Drivers of cropland abandonment in mountainous areas: A household decision model on farming scale in Southwest China

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ABSTRACT

Cropland abandonment has emerged as a prevalent phenomenon in the mountainous areas of China. While there is a general understanding that this new trend is driven by the rising opportunity cost of rural labor, rigorous theoretical and empirical analyses are largely absent. This paper first develops a theoretical model to investigate household decisions on farming scale when off-farm labor market is accessible and there is heterogeneity of farmland productivity and distribution. The model is capable of explaining the hidden reasons of cropland abandonment in sloping and agriculturally less-favored locations. The model also unveils the impacts of heterogeneity of household labor on fallow decisions and the efficiency loss due to an imperfect labor market. The model is empirically tested by applying the Probit and Logit estimators to a unique household and land-plot survey dataset which contains 5258 plots of 599 rural households in Chongqing, a provincial level municipality, in Southwest China. The survey shows that more than 30% of the sample plots have been abandoned, mainly since 1992. The econometric results are consistent with our theoretical expectations. This work would help policy-makers and stakeholders to identify areas with a high probability of land abandonment and farming practice which is less sustainable in the mountainous areas.

1. Introduction

Cropland abandonment have occurred in West Europe (Gellrich et al., 2007) since the 19th century, then in parts of America since the early 20th century, and later in Southeast Asia (Rhemtulla et al., 2009; Fox et al., 2009). In recent years, this phenomenon has occurred in Eastern Europe and the former Soviet Union (Baumann et al., 2011; Prishchepov et al., 2013). Cropland abandonment is a complex multi-dimensional process with interlinked economic, environmental and social driving forces (Lambin and Meyfroidt, 2010). As such, it has long been a contentious issue worldwide because of difficulties in defining, measuring, monitoring and studying this process (Keenleyside and Tucker, 2010). As a consequence, the current extent and pattern of abandonment in many parts of the world are subject to open debates.

Cropland abandonment exerts mixed effects on economy, society, and ecosystem at both regional and local scales. Documented negative impacts include reduction of landscape heterogeneity (Höchtl et al., 2005), increased fire frequency (Dubinin et al., 2010), soil erosion, reduction of water provisioning (Gallart and Llorens, 2003; Sun et al., 2006), loss of biodiversity and reduced abundance of locally adapted species (Hodges, 2006), and loss of cultural and aesthetic value (Elbakidze and Angelstam, 2007). Documented positive consequences include the passive re-growth of native vegetation and forest plantations (Bonet and Pausas, 2004), water retention (Sileika et al., 2006), soil recovery, improved nutrient cycling and an increase in biodiversity (Benayas et al., 2007; Dunn, 2004).

Cropland abandonment has recently emerged as a noticeable phenomenon in the countryside of China. Although there is no official statistical data yet on cropland abandonment, anecdotal evidence from case studies in many regions indicates that it is widely spreading. A search of the literature on cropland abandonment written in Chinese over the period of 1993–2015 located 245 reports, of which, 47 are based on studies in eastern China,

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170 in central China and 13 in western China. Some of the reports also provide the ratio of abandoned area to the total cropland area of the case-study jurisdiction. The median of the reported ratios for the eastern, central, and western regions was 5.62%, 5.7%, and 4%, respectively.[1] While this literature review does not distinguish mountainous areas from others, one report on mountain area of southern Ningxia province in western China indicates that the abandonment ratio has reached 37.5% by 2009 in the case study area (Tian et al., 2010).

The most important concern with regard to cropland abandonment in China is its implication to food security given the well-known high scarcity of cropland in the country (Deng et al., 2006; Jiang et al., 2012; Lichtenberg and Ding, 2008; Yan et al., 2009). Every year, urban expansion and the construction of manufacturing centers, highways, railways and other infrastructures occupy a large amount of cropland, especially in eastern China (Liu et al., 2005; Tan et al., 2005; Wang et al., 2012). The 2014 Chinese Land Resources Bulletin, released by the Ministry of Land and Resources of the P. R. China in April 2015, shows that about 160,000 ha of cropland was newly occupied by construction projects in 2014. Floods, desertification and other natural disasters also ruin sizeable amount of croplands. In addition, a large proportion of formerly cultivated sloping croplands have been transferred to woodland and grassland for environmental protection purpose under the "Grain for Green" program.[2] The above cited Bulletin also reports that cropland loss in 2013 was about 350,000 ha. To counter cropland loss and ensure food security, the Chinese government has invested heavily in basic cropland protection, known as "*Jiben nongtian baohu*," and in land reclamation, and considerable progress has been made on these two fronts in the last ten years (Government of the People's Republic of China, 2004; Lichtenberg and Ding, 2008).

