, which was actively engaged in all stages of implementation. Regarding the evaluation of the success of the Burkinabé plan, the results were not as expected. The number of approved land registrations and the number of agricultural households receiving certificates of ownership recognition were far below the set targets. Indeed, according to the United States Agency for International Development (USAID, 2017), land management almost a decade after the enactment of the law keeps on being under customary norms and community control.

To empirically validate the theoretical analysis, I employ survey panel data which were collected and used by the Millennium Challenge Corporation to assess the progress of the rural land law in 2009. The dataset gives a complete picture of agricultural activities in rural Burkina Faso at the plot, individual and household level and provides detailed information on land use. I am able to track plots across time and test the land allocation mechanism with respect to farmers' productivity. Indeed, in treated villages, where the Millenium Challenge Corporation effectively informed rural population about the upcoming legal initiative, land is inefficiently allocated compared to control villages where information dissemmination did not take place.

I extend the analysis by studying what would happen if the land reform could expand to provide the so-called "collateralization effect", by allowing land to act as a guarantee to take up

a loan, thus granting access to the credit market. In this case, a race between mutual insurance and self-insurance through the credit markets would emerge. The corresponding theoretical result suggests that for certain levels of issued debt the self-insurance option is superior to the mutual insurance. The community insures against risk by allocating consumption units from productive to less productive agents in a recursive manner, however, borrowing against future income is not possible. Thus the self-insurance option can potentially substitute and crowd out mutual insurance.

The paper unfolds as follows. In section 2, the related literature is presented. In section 3, the background of the 2009 land reform in Burkina Faso motivates the study. In section 4, the theoretical model of a second generation optimal contract with limited commitment is presented, formalising the main mechanism. Section 5 presents empirical regularities related to the main pillars of the theoretical model and overviews the dataset in hand, while section 6 performs the empirical analysis to test the theoretical predictions. Section 7 extends the analysis to the "collateralization" effect illustrating the change in the model's dynamics and lastly section 8 concludes.

## 2 Literature Review

A large strand of literature advocates the importance of property rights in economic development. De Soto (2001) explicitly stresses the importance of property rights in alleviating poverty. He considers secured property rights as the means to higher investment, easier access to credit and higher surplus value creation. Deininger et al. (2003) highlights the key role of land policies for the developing world where large population increases and thus scarcity of land demands for higher land security. Besley and Ghatak (2010) build a sound theory of the multiple channels through which property rights affect economic activity.

However, the clear positive stance towards property rights comes into question in the case of developing countries. Two characteristics inhibit formal individual property from unfolding its benefits. First is the weak institutional framework. Weak institutions regarding the enforcement of property rights (Bellemare, 2010) or the marekts' functioning (Besley et al., 2012) can render formal land titling moot.[3] The second reason is customary arrangements that can effectively substitute for the lack of formal ownership (Chari et al., 2017; Gollin and Udry, 2019; Besley, 1995).[4] Bruce (2012) argues that within a bundle of customary behavioural codes, land ownership can be fairly well established. At the same time, those customary land tenure regimes exhibit an impressive degree of flexibility and adaptation (Bruce et al., 1994; Platteau, 1996). On the other hand, ambiguous property rights might disproportionally benefit people high in local hierarchy (Goldstein and Udry, 2008) or fail to grant tenants and small scale farmers with the appropriate bargaining power (Banerjee et al., 2002).

This work contributes to this literature by modelling the interaction between informal risk-sharing arrangements as those observed in rural areas of developing countries and a state intervention which aims to establish individual property. Thus, it offers a detailed description of the channel in which land reforms can affect customary institutions of land allocation.

The present study is also related to the literature of resource misallocation in the developping world. Institutional pluralism regarding land rights undoubtedly exerts a negative impact on the functioning of land markets. Restuccia and Santaeulalia-Llopis (2017) find extensive factor misallocation in Malawi and attribute it to customary institutions governing land allocation. Adamopoulos and Restuccia (2019) study a reform of land redistribution in Philippines that prohibited land market transactions causing a significant decrease in agricultural productivity. Chari et al. (2017) and Chen et al. (2017) document significant gains in land productivity from land reforms allowing land leases in China and Ethiopia respectively. This work presents land misallocation as the response of informal institutions of land management to implemented land reforms. It shows that misallocation can emerge in the transition from communal informal land governance to formal individual land ownership.

[3] Bellemare (2010) juxtaposes the effects of de jure and de facto property rights on agricultural productivity in Madagascar and finds null results for the former category due to poor enforcing institutions. Besley et al. (2012) challenging the magic bullet nature of the de soto arguement assert that the positive effect of property rights of granting access to credit depends largely on competition in this market

[4] This view of de facto ownership emerging through the functioning of informal institutions is consistent with the idea of endogenous property rights, an idea dating back to Demsetz (1974). Feder and Feeny (1991) present a detailed overview of the evolution of land rights by outlining the emergence of property in parallel with the development stage of the agricultural sector.

The present paper links the concept of property rights to the distinct characteristic of risk-sharing in rural communities. The pattern of village economies engaging into transfers of consumption units to tackle adverse shocks has been well documented in the literature. Townsend (1994) explores the magnitude or risk sharing in Indian villages. He finds a substantial flexibility from the side of community to adapt to adverse shocks, concluding that the assumption of collective insurance in village communities is not absurd. The form of transfers among the members of the community is studied by Platteau and Abraham (1987) and Udry (1994) who find that loans can actively serve as a risk-insurance mechanism.

The literature has also evolved on the theoretical front by building models of mutual insurance applied in village economies, under different types of frictions. Ligon et al. (2002) and Attanasio and Rıos-Rull (2000) build on the model of risk-sharing with limited commitment in order to explore the imperfect insurance observed in village economies as well as the effects of voluntary participation on the resulting allocation. Models of collective insurance have been employed to study various social phenomena in the developping world. Morten (2019) and Munshi and Rosenzweig (2016) study temporary migration of population with respect to risk-sharing in rural villages.

The paper in hand provides a novel contextualisation of property rights and risk insurance mechanisms in small agricultural communities as competing mechanisms. It traces the transmission of land reform's effects on risk-sharing contracts through the increase of the outside option. This results in land reform jeopardising mutual insurance by increasing the bargaining power of the individual within the community. In order to preserve risk-sharing, the community responds by misallocating land as to decrease deviation incentives from the informal contract.

# 3 Background on the land reform in Burkina Faso

A motivating example for the present study is the case of Burkina Faso, a landlocked country in the Western Africa's Sahelian zone. The economy of Burkina Faso is mostly based on agriculture (figure A.2), with a recent increase of mining activities due to a gold mining boom in 2009-2010. The vast majority of working population is engaging to rural activities (90%). The predominant form of agricultural production is small-scale farming, managed by members belonging to the same lineage or family (USAID, 2017).

Land use in Burkina Faso faces considerable problems mainly due to rapid increase of population fuelling competition for available land, high internal migration and climate change. While those threatening factors are in place, land tenure security scores are at a record low relative to other African countries (figure A.4). After independence in 1960, management of Burkinabé land was following entirely customary norms with the government only managing protected areas (Ouédraogo, 2002). The concept of private property over land appears in 1984 with the introduction of *Réorganisation Agraire Foncière (RAF)*. This legislation granted all land to the state in an attempt to disrupt the control of traditional chiefs over land, and allowed rural population to gain access to land following government's rules (Hughes, 2014). Amendments of this law (1991, 1996) introduced a type of private ownership through granting user-rights over plots of land.

## 3.1 Loi 034/2009

Much legislative progress has been achieved since the 1980s regarding land tenure. In 2009 Burkina Faso adopted an inclusive piece of rural land tenure legislation (*Loi 034/2009*). The law's application locus was rural areas and aimed at equitable access to land, enhancing productivity, sustainable management and social peace (*Article 1 Loi 034/2009*). The legislative procedure was preceded by the establishment of the National Committee for Secure Land Tenure (CNSFMR) under the Ministry of Agriculture aiming to coordinating rural land policy reform. The plan's most striking characteristic was inclusiveness, in terms of reconciliation between statutory land management based on national laws and customary land tenure referring to local norms. Rather than alienating all informal land practices, it integrated them in a formal national legislation.

In the attempt of introducing, implementing and monitoring the new legislation the Burkinabé government was assisted by the Millennium Challenge Corporation (MCC). This partnership led to a 5-year compact plan (2009-2014) of $58 million under the title Rural Land Governance Project (RLG) (section 5). Three activities took place under the Rural Land Governance plan. The first activity comprised of legal and procedural changes and dissemination of the details on the new legislation to rural communities. Activity 2 focused on developing the necessary institutional changes and capacity building, while activity 3 performed site-specific land tenure interventions (IMPAQ, 2015).

## 3.2 Rural Land Certificate of Possession (APFR)

The aforementioned inclusive character of the 2009's land reform was reflected in the capacity provided to individual farmers of issuing the so called Rural Land Certificate of Possession (Attestation de Possession Foncière Rurale, APFR). Articles 36-50 of the 039/2009 law outlines the procedures to be followed for the issuance of the APFR. The predominant characteristic of the APFR is that the community in which the individual, requesting the certificate, belongs to is strongly engaged in the procedure and has the capacity to veto it.

The APFR can be issued to either individuals or collective associations. The issuing period is 75 days conditional on no objections being raised by the community. Essentially, the community has to approve the request of the certificate before it is granted. The cross checking that the referred parcel does not belong to another individual is made with the direct involvement of the customary and traditional authorities (Hughes, 2014).

The APFR differs from full land title on the capacity that grants to the holder regarding sale of the allocated parcel. Productive use of land which can lead to profiting out of it is allowed, however, sale of the parcel to a third party is forbidden. Transfer of the certificate to members of the same family is allowed with no additional cost (Article 47, Loi 034/2009). Moreover, APFRs may be used to obtain bank loans depending on the bank's requirements (Hughes, 2014).

### 3.3 Assessment of the results of the RLG

However inclusive and innovative the land tenure legislation was, its results concerning grant of private ownership were not as expected. The Millennium Challenge Corporation (MCC), the organisation responsible also for the monitoring and the implementation of the new legislation in close collaboration with the Burkinabé government, issued reports on the progress of the programme. *[0]

| Indicators | Actually achieved (July 2014) | Target | (%) |
|---|---|---|---|
| Number of APFRs approved by the local government | 2167 | 6000 | 36.1% |
| Number of HHs receiving APFRs | 403 | 3000 | 13.4% |

Table 1: Results from Land Reform in Burkina Faso. Source: Millenium Challenge Corporation - Measuring Results of Rural Governance Programme (Millenium-Challenge-Corporation, 2016)

In table 1 the results after the end of the 5-year plan are presented regarding the issuances of the APFRs. The difference between the actually achieved numbers and the targets set by the MCC is substantial. A little more than one third of the set target of APFRs were approved by the local government, while the number of households actually receiving APFRs is a little more than one tenth of the target. Along these lines, the United States Agency for International Development (USAID) in its report on Burkina Faso in 2017, explicitly states:

> Although the 2009 Rural Land Law and the 2012 RAF provide the mandate and mechanisms to formalize and secure a variety of tenure types in rural Burkina Faso, most rural land continues to be governed according to customary, informal rules. (USAID, 2017)

In order to examine further the result of the land tenure reform in the region, I use survey data from the World Bank and in particular the Burkina Faso Enquête Multisectorielle Continue 2014 which belongs to the collection Living Standards Measurement Surveys (LSMS).[5] The study was conducted between 2014 - 2015 (5 years after the introduction of the reform) and it is nationally representative. Among many survey units there is the module referring to parcels which includes questions on the cultivating land each household holds. In figure 1, the responses to the method of land security are presented. It is striking that the option "Land Title" which would correspond to an APFR is only answered by 177 respondents. From figure 1, it is apparent that the predominant land tenure regime is the “Possesseur Terrien”, which represents all native people that have inherited land from their family (Ouédraogo, 2002). The

[0]Even though by the end of the compact the target of 6000 APFRs approved by local authorities was not met, the MCC asserts that the project resulted to 13,447 filed applications for APFRs

[5]Institut National de la Statistique et de la Démographie. Enquête Multisectorielle Continue (EMC) 2014. Ref. BFA-2014-EMC-v01-M. Downloaded from https://microdata.worldbank.org/index.php/catalog/2538/get-microdata

second most answered option is "None" indicating a complete absence of any official document certifying ownership.

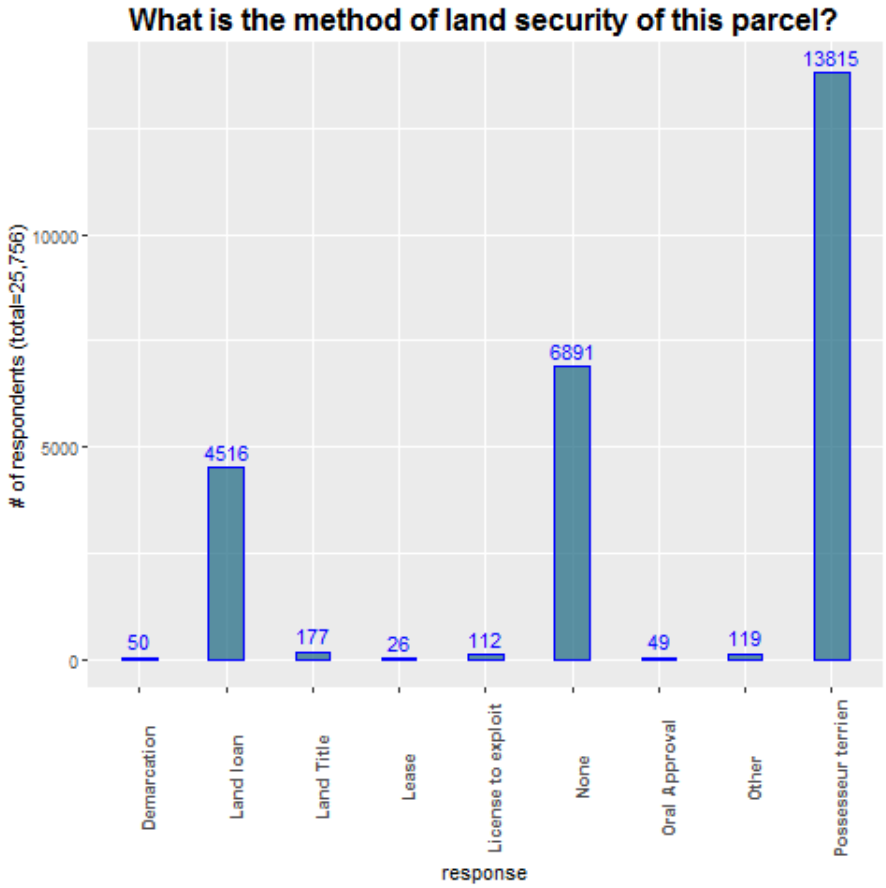



Figure 1: Burkina Faso Enquête Multisectorielle Continue 2014 - LSMS - World Bank

Economic theory has long advocated the benefits from establishing strong individual property rights. However, in the case of Burkina Faso, a puzzling phenomenon is observed. People are offered the opportunity to officially register their land plots, however they choose not to or they are prevented by local authorities. The reasoning behind this observation lies on the core of the present study. The premise which the theory builds upon is that land reforms introduced by the state act as a competing mechanism to the risk-sharing network developed in a community level.

# 4 One-Sided Limited Commitment with land re-allocation

The theoretical part of the present study models the functioning of risk-sharing informal contracts among members of rural communities and their interaction with land reforms when customary land re-allocation is in place. To motivate the assumptions of the model I need to define certain customary aspects of the social structure in rural communities of Western Africa.

Customary land management in Burkina Faso is generally considered homogeneous. A pre-

dominant social figure at a community level is that of the *land chief* (chef de terre).[6] The land chief is a religious figure with legal power and has the complete control over land on behalf of the community (Ouédraogo, 2002).[7] One of the main duties of the land chief is the *periodic redistribution of land*. This land re-allocation takes place among the members of the same community/village but also to foreigners in case they arrive. This practice aims at preventing the creation of monopolies in land-use or underuse of land plots. The periodic redistribution of land is decided upon the needs of the members of the community.

In the theoretical model presented in this section, the land chief is the principal of the risk-sharing contract. The informal arrangement not only prescribes consumption units allocation among community members but also allocates land among the members. The ultimate target of the model is to trace the interaction between those two components and its welfare implications.

The theoretical framework presented here attempts to shed light on the diverse views expressed regarding the land regime policy that should be followed in the African continent. Illustrative of the diversity of the land policy in Africa is the position that the World Bank has held. During the mid-1970s the World Bank was advocating a firm regime of strong individual property rights in Africa. It was persuaded by most of the literature's theoretical arguments relating land tenure security and agricultural productivity (Udry, 2011). However, this stance evolved over time, resulting to the adoption of a more favourable view towards customary land tenure systems. The flexibility and efficient adaptation of indigenous land sysytems were appreciated (Migot-Adholla et al., 1991).

The contract prescribes the pooling of all households' resources in the hands of the principal who allocates consumption back to them. The principal after allocating consumption, invests the remainder outside the village at a risk free rate $R = \frac{1}{\beta}$, where $\beta$ is the common to all discount factor. The principal is the only one that can borrow and lend resources outside the community, the households rely only on the risk-sharing mechanism. The environment builds on Ljungqvist and Sargent (2000).

The community is consisting of a large number of villagers with the preferences over consumption.

$$E_{-1}\sum_{t=0}^{\infty}\beta^t u(c_t)$$

where $u(c)$ is increasing and strictly concave and $\beta$ is the common discount factor ($\beta \in (0,1)$). Each villager receives a stochastic idiosyncratic productivity each period ($\{z_t\}_{t=0}^{\infty}$). Idiosyncratic productivity is iid with $Prob(z_t = z_s) = \Pi_s$, with $s \in \{1, 2, ..., S\}$ satisfying the property, $z_s < z_{s+1}$.

The villager is considered as a small agricultural household which produces output using a fraction of land as the primary production function. The technology is modeled as follows:

$$y_s = z_s f(\kappa_s \bar{l})$$

[6]The predominance of the land chief can be seen in figure A.3

[7]The land chief is considered to be descended from lineage of the group of the first occupants of the earth.

where $z_s$ is the idiosyncratic productivity, $\bar{l}$ denotes land, which is in fixed supply normalized to 1 and $\kappa_s$ is the variable of interest. It is the fraction of land that each period the principal decides for the villager to productively use it ($\kappa_s \in [0,1]$). $\kappa_s$ effectively captures land reallocation as a mechanism of risk sharing. Technology $f(.)$ is increasing in the fraction of land, $\kappa_s$ ($f'(.) > 0$), strictly concave ($f''(.) < 0$) and I assume that with no land there is no produced output $f(0) = 0$.

Participation of the household to the community risk sharing mechanism entails transfers towards and from the community. The budget constraint of each individual household is:

$$c_s = y_s + \tau_s, \quad \forall i \in N$$

If $\tau_s > 0$ then the household is receiving transfer from the community which adds up to the produced output, while if $\tau_s < 0$, the household is rendering part of its output to be granted as transfers to other members of the community.

