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Analysis

Can Land Fragmentation Reduce the Exposure of Rural Households to Weather Variability?☆

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ABSTRACT

Climate change continuously affects African farmers that operate in rain-fed environments. Coping with weather risk through credit and insurance markets is almost inexistent as these markets are imperfect in the African economies. Even though land fragmentation is often considered as a barrier to agricultural productivity, this article aims at analyzing whether land fragmentation, as an insurance alternative, is able to reduce farmers' exposure to weather variability. In order to address this research question, I use the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) data on Uganda. After dealing with the endogeneity of land fragmentation, I find that higher land fragmentation decreases the loss of crop yield when households experience rainfall anomalies, but remains detrimental for those households that are not exposed to such irregularities. Therefore, policy makers should be cautious while implementing uniform land consolidation programs.

1. Introduction

Global warming is a crucial issue for the African continent and it is expected that its impacts will be even more severe in the future. While Africa is the least responsible for global greenhouse gases (GHG) emissions, it will be the most affected by them owing to low adaptive capacity (Collier et al., 2008). The majority of the population lives in rural areas and is engaged in the agricultural sector which is highly sensitive to weather variability. Because of the lack of irrigation infrastructure, weather conditions affect directly agricultural production and livelihoods (Barrios et al., 2008; Schlenker and Lobell, 2010; Kahsay and Hansen, 2016). Also, climate change increases the frequency and the severity of extreme event, such as floods and droughts. As a result, a great part of the African population has already experienced a variety of stresses and shocks (Barrios et al., 2008). These extreme events have serious impacts on agricultural production, so as gradual changes in climate.

These effects are amplified by the limited capacity of African countries to deal with it. The possibilities to cope with weather risk through credit and insurance markets are almost inexistent since these markets are imperfect in the African economies.[1] In absence of such formal risk-spreading mechanisms, land fragmentation can be an alternative mean for risk reduction, be it exogenously imposed or chosen. This article aims at verifying if this feature of land fragmentation is valid for households that face rainfall irregularities.

Land fragmentation is the practice of farming a number of spatially separated plots of owned or rented land by the same farmer (McPherson, 1982). It is a phenomenon that is observed in many countries especially in the developing ones. The literature classifies the causes of land fragmentation into two categories of possible explanations: i) "supply-side" factors such as inheritance process and population pressure and ii) "demand-side" explanations that consider fragmentation as choice made by farmers. In the developing world, fragmentation arises as a result of a mixture of both aspects, supply side and demand side factors. According to the World Agricultural Census by FAO, the average number of parcels operated by a farmer is 3.5 worldwide during 1995–2005.

Land fragmentation is often considered as detrimental for agricultural sector development. Empirical evidence suggests that higher fragmentation of land holdings reduces agricultural output and agricultural productivity (Wan and Cheng, 2001; Rahman and Rahman, 2009; Van Hung et al., 2007; Tan et al., 2010). Another obstacle to enhancing agricultural productivity associated with land fragmentation is the distance between parcels. In particular, when parcels are

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[1] There are insurance products present on the African continent, such as crop insurance and index-based insurance, but their take-up rate is very low.

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dispersed, travel time and costs in displacing labor and machines can increase (Shuhao et al., 2008). In addition, land fragmentation can prevent farmers from using machinery (Foster and Rosenzweig, 2011). As well, it can generate fencing costs and conflicts among neighbors (Demetriou, 2013).

However, no consensus is established in the empirical literature regarding a robust negative impact of land fragmentation on agricultural outcomes.[2] For instance, Blarel et al. (1992) find that the level of land fragmentation has no significant impact on yield and therefore reject the hypothesis that fragmentation is inefficient in the case of Ghana and Rwanda.

Land fragmentation can in fact provide benefits to farmers: it reduces exposure to risk; it allows for crop scheduling and for use of several agro-ecological zones. In particular, land fragmentation reduces risk because it offers a greater variety of soils and growing conditions. This is especially the case in areas composed of micro-environments where fiends are affected by various degrees of moisture, wind, hail, pests, isolation and drainage (Bentley, 1987). As a consequence, it can facilitate risk management through seasonal and spatial diversification of crop production (Blarel et al., 1992; Bentley, 1987; Van Hung et al., 2007). Two dimensions of land fragmentation can improve the ability of farmers to diversify weather risk: the physical distance between the parcels and the different agro-ecological characteristics of the different parcels. McCloskey (1976) is among the first economists to document the ability of scattered parcels to reduce the crop production risk. Blarel et al. (1992) found that land fragmentation reduces the variability of agricultural output per acre. Fragmentation also allows for adjustments of household labor across seasons since crop scheduling is easier when parcels are scattered in different locations with different agro-ecological characteristics (Fenoaltea, 1976). Furthermore, land fragmentation improves agro-biodiversity as crops are better matched with the operated soil types (Di Falco et al., 2010).

