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Effects of land lease policy on changes in land use, mechanization and agricultural pollution

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ABSTRACT

Land fragmentation has restrained the development of Chinese agriculture with the application of agricultural machinery. Meanwhile, agricultural pollution has caused serious problems with development. To address these problems, China's government proposed a new farmland lease policy and built larger farms beginning in 2013. However, changes in land fragmentation may also have unexpected problems for Chinese agriculture. This study investigated the effects of these changes on changes in land use, the application of machinery and agricultural pollution. We analyzed a developed area (in the fields of both agriculture and industry) and studied the decision-making habits of farmers in the area. An agent-based model was proposed with the same decision-making habits as in the real world. The results indicated that land lease increased agricultural profits very little in Jiangsu, China. Meanwhile, the application of land lease policy increased pollution. To alleviate pollution and increase profits, a new policy for large automatic protection machinery (i.e., large spraying machinery) should be introduced by governments simultaneous with land lease policy. Farmers could realize greater profits through the introduction of land lease policy and high-efficiency machinery. The sustainable development of agriculture in Jiangsu requires the integration of these government policies.

1. Introduction

Chinese farmers possess 30-year use rights to their farmland according to the 2003 Rural Land Contracting Law and other central policy directives (Deininger and Jin, 2005). Land use rights certificates are created by and affirmed by the seals of county governments (Li, 2016; Wang et al., 2015). This means that land lease in China is not easy without government support. The importance of land lease policy has been frequently studied. A well-functioning land rental environment in China would improve development of the rural economy (Kimura et al., 2011). According to literature, better-enforced tenure security increased incentives to transfer land to more efficient uses (Deininger and Jin, 2009). Ma et al. (2015) suggested causes of current land tenure insecurity in rural China. The effect of land fragmentation on labor productivity (China rural area) was studied by Jia and Petrick (2013). Many researchers proved that land fragmentation caused productivity losses (Chen et al., 2009; Wan and Cheng, 2001). However, changes in land fragmentation (inspiring land lease policy) may also present problems for Chinese agriculture. Small farm size, low rural household income, and limited access to capital have restrained the development of Chinese agriculture (Liu et al., 2014).

Meanwhile, China's development in recent decades has resulted in serious damage to the environment upstream of the agricultural sector, on farms and downstream (Norse and Ju, 2015). According to the Chinese government (MEP, 2010), agriculture has overtaken industry and become the dominant source of water pollution (generating 44% of chemical oxygen demand, 57% of nitrogen demand and 67% of phosphate demand) since 2005. Overuse of fertilizers also caused greenhouse gas emissions (Liu et al., 2011) and a decrease of 0.5 units in the soil pH in the major crop production regions over the last two decades (Guo et al., 2010). Land fragmentation also limited the application of large automatic protection machinery (i.e., spraying machinery), which could decrease use of fertilizer and pesticides. Overuse of fertilizer is a social behavior in China, although it is economically irrational (Smith and Siciliano, 2015). Large automatic protection machinery could reduce farmers' use of fertilizer through high technology.

To improve the development of rural areas, the Chinese central government encouraged farmers to rent their lands to others to develop larger family farms in the No. 1 Central Document at the beginning of 2013. Some incentives were proposed by local

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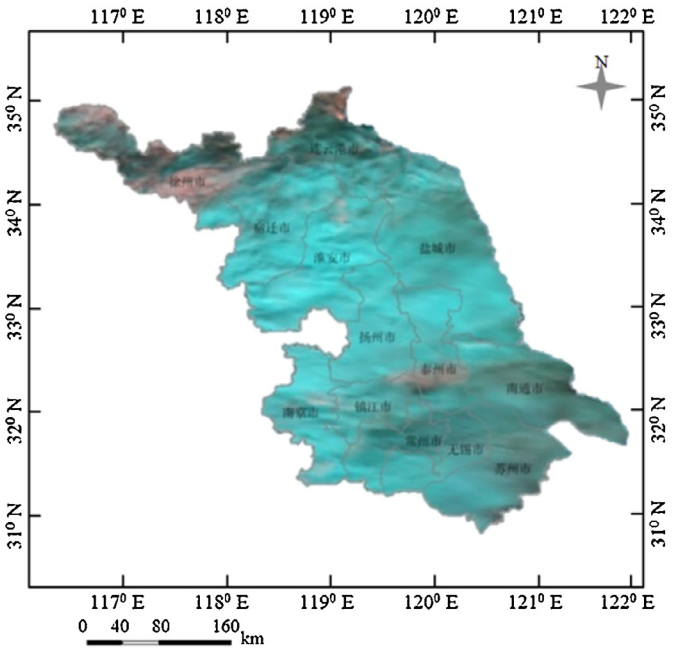

Fig. 1. Study area location: Jiangsu Province, China.

governments to encourage gradual land lease (2014, 2015). Based on these land lease policies, Chinese agriculture would be transformed from small family farms to large-scale cooperation-based farms (Han, 2014). Our research on land lease gave special attention to its effects on changes in land use, the application of machinery and agricultural pollution. The contribution of our paper is to show the effects of the new land policy in Jiangsu Province, China. The effects involved the types of crops, mechanization, productivity and environmental impact of farming. Larger farmers and local governments can make more efficient decisions based on these effects in the future.