The land chief (principal) maximizes her stream of profits, which consists of the contemporaneous difference between the pooled output and the consumption allocation, and the discounted future profits stream. In a recursive form, the objective function is

$$P(v) = \max_{\{c_s,\kappa_s,w_s\}} \sum_{s=1}^{S} \Pi_s \Big[ (y_s - c_s) + \beta P(w_s) \Big]$$

or equivalently substituting the villager's budget constraint :

$$P(v) = \max_{\{\tau_s,\kappa_s,w_s\}} \sum_{s=1}^{S} \Pi_s \Big[ (-\tau_s) + \beta P(w_s) \Big]$$

where $v$ is the expected discounted future utility previously promised to the villager and $w_s$ is the promised value with which the agent will enter next period, given that $z_t = z_s$.

In the absence of commitment frictions the economy reaches its first best.

**Proposition 1**: *Given a promised utility $v$, the first best allocation satisfies the following properties. Consumption and promised utility are constant and equal to the levels $c^{fb}(v)$ and $w^{fb}(v)$, while $\kappa^{fb}$ is increasing in the relative idiosyncratic productivity*

**Proof**: See Appendix

In the case of a commitment friction, while the head of the community is committed to the agreement, the villager is not. However, what fundamentally changes is the outside option of the villager. The primary channel of interaction between the land reform that aims to establishing strong individual property rights and the contractual agreement among community members emerges through the workings of the outside option. Assumption 1 defines the rationale behind its formulation.

**Assumption 1**: *The land reform allows the agent-villager to register the fraction of land she was last allocated with, inside the contract.*

Assumption 1 determines the form of the outside option of the agent-villager.

$$u(z_s f(\kappa_s)) + \beta v^{\text{aut}}(\kappa_s)$$

First, notice that the fraction of land allocated to productive use is endogenous and it is determined within the contract. Second, due to the limited commitment friction, the agent-villager can leave the contract at any state. If she does so, due to the existence of a land reform, she can register the last allocated fraction of land (from within the contract) as individual property.

The continuation value of autarky takes the following form:

$$v^{\text{aut}}(\kappa_s) = \sum_{t=0}^{\infty} \beta^t \sum_{r=1}^{S} \Pi_r u(z_r f(\kappa_s))$$

Notice that the level of fraction of land is constant and equal to what was last decided within the contract.

The participation constraint of the contract takes the form:

$$u(c_s) + \beta w_s \geq u(z_s f(\kappa_s)) + \beta v^{\text{aut}}(\kappa_s) \qquad [\mathbf{PC}]$$

The head of the community is choosing consumption allocated to the agent-villager, fraction of land and promised utility, in order to maximize her stream of profits.

$$P(v) = \max_{\{c_s, \kappa_s, w_s\}} \sum_{s \in S} \Pi_s \Big[ (z_s f(\kappa_s) - c_s) + \beta P(w_s) \Big]$$

where $v$ is the promised utility that agent-villager enters the current period with and carries all past histories, in order to recursify the problem.

The maximization problem of the principal takes the following form:

$$\begin{aligned}
P(v) = \max_{\{c_s, \kappa_s, w_s\}} & \sum_{s=1}^{S} \Pi_s \Big[ (z_s f(\kappa_s) - c_s) + \beta P(w_s) \Big] \\
& \sum_{s=1}^{S} \Pi_s \{u(c_s) + \beta w_s\} \geq v \qquad [\mathbf{PKC}] \\
& u(c_s) + \beta w_s \geq u(z_s f(\kappa_s)) + \beta v^{\text{aut}}(\kappa_s) \qquad [\mathbf{PC}] \quad \forall s \\
& \kappa_s \in [0,1] = \begin{cases} \kappa_s \geq 0 \\ 1 - \kappa_s \geq 0 \end{cases} \\
& \sum_{s=1}^{S} \Pi_s \kappa_s \leq 1 \\
& w_s \in [v^{\text{aut}}, \bar{v}]
\end{aligned}$$

**Proposition 2**: *For a given promised utility $v$, when the participation constraint is non-binding, the consumption and promised utility allocations are constant and equal to $c_s = g_1(v)$ and $w_s = v$, while the fraction of land reaches the first best ($\kappa_s = \kappa_{max}$). When the participation constraint binds then consumption, promised utility and fraction of land satisfy equations 1, 2 and 3.*

$$u'(c_s)[\theta + \phi_s] = 1 \tag{1}$$

$$P'(w_s) = -(\theta + \phi_s) \tag{2}$$

$$u'(z_s f(\kappa_s)) = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{z_s f'(\kappa_s)} - \frac{1}{z_s} \frac{\beta}{1-\beta} E_r u'(z_r f(\kappa_s)) z_r \tag{3}$$

**Proof**: See Appendix

From relations (1) and (2) the following is derived:

$$u'(c_s) = \frac{1}{P'(w_s)}$$

which states that the villager's marginal rate of substitution between current consumption and promised utility should be equal to the land chief's marginal rate of transformation.

The effects of the land reform can be seen in relation (3). With certain manipulations, equation (3) reads:

$$\underbrace{v_3 + z_s f'(\kappa_s)}_{\substack{\text{Marginal Increase in} \\ \text{Land Chief's Revenues}}} = \underbrace{u'(z_s f(\kappa_s)) z_s f'(\kappa_s) \phi_s}_{\substack{\text{Agent's Marginal Benefit} \\ \text{from deviation}}} + \underbrace{\phi_s \beta \frac{\partial v_{aut}(\kappa_s)}{\partial \kappa_s}}_{\substack{\text{Land Reform's} \\ \text{Intertemporal effect}}}$$

Which shows that the principal when optimally choosing the fraction of land to be allocated to the agent, she equates her marginal benefit to the villager's marginal benefit. The principal's marginal benefit constitutes the marginal increase in her revenues. On the right hand side of the equation the marginal benefit of the villager appears as the sum of the intratemporal marginal benefit from deviating at the current period plus the intertemporal effect of the land reform due to the assurance effect. In particular, the derivative of the continuation autarky value that the farmer attains if she deviates from the contract with fraction of land lastly allocated to her ($\kappa_s$) takes the following form:

$$\frac{\partial v^{\text{aut}}}{\partial \kappa_s} = \frac{1}{1-\beta} f'(\kappa_s) \underbrace{E_r u'(z_r f(\kappa_s)) z_r}_{\omega > 0}$$

It is worth noticing that in the expression of the continuation value in the outside option, idiosyncratic productivity ($z_r$) and fraction of land ($\kappa_s$) have different subscripts denoting that once reneging the contract, land ceases adjusting to produtivity shocks, turning the $\omega$ term dependent only on the probability distribution of idiosyncratic productivity. This stems directly

from the functioning of the assurance effect. The land reform ensures ownership of land but nothing more.

The model as delineated above presents an interesting trade-off which encompasses the core interaction between land rights and risk sharing when seen as competing mechanisms. Notice that the level of fraction of land ($\kappa_s$) has two opposing effects on the model. First it raises the revenues of the community. This can be seen from the objective function of the principal-head of the community. A higher level of $\kappa_s$ will increase the produced output for a given realisation of $z_s$ and consequently the size of the pie to be allocated among consumption to households and profits for the principal. At the same time, $\kappa_s$ is on the right hand side of the participation constraint. A higher fraction of land allocated to the villager makes the outside option more attractive, increasing deviation incentives.

In order to characterize the nature of the land tenure system under the contract in the presence of a land reform as an outside option, I define the following possible land regimes:

**Definition**: *A land regime is* ***productive*** *if it adjusts fraction of land positively to idiosyncratic productivity* ($\frac{\partial \kappa_s}{\partial z_s} > 0$). *It is* ***rigid*** *if it does not adjust fraction of land to changes in idiosyncratic productivity* ($\frac{\partial \kappa_s}{\partial z_s} = 0$) *and it is* ***counter productive*** *when it adjusts fraction of land opposite to idiosyncratic productivity* ($\frac{\partial \kappa_s}{\partial z_s} < 0$).

By manipulating the optimality condition with respect to fraction of land, I can obtain an optimal response of the $\kappa_s$ to realisations of idiosyncratic productivity.

$$\mathcal{H}(\kappa_s, z_s) = \frac{v_3 + z_s f'(\kappa_s)}{f'(\kappa_s)} - \phi_s \left[ z_s^{1-\alpha} \kappa_s^{-\alpha(1-\gamma)} + \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi \right] = 0$$

Applying the implicit function theorem on function $\mathcal{H}(z_s, \kappa_s)$, I can derive a relation between fraction of land and idiosyncratic productivity which leads to proposition 3.

$$\frac{\partial \kappa_s}{\partial z_s} = -\frac{\frac{\partial \mathcal{H}(z_s, \kappa_s)}{\partial z_s}}{\frac{\partial \mathcal{H}(z_s, \kappa_s)}{\partial \kappa_s}}$$

**Proposition 3**: *For a given $v$ and for each $s \in S$ that leads to a binding participation constraint, there exists threshold $z_s^*$ which determines the nature of the land regime under the contract.*

| **Land Regime** | | $z_s$ |
|---|---|---|
| **Productive** | $\frac{\partial \kappa_s}{\partial z_s} > 0$ | $z_t > z_s^* = \frac{1-\phi_s u'(z_s^* f(\kappa_s))}{\phi_s u''(z_s^* f(\kappa_s)) f(\kappa_s)}$ |
| **Rigid** | $\frac{\partial \kappa_s}{\partial z_s} = 0$ | $z_t = z_s^* = \frac{1-\phi_s u'(z_s^* f(\kappa_s))}{\phi_s u''(z_s^* f(\kappa_s)) f(\kappa_s)}$ |
| **Counter Productive** | $\frac{\partial \kappa_s}{\partial z_s} < 0$ | $z_t < z_s^* = \frac{1-\phi_s u'(z_s^* f(\kappa_s))}{\phi_s u''(z_s^* f(\kappa_s)) f(\kappa_s)}$ |

Using the following functional forms for utility and technology that satisfy the conditions on

monotonicity and concavity,

$$u(c_s) = \frac{c_s^{(1-\alpha)}}{1-\alpha}$$
$$y_s = z_s f(\kappa_s) = z_s \kappa_s^{1-\gamma}$$

the above proposition takes the following form:

| Land Regime | | $z_s$ |
|---|---|---|
| **Productive** | $\frac{\partial \kappa_s}{\partial z_s} > 0$ | $z_t < z_s^* = [(1-\alpha)\phi_s]^{\frac{1}{\alpha}} \kappa_s^{-(1-\gamma)}$ |
| **Rigid** | $\frac{\partial \kappa_s}{\partial z_s} = 0$ | $z_t = z_s^* = [(1-\alpha)\phi_s]^{\frac{1}{\alpha}} \kappa_s^{-(1-\gamma)}$ |
| **Counter Productive** | $\frac{\partial \kappa_s}{\partial z_s} < 0$ | $z_t > z_s^* = [(1-\alpha)\phi_s]^{\frac{1}{\alpha}} \kappa_s^{-(1-\gamma)}$ |

**Proof**: See Appendix

The result from proposition 3 illustrates the variability of the customary land tenure regime. In the presence of a land reform as an outside option, the principal responds strategically to the allocation of land to the agent such that to keep the contract sustainable at all times. This means that given an allocation of consumption, promised utility and a realisation of idiosyncratic productivity, the contract might optimally adjust fraction of land downwards, upwards or not at all. This is due to the strategic way of the principal to enforce contract participation. The land chief when proceeding to redistribution of land weighs those two opposing effects. How much allocated land, increases the size of the pie (her revenues) and how much the incentives of the villager to deviate. This essentially depends on how close to a realisation of productivity that would lead to a binding participation constraint the current idiosyncratic productivity is. This is when the threat of reneging the contract from the side of the villager becomes credible.

This strategic behavior regarding allocation of land, entails efficiency costs. In the absence of the limited commitment friction, the incentives of the principal would be in line with a flexible land tenure regime. A flexible land tenure regime would increase principals revenues and would increase the size of the pie to be distributed among the members of the community. A land reform distorts those incentives, and induces a strategic allocation of land, which might lead to productive villagers being allocated smaller fraction of land, due to the threat of deviating from the contract.

# 5 Data from Burkina Faso

## 5.1 Rural Land Governance Project

The empirical analysis is employing the Millennium Challenge Corporation (MCC) compact with the government of Burkina Faso. The ultimate aim of this project was alleviation of poverty by boosting economic growth. This 5-year plan, agreed in July 2008, consisted of four distinct projects aiming at different targets. The rural land governance (RLG) project, the agricultural development project, the roads project and the Burkinabé response improvement of girls' chances to succeed to schools projects (BRIGHT II).

The present work focuses on the first project, the rural land governance. The motivation of the project was the pervasiveness of land conflicts due to scarcity of land resources and tension between statutory laws and customary norms regarding land tenure. Its primary target was to establish a legal framework through which rural population could gain easier access to local land governance and administration.

The RLG consisted of three main activities implemented in a sequential manner. The first activity focused on the legal and procedural change and communication. The second addresses the institutional development and capacity building and the third attempted site-specific land tenure interventions (table 11).

The time span of the compact was 5 years, from 2009 to 2014. The project was divided in two phases in which the prescribed activities took place sequentially. Phase I of the programme lasted from 2009-2012. This phase focused on 17 pilot communes, where it implemented activity 1's plan and started implementing the actions described in activity 2 and 3. In Phase II the implementation of the plan was extended to 30 additional communes, reaching a total of 47 communes for which the MCC implemented the RLG project.

## 5.2 Monitoring the progress of RLG project

The MCC assigned the evaluation of the project to an independent organization, IMPAQ. The evaluation consists of collection of survey data from the 34 communes, 17 of which participated as treated or ans 17 as control areas during phase I (figure A.5). The survey is divided in baseline and interim, which refer to pre-reform and post-reform time periods respectively. However, the interim survey is conducted at the end year of phase I, so it does not capture the effects of phase II activities. As a result, only the legal initiation of the reform, the dissemination of information regarding this legal option to rural population and some early option of APFR (ownership) issuance is evaluated.

The baseline and interim survey consist of four questionnaires focusing on different levels. Household, individual, parcel and production are the topics covered in the questionnaires. The size of the sample is 3,352 households from all 34 communes, accounting for more than 10,000 individuals and more than 6,000 land plots used for cultivation.

## 5.3 Empirical Regularities in Burkina Faso

- ***Role of traditional leaders***

Burkina Faso is characterised by a pluralistic ethnic and religious environment. Apart from Mossi who constitute the major ethnicity of over 50% of the population, there are numerous others (Touaregs, Peuls, Lobi, Gourmantché etc). The existence of strong ethnic and religious norms exerts great influence on land rights and grants traditional leaders with extensive power over them.

Despite the ethnic and religious heterogeneity, customary land management in Burkina Faso is generally considered to be homogeneous. A predominant social figure in rural communities is that of the *land chief* (chef de terre or "Tengsoaba" in Mossi). The land chief is a religious figure with legal power that has the complete control over land on behalf of the community

(Ouédraogo, 2002).[8] The land chief is considered to be the intermediator between the living and their ancestors ensuring righteous land management as land is considered to be owned by the ethnicity, clan, extended family but not individually. One of the main duties of the land chief is the *periodic redistribution of land*. This land re-allocation takes place among the members of the same community/village but also to foreigners in case they arrive. This practice aims at preventing the creation of monopolies in land-use or underuse of land plots. The periodic redistribution of land is decided upon the needs of the members of the community.

Round 4 of the Afrobarometer, a pan-African survey on economic, social and political attitudes, took place in 2008, coinciding with the introduction of the land legislation under examination. The effect of traditional leaders in rural communities' issues is shown in figure A.6. In 8 out of the 13 administrative regions in Burkina Faso, traditional leaders exert sizeable influence to the community's functioning.

The Afrobarometer provides more details on the issues that the traditional leaders have a word on. In particular, the survey poses the question of who is primarily responsible for allocating land. In almost all regions there is a non-negligible percentage of people who answer that traditional leaders are responsible for land management (in all regions but Centre-Est, Plateau Central an Est, this percentage exceeds 20%). In six out of the thirteen administrative regions, most people answer as the first choice that traditional leaders are the primarily responsible for allocating land (figure A.7).

- ***Land***

Agriculture in Burkina Faso is predominantly organized at a small scale. The majority of the individuals engaged in farming operate a parcel of at most 2 hectares (figure A.9) with the average plot size being of 1.5 hectare (table 7). Even though households are large in terms of household members, the average household operates approximately 2.5 plots (table 8) with the average household's land holdings covering an area of approximately 4 hectares (table 9).

As cultural norms govern the allocation of land within the community, the size of the parcel that an individual cultivates is not written in stone, but changes according to not only the needs of the household but also the needs of the community. This leads to significant land reshuffling among the members of the same community.

The panel dataset allows tracking of specific parcels reported in both waves. As a result, it was possible to compare the reported size of the corresponding parcel between the two waves. Figure A.11 exhibits the recorded plot size in the baseline and interim survey. Across all regions of Burkina Faso, very few plots did not experience a change in their size. Most of the plots are either lying closely above or below the 45 degree line signifying a small but non zero size variation.

In addition, land holdings' variation does not cancel out at the household level. Aggregating land size at the household level in figure A.10 evinces large changes in households' land holdings. This provides an insight on the nature of land allocation. The size of households land holdings is not fixed and land parcels are re-allocated among household members but rather there is land re-allocation across households.

[8]The land chief is considered to be descended from lineage of the group of the first occupants of the earth.

As far as the intensive margin of the plot size variation is concerned, a 10% of the plots in the sample experienced no change. 50% of the respondents reported variation lying in the range from a 18% decrease a percentage increase of 10% . It is worth noticing that the distribution of land size variation does not change when plot size is aggregated at the individual and household level (table 10).

# 6 Evidence from the RLG programme in Burkina Faso

The present section attempts to validate the theoretical prediction exploiting the panel data from the RLG project.

The case of Burkina Faso constitutes an ideal application locus for the theory developed in this work. Firstly, the panel dataset allows the comparison between communes that were exposed to the treatment and others that were not (figure A.5). Secondly, the time gap between the two survey waves is not large allowing us to accurately capture changes in both land and productivity without omitting important events in between 2009/10 and 2011/12. Lastly, the survey design was built with the aim of assessing the impact of the 2009 land reform in its first stages, therefore allowing to test the implications of the introduction of a land reform.

The central theoretical result refers to the non-monotonic relation between land allocation and productivity levels in the presence of a land reform. In particular, the testing hypothesis reads as follows:

**Testing Hypothesis**: *In treated areas, individuals exhibiting low level of agricultural productivity are increasing their share of land, while high productivity individuals are decreasing their share of land. In control areas, low productivity individuals are decreasing their share of land, while high productivity individuals are increasing their share of land, since the absence of the outside option leads to an efficient allocation*

The testing hypothesis addresses the effect of a land reform on the allocation of land. As already shown, agricultural plots both at the individual and the household level experience significant change in their size between the two waves. I exploit this variation for the empirical analysis.