This article aims at analyzing the ability of fragmented land to reduce their exposure of farmers to rainfall variability. More precisely, the objective is to study empirically whether households with higher degree of fragmented land incur smaller reductions in their agricultural income when they are subject to rainfall irregularities. The contribution of the paper is twofold: i) it provides a quantitative approach on the incidence of land fragmentation on agricultural income by considering rainfall variability, which to the best of my knowledge, has not been addressed by the literature; and ii) it contributes to the debate on advantages and disadvantages of land fragmentation in the case of Uganda.

Land fragmentation is measured by the number of parcels that the household owns and also by a Simpson Index calculated for these parcels. This index combines the number of parcels and the distribution of area among the different parcels. An important issue rarely considered in the literature, is the endogeneity of land fragmentation. Farmers may choose their level of land fragmentation in order to cope with production risk, even though this choice is highly dependent on the extent to which land markets are dynamic. Also, farmer's choice of fragmentation can be affected by some unobserved individual characteristics that influence the level of agricultural income as well (management ability, entrepreneurial spirit). To address this issue, I instrument the fragmentation in operated land with the fragmentation in inherited land, as inherited land fragmentation is exogenously imposed on the household (Foster and Rosenzweig, 2011). I use data from the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) for the years 2005/2006, 2009/2010, 2010/2011 and 2011/2012 established by the World Bank. I find that the impact of land fragmentation on crop yields depends on rainfall variability: it increases yields when households face rainfall variability (by mitigating crop losses), but decreases them otherwise. The results show that the higher the rainfall deviation, the higher the beneficial effect of land fragmentation. These results are robust across different empirical specifications.

Because of the widely perceived inefficiencies of land fragmentation, some countries like Kenya, Tanzania and Rwanda, have adopted land consolidation programs. In the case of Uganda, land fragmentation seems to offer risk-reduction possibilities to farmers that are subject to rainfall irregularities, but it remains detrimental for farmers that do not experience such anomalies.The policy implication of this article is not to fully support land fragmentation, but rather to draw attention on the careful design of consolidation policies by taking into account the economic and agro-ecological circumstances. Even within a country, a uniform consolidation process might not be equally favorable to all farmers. Fragmentation can particularly offer benefits in areas characterized with various micro-environments, where land, labor and insurance markets are imperfect and mechanization of the agricultural activities are at very low stage of development (Bentley, 1987).[3] If the labor market is imperfect, labor supply is fixed by the household endowment and there is an important need to spread labor temporally. Moreover, farmers fail to cultivate land due to land market imperfections rather than its small size or fragmentation. Therefore, addressing land, labor and insurance market imperfections might be a priority for enhancing agricultural productivity. Engaging in uniform consolidation process that is often very costly should be supported with indeed cost/benefit analysis of both land consolidation and fragmentation for farmers operating in different environments.

The article is organized as follows. Section 2 describes the land tenure systems and climate variability in Uganda. Section 3 describes the data, the measures of land fragmentation and rainfall anomalies, and gives the descriptive statistics. Section 4 introduces the econometric specification and discusses the endogeneity problems. Section 5 presents the results of the main estimation equation and includes robustness checks and discussion. Finally, Section 6 includes a summary of the results, policy implications and further research ideas.

2. Background

The Constitution of Uganda includes customary, freehold, mailo and leasehold tenure systems recognized by the Land Act of Uganda 1998. The mailo system represents a sub-division of land where the basic unit is a square mile, hence the name mailo. Mailo land is owned with assigned individual property rights certified by a land title. Similarly, freehold land holders have full ownership over their land. This implies that holders can use land for any purpose and sell, let, lease and dispose it off. Leasehold system is a system of owning land for a particular period of time. The leasehold transactions are contractual and allow both contract parties to define the terms and conditions of access and usage.

Customary tenure system dominates the other systems. According to the FAO, it represents 75% of the total land which makes it the most common form of tenure in the country. Land is therefore mainly governed by customs, rules and regulations of a particular community. Due to these regulations, the main cause of land fragmentation is the inheritance system. In Uganda, population growth together with the traditional inheritance protocols are supposed to be the most important driver of the increased land fragmentation (Nkonya et al., 2004). For instance, when the head of a household dies, his land is sub-divided

[2] Such divergence between authors might be also linked to how yields are measured. A growing literature takes into consideration measurement errors due to self-reported land surfaces and uses more objective measures such as GPS coordinates measures when studying land size and productivity relationship. This might change the direction of the debate. In this article I use both self-reported land size and GPS measures as robustness check.

[3] Low adoption of technology will make difficult for farmers to exploit scale economies of consolidated land especially if labor markers are imperfect.