2. Research area and data

Jiangsu province is an eastern coastal province of the People's Republic of China, and the Jiangsu government has proposed some initial incentives for land lease. In 2014, Jiangsu province was China's number 2 province in GDP and number 3 province in agricultural output. The southern area is one of the most developed areas in China and is home to many of the world's leading exporters of electronic equipment, chemicals and textiles. Most of the Jiangsu area (Fig. 1) consists of plains with a well-developed irrigation system except for some small mountains in the northeast area (plains cover 68% of the province's surface, and water covers 18%). Five and eight-tenths percent of Chinese grains are produced in this area. Most of Jiangsu has a humid subtropical climate, with temperatures averaging −1 to 4 °C (30–39 °F) in January and 26–29 °C (79–84 °F) in July (average annual rainfall is 800–1200 mm). Because the average farm in Jiangsu is only 0.045 ha, land lease policy will cause major changes in this area (the study area is shown in Fig. 1). Meanwhile, agricultural pollution has caused many problems in Jiangsu. In fact, Jiangsu province has the most serious overuse of fertilizers of all areas in China. Of synthetic N alone, more than 40,000 kg ha^{-1} per year is used (Norse and Ju, 2015). Environmental pollution should be a factor in consideration of the suggested land lease policy in this area.

This paper analyzed agriculture in the Jiangsu area and sought to answer the question "what will happen if many farmers rent their land to others?" Changes in land use, mechanization, and agricultural pollution in the Jiangsu area are discussed in this paper. The data on the Jiangsu area in this paper came from the statistical yearbook of Jiangsu province (JSB, 2015) and the statistical yearbook of agriculture costs (NDRC Price Department, 2015).

Table 1
Land use in Jiangsu, China (2014).

		Percent of land use
Summer crops	Wheat	84%
	Rapeseed	13%
	Others	3%
Autumn crops	Rice	74%
	Maize	12%
	Soybean	6%
	Cotton	4%

Table 3
Percentages of different planting methods in Jiangsu, China (2014).

	Method I	Method II	Method III	Method IV
Wheat	0.04%	1.96%	1.96%	96.04%
Rice	1.3%	23.8%	3.8%	71.3%
Maize	3.3%	11.7%	18.7%	66.3%
Cotton	54%	6%	36%	4%
Soybean	30%	30%	20%	20%
Rapeseed	76.5%	13.5%	8.5%	1.5%

Most farmers plant wheat (summer crop) and rice (autumn crop) in Jiangsu every year. The percentages of the planting areas for different crops are shown in Table 1 (JSB, 2015). There are six traditional crop rotations in the area: wheat and rice, wheat and maize, wheat and cotton, wheat and soybeans, rapeseed and rice, and rapeseed and cotton. The percentages of the six crop rotations are shown in the second column of Table 4. Meanwhile, the statistical yearbook shows that the productivity of crops in Jiangsu province remained similar from 2008 to 2014 (JSB, 2015; Ito, 2010). The ratios (ton/hectare) of crop yield and land area over these seven years were 6.029, 6.127, 6.124, 6.219, 6.32, 6.385, 6.493 (JSB, 2015). Based on these data, we found that the crop yield in the study area did not increase sharply even with increases in labor productivity and economic development.

This lack of increase meant that farmers did not need to change their rotation schedules for agronomic reasons even using same rotation schedule (one of the six rotation schedules) every year.

In Jiangsu, the most developed area in China, machinery has been used to plant different crops. Four main steps—soil tillage, sowing/transplanting, crop protection, and harvesting—are used in this paper for all the crops in the area. Based on the annual report (2015) of the Jiangsu Agricultural Machinery Bureau (http://www.jsnj.gov.cn/144/gkbg/) and the statistical yearbook (JSB, 2015), Table 2 shows data on farmers' use of machinery. The crop protection machinery in Table 2 refers to large automatic spraying machinery. However, no large automatic machinery is used to spray fertilizers and pesticides (manual and partially-automatic small protection machinery is currently used). The use of machinery for harvesting and sowing/transplanting is not the same for different crops (Table 2). Table 2 shows that the planting of wheat and rice is the most mechanized in Jiangsu province.

Because soil tillage and crop protection in Table 2 are the same for all crops, this paper defines four types of planting methods: Method I (sowing/transplanting by hand and harvesting by hand), Method II (sowing/transplanting by hand and harvesting by machinery), Method III (sowing/transplanting by machinery and harvesting by hand), Method IV (sowing/transplanting by machinery and harvesting by machinery). Based on Table 2, this paper obtains the percentages of the different planting methods and lists them in Table 3.