For each household $h$, the land holdings are defined as:

$$hh.land_{h,t} = \sum_{p \in h} \kappa_{p,t}$$

$\kappa_p$ is the size of plot $p$ operated by a member of household $h$ in time $t$ and the total land holdings are the sum of all plots operated by members of the household in each wave.

According to the theoretical part, land allocation is determined by the level of productivity. I build a measure of productivity for each household in the sample based on plot productivity. To allow for effective comparison between different crop types, I use the monetary value of sold harvest.

$$agricultural\ productivity_p = \frac{q_{c,p} * p_{c,i}}{\kappa_p}$$

where $q_{c,p}$ is the quantity of crops produced in plot $p$ expressed in the local measurement unit. $p_{c,i}$ is the price per local measurement unit for the specific crops grown in plot $p$ and $\kappa_p$ is the size of the plot.

In case the respondent has sold part of the production to the market then the $p_{c,i}$ is her selling price per local measurement unit. However, the majority of the farmers do not sell their harvest but keep it for household-consumption. In cases, in which I do not have actual realised price data at the individual level, $p_{c,i} \equiv p_{c,v}$ where $p_{c,v}$ is the price of the specific crops calculated as the mean price of all other farmers in the village that have sold the same crop. I generalise geographically in case there is no crop-unit specific price data by using community ($p_{c,i} \equiv p_{c,com}$) and country prices ($p_{c,i} \equiv p_{c,bf}$). The numerator is expressed in \$ while the denominator is expressed in hectares. Hence agricultural productivity is measured in \$/ha.

Even with the aforementioned geographical generalizations, imputed prices correspond to a low proportion of plots that reported production data, signifying a very low participation to the goods markets, rendering the corresponding crop-price-unit matching difficult, as shown in table 2.

| Season | Production (# parcels with available data) | Imputed prices (# parcels with imputed data) | |
|---|---|---|---|
| Dry 2008/09 | 396 | 160 | 40% |
| Rainy 2008/09 | 9,035 | 1,814 | 20% |
| Dry 2009/10 | 161 | 100 | 62% |
| Rainy 2009/10 | 10,154 | 2,141 | 21% |
| Dry 2010/11 | 629 | 372 | 59% |
| Rainy 2010/11 | 14,748 | 2,878 | 19.5% |
| Dry 2011/12 | 406 | 294 | 72.4% |
| Rainy 2011/12 | 15,521 | 3,128 | 20% |

Table 2: On the second column is the number of parcels for which production data are available, in the third is the number of parcels for which prices per local unit of measure are imputed. The low percentages are due to the different local units of measurement used and the low participation to goods market.

I proceed next in deriving the household productivity. This requires the aggregation of plot productivity at the household level, since the average household operates more than one plots. Therefore, I derive the weighted mean of agricultural productivity for all parcels under household's use.

For each household $h$:

$$household\ productivity_h = \Sigma_{p \in h}\Big(agricultural\ productivity_p * \frac{\kappa_p}{\Sigma_{p \in i}\kappa_p}\Big)$$

Where the weights used in the specification are determined by the relative size of the particular plot with respect to the total size of household land holdings.

In the theoretical result, productivity is not set in absolute terms but rather relative. In fact, the corresponding proposition predicts that in the presence of a land reform, less productive household in the community would be allocated more land, while more productive less. As such, the ranking of high and low productivity takes place in the context of the community. In order to capture this empirically, I compute the median village productivity for all villages in the sample. Subsequently, I record whether *household productivity*$_h$ is below the median at the village level through the following dummy variable:

$$\textit{below village median}_h = \begin{cases} 1 & \text{for } \textit{household productivity}_h < \text{median village productivity}_v \\ 0 & \text{for } \textit{household productivity}_h \geq \text{median village productivity}_v \end{cases} \forall v, t$$

The following specification is testing the household land holdings based on household productivity ranking within the community.

$$\begin{aligned} hh.land_{h,t} = \alpha_{h,t} &+ \beta_0 * \text{household productivity}_{h,t} \\ &+ \beta_1 * \text{below-village-median}_{h,t} \\ &+ \beta_2 * X_{h,t} \\ &+ \beta_3 * \zeta_h + \beta_4 \zeta_{v,t} + \epsilon_{h,t} \end{aligned} \tag{4}$$

where $X_{h,t}$ is a vector of household and land controls. In particular, $X_{h,t}$ controls for households' land regime, rights upon land, years of use, irrigation investments and other.[9] Moreover, $\zeta_h$ controls for unobserved heterogeneity across households, while $\zeta_{v,t}$ is a dummy variable controling for village and time fixed effects, controling for unobserved heterogeneity across villages. Lastly, in both specifications, standard errors were clustered at the commune level consistently with the sample design of the survey.

Table 3 shows a clear difference between households residing in treated areas compared to those residing in control areas. The $\hat{\beta}_1$ estimated coefficient is positive and statistically significant for the low productivity individuals in treated areas (column 1), signifying that in communes where the option of the land reform was disseminated effectively, low productivity individuals acquired more land relative to the high productivity individuals. In particular for a low level

[9]

$$X_{h,t} = \begin{bmatrix} \text{share of land in which the hh lives in}_{h,t} \\ \text{share of land within the village}_{h,t} \\ \text{share of inherited land}_{h,t} \\ \text{share of land given by the chief}_{h,t} \\ \text{number of years hh uses the land}_{h,t} \\ \text{share of land hh has right to plant trees}_{h,t} \\ \text{share of land hh has right to lend}_{h,t} \\ \text{share of irrigated land}_{h,t} \\ \text{share of land with conflict}_{h,t} \\ \text{hh's number of plots}_{h,t} \\ \text{hh's average age}_{h,t} \\ \text{hh's size}_{h,t} \end{bmatrix}$$

Note that for all variables that needed to be aggregated from the parcel to the household level, aggregation used the weighted mean of all plots under household's operation, with relative parcel land over total household's land used as weights.

Table 3: Results from LSDV on regression (4)

| | *Dependent variable:* | *Dependent variable:* |
|---|---|---|
| | Household Land Holdings Treated Areas | Household Land Holdings Control Areas |
| | (1) | (2) |
| below.median | 0.699* | -0.394 |
| | (0.415) | (0.604) |
| Constant | 1.224 | -2.890 |
| | (5.210) | (5.950) |
| Household Controls | Yes | Yes |
| Household FE | Yes | Yes |
| Village+Time FE | Yes | Yes |
| Commune Clustered SE | Yes | Yes |
| Observations | 1,318 | 959 |
| $R^2$ | 0.976 | 0.984 |
| Adjusted $R^2$ | 0.381 | 0.340 |
| Residual Std. Error | 2.151 (df = 51) | 2.801 (df = 23) |
| F Statistic | 1.640** (df = 1266; 51) | 1.527 (df = 935; 23) |

*Note:* *p<0.1; **p<0.05; ***p<0.01

Column (1) corresponds to the 17 treated communes and columns (2) corresponds to the 17 control communes. Household productivity has been winsorized at the 2% level. Household productivity is measured in dollars/sq.m

productivity individual a $1\$/sq.m$ increase in productivity, corresponds to larger land size by 0.699 hectares compared to the high productivity individuals. On the other hand, in control areas the corresponding $\beta_1$ coefficient is statistically insignificant, indicating a difference between high and low productivity individuals to be indistinguishable from 0 and if anything has a negative sign.

To further support the empirical results, I estimate a modified specification of equation (4). Firstly, I use a fixed effect within estimator and secondly I add the interaction term:

$$below\ village\ median_{h,t} * household\ productivity_{h,t}$$

in order to examine how the household's relative position affects the correlation between acquired land and household's productivity. Consequently, the specification reads:

$$\begin{aligned} hh.land_{h,t} = \alpha_{h,t} &+ \beta_0 * \text{household productivity}_{h,t} \\ &+ \beta_1 * \text{below-village median}_{h,t} * \text{household productivity}_{h,t} \\ &+ \beta_3 * \text{below village median}_{h,t} \\ &+ \beta_2 * X_{h,t} + \epsilon_{h,t} \end{aligned} \tag{5}$$

where the control vector remains the same as in specification (4) and the within estimator takes care of unobserved household and time heterogeneity. To account for aggregate shocks that might have an effect on the relation between land allocation and household's productivity I add a control variable that records the production of the remaining households residing in the village.

Table 4 presents the results from the estimation of specification (5). Consistently with the previous estimates, the low productivity households in treated areas acquire more land than the high productivity ones. Moreover, a household which is below the median productivity at the village level and experiences an unit increase in productivity acquires more land compared to the high productivity household in the same village. On the other hand, the coefficients of interest in control areas are indistinguishable from zero in control areas.

Table 4: Resutls from regression (5)

| | *Dependent variable:* | *Dependent variable:* |
|---|---|---|
| | Household Land Holdings Treated Areas | Household Land Holdings Control Areas |
| | (1) | (2) |
| hh.productivity*below.median | 2.793** | 21.350 |
| | (1.334) | (14.485) |
| Household Controls | Yes | Yes |
| Commune Clustered SE | Yes | Yes |
| Observations | 1,318 | 959 |
| $R^2$ | 0.429 | 0.344 |
| Adjusted $R^2$ | -4.491 | -6.669 |
| F Statistic | 7.347*** (df = 14; 137) | 3.066*** (df = 14; 82) |

*Note:* *p<0.1; **p<0.05; ***p<0.01

Column (1) corresponds to the 17 communes that were treated areas and column (2) corresponds to 17 communes that were control areas. Difference in individual land holdings is winsorized at 1% level. Individual productivity is measured in dollars/sq.m

# 7 Collateralization effect

The analysis so far has adopted a positive stance on the study of the interaction between informal risk sharing and statutory land reforms. It examined the response of informal insurance contracts to a land reform that increases the outside option of the household by granting it the simplest and most direct of land rights benefits, the assurance effect.

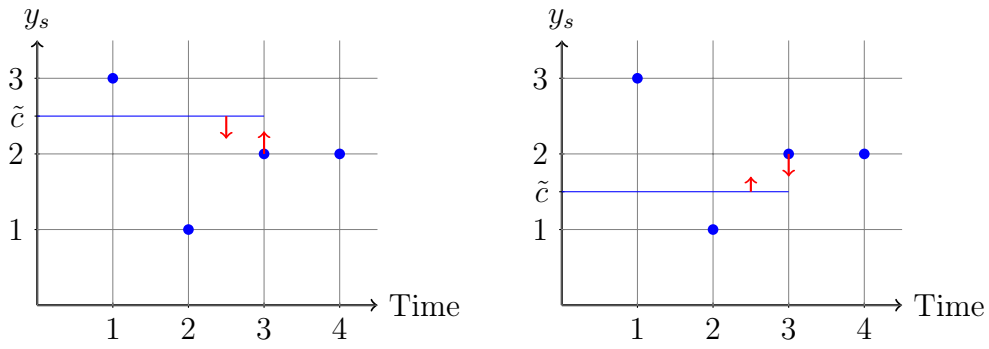
Already from assumption 1, the effect of the land reform on the contract is that the household is rest assured that the last allocated fraction of land, will remain under its ownership in the future. This effect increased the outside option of the household by giving rise to the limited commitment friction. However, the contract in order to survive responds to this change by misallocating land. In this way, it effectively ensures households' voluntary participation at a production efficiency cost.

In this section, the analysis proceeds to a normative policy prescription that can inform the design of land reform policies. The main advantage of informal risk-sharing is that it provides

partial insurance to its participants. Therefore, the land reform on top of the assurance effect should also guarantee the collateralization effect. The collateralization effect of land rights can grant the affected areas with access to credit, which in turn can provide the formal self-insurance required to substitute for the informal mututal-insurance.

The aforementioned collateralization effect was weakly defined in the 2009 land reform in Burkina Faso, since the APFR could operate as an official document allowing land to be pledged as collateral, but this depended on banks' requirements (Hughes, 2014).

The reason why the collateralization effect could effectively provide the self-insurance to substitute for the mutual-insurace is based on the functioning of the one-sided limited commitment informal contract. An insightful exposition of the one-sided limited commitment contract's functioning is provided by Zhang (2013) and summarized below.




(a) Case 1 (b) Case 2

Figure 2: Cases of consumption smoothing under one-sided limited commitment.
source: Zhang (2013)

In figure 2, Zhang 2013 exhibits two cases that reveal the limitations of the one-sided limited commitment contact operations. The economy lasts for four periods. Endowment is not stochastic and takes the following values, $y_3$ in period 1, $y_1$ in period 2, and $y_2$ in periods 3 and 4, with $y_1 < y_2 < y_3$. The first question is whether consumption smoothing can be achieved between period 1 and period 2. The answer is yes, since the principal can transfer wealth from period 1 (when the maximum endowment is realised) to period 2 (when the minimum endowment is realised) in order to smooth consumption. Note that $\tilde{c}$ could be anywhere between $y_3$ and $y_1$ and would still satisfy the participation constraint in period 2 - therefore making consumption smoothing possible. The following question is whether consumption smoothing can be achieved between period 2 and period 3. The answer depends on the level of $\tilde{c}$ allocated between periods 1 and 2. In case 1 (figure 2a) $\tilde{c}$ is higher than $y_2$, the endowment to be realised in period 3. Therefore there is space for transfer of wealth between period 2 and period 3 that still satisfies the participation constraint in period 3. Note however that if $\tilde{c}$ between periods 1 and 2 was set below $y_2$ as shown in figure 2b, further consumption smoothing would require transfer of wealth from period 3 to period 2. However, this is not feasible, since the allocated consumption would not satisfy the participation constraint in period 3.

Zhang's analysis reveals a critical characteristic of the one-sided limited commitment contract. Due to the presence of limited commitment, the contract allows for transfers of wealth from

present high endowment states to future lower endowment states, but cannot achieve transfers of wealth from future high endowment states to present low endowment states. In other words, the agent cannot borrow against her future high income.

The claim of the present section is that a land reform that grants access to credit markets, promoting the collateralization effect of land rights, constitutes a superior option for the risk-averse household. The reason is twofold. First, compared to the outside option with only the assurance effect (analysed in section 4) it can additionally provide self-insurance options for the household to attain the desired consumption smoothing. Second, with respect to the allocation provided by the contract, issuing debt through access to the credit markets can perform the operation that was not feasible under one-sided limited commitment, namely to allow households to borrow against their future endowments.

To formalize the claim, I depart from the production economy of section 4 and focus on stochastic endowment economy in favour of tractability. I compare two versions of this economy, one operating under the one-sided limited commitment informal contract and the second allowing the household to issue debt.

In particular, the two economies under examination are the following:[10]

**OSLC**

$$P(v) = \max_{\{c_s, w_s\}} \sum_{s=1}^{S} \Pi_s \Big[ (\bar{y}_s - c_s) + \beta P(w_s) \Big]$$

$$\sum_{s=1}^{S} \Pi_s \Big[ u(c_s) + \beta w_s \Big] \geq v \quad [\mathbf{PKC}]$$

$$u(c_s) + \beta w_s \geq u(\bar{y}_s) + \beta \nu_{aut} \quad \forall s \quad [\mathbf{PC}]$$

$$c_s \in [c_{min}, c_{max}] \quad w_s \in [\nu_{aut}, \bar{v}]$$

**Debt Economy**

$$\max_{\{c_t, d_t\}} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$c_t + (1+r) d_{t-1} = y_t + d_t$$

$$lim_{j \to \infty} \frac{d_{t+j}}{(1+r)^j} = 0$$

The OSLC economy is the principal-agent dynamic contract analysed in section 4 but in simpler form with stochastic endowment and not stochastic productivity. The debt economy represents the household maximizing expected utility under its budget constraint where $(1+r)d_{t-1}$ denotes debt obligations maturing at time $t$ and $d_t$ denotes the acquisition of debt maturing at time $t+1$. Moreover the household is subjected to a transversality condition, preventing it from dying holding debt. Preferences $u()$ and endowment $y_t$ maintain the same properties as under the contract. So the probability distribution of the stochastic component $y$ is identical under both economies.

**Proposition 4**: *For debt levels that satisfy* $d_j \geq \frac{r}{1+r} \sum_{\kappa=1}^{j} [E(y_j) - y_\kappa] \quad \forall j \in S$ *the debt economy provides a consumption allocation that second order stochastically dominates the consumption allocation provided by the OSLC economy, and therefore is strictly preferred by the risk-averse household.*

**Proof**: See Appendix

[10] the OSLC economy is expressed in a recursive form to facilitate the implementation of its solution algorithm.

Based on proposition 4, land reform policy can be sufficiently informed in order to serve its purpose. The advantages of a land reform can be materialized and supersede those of mutual insurance only by exploiting both the assurance and the collateralization effect. Those two effects combined can provide a superior outside option to the informal contract and achieve the desired results of strong individual property rights.

# 8 Conclusion

The study of the interaction between land reforms and customary risk-sharing mechanisms as illustrated in section 4 provides valuable lessons regarding policy design of land reforms in weak institutional frameworks.

Attempts for reforming land rights should take into serious consideration the pre-existence of customary safety networks. This is critical in cases of ethnic minorities, or vulnerable groups of people that have to rely solely to the community for tackling risk. Those customary norms prescribe transfers of consumption units and land re-allocation as ways to insure their members against risk. When these two mechanisms constitute the predominant means of risk-sharing in the affected communities, then a land reform can distort the functioning of the customary contract.

As shown in section 4 the land reform's effect on the outside option can cause efficiency costs. It creates a clear trade-off between the amount of risk-sharing and production efficiency. In order for communities to maintain the existence of their informal contracts they can manipulate land allocation in a counter-productive way. In this case, a land reform can lead to misallocation of land, an inefficiency that would have been avoided, were the community was unaffected by land reforms.

Lastly, the present study provides a potential theoretical justification of the World Bank's stance on land rights in Africa. The international organization, since the early 1990s has adopted a more inclusive and integrating policy stance regarding the functioning of local communities regarding land management. Based on section 4 it is explicit that the land tenure regime under the informal contract can achieve a certain flexibility of adjustment to productivity leading to a more efficient allocation of land.

To conclude, the implementation of a land reform aiming at granting private property should be preceded by a careful documentation and examination of the way local communities operate. The effect of a reform on the rural population might be beneficial if it strengthens the bargaining position of the villager, but also could bring detrimental effects regarding output efficiency.

