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Land abandonment under rural restructuring in China explained from a cost-benefit perspective

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ABSTRACT

China has experienced socio-economic transitions in recent decades, featuring a large amount of rural labor migrating into urban areas. As a response, rural land use has been restructured across large areas. In this process, vast amounts of land have been abandoned due to labor loss, especially in mountainous areas. Understanding how land attributes determine which land parcels are abandoned is essential to sustainable development of rural areas. Here we examine how two main farmland parcel attributes, farmland-to-housing distance and land quality, by affecting farming costs and benefits, and thereby profits, determine farmland abandonment. We constructed a semi-empirical crop profit model based on output benefits and input costs derived from household survey data from mountainous Wulong County, Chongqing Province, China. With this model, crop profits can be estimated and in turn the farmland-to-housing distances at which farming profits diminish to zero ("zero profit distance", abbreviated as "ZPD") can be identified. Based on the hypothesis that land will be abandoned when cultivation cannot make profits, ZPD values can be used to predict patterns of abandonment. At current price levels, the ZPD values are 5.94 km, 3.84 km, 2.52 km and 1.48 km for first-class, second-class, third-class and fourth-class land, respectively. Overall, the observed occurrence of land abandonment in relation to farmland-to-housing distance and land quality is concordant with the model's predictions, supporting the underlying hypothesis that land will be abandoned when the farmland-to-housing distance exceeds the ZPD. These findings may serve as an important tool for predicting land abandonment and identifying countermeasures for mountainous areas.

1. Introduction

According to MacDonald et al. (2000) and Strijker (2005), land abandonment is often related to rural depopulation and the rise of rural labor opportunity cost. China has experienced rapid and far-reaching transitions since Deng Xiaoping launched economic reforms in 1978, with GDP increasing nearly 8% annually. As China has evolved into a majority urban country, a large amount of rural labor has migrated into urban areas to seek better work, education and standards of living (Tao Yang, 1997; De Brauw et al., 2002; Zhang and Song, 2003; Song and Pijanowski, 2014). A shortage of rural labor is becoming a limiting factor for agricultural activities (Chen et al., 2009) and therefore a great challenge to rural areas and agricultural production (Woods, 2005, 2012; Long et al., 2011, 2012, 2016; Long, 2014; Song and Liu, 2014). Faced with this challenge, rural restructuring has occurred, of which farmland restructuring is a main component. In farmland restructuring, crop production becomes increasingly concentrated on high-quality land, whereas marginal land is abandoned (van Dijk et al., 2005; Rudel et al., 2005; Sanz et al., 2013).

Land abandonment accompanying rural land restructuring has been observed worldwide in recent decades (Baldock et al., 1996; van Dijk et al., 2005; Gellrich et al., 2007a; MacDonald et al., 2000), especially in developed countries. Thus, land abandonment has featured prominently in Europe, North America and Japan (Caraveli, 2000; Rudel et al., 2005; Sluiter and De Jong, 2007). In Europe, in particular, extensive research has recently been done on land abandonment and ecological recovery in areas such as the south of France (Sanz et al., 2013), Portugal (van Doorn and Bakker, 2007), Switzerland (Price et al., 2015), and Austria (Silber and

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Wytrzens, 2006); it has also been studied in the Mediterranean area in general (Weissteiner et al., 2011). Land abandonment has also been occurring in developing countries including China (Liu and Li, 2006). As well as Chile (Díaz et al., 2011) and Argentina (Izquierdo and Grau, 2009).

Although no official data have been released regarding the amount of land abandoned in China, some research has been done on the severity of land abandonment (Dong et al., 2011). In particular, a literature review revealed reports of land abandonment from 26 provinces (about 2/3 of the total) (Liu and Li, 2006). Moreover, by interpreting remote sensing images, our research group has found that about 15% of land was abandoned in south China between 2003 and 2013 (Li et al., 2014).

Much research has been done on the forces driving land abandonment throughout the world, and has found it to happen often in areas where farming faces particular challenges. Thus, land abandonment has often occurred in mountainous areas where labor losses could not easily be replaced by the use of machinery (MacDonald et al., 2000). Examples of this phenomenon are widespread, coming from Swiss mountains (Gellrich et al., 2007b; Gellrich and Zimmermann, 2007), the Alps (Gellrich et al., 2008; Walther, 1986; Gehrig-Fasel et al., 2007), the Pyrenees (Mottet et al., 2006), and the Ecuadorian Andes (Harden, 1996). In addition to steep slope (Gellrich and Zimmermann, 2007), other factors leading to abandonment include poor soil (Sluiter and De Jong, 2007; Díaz et al., 2011) and difficult road access (Gellrich et al., 2007b). The basic driver underlying land abandonment is a change in the relative prices of inputs and outputs (Strijker, 2005).

