Land Use Policy 45 (2015) 1–7

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Impact of urbanization on cultivated land changes in China

Xiangzheng Deng[a,d,*], Jikun Huang[a], Scott Rozelle[b], Jipeng Zhang[c], Zhihui Li[a,d,e]

[a] Center for Chinese Agricultural Policy, Chinese Academy of Sciences, Beijing 100101, China
[b] Freeman Spogli Institute for International Studies, Stanford University, Stanford, CT, USA
[c] Southwestern University of Finance and Economics, 611074 Chengdu, China
[d] Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[e] University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Article history:
Received 11 October 2014
Received in revised form
21 December 2014
Accepted 4 January 2015

Keywords:
Urbanization mode
Cultivated land changes
Three-stage least-square method
China

ABSTRACT

This article aims to evaluate the impact of urbanization and different urbanization modes on cultivated land changes using an econometric model that incorporates socio-economic and policy factors in the eastern China, which experience the great urbanization in recent years. Based on land-use remote sensing data interpreted from Landsat Thematic Mapper/Enhanced Thematic Mapper digital images of Chinese Academy of Sciences and a unique set of socio-economic data, an econometric model is developed to empirically estimate the impacts on cultivated land changes. Although urbanization has an effect on the changes of cultivated land, its effect is marginal. Moreover, the expansion of built-up areas in different urbanization modes causes varying impacts on changes in cultivated land use in different regions. Assuming that other factors remain constant, compared with the expansion of villages or the development of small towns, in the periods of 1995–2000, the urbanization in the more developed eastern region alleviates the loss of cultivated land by 7%, while during 2000–2008 the rapid urbanization lead to the cultivated land loss increase by 29.2%. The policies designed to protect cultivated land by encouraging people move to small towns may actually accelerate the occupation of cultivated land.

Introduction

According to United Nations, from 2009 to 2050, 1.86 billion more people will live in urban areas and the level of urbanization is expected to rise from 50 to 69%. Although urbanized land area comprises just 2% of the earth's surface, more than half of the world's population lives in urban areas. In China, the urbanization rate, measured as urban population, rose from 17.92 to 52.57% between 1978 and 2012 (National Bureau of Statistics of China, 2013), with over half of the population in China living in urban areas in 2012.

As to the impacts of urbanization, it not only creates positive externalities through technological innovation and shared information, such as outstanding economic growth, increasing farming production, but also generates negative externalities such as problems in public safety, health, social equality, etc. (Bai et al., 2011; Wu et al., 2011). One of the major negative effects of urbanization for developing countries is the losing of cultivated land, for which researchers have various views. One view is that urbanization, especially the expansion of large cities and regions that have experienced rapid economic growth and urban development, causes the loss of cultivated land (Deng et al., 2009; Liu et al., 2014; Tan et al., 2005). On the opposite, many researchers conjecture that urbanization and the consequent population shift from agricultural to non-agricultural sectors can play an active role in promoting the conservation of cultivated land since the per capita land consumption in urban areas is much lower than in rural and town areas (Huang et al., 2005). For the impact of different urbanization modes on the changes in cultivated land, some state that the expansion of small towns and rural villages lacks sufficient focus and covers a large area of cultivated land, the leaders of small cities believe that urban land is more profitable than agricultural land, so they think that economic success is more likely to happen on urban land, which leads to a significant loss of cultivated land (Skinner et al., 2001), and more and more researchers identify that land occupied by rural settlements/residential land resulted in the loss of cultivated land (Tan et al., 2011; Xi et al., 2012). Others claim that the infrastructure built along with the expansion of cities occupies large amount of land, which leads to the large decrease in the cultivated land (Islam and Hassn, 2013).

* Corresponding author at: Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China.
Tel.: +86 10 64888980.
E-mail addresses: dengxz.ccap@igsnrr.ac.cn (X. Deng), jkhuang.ccap@igsnrr.ac.cn (J. Huang), rozelle@standford.edu (S. Rozelle), jpzhang@swufe.edu.cn (J. Zhang), lizh.12b@igsnrr.ac.cn (Z. Li).

http://dx.doi.org/10.1016/j.landusepol.2015.01.007
0264-8377/

Accelerated development of urbanization and deputes about the impact of urbanization on cultivated land changes make the relationship between urbanization and cultivated land changes a hot topic in recent years. Most researchers conducted case studies to quantitatively analyze the changes of cultivated land along with urban expansion (Liu et al., 2012; Tang et al., 2008) and the driving forces and impact mechanism of urbanization and associated cultivated land conversion (Jiang et al., 2012). While less concerns had been focused on the growth of rural residential land, about 60% of the rural residential land was converted from farmland in China (Long et al., 2007; Tian et al., 2007), and more than 92% of the increased rural residential land was from farmland in economic developed region of coastal China (Long et al., 2009). Especially, researches that combine the sprawl of urbanization of cities and expansion of rural residential land in small villages and towns to study the impacts on cultivated land are much less.

In this article, we aim to explore the impact of different urbanization modes ("Village", "Town", "City") on cultivated land changes using an econometric model that incorporates socio-economic and policy factors. Taking the fact that the urbanization is more obvious in the eastern China into account, we focus on the study in the eastern China, where experience the great urbanization in these recent years.