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# 9 Appendix

## A Proofs

From envelope theorem, $P'(v) = -\mu$ , which if combined with the optimality condition for $w_s$ gives:

$$P'(w_s) = P'(v) - \frac{\lambda_s}{\Pi_s}$$

**Proposition 1** :

**Proof**: Under the first best, commitment friction is absent, hence in the optimization problem, the principal-head of the community does not take into account the participation constraint of the agent-villager. Hence the problem becomes:

# 10 First Best

$$P(v) = \max_{\{c_s,\kappa_s,w_s\}} \sum_{s\in S} \Pi_s \Big[(z_s f(\kappa_s) - c_s) + \beta P(w_s)\Big]$$

$$\sum_{s\in S} \Pi_s\{u(c_s) + \beta w_s\} \geq v \qquad [\textbf{PKC}] \qquad : (\theta)$$

$$\kappa_s \in [0,1] = \begin{cases} \kappa_s \geq 0 & : (\Pi_s \nu_{1s}) \\ 1 - \kappa_s \geq 0 & : (\Pi_s \nu_{2s}) \end{cases}$$

$$w_s \in [v^{\text{aut}}, \bar{v}]$$

$$\sum_{s=1}^{S} \Pi_s \kappa_s \leq 1 \qquad : (v_3)$$

Assigning the designated lagrange multipliers above, the lagrangian becomes:

$$\mathcal{L} = \sum_s \Pi_s \Big[(z_s f(\kappa_s) - c_s) + \beta P(w_s)\Big] +$$
$$+\theta \Big[\sum_{s\in S} \Pi_s [u(c_s) + \beta w_s] - v\Big]$$
$$+\Pi_s \nu_{1s} \kappa_s + \Pi_s \nu_{2s}(1 - \kappa_s) - v_3$$

Deriving optimality conditions with respect to the choice variables:

$$\frac{\partial \mathcal{L}}{\partial w_s} = 0 \to \beta P'(w_s) + \theta\beta = 0 \to P'(w_s) = -\theta \quad [\text{constant}]$$

$$\frac{\partial \mathcal{L}}{\partial c_s} = 0 \Rightarrow -1 + \theta u'(c_s) = 0 \Rightarrow u'(c_s) = \frac{1}{\theta} \quad [\text{constant}]$$

Taking the foc wrt $\kappa_s$ the problem becomes:

$$\frac{\partial L}{\partial \kappa_s} = 0 \Rightarrow z_s f'(\kappa_s) + v_{1s} - v_{2s} - v_3 = 0 \Rightarrow$$
$$z_s f'(\kappa_s) = v_{2s} + v_3 - v_{1s}$$

Assume that constraints on $\kappa_s$ are slack, so that corner solutions excluded - and Inada conditions are satisfied, $\nu_{1s}$, $\nu_{2s} = 0$

$$z_s f'(\kappa_s) = v_3 \Rightarrow \kappa_s = f'^{-1}\Big(\frac{v_3}{z_s}\Big)$$

From the constraint that

$$\Sigma_s \kappa_s = 1$$
$$\sum_s f'^{-1}(\frac{v_3}{z_s}) = 1$$

Assuming that $f(x) = x^{1-\gamma}$ then $f'(x) = (1-\gamma)x^{-\gamma}$ and $f'^{-1}(x) = \Big(\frac{x}{1-\gamma}\Big)^{-\frac{1}{\gamma}}$ where now $x = \frac{v_3}{z_s}$. Hence I get an expression for $\kappa_s$ at the first best which is the following

$$\kappa_s^{fb} = \Big(\frac{v_3}{(1-\gamma)z_s}\Big)^{-\frac{1}{\gamma}} \Rightarrow \kappa_s^{fb} = \Big(\frac{(1-\gamma)z_s}{v_3}\Big)^{\frac{1}{\gamma}}$$

Optimal allocation of land is increasing in productivity and decreasing in scarcity of land.

Now since the constraint $\sum_s \kappa_s = 1$ should always hold with equality,

$$\sum_s \kappa_s^{fb} = 1 \Rightarrow \sum_s \Big(\frac{(1-\gamma)z_s}{v_3}\Big)^{\frac{1}{\gamma}} = 1 \Rightarrow v_3^{\frac{1}{\gamma}} = (1-\gamma)^{\frac{1}{\gamma}} \sum_s z_s^{\frac{1}{\gamma}} \Rightarrow v_3 = \Big(\gamma^{\frac{1}{\gamma}} \sum_s z_s^{\frac{1}{\gamma}}\Big)^{\gamma}$$
$$\Rightarrow v_3 = \gamma\Big(\sum_s z_s^{\frac{1}{\gamma}}\Big)^{\gamma}$$

Then plugging this expression to the $\kappa_s^{fb}$ above I get,

$$\kappa_s^{fb} = \Big(\frac{(1-\gamma)z_s}{v_3}\Big)^{\frac{1}{\gamma}} \Rightarrow$$
$$\kappa_s^{fb} = \frac{((1-\gamma)z_s)^{\frac{1}{\gamma}}}{\Big(\gamma\Big(\sum_s z_s^{\frac{1}{\gamma}}\Big)^{\gamma}\Big)^{\frac{1}{\gamma}}} \Rightarrow$$
$$\kappa_s^{fb} = \Big(\frac{(1-\gamma)}{\gamma}\Big)^{\frac{1}{\gamma}} \frac{z_s^{\frac{1}{\gamma}}}{\sum_s z_s^{\frac{1}{\gamma}}}$$

**Proposition 2**:

**Proof**: The maximization problem in the presence of the commitment friction takes the following form:

$$
\begin{aligned}
P(v) = \max_{\{c_s,\kappa_s,w_s\}} & \sum_{s=1}^{S} \Pi_s \Big[ (z_s f(\kappa_s) - c_s) + \beta P(w_s) \Big] \\
& \sum_{s=1}^{S} \Pi_s \{ u(c_s) + \beta w_s \} \geq v \qquad [\mathbf{PKC}] \qquad : (\theta) \\
& u(c_s) + \beta w_s \geq u(z_s f(\kappa_s)) + \beta v^{\text{aut}}(\kappa_s) \qquad [\mathbf{PC}] \quad \forall s \qquad : (\Pi_s \phi_s) \\
& \kappa_s \in [0,1] = \begin{cases} \kappa_s \geq 0 & : (\Pi_s \nu_{1s}) \\ 1 - \kappa_s \geq 0 & : (\Pi_s \nu_{2s}) \end{cases} \\
& \sum_{s=1}^{S} \Pi_s \kappa_s \leq 1 \qquad : (v_3) \\
& w_s \in [v^{\text{aut}}, \bar{v}]
\end{aligned}
$$

The corresponding Lagrangean reads,

$$
\begin{aligned}
\mathcal{L} = \sum_{s \in S} \Big[ (z_s f(\kappa_s) - c_s) + \beta P(w_s) \Big] + & \\
& + \theta \Big[ \sum_{s \in S} \Pi_s [u(c_s) + \beta w_s] - v \Big] \\
& + \Pi_s \phi_s \Big[ u(c_s) + \beta w_s - u(z_s f(\kappa_s) - \beta v^{\text{aut}})(\kappa_s) \Big] + \\
& + \Pi_s \nu_{1s} \kappa_s + \Pi_s \nu_{2s} (1 - \kappa_s) - v_3 (\sum_s \Pi_s \kappa_s - 1)
\end{aligned}
$$

Before deriving the optimality conditions, I derive the following:

$$
\begin{aligned}
\frac{\partial v^{\text{aut}}}{\partial \kappa_s} &= \frac{1}{1-\beta} \sum_r \Pi_r u'(z_r f(\kappa_s)) z_r f'(\kappa_s) \\
\frac{\partial v^{\text{aut}}}{\partial \kappa_s} &= \frac{1}{1-\beta} f'(\kappa_s) \sum_r \Pi_r u'(z_r f(\kappa_s)) z_r \\
\frac{\partial v^{\text{aut}}}{\partial \kappa_s} &= \frac{1}{1-\beta} f'(\kappa_s) \underbrace{E_r u'(z_r f(\kappa_s)) z_r}_{\omega > 0} \\
\frac{\partial v^{\text{aut}}}{\partial \kappa_s} &= \frac{1}{1-\beta} f'(\kappa_s) \omega
\end{aligned}
$$

Deriving the focs:

$$
\frac{\partial L}{\partial c_s} : \qquad \Pi_s(-1) + \theta \Pi_s u'(c_s) + \phi_s \Pi_s u'(c_s) = 0 \rightarrow u'(c_s)[\theta + \phi_s] = 1 \tag{6}
$$

$$
\frac{\partial L}{\partial w_s} : \qquad \Pi_s \beta P'(w_s) + \theta \Pi_s \beta + \phi_s \Pi_s \beta = 0 \rightarrow P'(w_s) = -(\theta + \phi_s) \tag{7}
$$

$$\frac{\partial L}{\partial \kappa_s}: \quad \Pi_s z_s f'(\kappa_s) - \Pi_s \phi_s \left[ u'(z_s f(\kappa_s)) z_s f'(\kappa_s) + \beta \frac{\partial v^{\text{aut}}}{\partial \kappa_s} \right] + \Pi_s \nu_{1s} - \Pi_s \nu_{2s} - v_3 = 0$$

$$\Pi_s z_s f'(\kappa_s) - \Pi_s \phi_s \left[ u'(z_s f(\kappa_s)) z_s f'(\kappa_s) + \beta \frac{1}{1-\beta} f'(\kappa_s) \sum_r \Pi_r u'(z_r f(\kappa_s)) z_r \right] + \Pi_s \nu_{1s} - \Pi_s \nu_{2s} - v_3 = 0$$

$$z_s f'(\kappa_s) \Big[ 1 - \phi_s u'(z_s f(\kappa_s)) \Big] - \phi_s \frac{\beta}{1-\beta} f'(\kappa_s) \omega + [\nu_{1s} - \nu_{2s}] - v_3 = 0$$

[Assume that constraints on $\kappa_s$ are slack
corner solutions excluded due to Inada conditions$\nu_{1s}, \nu_{2s} = 0$]

$$z_s \Big[ 1 - \phi_s u'(z_s f(\kappa_s)) \Big] = \phi_s \frac{\beta}{1-\beta} f'(\kappa_s) \omega + v_3$$

$$\Big[ 1 - \phi_s u'(z_s f(\kappa_s)) \Big] = \frac{\phi_s}{z_s} \frac{\beta}{1-\beta} \omega + \frac{v_3}{z_s f'(\kappa_s)}$$

$$\phi_s u'(z_s f(\kappa_s)) = 1 - \frac{\phi_s}{z_s} \frac{\beta}{1-\beta} \omega + \frac{v_3}{z_s f'(\kappa_s)}$$

$$u'(z_s f(\kappa_s)) = \frac{1}{\phi_s} - \frac{1}{z_s} \frac{\beta}{1-\beta} \omega + \frac{v_3}{\phi_s z_s f'(\kappa_s)}$$

$$u'(z_s f(\kappa_s)) = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{z_s f'(\kappa_s)} - \frac{1}{z_s} \frac{\beta}{1-\beta} \omega \tag{8}$$

**Proposition 3**:

**Proof**: Let the following functional forms:

$$u(c_s) = \frac{c_s^{(1-\alpha)}}{1-\alpha}$$

and

$$y = z_s f(\kappa_s) = z_s \kappa_s^{1-\gamma}$$

1. First I derive the $\frac{\partial v_{aut}}{\partial \kappa_s}$ under those functional forms.

$$\frac{\partial v_{aut}}{\partial \kappa_s} = \sum_{t=0}^{\infty} \beta^t \sum_{r=1}^{S} \Pi_r u'(z_r f(\kappa_s)) z_r f'(\kappa_s)$$

$$\frac{\partial v_{aut}}{\partial \kappa_s} = \frac{1}{1-\beta} f'(\kappa_s) \sum_{r=1}^{S} \Pi_r u'(z_r f(\kappa_s)) z_r$$

$$\frac{\partial v_{aut}}{\partial \kappa_s} = \frac{1}{1-\beta} f'(\kappa_s) \underbrace{\sum_{r=1}^{S} \Pi_r u'(z_r f(\kappa_s)) z_r}_{\omega > 0}$$

**Using the functional forms to get $\omega$**

$$\omega = \sum_r \Pi_r u'(z_r f(\kappa_s)) z_r = E_r u_c(z_r f(\kappa_s)) z_r$$

Plugging the functional forms of $u, f$

$$\omega = \sum_r \Pi_r z_r^{-\alpha} f(\kappa_s)^{-\alpha} z_r$$

$$\omega = \sum_r \Pi_r z_r^{-\alpha} (\kappa_s^{1-\gamma})^{-\alpha} z_r$$

$$\omega = \kappa_s^{-\alpha(1-\gamma)} \sum_r \Pi_r z_r^{-\alpha}$$

$$\omega = \kappa_s^{-\alpha(1-\gamma)} \underbrace{\sum_r \Pi_r z_r^{-\alpha}}_{=\xi>0\text{: constant}}$$

Now plug this expression to the foc wrt $\kappa_s$:

$$u'(z_s f(\kappa_s)) = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{z_s f'(\kappa_s)} - \frac{1}{z_s} \frac{\beta}{1-\beta} \omega$$

$$\Big[z_s f(\kappa_s)\Big]^{-\alpha} = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{z_s f'(\kappa_s)} - \frac{1}{z_s} \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi$$

$$z_s^{-\alpha} \Big[\kappa_s^{1-\gamma}\Big]^{-\alpha} = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{z_s f'(\kappa_s)} - \frac{1}{z_s} \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi$$

$$z_s^{-\alpha} \kappa_s^{-\alpha(1-\gamma)} = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{z_s f'(\kappa_s)} - \frac{1}{z_s} \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi$$

Now I want to derive a relationship between $\kappa_s$ and $z_s$ from the above relationship which is the optimal rule for setting the fraction of land.

**Step 1** Multiply by $z_s$:

$$z_s^{1-\alpha} \kappa_s^{-\alpha(1-\gamma)} = \frac{1}{\phi_s} \frac{v_3 + z_s f'(\kappa_s)}{f'(\kappa_s)} - \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi$$

**Step 2** Multiply by $\phi_s$:

$$\phi_s z_s^{1-\alpha} \kappa_s^{-\alpha(1-\gamma)} = \frac{v_3 + z_s f'(\kappa_s)}{f'(\kappa_s)} - \phi_s \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi$$

**Step 3** Transfer everything to the RHS and name it $\mathcal{H}(\kappa_s, z_s)$ on which you apply the IFT

$$\mathcal{H}(\kappa_s, z_s) = \frac{v_3 + z_s f'(\kappa_s)}{f'(\kappa_s)} - \phi_s z_s^{1-\alpha} \kappa_s^{-\alpha(1-\gamma)} - \phi_s \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)} \xi = 0$$

From the IFT i know the following:

$$\frac{\partial \kappa_s}{\partial z_s} = -\frac{\frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial z_s}}{\frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s}}$$

where

$$\frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial z_s} = \frac{f'(\kappa_s)}{f'(\kappa_s)} - (1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} z_s^{-\alpha} = 1 - (1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} z_s^{-\alpha}$$

and and

$$\frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s} = \frac{z_s f''(\kappa_s) f'(\kappa_s) - z_s f'(\kappa_s) f''(\kappa_s) - v_3 f''(\kappa_s)}{[f'(\kappa_s)]^2} - (-\alpha(1-\gamma)\phi_s z_s^{1-\alpha} \kappa_s^{-\alpha(1-\gamma)-1}) -$$

$$(-\alpha(1-\gamma)\phi_s \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)-1} \xi) \Rightarrow$$

$$\Rightarrow \frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s} = -\frac{v_3 f''(\kappa_s)}{[f'(\kappa_s)]^2} + \alpha(1-\gamma)\phi_s z_s^{1-\alpha} \kappa_s^{-\alpha(1-\gamma)-1} + \alpha(1-\gamma)\phi_s \frac{\beta}{1-\beta} \kappa_s^{-\alpha(1-\gamma)-1} \xi \Rightarrow$$

$$\Rightarrow \frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s} = \alpha(1-\gamma)\phi_s \kappa_s^{-\alpha(1-\gamma)-1} \left( z_s^{1-\alpha} + \frac{\beta}{1-\beta} \xi \right) - \frac{v_3 f''(\kappa_s)}{[f'(\kappa_s)]^2} \Rightarrow [\text{Notice } f''(\kappa_s) < 0]$$

$$\Rightarrow \frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s} = \alpha(1-\gamma)\phi_s \kappa_s^{-\alpha(1-\gamma)-1} \left( z_s^{1-\alpha} + \frac{\beta}{1-\beta} \xi \right) - \frac{v_3(-\gamma)(1-\gamma)\kappa_s^{(-\gamma-1))}}{(1-\gamma)^2 \kappa_s^{2(-\gamma)}} \Rightarrow$$

$$\Rightarrow \frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s} = \alpha(1-\gamma)\phi_s \kappa_s^{-\alpha(1-\gamma)-1} \left( z_s^{1-\alpha} + \frac{\beta}{1-\beta} \xi \right) + v_3 \frac{(\gamma)}{(1-\gamma)} \kappa_s^{(\gamma-1)}$$

Hence the IFT becomes as follows:

$$\frac{\partial \kappa_s}{\partial z_s} = -\frac{\frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial z_s}}{\frac{\partial \mathcal{H}(\kappa_s, z_s)}{\partial \kappa_s}} = -\frac{1 - (1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} z_s^{-\alpha}}{\alpha(1-\gamma)\phi_s \kappa_s^{-\alpha(1-\gamma)-1} \left( z_s^{1-\alpha} + \frac{\beta}{1-\beta} \xi \right) + v_3 \frac{(\gamma)}{(1-\gamma)} \kappa_s^{(\gamma-1)}}$$

$$\frac{\partial \kappa_s}{\partial z_s} = \frac{(1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} z_s^{-\alpha} - 1}{\alpha(1-\gamma)\phi_s \kappa_s^{-\alpha(1-\gamma)-1} \left( z_s^{1-\alpha} + \frac{\beta}{1-\beta} \xi \right) + v_3 \frac{(\gamma)}{(1-\gamma)} \kappa_s^{(\gamma-1)}}$$

Note that the sign of the relationship between $\kappa_s$ and $z_s$ depends on the sign of the nominator:

1. **Flexible Land Regime**: $\frac{\partial \kappa_s}{\partial z_s} > 0$

$$\begin{aligned}
&(1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} z_s^{-\alpha} - 1 > 0 \rightarrow \\
&\rightarrow (1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} z_s^{-\alpha} > 1 \rightarrow \\
&\rightarrow (1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} > \frac{1}{z_s^{-\alpha}} \rightarrow \\
&\rightarrow z_s^{\alpha} < (1-\alpha)\phi_s \kappa_s^{-\alpha(1-\gamma)} \rightarrow \\
&\rightarrow z_s < [(1-\alpha)\phi_s]^{\frac{1}{\alpha}} \kappa_s^{-(1-\gamma)}
\end{aligned}$$

2. **Rigid Land Regime**: $\frac{\partial \kappa_s}{\partial z_s} = 0$

$$z_s = [(1-\alpha)\phi_s]^{\frac{1}{\alpha}} \kappa_s^{-(1-\gamma)}$$

3. **Counter Productive Land Regime**: $\frac{\partial \kappa_s}{\partial z_s} < 0$

$$z_s > [(1-\alpha)\phi_s]^{\frac{1}{\alpha}} \kappa_s^{-(1-\gamma)}$$

To summarise the above result, the risk-sharing contract within the community might end up with a land allocation regime that falls within one or more of the following categories, depending on the relation between idiosyncratic productivity and fraction of land allocated to the villager at the time of the land reform implementation. ■