Nevertheless, there has been little work done to develop models that can quantitatively relate land abandonment to land attributes. In the present study, we develop a model, parameterize it with actual data, and then test it by comparing predicted and observed patterns of land abandonment. This research builds upon a previous study (Zhang et al., 2014) that showed that land quality and farmland distance to the homestead (henceforth referred to as "land distance") are the most important factors influence land abandonment in Wulong County (Chongqing Municipality), a mountainous area of China.

Here we develop and test a cost-benefit model based on the hypothesis that land will be abandoned when it is not profitable to grow crops there. This model was designed to predict patterns of land abandonment based on land quality rankings, land distance data, and crop information. Like our previous study (Zhang et al., 2014), the present one takes advantage of abundant first-hand data collected through surveys of numerous households in the study area from 2011 to 2013.

2. Materials and methods

2.1. Description of the investigated field sites and data collection

The study area is located in Wulong County (Fig. 1) in southwestern China. In this county, 70–80% of the total area is mountainous and covered by forest, with the remaining area used for agriculture and construction. According to the statistical data issued by the Statistical Bureau of Wulong County (2001, 2010), this county has experienced great labor loss since 2001. Through the end of 2009, rural labor had diminished by nearly 20% compared to 2001. Over the same period, nearly 10% of cropland was abandoned. The climate supports a two- or three-crop rotation system, but farmers are restricted to single crop rotation due to a lack of labor.

A total of four villages were selected for investigation: Eguan, Qianjin, Dongsheng and Chepan, which are located on mountainsides in Wulong county (see Fig. 1.). The elevation varies from 267 m to 1920 m, with much of land in these four villages being very steep. According to the land use map supplied by the local government, cropland accounts for 22.17% of the total land in the four villages, with a higher proportion in Eguan and Qianjin than in Dongsheng and Chepan (Fig. 1).

The four villages have experienced major rural-urban labor migration, with some land abandoned due to lack of labor. For a household with young labor, the main income always comes from payment for off-farm work. However, agricultural income is a major part of the income for households without young labor. In these villages, the market is well-developed, and thus villagers can buy or sell agricultural products in the market. However, there is a very limited market for low-wage agricultural laborers.

Due to the steep terrain in these four villages, traffic conditions are very poor. Farmers commute between land parcels and their houses on foot and carry their products in pack baskets. The main crops for this area are maize, rice, sweet potato, potato, and some cash crops such as tobacco. Sweet potato and potato are always interplanted with maize, which is the most common crop, accounting for almost half the cropland. Owing to strict planting requirements for rice and tobacco, with paddy rice needing to be close to water resource and tobacco suitable for planting only at elevations between 1000 m and 1200 m, they are excluded from this analysis. This leaves the three other main crops and their combinations: maize, sweet potato, potato, maize-sweet potato, maize-potato, and maize-sweet potato-potato.

The main data source was our first-hand data collected by a household survey conducted in 2012 using a semi-structured questionnaire. About 80 households were randomly selected for surveying in each of the four studied villages. In all, the survey covered 307 households and 2433 land parcels. The total area of cropland involved was 136.2 ha. Each household owns about ten parcels of land, each with an average area less than 0.06 ha.

The questionnaire's responses provided abundant information on the households and associated land parcels. For each household, information was collected on each member, including his or her age, gender, amount of time devoted to agricultural work and off-farm work, and income. For all land parcels associated with each household, including parcels they owned (whether cultivated by them, abandoned or rented out to others for cultivation) or that they rented from others (for cultivation), we recorded attributes including land slope, land quality, and distance to residence. The land quality information was taken from local-government-issued land-use certificates, which classified land quality into four ranks based on their output capacity: first class, second class, third class and fourth class, with first class land having the highest output capacity and fourth class the lowest. Additionally, management characteristics for each parcel, including capital and labor inputs, as well as agricultural product outputs were recorded.

2.2. Crop profit calculation and main variable estimation

Crop profit from cultivation is the net income after costs are subtracted from sales revenue generated by agricultural product market sales. The costs include capital costs and labor costs. Capital costs include expenditures for seeds, fertilizer, pesticides, herbicides, and other materials, while labor cost represents the total amount of time put into the cultivation and harvesting of crops, multiplied by the wage for that labor. Thus,

$$R_i = P_i{*}Q_i - C_{xi} - W{*}L_i \quad (1)$$

where R_i is the profit from cultivation when planting crop i, P_i is the sale price of crop i, Q_i is the production of crop i, C_{xi} and L_i are, respectively, the capital input and labor input (in days) for crop i, and W is the (daily) labor wage.