Data

In this study, we use the built-up area as an index to distinguish the urbanization modes. The built-up area data comes from the land-use database of the Resources and Environment Scientific Data Center, Chinese Academy of Sciences (Deng et al., 2006; Liu et al., 2003, 2010). The land-use database is constructed from remotely sensed digital images by the US Landsat TM/ETM satellite with a spatial resolution of $30 \times 30\,\text{m}^2$. The land-use data analyzed by this study covers four periods: (1) the late 1980s, mainly including the data from 1986 to 1989 (henceforth, referred to as 1988 data for brevity); (2) the middle of 1990s, including the data from 1995 to 1996 (henceforth, 1995); (3) the late 1990s, including the data from 1999 to 2000 (henceforth, 2000); and (4) the late 2000s, including the data from 2005 to 2008 (henceforth, 2008). We used geographic information system (GIS) technology to aggregate the built-up areas with stable forms and spatially continuous patches to the level of county or city, which are the basic analysis units in this study. The summary statistics are presented in Table 1.

In order to analyze the effects of different urbanization modes on the changes in cultivated land, we divided the patches into three categories based on the calculation of built-up area. The first category includes all patches with a built-up area less than $0.5\,\text{km}^2$. In fact, as these patches are mostly equivalent to rural residential areas in the scale, they are defined as the built-up area in the "Village" mode. The second category includes all patches with a built-up area between 0.5 and $5\,\text{km}^2$, which is referred to as the "Town" mode urbanization because a typical large township area usually ranges between 1 and $5\,\text{km}^2$. The third category refers to all patches with a built-up area more than $5\,\text{km}^2$, which is defined as a built up area in the "City" mode in this study. These three categories of urbanization modes or build-up areas are not only closely related to the administrative levels of villages, towns and cities, but also ensure that the analyses of urbanization modes are comparable over time and space. On the basis of the classification of urbanization modes, we calculated a set of ratio variables, which are calculated as the ratio of the built-up area in each urbanization mode to the total built-up area in each county (city) as follows: $R_{ij} = \frac{A_{ij}}{A_j}$

where R is the ratio of built-up area to total built-up area, A represents the area, i represents the urbanization mode and j represents the county (city). This enables the analysis of the differences between the changes in built-up areas in rural regions and those in different urban districts.

The geophysical factors used in this study include geographical locations, average slope, plain area proportion, elevation, precipitation and air temperature of each county (city) (Table 1). The geographical locations include two variables: one is the distance to the provincial capital and the other is the distance to the nearest port city, which were calculated based on the topographic map of 1:250,000 scale obtained from the State Bureau of Surveying and Mapping of China. The data of slope and elevation of the counties (cities) were extracted from the national digital elevation model (DEM) of 1:250,000 scale. The data of precipitation and average air temperature were derived based on the data from the climatic stations affiliated with China Meteorological Administration from 1950 to 2008. Using the map algebra in GIS, we first interpolated the site-based climate records into the surface with a spatial resolution of 1 km by 1 km, and then aggregated the cell-based information on the air temperature surface to the administrative units in counties (cities) using GIS spatial analysis techniques (Deng et al., 2008, 2010). The socio-economic data such as GDP and population were obtained from the Social and Economic Statistical Yearbook of China's counties (cities) (National Bureau of Statistics of China, 1996, 2000, 2005, 2008).

In order to better analyze the impacts of economic growth on cultivated land and expansion of built-up areas, we controlled for economic growth factors and a slew of land-use-related policy factors, including the non-agricultural population registered, upgrades of county to city, foreign direct investment per capita and whether the region is the development zones, which were obtained from Statistical Yearbook of China (National Bureau of Statistics of China, 1996, 2000, 2005, 2008).

Considering that rapid urbanization mostly occurs in the eastern China, our empirical analysis focuses on the expansion of built-up area in the eastern provinces. Further, due to China's administrative division changes over time, we revisited 18 counties/cities within eastern 14 provinces or municipalities (Heilongjiang, Jilin, Liaoning, Beijing, Tianjin, Hebei, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi and Hainan) based on the neighborhoods of residential polygons with the reference of year 2005. Finally, we prepared the panel data of land use, policy, economic and geophysical factors for the total 1738 valid samples (counties or cities/districts) of year 1988, 1995, 2000 and 2008, to investigate the impact of urbanization on cultivated land changes in China.

Model

The main objective of our empirical analysis is to investigate the determinants of different urbanization modes and their impacts on the changes in cultivated land in time and space. The selection of underlying factors that drive urban expansion and cultivated land conversion is important for our analysis, based on previous studies (Jiang et al., 2012; Long et al., 2007; Xie et al., 2005) and the three urbanization modes, we select relevant driving factors and propose the following empirical models:

Cultivated land area = *Fc* (urbanization mode, social and economic variables, geophysical variables, other control factors, *random error term*)

The dependent variable cultivated land area is the total area of cultivated land presented in hectares and the urbanization mode is represented by ratio variable R_i. In total, we constructed four regression models. We used data of four years 1988, 1995, 2000, 2008, which were computed at the county (or city) level.

The explanatory variables in model *Fc* are defined as follows. The social and economic variables include GDP, Agricultural GDP,