**Notes on Propostions 2 & 3**:

The results stemming from the two propositions hold under the case in which corner solutions at the level of $\kappa_s$ are ruled out. Below I address the case in which corner solutions are included in the analysis. I will only work on the optimality condition with respect to $\kappa_s$ as the remaining choice variables do not change.

wrt $\kappa_s$:

$$\frac{\partial \mathcal{L}}{\partial \kappa_s} = 0$$

$$\Pi_s z_s f'(\kappa_s) - \Pi_s \phi_s \Big( u'(z_s f(\kappa_s)) z_s f'(\kappa_s) + \beta \frac{\partial v_{aut}(\kappa_s)}{\partial \kappa_s} \Big) + \Pi_s v_{1s} - \Pi_s v_{2s} = 0$$

$$z_s f'(\kappa_s) - \phi_s \left( u'(z_s f(\kappa_s) z_s f'(\kappa_s) + \frac{\beta}{1-\beta} f'(\kappa_s) \omega(\kappa_s) \right) + \nu_{1s} - \nu_{2s} = 0$$

Below I take cases that partition the parameter space $\kappa_s \in [0,1]$:

(a) $\kappa_s \geq 0$ is binding, $\kappa_s = 0$, which implies $v_{1s} > 0$ and $v_{2s} = 0$
The optimality condition reads:

$$z_s f'(\kappa_s) - \phi_s \Big( u'(z_s f(\kappa_s)) z_s f'(\kappa_s) + \frac{\beta}{1-\beta} f'(\kappa_s) \omega(\kappa_s) \Big) + v_{1s} = 0$$

I can rule out this case by examining the participation constraint under this case, which must hold with equality since $\phi_s > 0$.

$$u(c_s) + \beta w_s = u(z_s f(\kappa_s)) + \beta v_{aut}(\kappa_s)$$

The right hand side of the PC is strictly positive, since from foc wrt $c_s$:

$$u'(c_s) = \frac{1}{\theta + \phi_s} \xrightarrow{\theta, \phi_s > 0} c_s = u'^{-1}(\frac{1}{\theta + \phi_s}) > 0$$

The left hand side for a binding non-negative constraint on $\kappa_s$ becomes:

$$u(z_s f(0)) + \beta v_{aut}(0) = 0$$

where the first term using $f(0) = 0$ from the properties of the production function is 0 and thus $u(0) = 0$ and the second term $v_{aut}(0) = \sum_{t=1}^{\infty} \beta^t \sum_{r=1}^{S} \Pi_r u(z_r f(0)) = 0$. As a result this case cannot hold with a binding non-negative constraint on $\kappa_s$ since the PC will not bind.

(b) $1 - \kappa_s \geq 0$ is binding, $\kappa_s = 1$ which implies $v_{1s} = 0$ and $v_{2s} > 0$

$$\boxed{z_s f'(\kappa_s)|_{\kappa_s=1} - \phi_s \Big( u'(z_s f(\kappa_s))|_{\kappa_s=1} z_s f'(\kappa_s)|_{\kappa_s=1} + \frac{\beta}{1-\beta} f'(\kappa_s)|_{\kappa_s=1} \omega(\kappa_s)|_{\kappa_s=1} \Big) - v_{2s} = 0}$$

(c) $\kappa_s \in (0, 1)$ which implies $v_{1s} = v_{2s} = 0$.

$$z_s f'(\kappa_s) - \phi_s u'(z_s f(\kappa_s)) z_s f'(\kappa_s) - \phi_s \frac{\beta}{1-\beta} f'(\kappa_s) \omega(\kappa_s) = 0$$

$$\boxed{z_s f'(\kappa_s) - \phi_s \Big[ u'(z_s f(\kappa_s)) z_s f'(\kappa_s) - \frac{\beta}{1-\beta} f'(\kappa_s) \omega(\kappa_s) \Big] = 0} \quad \forall \kappa_s \in (0, 1)$$

**Note**: From cases (a), (b) and (c) we can rule out only $\kappa_s = 0$. The optimality condition is consistent with $\kappa_s \in (0, 1]$.

In fact the following additional analysis that the optimality condition can accommodate both cases (ie $\kappa_s = 1$ and $\kappa_s \in (0, 1)$) reads:

- From the optimality condition in case (b), I get:

$$z_s f'(1) - \phi_s \left( u'(z_s f(1)) z_s f'(\kappa_s) + \frac{\beta}{1-\beta} f'(1) \omega(1) \right) = \nu_{2s} > 0$$

  and from the optimality condition in case (c), I get that:

$$z_s f'(\kappa_s) - \phi_s \Big[ u'(z_s f(\kappa_s)) z_s f'(\kappa_s) - \frac{\beta}{1-\beta} f'(\kappa_s) \omega(\kappa_s) \Big] = 0 \quad \forall \kappa_s \in (0, 1)$$

- Combining the two I infer that the RHS for $\kappa_s = 1$ should be larger than the RHS for $\kappa_s \in (0, 1)$ and I will show that.
- $z_s f'(1) < z_s f'(\kappa_s) \quad \forall \kappa_s \in (0, 1)$ since f is stricly convave.
- Based on the above, a necessary condition for the inequality to hold is that

$$\phi_s \Big( u'(z_s f(\kappa_s))|_{\kappa_s=1} z_s f'(\kappa_s)|_{\kappa_s=1} + \frac{\beta}{1-\beta} f'(\kappa_s)|_{\kappa_s=1} \omega(\kappa_s)|_{\kappa_s=1} \Big) < \phi_s \Big[ u'(z_s f(\kappa_s)) z_s f'(\kappa_s) + \frac{\beta}{1-\beta} f'(\kappa_s) \omega(\kappa_s) \Big]$$

  which holds since
  - $u'(z_s f(1)) z_s f'(1) < u'(z_s \kappa_s) z_s f'(\kappa_s) \quad \forall \kappa_s \in (0, 1)$ since u and f are strictly concave.

– and $f'(1)\omega(1) < f'(\kappa_s)\omega(\kappa_s) \quad \forall \kappa_s \in (0,1)$ again due to concavity of u and f.

– Since there is no contradiction so far I proceed to the sufficient condition for the inequality to hold, ie for $v_{2s} > 0$:

$$z_s\Big[f'(\kappa_s) - f'(1)\Big]$$
$$<$$
$$\Bigg[u'(z_s f(\kappa_s))z_s f'(\kappa_s) + \frac{\beta}{1-\beta}f'(\kappa_s)\omega(\kappa_s)\Bigg] - \Bigg[u'(z_s f(1))z_s f'(1) + \frac{\beta}{1-\beta}f'(1)\omega(1)\Bigg] \rightarrow$$
$$f'(\kappa_s)\Big[z_s u'(z_s f(\kappa_s)) + \frac{\beta}{1-\beta}\omega(\kappa_s) - z_s\Big] - f'(1)\Big[z_s u'(z_s f'(1)) + \frac{\beta}{1-\beta}\omega(1) - z_s\Big] > 0$$

which holds since the right term is larger than the left term. Note that inside the brackets, we are subtracting the same $z_s$.

The diference derived above can give an expression for $\nu_{2s}$.

Since both cases ((b) and (c)) can occur under a binding PC, then I should examine all possible contingencies - by combining the sole case under a slack PC and the two possible cases under a binding PC.

1. Case Slack PC: $\phi_s = 0$
   (a) $\kappa_s = 1$
2. Case Binding PC: $\phi_s > 0$
   (a) $\kappa_s = 1$
   (b) $\kappa_s \in (0,1)$

First take only two states: $s_L$ and $s_H$.

Then for $s_L$ and based on the above there can only be 3 cases possible:

- Case 1a: $\phi_{s_L} = 0$ and $\kappa_{s_L} = 1$
- Case 1b: $\phi_{s_L} > 0$ and $\kappa_{s_L} = 1$
- Case 1c: $\phi_{s_L} > 0$ and $\kappa_{s_L} \in (0,1)$

Then for $s_H$ and based on the above there can only be 3 cases possible:

- Case 2a: $\phi_{s_H} = 0$ and $\kappa_{s_H} = 1$
- Case 2b: $\phi_{s_H} > 0$ and $\kappa_{s_H} = 1$
- Case 2c: $\phi_{s_H} > 0$ and $\kappa_{s_H} \in (0,1)$

As a result, you need to compute the allocation for all $3 \times 3$ cases - rule out any if they cannot hold and apply maximization to the remaining. This means that you derive all allocations which are $\{c_L, c_H, w_L, w_H, \kappa_L, \kappa_H\}$ for each of the 9 cases.

9 cases

1. **Case 1a, Case 2a**
   Slack PC-low: $u'(c_l) = 1/\theta$, $P'(w_l) = -\theta$
   Slack PC-high: $u'(c_h) = 1/\theta$, $P'(w_h) = -\theta$
   Hence, $c_l = c_h$ and $w_l = w_h$
   Slack PC-low: $u(c_l) + \beta w_l > u(z_l f(1)) + \beta v_a(1)$
   Slack PC - high: $u(c_h) + \beta w_h > u(z_h f(1)) + \beta v_a(1)$
   Condition: $u(c_h) + \beta w_h = u(c_l) + \beta w_l > u(z_h f(1)) + \beta v_a(1)$

2. **Case 1a, Case 2b**
   Slack PC-low: $u'(c_l) = 1/\theta$, $P'(w_l) = -\theta$
   Binding PC-high: $u'(c_h) = 1/(\theta + \phi_h)$, $P'(w_h) = -(\theta + \phi_h)$
   Hence, $c_h > c_l$ and $w_h > w_l$
   From above: $u(c_h) + \beta w_h > u(c_l) + \beta w_l$
   Slack PC-low: $u(c_l) + \beta w_l > u(z_l f(1)) + \beta v_a(1)$
   Binding PC - high: $u(c_h) + \beta w_h = u(z_h f(1)) + \beta v_a(1)$
   From above rhs: $u(z_h f(1)) + \beta v_a(1) > u(z_l f(1)) + \beta v_a(1)$
   $\rightarrow u(z_h f(1)) > u(z_l f(1))$ which holds.

3. **Case 1a, Case 2c**
   Slack PC-low: $u'(c_l) = 1/\theta$, $P'(w_l) = -\theta$
   Binding PC-high: $u'(c_h) = 1/(\theta + \phi_h)$, $P'(w_h) = -(\theta + \phi_h)$
   Hence, $c_h > c_l$ and $w_h > w_l$
   From above: $u(c_h) + \beta w_h > u(c_l) + \beta w_l$
   Slack PC-low: $u(c_l) + \beta w_l > u(z_l f(1)) + \beta v_a(1)$
   Binding PC - high: $u(c_h) + \beta w_h = u(z_h f(\kappa_s)) + \beta v_a(\kappa_s)$
   $\rightarrow u(z_h f(\kappa_s)) + \beta v_a(\kappa_s) > u(z_l f(1)) + \beta v_a(1)$
   Conditions: $z_h f(\kappa_s) > z_l f(1)$ [necessary]
   and $\frac{u(z_h f(\kappa_s)) - u(z_l f(1))}{v_a(\kappa_s) - v_a(1)} > \beta$ [sufficient]

4. **Case 1b, Case 2a**
   Binding PC-low: $u'(c_l) = 1/(\theta + \phi_l)$, $P'(w_l) = -(\theta + \phi_l)$
   Slack PC-high: $u'(c_h) = 1/\theta$, $P'(w_h) = -\theta$
   From above: $c_l > c_h$ and $w_l > w_h$
   From above: $u(c_l) + \beta w_l > u(c_h) + \beta w_h$
   sub lhs & rhs: $u(z_l f(1)) + \beta v_a(1) > u(z_h f(1)) + \beta v_a(1)$
   $\rightarrow u(z_l f(1)) > u(z_h f(1))$ which cannot hold -**RULED OUT**

5. **Case 1b, Case 2b**
   Binding PC-low: $u'(c_l) = 1/(\theta + \phi_l)$, $P'(w_l) = -(\theta + \phi_l)$
   Binding PC-high: $u'(c_h) = 1/(\theta + \phi_h)$, $P'(w_h) = -(\theta + \phi_h)$
   Binding PC-low: $u(c_l) + \beta w_l = u(z_l f(1)) + \beta v_a(1)$
   Binding PC - high: $u(c_h) + \beta w_h = u(z_h f(1)) + \beta v_a(1)$
   Compare rhs: $u(z_h f(1)) + \beta v_a(1) > u(z_l f(1)) + \beta v_a(1)$
   From above: $u(c_h) + \beta w_h > u(c_l) + \beta w_l$
   which can hold if:
   (I) $u(c_h) - u(c_l) > \beta(w_l - w_h)$ but this would give different predictions for $phi_h$ and $\phi_l$ when taking w and c...

(II) $\beta(w_h - w_l) > u(c_l) - u(c_h)$ but this would give different predictions for $phi_h$ and $\phi_l$ when taking w and c...
(III) $u(c_h) > u(c_l)$ and $w_h > w_l$
So only (III) can hold which imples $\phi_h > \phi_l$

6. **Case 1b, Case 2c** Binding PC-low: $u'(c_l) = 1/(\theta + \phi_l)$, $P'(w_l) = -(\theta + \phi_l)$
Binding PC-high: $u'(c_h) = 1/(\theta + \phi_h)$, $P'(w_h) = -(\theta + \phi_h)$
Let $\phi_h > \phi_l$ then $c_h > c_l$ and $w_h > w_l$
From above: $u(c_h) + \beta w_h > u(c_l) + \beta w_l$
From binding PCs: $u(z_h f(\kappa_s)) + \beta v_a(\kappa_s) > u(z_l f(1)) + \beta v_a(1)$
Condition: $z_h f(\kappa_s) > z_l f(1)$ [necessary]
and $\frac{u(z_h f(\kappa_s)) - u(z_l f(1))}{v_a(\kappa_s) - v_a(1)} > \beta$ [sufficient]

7. **Case 1c, Case 2a** Binding PC-low: $u'(c_l) = 1/(\theta + \phi_l)$, $P'(w_l) = -(\theta + \phi_l)$
Slack PC-high: $u'(c_h) = 1/\theta$, $P'(w_h) = -\theta$
From above: $c_l > c_h$ and $w_l > w_h$
From above: $u(c_l) + \beta w_l > u(c_h) + \beta w_h$
From above with Binding PClow & Slack PChigh: $u(z_l f(\kappa_s)) + \beta v_a(\kappa_s) > u(z_h f(1)) + \beta v_a(1)$ which cannot hold as all terms on the left lower than all terms on the right. - **RULED OUT**

8. **Case 1c, Case 2b** Binding PC-low: $u'(c_l) = 1/(\theta + \phi_l)$, $P'(w_l) = -(\theta + \phi_l)$
Binding PC-high: $u'(c_h) = 1/(\theta + \phi_h)$, $P'(w_h) = -(\theta + \phi_h)$
Compare RHS of pc: $u(z_h f(1)) + \beta v_a(1) > u(z_l f(\kappa_s)) + \beta v_a(\kappa_s)$
Both pcs are binding: $u(c_h) + \beta w_h > u(c_l) + \beta w_l$
Which holds under the three cases of (1b, 2b) but we only keep the third which implies $\phi_h > \phi_l$

9. **Case 1c, Case 2c** Binding PC-low: $u'(c_l) = 1/(\theta + \phi_l)$, $P'(w_l) = -(\theta + \phi_l)$
Binding PC-high: $u'(c_h) = 1/(\theta + \phi_h)$, $P'(w_h) = -(\theta + \phi_h)$
Let $\phi_h > \phi_l$ then $c_h > c_l$ and $w_h > w_l$
From above: $u(c_h) + \beta w_h > u(c_l) + \beta w_l$
from binding PCs: $u(z_h f(\kappa_s^h)) + \beta v_a(\kappa_s^h) > u(z_l f(\kappa_s^l)) + \beta v_a(\kappa_s^l)$
The above holds for $\kappa_s^h > \kappa_s^l$ but also
for $\kappa_s^h > \kappa_s^l$ iff:
$\frac{u(z_h f(\kappa_s^h)) - u(z_l f(\kappa_s^l))}{v_a(\kappa_s^l) - v_a(\kappa_s^h)} > \beta$

Proposition 4:

**Proof**: Representing the two consumption allocations as two lotteries, ie probability distributions with different returns for each realisation, for proposition 4 to hold I just need to show that the lottery corresponding to the debt economy consumption allocation second order stochastically dominates the lottery corresponding to the OSLC economy. Then it follows that a risk-averse household would prefer the s.o.s dominant lottery.

Assume that $\mathcal{C} = R^+$ is the set of feasible consumption allocations under the two regimes I

examine. I represent the two regimes as lotteries with corresponding cumulative distributions $\mathcal{O}$ for the oslc economy and $\mathcal{D}$ for the debt economy. The corresponding density functions are $o$ and $d$. The maximal support of the two distributions is $[y_{\min}, y_{\max}]$ and $\mathcal{C} \in [y_{\min}, y_{\max}]$.

For $\mathcal{D}$ to second order stochastically dominate $\mathcal{O}$ I need to prove the two necessary and sufficient conditions:

1. $E(c^{debt}) \geq E(c^{oslc})$
2. $min\{c^{debt}\} \geq min\{c^{oslc}\}$

I start from proving condition 2, then condition 1 and then proceed to proving that a risk-averse agent strictly prefers the second order stochastically dominant allocation.

The one-sided limited commitment economy corresponds to the textbook model from Ljungqvist and Sargent (2000) chapter 20. Therefore I am using the equation 20.3.25 which provides a closed form solution for consumption:

$$u(c_j) = u(y_j) - \beta \sum_{\kappa=1}^{j} [u(y_j) - u(y_k)] \quad \forall j \in S \quad (20.3.25)$$

This relation informs about the optimal setting of the choice variable $c_j$ under the contract. Note that for $j = 1$ ie the lowest possible realisation of endowment, the following holds:

$$\begin{aligned} u(c_1) &= u(y_1) - \beta \sum_{\kappa=1}^{1} \Pi_k [u(y_1) - u(y_k)] \\ u(c_1) &= u(y_1) - \beta \Pi_1 [u(y_1) - u(y_1)] \\ u(c_1) &= u(y_1) \xrightarrow{u'()>0} c_1 = y_1 \end{aligned}$$

which denotes that the lowest value of consumption allocation under the oslc is equal to the lowest endowment realisation:

$$min\{c^{oslc}\} = y_{min} = y_1 \quad (9)$$

Note that in the debt economy the household can borrow in bad times and pay back in good times. As a result the $minc^{debt}$ cannot be lower than the minimum level of endowment realisation. Therefore, condition 2 holds.
From (20.3.25) I can find an upper bound for consumption. Due to the household being risk averse:

$$\begin{aligned} u(c_j) &= u(y_j) - \beta \sum_{\kappa=1}^{j} [u(y_j) - u(y_k)] \\ u(c_j) &\geq u\Big(y_j - y_j \beta \sum_{\kappa=1}^{j} \Pi_\kappa + \beta \sum_{\kappa=1}^{j} y_k\Big) \\ c_j &\leq y_j - y_j \beta \sum_{\kappa=1}^{j} \Pi_\kappa + \beta \sum_{\kappa=1}^{j} \Pi_k y_k \end{aligned}$$

where the RHS of the above inequality constitutes the upper bound for values of the consumption allocation under the oslc.