Against this background, on one hand, it seems that cropland abandonment has run in the wrong direction, being counterproductive and irrational. But on the other hand, the abandonment of marginal lands may facilitate native vegetation recovery, pushing agricultural production to concentrate on cropland with higher productivity and better infrastructure. Therefore, there is an urgent need to have a thorough understanding of the mechanisms and forces which drive cropland abandonment in China. Such an understanding can provide valuable guidance for smart land-use management and planning, balancing the trade-offs between the micro-rationality of farmers in farming intensity decision and macro-rationality for national food security policy design. This paper aims to meet this demand.

It is worth noting that there are ample empirical studies examining the drivers and determinants of cropland abandonment in Europe, Chile, Brazil and other regions (Baumann et al., 2011; Benayas et al., 2007; Díaz et al., 2011; Prishchepov et al., 2013; Renwick et al., 2013; Sikor et al., 2009). These studies indicate that cropland abandonment is a global phenomenon typically driven by rural-urban migration owing to the emergence of new economic opportunities outside farming for rural people, whereas drivers related to ecological conditions and mismanagement are of secondary importance. These new developments raise the opportunity cost of farming and thus reduce the relative profitability of traditional farming businesses. It is also noted that cropland abandonment may occur in areas that are less favorable to agricultural activities because of some restrictions related to ecological con-

ditions and accessibility. The parallel case studies in China also identify that the socio-economic progresses occurring in China have driven rural-to-urban migration and the growing opportunities in urban areas have boosted the cost of labor in rural areas. As a consequence, cropland on which farming activities become too costly is abandoned or converted to other uses (Li and Zhao, 2011; Liu et al., 2005; Liu and Li, 2005; Tian et al., 2009; Zhang et al., 2014).

What distinguish the case of China from others are arguably once again the much higher level of cropland scarcity and much larger rural population per unit of cropland in China. Because of this, China has a longstanding tradition of having a small-scale farming system. For example, a typical farming household in China manages only 0.56 ha of contracted land divided into 9.7 tracts (Dong, 1996; Lin, 1997), an area that is far too small when compared with household farming in Europe and many other countries. In China, the rural-urban migration often occurred seasonally and rural laborers never enjoyed a matched social status with their urban counterparts. In mountainous areas, the hoe and plow still serve as the main tools for agricultural production, although tillers have gradually gained acceptance and have become popular in the plains recently. Thus, a rigorous modeling understanding of forces which drive cropland abandonment dynamics in China must take these unique characteristics of China's small-scale household farming system into account. Zhang et al. (2014) and Li et al. (2014b) made important efforts in this direction.

Zhang et al. (2014) employed a multi-level statistical model to quantify the relationships between the parcel level (natural conditions), household level (household features), and village level (land use activity is more similar within the same village). They applied this model to a dataset of 2011 survey that covers 330 households and 1423 land parcels from 33 villages in Wulong county of Chongqing. Their regression shows that about 80% of the variance in occurrence of land parcel abandonment can be explained by the natural condition of the individual parcels and only 7% of the variance can be explained by the features of households, and furthermore, the household features they employed do not have connection with out-migration and wage income from non-agricultural activities. This result is puzzling because of its weak relationship with household decision and lack of connection to out-migration. In other words, the results from such multi-level statistical model cannot explain why the emergence of land abandonment at a significant scale was only a recent phenomenon and has been closely associated with the dynamics of out-migration of major laborers in a household. This puzzle suggests that it is necessary to develop a rigorous theoretical model and use this theoretical model to guide empirical research.

Li et al. (2014b) reported a preliminary attempt to link livelihood strategy of household to cropland abandonment with a simple multivariate linear regression model. It intended to show in a simple way that peasants with different livelihood strategies would make different land use decisions. For example, a household seeking off-farm employment would abandon some parcels of farmland belongs to the household, while a household seeking agricultural intensification strategy would not abandon its cropland. The dependent variable in the simple linear regression is the area abandoned by each household. Therefore, it is not a model at the parcel level. The regression was run on a dataset of 2011 survey that covers 975 households from 12 villages in 3 counties of Chongqing. However, this empirical model suffered from prefect co-linearity and other mis-specification problems such a lack of control for potential spatial interdependence across many households within the same village. As a consequence, the coefficient of the key explanatory variable "percentage of non-agricultural labor" has a wrong sign in 3 of the 4 regressions and are not significant in all 4 regressions; and the coefficient of another key variable "off-farm experience" have contradictory signs in two regressions where it is significant

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[1] Please note that these are inventory-to-inventory ratio in land use, not growth rate.

[2] Under the "Grain for Green" program, the government subsidizes those peasants who fallow their sloping croplands (over 25°) for the growing of natural vegetation (Feng et al., 2005; Xu et al., 2007; Groom et al., 2010).