Assume that the weak inequality holds with equality and consumption acquires its upper bound.

$$\begin{aligned} c_j &= y_j - y_j\beta\sum_{\kappa=1}^{j}\Pi_\kappa + \beta\sum_{\kappa=1}^{j}\Pi_k y_k \\ E(c_j) &= E(y_j) - E(y_j)\sum_{\kappa=1}^{j}\Pi_\kappa + \beta\sum_{\kappa=1}^{j}\Pi_k y_k \end{aligned} \tag{10}$$

and

$$\begin{aligned} Var(c_j) &= Var(y_j(1-\beta\sum_{\kappa=1}^{j}\Pi_k + \beta\sum_{\kappa=1}^{j}\Pi_\kappa y_\kappa)) \\ Var(c_j) &= (1-\beta\sum_{\kappa=1}^{j}\Pi_\kappa)^2 Var(y_j) \end{aligned} \tag{11}$$

(9) and (10) gives the first and second moment of the consumption allocation under the oslc.

**Debt Economy**

The Lagrangian for the problem above takes the following form:

$$\mathcal{L} = \sum_{t=0}^{\infty}\beta^t\{u(c_t) + \lambda_t\Big[y_t + d_t - c_t - (1+r)d_{t-1}\Big]\}$$

Deriving the first order conditions with respect to consumption and debt obligation maturing at the next period I have:

$$\begin{aligned} u'(c_t) &= \lambda_t \quad \text{wrt} \quad [c_t] \\ \lambda_t &= \beta(1+r)E_t\lambda_{t+1} \quad \text{wrt} \quad [d_t] \end{aligned}$$

I make the assumption that $\beta(1+r) = 1$. Hence the first order condition with respect to debt becomes:

$$\lambda_t = E_t\lambda_{t+1} \rightarrow u'(c_t) = E_t u'(c_{t+1}) \rightarrow \boxed{c_t = E_t c_{t+1}}$$[11]

I turn from the sequential budget constraint of the agent under the PR regime to the intertemporal budget constraint, in order to derive an expression for the lifetime consumption path prescribed by the problem.

$$\begin{aligned} c_t + (1+r)d_{t-1} = y_t + d_t &\xrightarrow{\text{solving for } (1+r)d_{t-1}} (1+r)d_{t-1} = y_t + d_t - c_t \quad [\text{at } t] \\ (1+r)d_t = y_{t+1} + d_{t+1} - c_{t+1} &\rightarrow d_t = \frac{y_{t+1} - c_{t+1}}{1+r} + \frac{d_{t+1}}{1+r} \quad [\text{at } t+1] \\ &\dots \\ (1+r)d_{t+j-1} &= \frac{y_{t+j} - c_{t+j}}{1+r} + \frac{d_{t+j}}{1+r} \quad [\text{at } t+j] \end{aligned}$$

[11] at the last step I am assuming that the marginal utility of consumption is linear, so that the expectation can pass through. Moreover, note that $c_t = E_t c_{t-1}$ stems from assuming quadratic preferences, which is appealing because you can have a closed form solution for consumption.

By substituting backwards, I obtain:

$$(1+r)d_{t+j-2} = \frac{y_{t+j-1} - c_{t+j-1}}{1+r} + \frac{d_{t+j-1}}{1+r}$$

$$...$$

$$(1+r)d_{t-1} \sum_{j=0}^{\infty} \frac{y_{t+j} - c_{t+j}}{(1+r)^j} + \frac{d_{t+j}}{(1+r)^j}$$

Here, I use the no-Ponzi scheme condition:

$$\lim_{j \to \infty} \frac{d_{t+j}}{(1+r)^j} = 0$$

Hence the expression for $d_{t-1}$ becomes:

$$(1+r)d_{t-1} = \sum_{j=0}^{\infty} \frac{y_{t+j} - c_{t+j}}{(1+r)^j}$$

Solving the above for consumption I have:

$$\sum_{j=0}^{\infty} \frac{c_{t+j}}{(1+r)^j} = \sum_{j=0}^{\infty} \frac{y_{t+j}}{(1+r)^j} - (1+r)d_{t-1}$$

where the LHS of the above expression can be written as follows:

$$\sum_{j=0}^{\infty} \frac{c_{t+j}}{(1+r)^j} = c_t + \frac{c_{t+1}}{(1+r)} + \frac{c_{t+2}}{(1+r)^2} + ...$$

The agent optimally sets:

$$c_t = E_t(c_{t+1}) \quad \forall t$$

Hence,

$$\sum_{j=0}^{\infty} \frac{c_{t+j}}{(1+r)^j} = c_t \sum_{j=0}^{\infty} \frac{1}{(1+r)^j} = c_t \frac{1+r}{r}$$

Hence, the intertemporal budget constraint is given by:

$$\frac{1+r}{r} c_t = E_t \sum_{j=0}^{\infty} \frac{y_{t+j}}{(1+r)^j} - (1+r)d_{t-1}$$

$$c_t = \frac{r}{1+r} E_t \sum_{j=0}^{\infty} \frac{y_{t+j}}{(1+r)^j} - \frac{r}{1+r}(1+r)d_{t-1}$$

$$\boxed{c_t = \frac{r}{1+r} E_t \sum_{j=0}^{\infty} \frac{y_{t+j}}{(1+r)^j} - r d_{t-1}} \quad [I]$$

I use $[I]$ to derive the first and second moment for consumption under the PR regime. (For expositional reasons I substitute $c_t$ with $c_t^{pr}$ to denote that consumption corresponds to the PR regime).
Taking expectation in $[I]$:

$$
\begin{aligned}
E(c_t^{debt}) &= E\left[\frac{r}{1+r}\sum_{j=0}^{\infty}\frac{y_{t+j}}{(1+r)^j} - rd_{t-1}\right] \\
E(c_t^{debt}) &= \frac{r}{1+r}E\left[\sum_{j=0}^{\infty}\frac{y_{t+j}}{(1+r)^j}\right] - rd_{t-1} \\
E(c_t^{debt}) &= \frac{r}{1+r}E\left[\frac{y_t}{(1+r)^0} + \frac{y_{t+1}}{(1+r)^1} + \frac{y_{t+2}}{(1+r)^2} + ...\right] - rd_{t-1} \\
E(c_t^{debt}) &= \frac{r}{1+r}\left[\frac{E(y_t)}{(1+r)^0} + \frac{E(y_{t+1})}{(1+r)^1} + \frac{E(y_{t+2})}{(1+r)^2} + ...\right] - rd_{t-1} \\
E(c_t^{debt}) &= \frac{r}{1+r}E(y_t)\left[\frac{1}{(1+r)^0} + \frac{1}{(1+r)^1} + \frac{1}{(1+r)^2} + ...\right] - rd_{t-1} \\
E(c_t^{debt}) &= \frac{r}{1+r}E(y_t)\sum_{j=0}^{\infty}\frac{1}{(1+r)^j} - rd_{t-1} \\
E(c_t^{debt}) &= \frac{r}{1+r}E(y_t)\frac{1}{1-\frac{1}{1+r}} - rd_{t-1} \\
E(c_t^{debt}) &= \frac{r}{1+r}E(y_t)\frac{1+r}{r} - rd_{t-1} \\
E(c_t^{debt}) &= E(y_t) - rd_{t-1}
\end{aligned}
\tag{12}
$$

correspondingly the variance of the consumption allocation under the debt economy is the

following: Now take the Variance of $[I]$:

$$Var(c_t^{debt}) = Var\left[\frac{r}{1+r}\sum_{j=0}^{\infty}\frac{y_{t+j}}{(1+r)^j} - rd_{t-1}\right]$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var\left[\sum_{j=0}^{\infty}\frac{y_{t+j}}{(1+r)^j}\right]$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var\left[\frac{y_t}{(1+r)^0} + \frac{y_{t+1}}{(1+r)^1} + \frac{y_{t+2}}{(1+r)^2} + \frac{y_{t+3}}{(1+r)^3} + ...\right] \quad y_t \text{ is iid}$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 \left[Var\left(\frac{y_t}{(1+r)^0}\right) + Var\left(\frac{y_{t+1}}{(1+r)^1}\right) + Var\left(\frac{y_{t+2}}{(1+r)^2}\right) + Var\left(\frac{y_{t+3}}{(1+r)^3}\right) + ...\right]$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 \left[\left[\left(\frac{1}{1+r}\right)^2\right]^0 Var(y_t) + \left[\left(\frac{1}{1+r}\right)^2\right]^1 Var(y_t) + \left[\left(\frac{1}{1+r}\right)^2\right]^2 Var(y_t) + ...\right.$$

since $Var(y_t) = Var(y_{t+1}) = Var(y_{t+2}) = ... = Var(y_{t+j})$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var(y_t)\left[\left[\left(\frac{1}{1+r}\right)^2\right]^0 + \left[\left(\frac{1}{1+r}\right)^2\right]^1 + \left[\left(\frac{1}{1+r}\right)^2\right]^2 + ...\right]$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var(y_t)\sum_{j=0}^{\infty}\left[\left(\frac{1}{1+r}\right)^2\right]^j$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var(y_t)\frac{1}{1-\frac{1}{(1+r)^2}}$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var(y_t)\frac{1}{\frac{(1+r)^2-1}{(1+r)^2}}$$

$$Var(c_t^{debt}) = \left(\frac{r}{1+r}\right)^2 Var(y_t)\frac{(1+r)^2}{(1+r)^2-1}$$

$$Var(c_t^{debt}) = \frac{r^2}{(1+r)^2}Var(y_t)\frac{(1+r)^2}{(1+r)^2-1}$$

$$Var(c_t^{debt}) = \frac{r^2}{(1+r)^2-1}Var(y_t)$$

$$Var(c_t^{debt}) = \frac{r^2}{1+2r+r^2-1}Var(y_t)$$

$$Var(c_t^{debt}) = \frac{r^2}{2r+r^2}Var(y_t)$$

$$Var(c_t^{debt}) = \frac{r^2}{r(2+r)}Var(y_t)$$

$$Var(c_t^{debt}) = \frac{r}{(2+r)}Var(y_t) \tag{13}$$

(11) and (12) give the first and second moments for the consumption allocation under the debt economy.

First notice that the variance of the debt economy's consumption allocation is lower than the variance of the oslc consumption allocation. It just suffices to show that $\frac{r}{2+r} < (1 - \frac{1}{1+r}\sum_{\kappa=1}^{j}\Pi_\kappa)$. Note that the lower bound of the rhs of the inequality is when $j = S$, hence the $\sum_{\kappa=1}^{j}\Pi_\kappa) = 1$ takes its maximum value, as a result the lower bound of the rhs is $(1-\frac{1}{1+r}) = \frac{r}{1+r}$ which is larger than $\frac{r}{2+r}$. As result, it holds that $\frac{r}{2+r} < (1 - \frac{1}{1+r}\sum_{\kappa=1}^{j}\Pi_\kappa) \quad \forall j$ and therefore $\frac{r}{2+r} < (1 - \frac{1}{1+r}\sum_{\kappa=1}^{j}\Pi_\kappa)^2$

Note that for $d^* < \frac{r}{1+r}\sum_{\kappa=1}^{j}\Pi_\kappa[E(y_j) - y_k]$ and combining (9) and (10) I obtain condition 1 for second order stochastic dominance.

Since conditions 1 and 2 with these assumptions hold, then I infer that the consumption allocation under the debt economy second order stochastically dominates the consumption allocation from the oslc economy. Therefore it will provide the household with higher expected utility as shown below:

**Definition**: Distribution $\mathcal{D}$ second order stochastically dominates distribution $\mathcal{O}$ if for every $x \in \mathcal{C}$:

$$\int_{y_{\min}}^{x} \mathcal{D}(c)dc \leq \int_{y_{\min}}^{x} \mathcal{O}(c)dc$$

What I want to show is that when the cumulative distribution $\mathcal{D}$ second order stochastically dominates distribution  then the risk averse agent prefers $\mathcal{D}$ since it delivers higher expected utility ie

$$\int_{y_{\min}}^{y_{\max}} u(c)d(c)dc \geq \int_{y_{\min}}^{y_{\max}} u(c)o(c)dc \rightarrow \int_{y_{\min}}^{y_{\max}} u(c)d(c)dc - \int_{y_{\min}}^{y_{\max}} u(c)o(c)dc \geq 0$$

I take the RHS of the above expression:

$$\int_{y_{\min}}^{y_{\max}} u(c)d(c)dc - \int_{y_{\min}}^{y_{\max}} u(c)o(c)dc \qquad \text{[integrating by parts]}$$

$$\Big[u(c)\mathcal{D}(c)\Big]_{y_{\min}}^{y_{\max}} - \int_{y_{\min}}^{y_{\max}} u'(c)\mathcal{D}(c)dc - \Big[u(c)\mathcal{O}(c)\Big]_{y_{\min}}^{y_{\max}} + \int_{y_{\min}}^{y_{\max}} u'(c)\mathcal{O}(c)dc$$

$$u(y_{\max}) - 0 - \int_{y_{\min}}^{y_{\max}} u'(c)\mathcal{D}(c)dc - u(y_{\max}) + 0 + \int_{y_{\min}}^{y_{\max}} u'(c)\mathcal{O}(c)dc$$

$$\int_{y_{\min}}^{y_{\max}} u'(c)\Big[\mathcal{O}(c) - \mathcal{D}(c)\Big] \qquad \text{[integrating by parts]}$$

$$\text{also define} \quad S_o(c) = \int_{y_{\min}}^{c} \mathcal{O}(c)dc \quad \text{and} \quad S_d(c) = \int_{y_{\min}}^{c} \mathcal{D}(c)dc$$

$$\Big[u'(c)\Big(S_o(c) - S_d(c)\Big)\Big]_{y_{\min}}^{y_{\max}} - \int_{y_{\min}}^{y_{\max}} u''(c)\Big[S_o(c) - S_d(c)\Big]dc$$

$$u'(y_{\max})\Big[S_o(y_{\max}) - S_d(y_{\max})\Big] - \int_{y_{\min}}^{y_{\max}} u''(c)\Big[S_o(c) - S_d(c)\Big]dc$$

$$\text{note} \quad S_o(y_{\max}) - S_d(y_{\max}) = 0$$

$$- \int_{y_{\min}}^{y_{\max}} u''(c)\Big[S_o(c) - S_d(c)\Big]dc$$

I know that $\mathcal{D}$ second order stochastically dominates $\mathcal{O}$, so that $S_o(c) > S_d(c)\ \forall c \in \mathcal{C}$ and $u''(c) < 0$ so the above last expression is positive indicating that the risk averse agent derives higher expected utility under the debt economy regime compared to the oslc.

Note that above I have made the assumption that the cumulative distribution of the PR regime second order stochastically dominates the cumulative distribution under autarky and as a direct result, the expected utilities are related as shown.

# A Figures

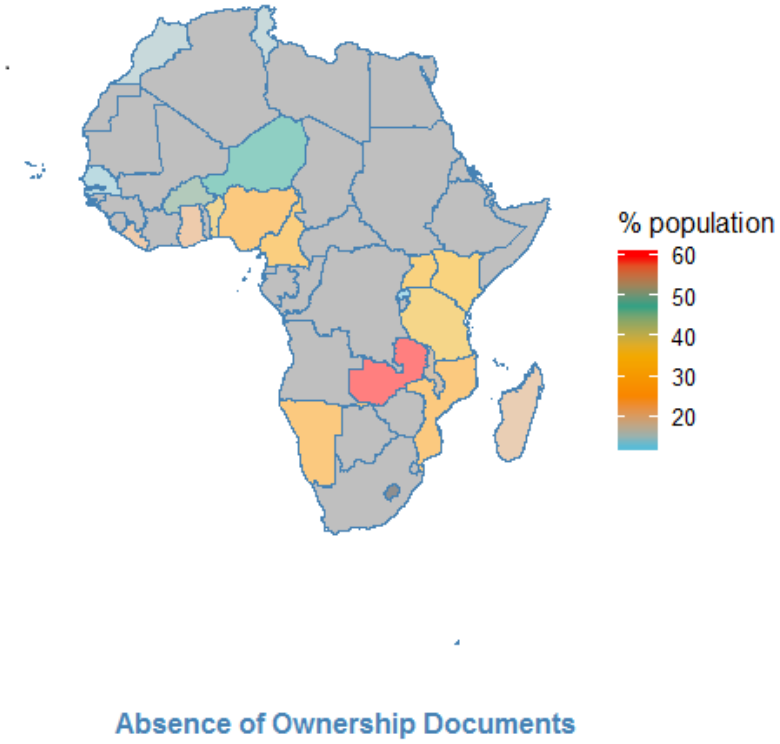


Figure A.1: Absence of Ownership Documents in African Countries (pri (2019))

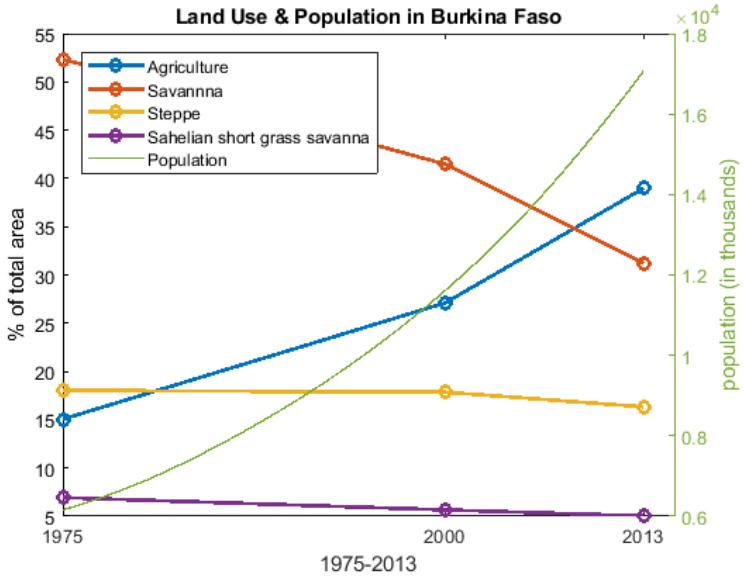


Figure A.2: Source: West Africa: Land Use and Land Cover Dynamics & United Nations

| Rural Land Governance Project | | | |
|---|---|---|---|
| **Activities** | **Title** | **Description** | **Phases** |
| **Activity No 1** | **Legal and Procedural Change and Communication** | 1. Support government's efforts to develop and implement improved rural land legislation and to develop, revise and implement other legal and procedural frameworks.<br>2. Significant public outreach program to inform people about the new legislations and its expected benefits | Phase I (2009-2012) (national level) |
| **Activity No 2** | **Institutional Development and Capacity Building** | 1. Improve institutional capacity to deliver land services in rural areas.<br>2. Funding of series of land registration, mapping and decentralization services. | Phase I (2009-2012) (17 communes) Phase II (2012-2014) (additional 30 communes) |
| **Activity No 3** | **Site-Specific Land Tenure Interventions** | 1. Site specific land rights formalization sub-activities<br>2. Provision of APFR certificates<br>3. Preparation of land titles and leases in selected project areas. | Phase I (2009-2012) (17 communes) Phase II (2012-2014) (additional 30 communes) |

Table 5: Burkina Faso Rural Land Governance Project Impact Evaluation (IMPAQ, 2015)

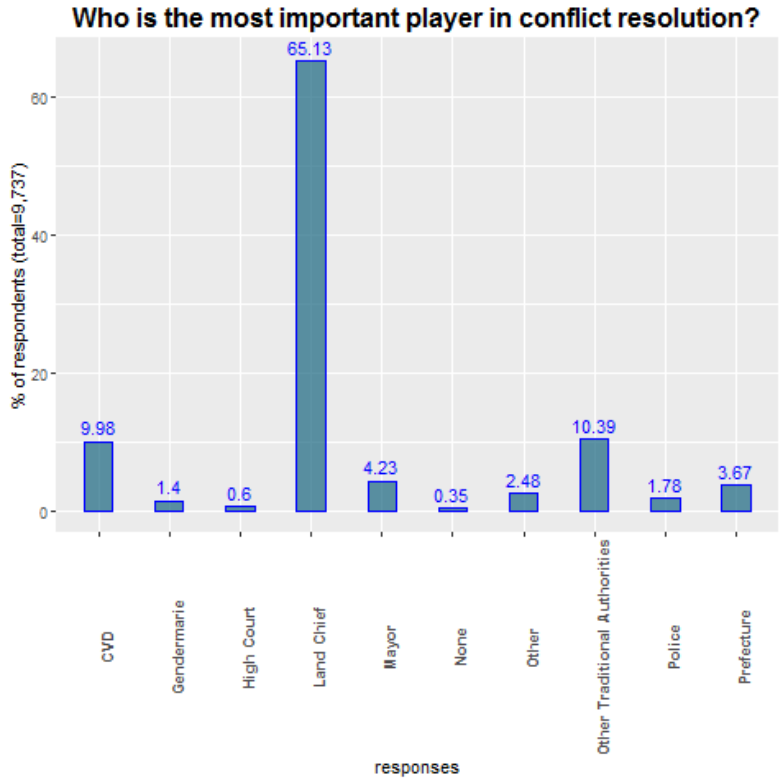


Figure A.3: MCC - Baseline Survey - Conflict Resolution

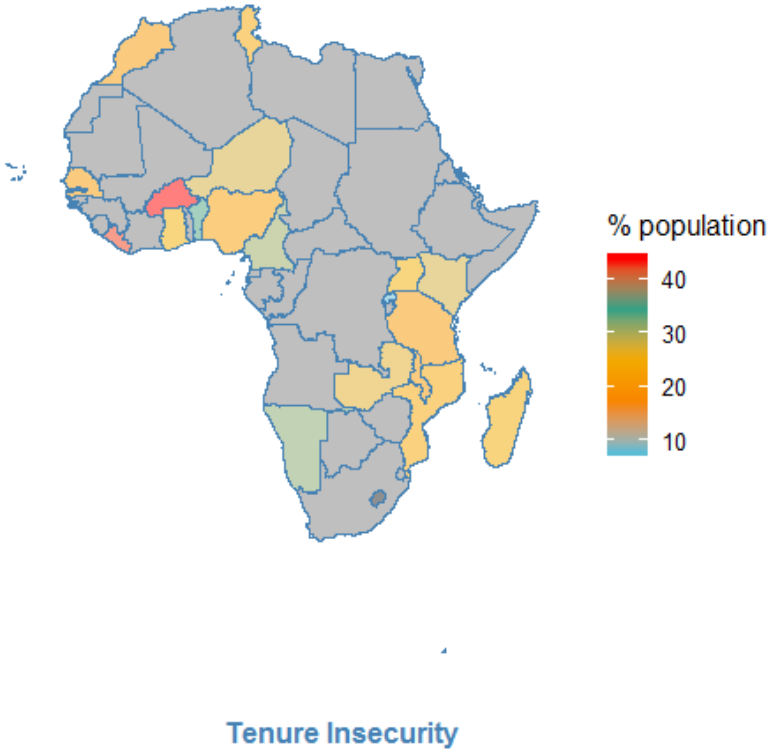


Figure A.4: Note: Tenure insecurity: : % of people who believe it is somewhat or very likely that they could lose their right to use their property or part of it against their will in the next 5 years.

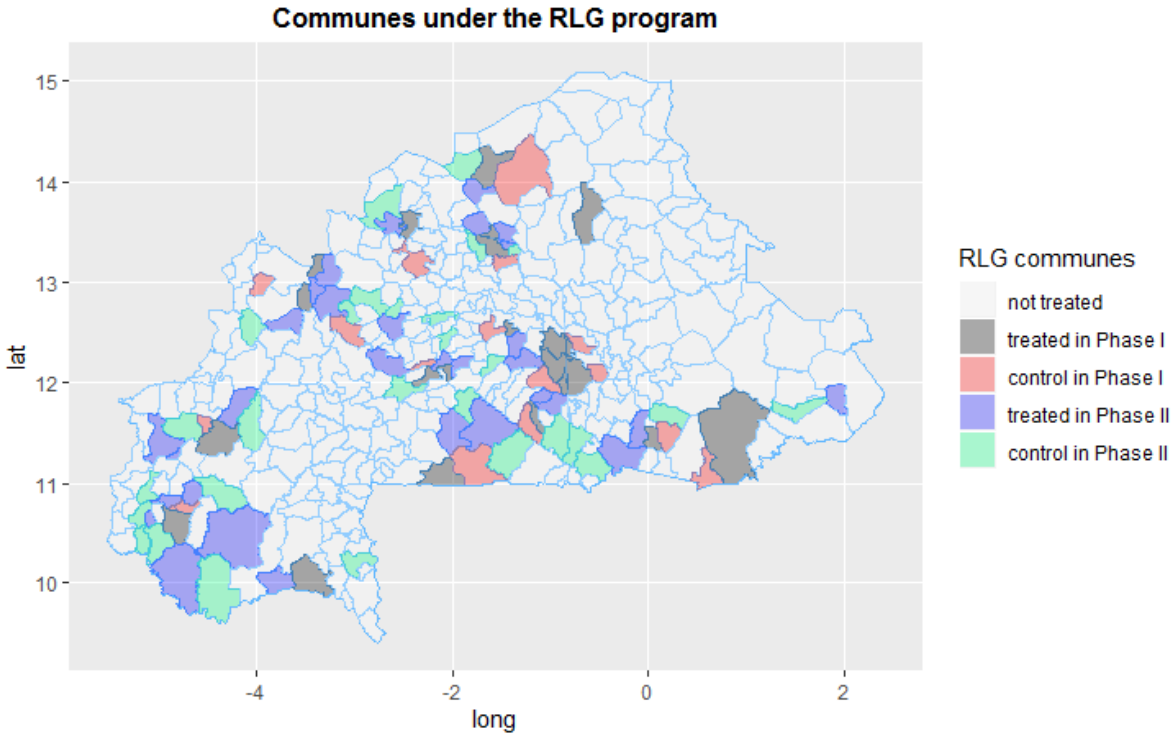


Figure A.5: Communes that participated to Phase I and Phase II of the RLG

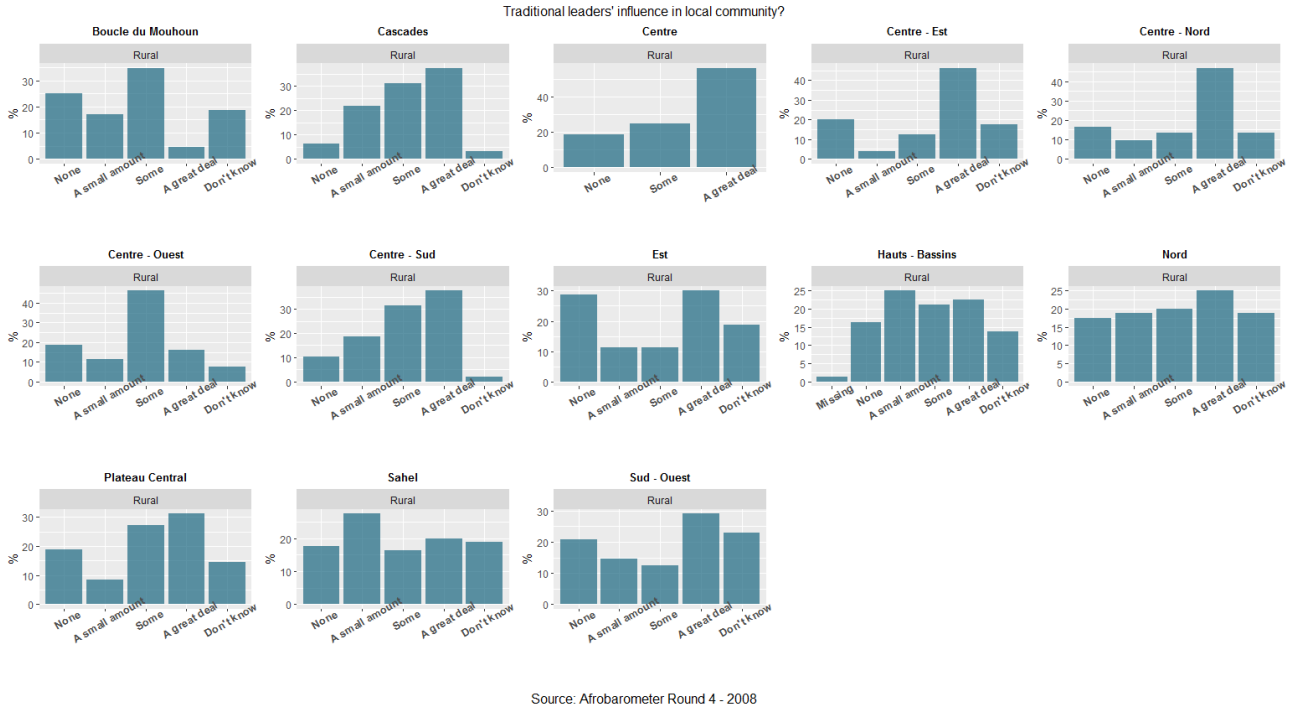


Figure A.6: Traditional leaders' influence in local community

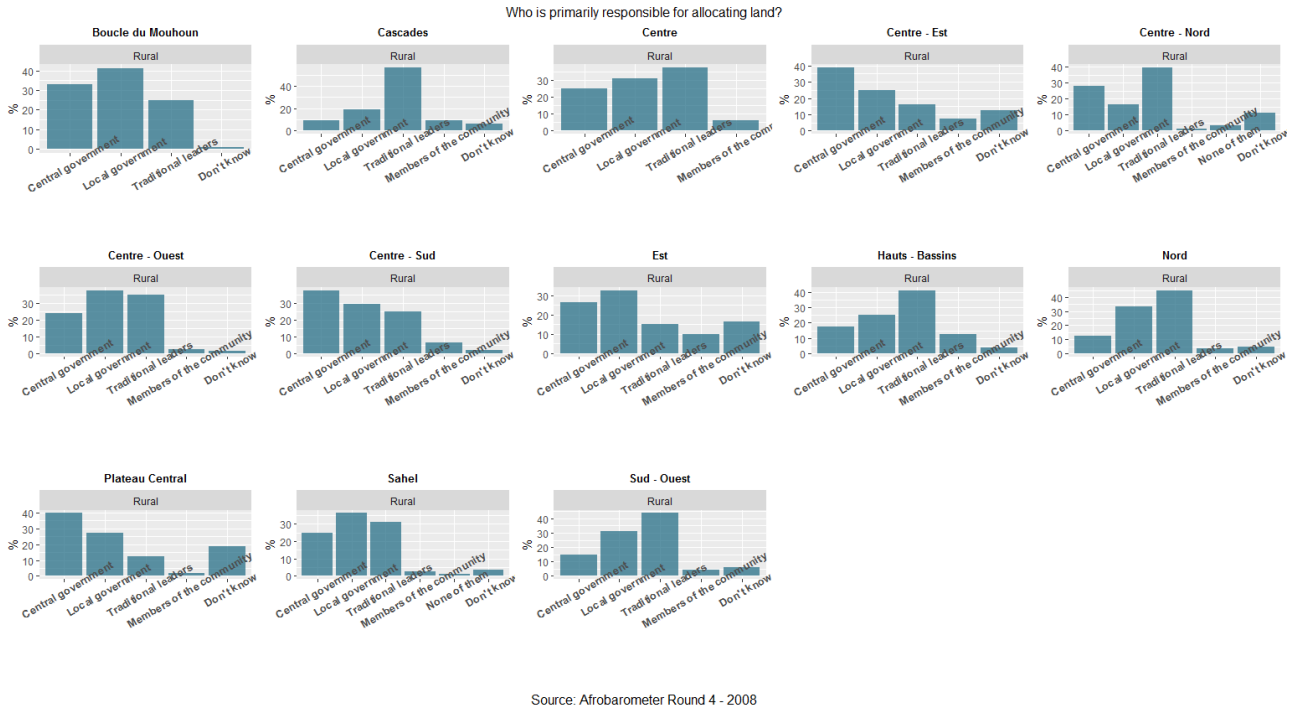


Figure A.7: Who is primarily responsible for allocating land

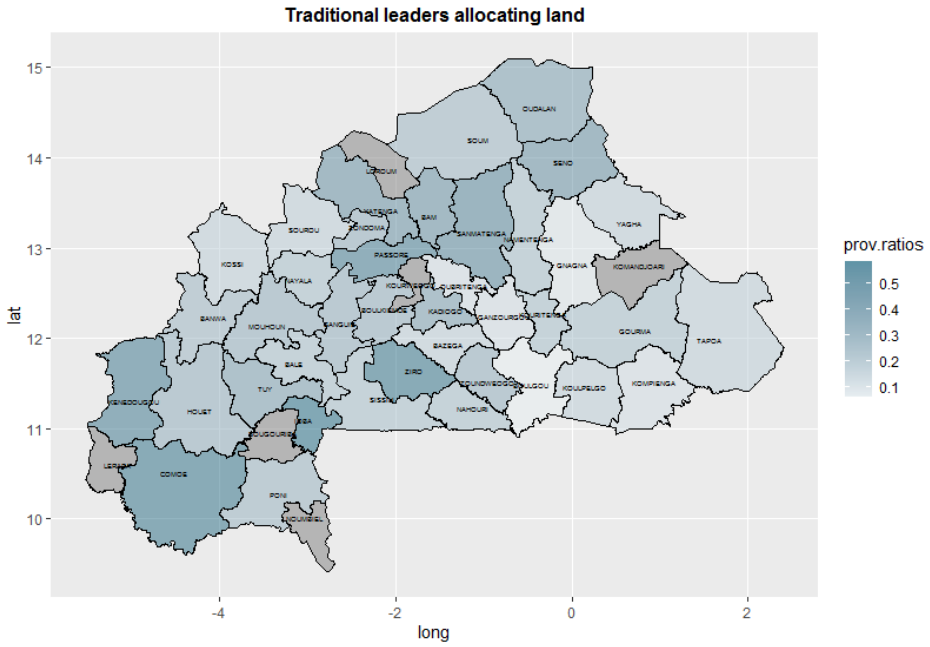


Figure A.8: Role of leaders in allocating land by administrative province

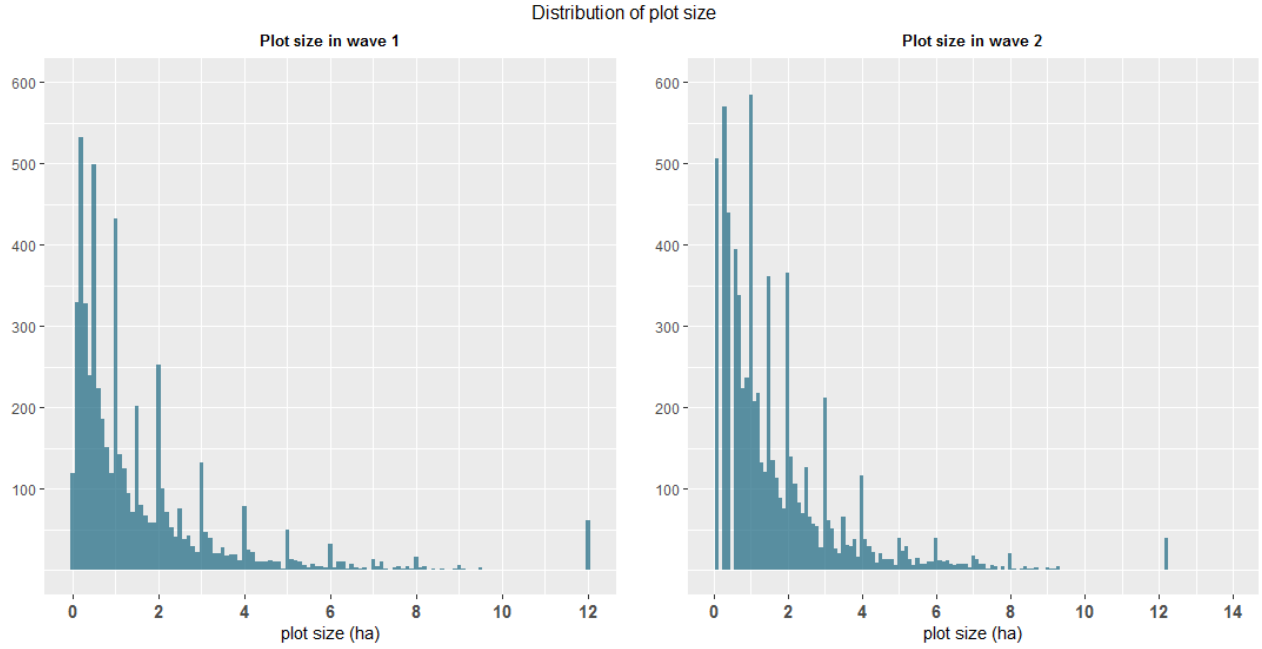


Figure A.9: Distribution of plot size

# B Tables

### Production value based productivity measure

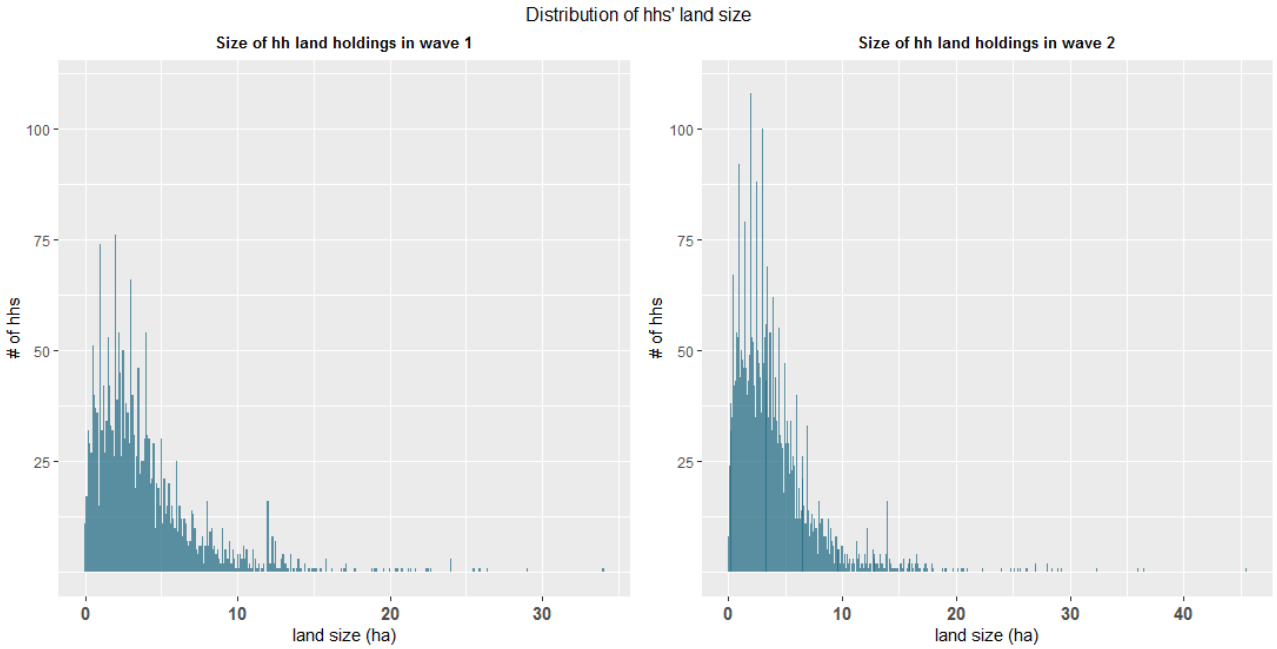


Figure A.10: Distribution of household land holdings

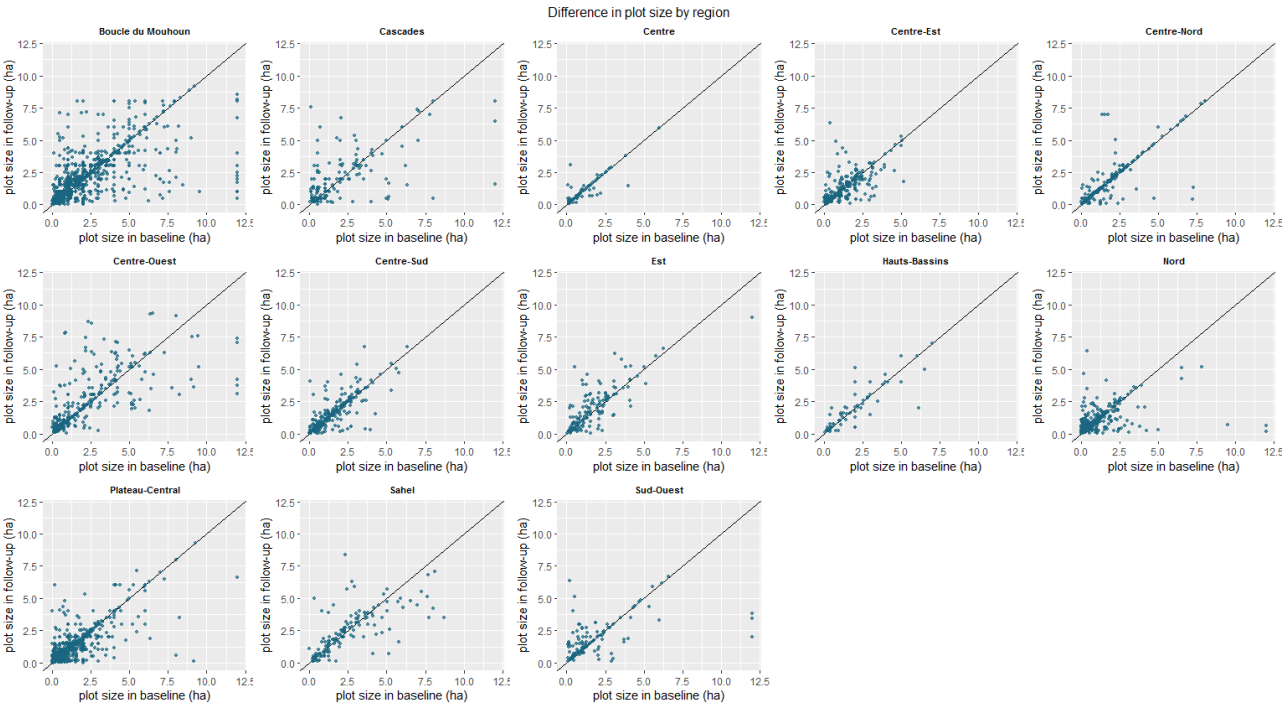


Figure A.11: Difference in plot size by region

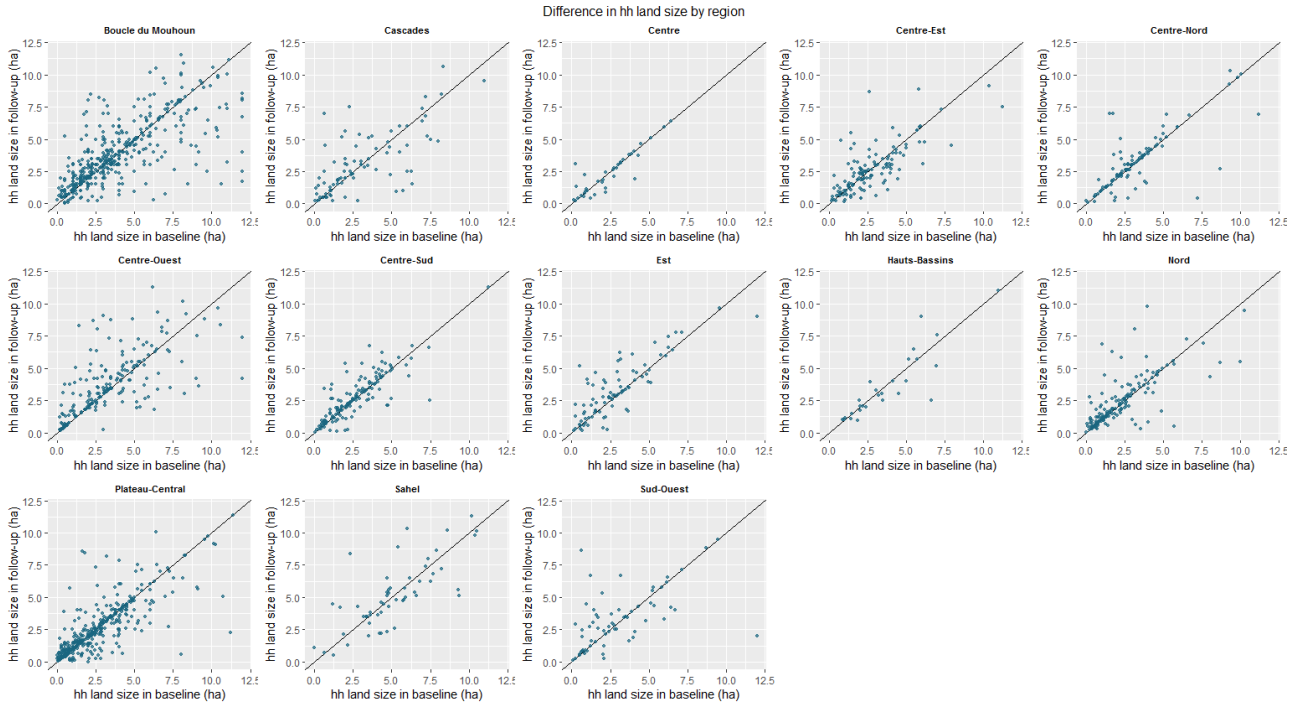


Figure A.12: Difference in household land holdings per region

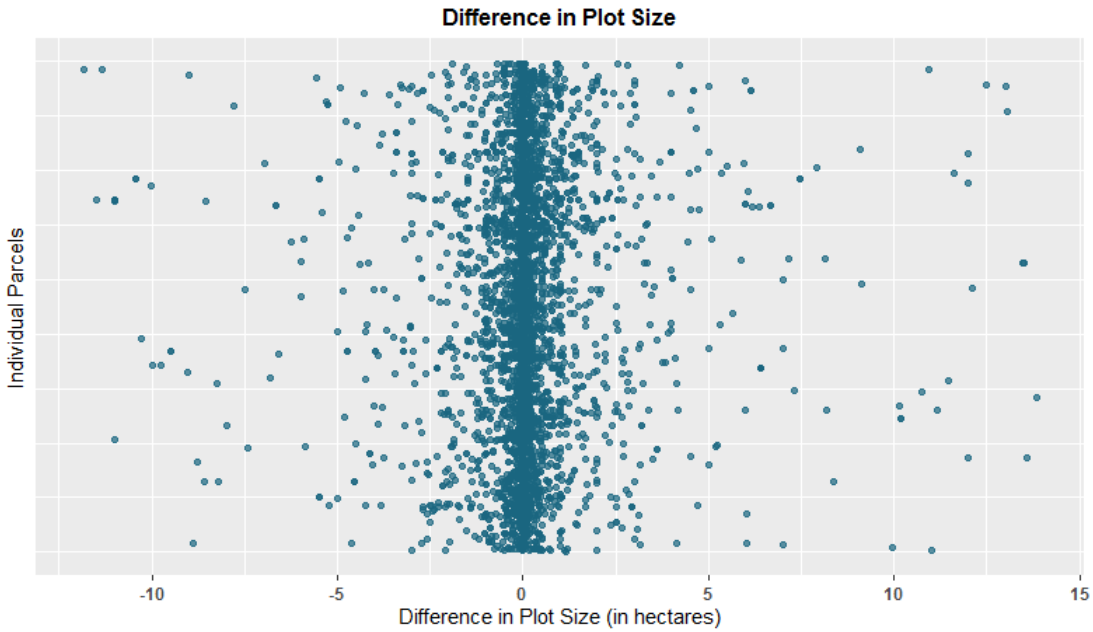


Figure A.13: Difference in plot size at the individual level

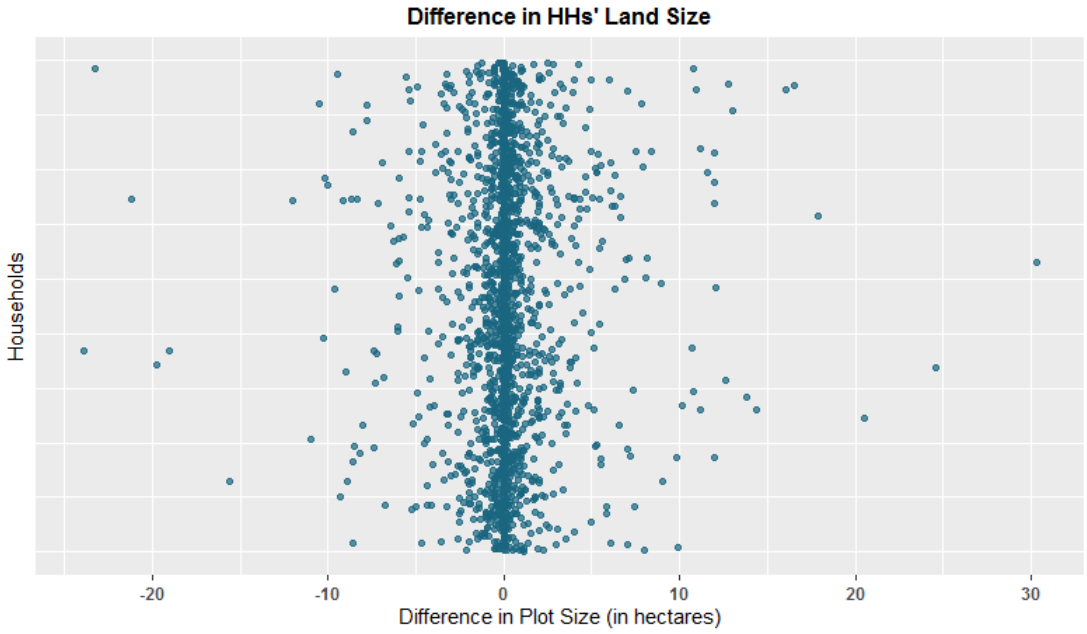


Figure A.14: Difference in plot size at the household level

| Season | Production (# parcels with available data) | Imputed prices (# parcels with imputed data) | |
|---|---|---|---|
| Dry 2008/09 | 396 | 160 | 40% |
| Rainy 2008/09 | 9,035 | 1,814 | 20% |
| Dry 2009/10 | 161 | 100 | 62% |
| Rainy 2009/10 | 10,154 | 2,141 | 21% |
| Dry 2010/11 | 629 | 372 | 59% |
| Rainy 2010/11 | 14,748 | 2,878 | 19.5% |
| Dry 2011/12 | 406 | 294 | 72.4% |
| Rainy 2011/12 | 15,521 | 3,128 | 20% |

Table 6: On the first column is the number of parcels for which production data are available, in the second is the number of parcels for which prices per local unit of measure are imputed. The low percentages are due to the different local units of measurement used.

| | Min. | Q1 | Median | Mean | Q3 | Max | Obs |
|---|---|---|---|---|---|---|---|
| Baseline | 0.01 | 0.41 | 1 | 1.59 | 2.01 | 12 | 5,680 |
| Interim | 0.01 | 0.37 | 0.91 | 1.51 | 2 | 14 | 9,108 |

Table 7: Size of parcels (in ha)

| | Min | Q1 | Median | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| Baseline | 1.00 | 1.00 | 2.00 | 2.48 | 3.00 | 18.00 |
| Interim | 1.00 | 1.00 | 2.00 | 2.73 | 3.00 | 17.00 |

Table 8: Number of parcels per household

| | Min | Q1 | Median | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| Baseline | 0.01 | 1.58 | 3.00 | 3.94 | 5.02 | 34.00 |
| Interim | 0.01 | 1.75 | 3.24 | 4.11 | 5.25 | 45.50 |

Table 9: Size of HH's land holdings (in ha)

| | Min | Q1 | Median | Mean | Q3 | Max |
|---|---|---|---|---|---|---|
| plot level | -99.5 | -17.3 | 0.00 | -3.36 | 9.44 | 100 |
| individual level | -99.5 | -18.20 | 0.00 | -4.10 | 8.89 | 100 |
| hh level | -99.5 | -18.86 | 0.00 | -5.15 | 7.95 | 100 |

Table 10: Distribution of land size difference

| Rural Land Governance Project | | | |
|---|---|---|---|
| **Activities** | **Title** | **Description** | **Phases** |
| **Activity No 1** | **Legal and Procedural Change and Communication** | 1. Support government's efforts to develop and implement improved rural land legislation and to develop, revise and implement other legal and procedural frameworks.<br>2. Significant public outreach program to inform people about the new legislations and its expected benefits | Phase I (2009-2012) (national level) |
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Table 11: Burkina Faso Rural Land Governance Project Impact Evaluation (IMPAQ, 2015)

## C Naive productivity measure

Even though the production value based productivity measure is highly accurate and allows for cross-crop comparison, it restricts the sample significantly, due to low market participation from the side of the individual farmers and sizeable heterogeneity across local measurement units. To address this issue I proceed in performing the same analysis by employing a naive productivity measure, agnostic to the type of crops.

For plot $p \in P$ where $P$ is the set of all plots in the survey, I calculate the following

$$agricultural\ productivity_p = \frac{q_p}{\kappa_p}$$

where $q_p$ is the quantity produced and $\kappa_p$ is the size of the plot $p$.

Table 12 shows the estimation results from regression (5) with the naive productivity measure used to build individual productivity. The results are robust to this specification as well.

Table 12: Results from (4)

| | *Dependent variable:* | |
|---|---|---|
| | $\Delta\kappa_{i,2012/09}$ | |
| | treated EAs | control EAs |
| | (1) | (2) |
| below-median×ind.productivity | 0.197** | 0.066 |
| | (0.079) | (0.170) |
| Individual controls | Yes | Yes |
| Household control | Yes | Yes |
| Observations | 1,620 | 1,343 |
| $R^2$ | 0.220 | 0.185 |
| Adjusted $R^2$ | 0.213 | 0.176 |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | |

As a robustness check, the focus is swifted on the direction of the difference in land size so as to account only individuals that experienced an increase in land after the rerorm. Therefore, the analysis proceeds in building a dummy variable *Increase* which takes the value 1 if the change in plot size between the two waves is positive and 0 if not.

$$Increase_i = \begin{cases} 1 & \Delta\kappa_{2012/09} > 0 \\ 0 & \Delta\kappa_{2012/09} \leq 0 \end{cases}$$

Since the dependent variable is a dummy, I need to use a non-linear specification to compute the effect of the individual productivity for an individual ranking below the village median productivity to the difference in land size between the two waves. The specification to be estimated is the following probit model:

$$Pr[\text{increase } = 1|X] = \Phi(\beta_1 \text{Below-village-median}_{1,2009} * \text{Individual productivity}_{i,2009} + X'\beta_2) \tag{14}$$

where $\Phi()$ is the cdf of the standard normal distribution and $X$ is a matrix of control variables addressing individual and household characteristics.

Estimating the probit model, specified in equation (14) raises the following results (table 13). As it can be inferred, the sample has been divided into treated and control areas, where treatment is defined as the implementation of the first stages of the land reform. The result is in line with the theoretical proposition 3, since for those individuals that rank below the village median and hence can be classified as low productivity, an one unit raise in their productivity would affect positively the probability of the individual obtaining more land in 2012 compared to those individuals that rank above the village median. The interesting part is that this effect is not observed in the control areas. For the control areas not only the effect of the interaction term is insignificant but its sign points toward an efficient allocation of land, in which low productivity individuals lose land.

Table 13: Results from (5)

| | *Dependent variable:* | |
|---|---|---|
| | Pr(increase = 1\| X) | |
| | treated | control |
| | (1) | (2) |
| below-median×ind.productivity | 0.123* | −0.058 |
| | (0.075) | (0.098) |
| Individual controls | Yes | Yes |
| Household control | Yes | Yes |
| Observations | 1,324 | 1,230 |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | |