Agricultural Productivity and Urbanization: Evidence from Grain and Tobacco Production Efficiency in China

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Abstract: This paperbased on grain production efficiency and tobacco production efficiency studies the impact of agricultural productivity on urbanization in open economy. Theoretically, a theoretical model allowing biased technological progress is constructed. The research finds that when technological progress is labor-saving technological progress, the improvement of agricultural productivity can significantly improve the level of urbanization. Empirically, using The Panel data of Chinese cities from 2000 to 2014, the empirical study finds that The improvement of grain production efficiency and the improvement of tobacco as a cash crop production efficiency will significantly improve the urbanization rate, and each standard deviation increase of agricultural productivity will increase the urbanization rate by about 4-9.6 percentage points, or about 12-30%. The above findings are robust and hold even after using instrumental variables and introducing more control variables. The research of this paper shows that the improvement of staple grain production efficiency and cash crop production efficiency can effectively improve the level of urbanization in China. Under the new normal of the economy, implementing the rural revitalization strategy and continuing to improve the efficiency of agricultural production is conducive to further improving the urbanization rate and boosting high-quality economic development.

Key Words: Grain Production Efficiency, Tobacco Production Efficiency, Urbanization

Tob Regul Sci.™ 2021;7(6): 5172-5183
DOI: doi.org/10.18001/TRS.7.6.10

INTRODUCTION

According to the World Bank Human Development Index (HDI), urbanization is closely related to sustained economic growth and continuous improvement of people's income in all developed countries. Literature on economic development also holds that urbanization is a necessary process accompanied by economic development. With the continuous growth of economy, the proportion of agricultural population engaged in agricultural production gradually decreases and the urbanization rate gradually increases[1,2]. Therefore, it is very important to study how to improve the level of urbanization to promote high-quality economic development.

China's urbanization level is relatively backward

in the world. At the end of 2019, China's urbanization rate was only 60.60%, far lower than OECD countries and high-income countries. Moreover, China's urbanization level still lags behind the level of economic development and industrialization process[3], and even lags behind the level of foreign countries at the same level of development or developed countries at the same stage of development. The urbanization rate still needs to be further improved.

On the other hand, China's agricultural productivity is far below the average level of high-income countries. According to the China Modernization Journal 2012: Research on Agricultural Modernization published by the China Modernization Strategy Research Group and the China Modernization Research Center of the Chinese Academy of Sciences in 2012, China's agricultural productivity is 47% of the global average, production efficiency of cash crops is also far below the world average, with tobacco, for example, being only 39% of the global average, Both main grain production efficiency and cash crop production efficiency are far lower than the average level of high-income countries. The report also pointed out that, based on the theoretical analysis of agricultural modernization, whether it is primary, secondary or comprehensive agricultural modernization index, which can reflect the efficiency of a country's agricultural production, China ranks below 50 in the world.

The above phenomenon make us think whether there is an internal connection between China's low urbanization level and low agricultural productivity. Can the improvement of agricultural productivity improve the level of urbanization? If so, how much? There is little literature to answer this question, at least to the best of our knowledge.

This may result from two competing theoretical explanations of the impact of agricultural productivity on urbanization. Early literature believed that the improvement of agricultural productivity was a necessary prerequisite for urbanization, because the surplus labor generated by the improvement of agricultural productivity provided the possibility for the emergence of urban population[4,1]. In addition, the improvement of agricultural productivity will increase social demand for urban industrial products, thus promoting urbanization[5,6,7]. However, the improvement of agricultural productivity may reduce the level of urbanization. Mokyr(1977)[8], Krugman (1987)[9], Matsuyama(1992)[10] found in their study that if the agricultural sector has a comparative advantage, it will attract more factors into the agricultural sector and thus hinder the urbanization process.

This paper holds that the reason for the existence of two competing theoretical explanations is related to the bias of agricultural technological progress, and the impact of different bias of technological progress on urbanization is different. In order to study the influence of agricultural productivity on urbanization theoretically and systematically, this paper constructs a theoretical model that allows the bias of technological progress. This paper adopts CES production function to construct a small open economic model containing two sectors, and allows factor bias of technological progress in agricultural sector. Based on the factor bias of technological progress that leads to the improvement of agricultural productivity, relevant predictions of the impact of agricultural productivity on urbanization are proposed. It is found that the impact of agricultural productivity on urbanization depends on the direction of technological progress. When technological progress is neutral, the improvement of agricultural productivity will hinder the process of urbanization. When technological progress is land-enhanced technological progress or labor-enhanced technological progress and labor and land are not strong complement, the improvement of agricultural productivity will also hinder urbanization. Only when technological progress is labor-enhanced technological progress and labor and land complement strongly, the improvement of agricultural productivity will enhance urbanization level.

Empirically, this paper uses panel data of 230 cities in China for 15 years from 2000 to 2014 to empirically investigate the impact of agricultural productivity on urbanization. Agricultural productivity is measured by average grain output and average tobacco output, grain represents main grain, tobacco represents cash crop,while urbanization level is measured by the proportion of non-agricultural population in the total population.

Empirical analysis shows that there is a significant positive correlation between agricultural productivity and urbanization in prefecture-level cities in China, which means that the improvement of agricultural productivity will significantly improve the level of urbanization. Every 1 standard deviation increase in agricultural productivity will increase the urbanization rate by about 4-9.6 percentage points, or about 12%-30%. The above findings are very robust. The benchmark empirical results of this paper are still valid after using urban average topographic slope, urban average topographic relief, urban latitude and historical per capita grain yield as instrumental variables, replacing the measurement method of agricultural productivity and introducing more control variables. The results of this paper show that the implementation of the rural revitalization strategy and the improvement of agricultural productivity are not only conducive to the high-quality development of agriculture and rural areas, but also conducive to the improvement of the level of urbanization, thus promoting the high-quality development of the overall economy. The research results of this paper also implicitly reveal that the technological progress that promotes the improvement of Agricultural productivity in China belongs to the strong labor-saving technological progress.

The rest of this paper is arranged as follows: The second part is related literature review; The third part is theoretical model and research hypothesis; The fourth part is data and empirical design; Part v empirical results; The sixth part is the conclusion.

LITERATURE REVIEW

The research on the relationship between agricultural productivity and urbanization has always been concerned by academic circles. Most scholars believe that in closed economies, increased agricultural productivity promotes urbanization. By analyzing the classical model constructed by predecessors, we summarize the influencing mechanism as "supply" and "demand" channels. "Supply" channel: The improvement of agricultural productivity will lead to the emergence of surplus rural labor force with marginal labor productivity approaching zero or even less than zero. When labor force can freely flow, surplus rural labor force will migrate to cities and become a new urban industrial population to promote urbanization [1,11]. "Demand" channel: The improvement of agricultural productivity will increase the total social income, thus increasing the social demand for urban industrial products. The increase of the relative demand for urban industrial products will promote the transfer of rural agricultural population to urban industrial sectors, thus promoting urbanization [12,7,13].

In open economies, the impact of agricultural productivity on urbanization is different. First, surplus Labour in the "supply" channel will no longer be necessary for urbanization. The model established by Zhang and Wan (2013)[14] shows that under the condition of open economy, the constraint of surplus grain on urbanization level will be reduced because food can be imported. Similarly, if labor can freely flow between different economies, local urbanization will no longer be affected by whether there is a surplus rural labor supply. Second, the price of goods in small open economies is entirely determined by external markets, and the increase in the relative demand for industrial goods in cities can also be supplied by external markets, so the "demand" channel will also lose its effect. Finally, due to the existence of comparative advantages, higher agricultural productivity may even attract resources to the agricultural sector with comparative advantages, hindering the urbanization process[8,15,16]. In open economies, there is no consistent conclusion on the impact of agricultural productivity on urbanization. In this paper, Nunn and Qian(2011) constructed a simple economic model. As long as agricultural products in this model lack price elasticity of demand, the number of labor force in agricultural sector will decrease with the increase of agricultural productivity, so that more agricultural surplus labor force will flood into cities.[17] Thereafter the author chose the suitable for cultivating high in calories, high yield of the potato regional variables and the time of the old world from the new variables, assessment of potatoes to the old world population growth and the impact of urban development, the results showed that the introduction of the potato to a certain extent, improve the eighteenth and nineteenth century, the development of population and urbanization. Chen

and Kung(2016) also based on historical data, discussed the impact of corn on the population growth, urbanization rate and per capita income of Chinese society.[18] Using prefectural data, they concluded that corn contributed 19% of China's population growth from 1776 to 1910. But it has failed to significantly improve indicators of economic development, such as urbanization rates and per capita income. Foster and Rosenzweig(2004,2007) investigated the use of high-yield crop varieties in India and found that the urban industrial sector grew more slowly in areas where agricultural productivity increased more.[19,20]

This paper believes that the reason for the difference is related to the factor bias of agricultural technological progress. The previous theoretical literature on the relationship between agricultural productivity and urbanization is the same as the model established by Mastuyama(1992)[10]. Agricultural sector only uses one factor to produce, so there is only Hicks neutral technological progress. In open economies, it can only be concluded that the improvement of agricultural productivity will hinder urbanization. However, if there is a technological bias in technological progress, the impact of the improvement of agricultural productivity on urbanization may be different. Therefore, we constructed a small open economic model with biased technological progress based on Acemoglu(2010) biased technological progress model.[21] In this model, agricultural sector uses land and labor as complementary factors to produce, and uses CES production function to allow factor bias in technological progress. The establishment of this model makes it possible for us to discuss the relationship between agricultural productivity and urbanization in open economies.

THEORETICAL MODEL

In small open economies, there are two production sectors: urban industrial sector and rural agricultural sector. The production function of urban industrial sector is as follows:

$$Y_m = A_m * L_m \quad (1)$$

Where A_m is productivity of urban industrial sector, L_m is labor population of urban industrial sector, Y_m is output value of urban industrial sector. According to Equation (1), it can be calculated that the marginal output of labor in urban industrial sector is:

$$MPL_m = A_m \quad (2)$$

The production function of rural agricultural sector is in the form of CES function:

$$Y_a = A_n[\beta(A_l L_a)^{\frac{\sigma-1}{\sigma}} + (1-\beta)(A_d D)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \quad (3)$$

Y_a represents output value of rural agricultural sector, L_a, D representing labor population and land use of rural agricultural sector respectively, L_a plus L_m equals 1. A_n, A_l, A_d are hicks neutral technological progress, labor-enhanced technological progress and land-enhanced technological progress respectively, and σ are elasticity of substitution and greater than 0. Thus, it can be concluded that the marginal output of labor of rural agricultural sector is

$$MPL_a = \beta A_n A_l[\beta + (1-\beta)(\frac{A_d D}{A_l L_a})^{\frac{\sigma-1}{\sigma}}]^{\frac{1}{\sigma-1}} \quad (4)$$

We assume that labor can move freely between rural and urban areas, so wages in the two sectors should be equal in equilibrium, and prices in small open economies are all given and available by the external market, that they may have

$$P_m^* MPL_m = w = P_a^* MPL_a \quad (5)$$

Combining (4) and (5) can be deduced

$$L_a^* = \frac{A_d D}{A_l}\{\frac{\beta}{1-\beta}[\beta^{-\sigma}(\frac{P_a^*}{P_m^*})^{1-\sigma}(\frac{A_n A_l}{A_m})^{1-\sigma} - 1]\}^{\frac{\sigma}{1-\sigma}} \quad (6)$$

When $\sigma = 1$ Eq. (3) degenerates into the Cobb-Douglas production function, $Y_a = A L_a^{\beta} D^{1-\beta}$, where $A = (A_n A_l^{\beta} A_d^{1-\beta})$, corresponding to get

$$L_a^* = (1-\alpha)^{\frac{1}{\alpha}}(\frac{P_a^*}{P_m^*})^{\frac{1}{\alpha}}(\frac{A}{A_m})^{\frac{1}{\alpha}} D \quad (7)$$

We first see equation (7), when $\sigma = 1$, When the production function is reduced to Cobb-Douglas form, in the rural agricultural sector, only Hicks neutral technological progress exists. When the price is set by the international market, the increase will lead to an increase. In other words, the improvement of agricultural productivity will increase the proportion of labor population in the agricultural sector and hinder urbanization. This

result is consistent with that of the model constructed by Mastuyama(1992).

When the production function of rural agricultural sector is in the form of CES, and, we can judge the impact of different agricultural technological progress on rural agricultural population in small open economies according to Equation (6). It is easy to obtain $\partial L_a^* / \partial A_n > 0$, when technological progress is Hicks neutral technological progress, and it is also easy to get $\partial L_a^* / \partial A_d > 0$, when technological progress is land enhancement. In small open economies, hicks neutral technological progress in the agricultural sector and land-enhanced technological progress will both benefit the increase of agricultural population and hinder urbanization. The situation becomes more complicated when technological progress is labor-enhanced.

When $1 > \sigma > 1 - \beta^{\sigma}(\frac{P_{\mathrm{m}}^*}{P_a^*})^{1-\sigma}(\frac{A_m}{A_n A_l})^{1-\sigma}$, At this time $\partial L_a^* / \partial A_l > 0$, labor-enhanced technological progress will still increase the agricultural population and hinder urbanization. Thus, proposition 1 to be tested in this paper can be obtained.

Proposition 1: The improvement of agricultural productivity will reduce the level of urbanization.

When $\sigma < 1 - \beta^{\sigma}(\frac{P_{\mathrm{m}}^*}{P_a^*})^{1-\sigma}(\frac{A_m}{A_n A_l})^{1-\sigma}$, At this time $\partial L_a^* / \partial A_l < 0$, labor-enhanced technological progress can still promote the increase of urban industrial population. At this time, the type of technological progress is called strong labor-saving technological progress. Thus, proposition 2 to be tested in this paper can be obtained.

Proposition 2: The improvement of agricultural productivity will enhance the level of urbanization.

EMPIRICAL MODEL AND VARIABLE DESCRIPTION

In order to test the relationship between urbanization and agricultural productivity, this paper established a basic econometric model (8) to test and discuss it.

$$Urb_{i,t} = \beta_1 + \beta_2 \times Arg_{i,t} + \beta X_{i,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (8)$$

Urb is the explained variable urbanization level, which is measured by dividing the non-agricultural population of the city by the total population at the end of the year. *Arg* is the core explanatory variable of agricultural productivity, which is measured by average agricultural food production. In order to further test the impact of cash crop production efficiency on urbanization, this paper also uses the agricultural average tobacco production to measure agricultural productivity. The subscript *i*, *t* represents the city and the time. β_1 is the intercept term, μ_i represents the fixed effect of city, ω_t represents the fixed effect of time, $\varepsilon_{i,t}$ is the residual term, and X is a series of control variables added as required. We're going to focus on β_2.

Agricultural productivity and urbanization may be mutually causal, and only equation (8) is used for empirical test, which may lead to endogenous problems. On the basis of Equation (8), this paper uses the urban average topographic slope (Z_1), the average topographic relief (Z_2), the latitude of the city (Z_3) and the average grain/tobaccooutput of the province where the city is located in 1949 (Z_4) as the instrumental variables of the urban average grain/tobacco outpu, and uses Equation (9) and equation (10) to carry out 2SLS regression.

$$Arg_{i,t} = \alpha_1 + \sum_{j=1}^{4} \alpha_2 \times Z_{j,i} + \alpha X_{i,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (9)$$

$$Urb_{i,t} = \beta_1 + \beta_2 \times Arg_{i,t} + \beta X_{i,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (10)$$

Selection of data and indicators

This paper uses panel data of 230 prefecture-level cities in China from 2000 to 2014 for 15 years to test the impact of agricultural productivity on urbanization. The non-agricultural population data are from China Urban Statistical Yearbook, and China Population and Employment Statistical Yearbook. Agricultural productivity data come from China Rural Statistical Yearbook. The main control variable is per capita GDP to control the economic development level of each region. More control variables will be introduced to test the robustness of the results in the robustness test. The data in this paper are all from China Urban Statistical Yearbook, China Population and Employment Statistical Yearbook and Wind

database. Table 1 shows the descriptive statistics for the core variables that will be used in this article:

Table 1
Descriptive statistics of core variables

Variable Name	Observations	Mean	S.D.	Min	Max
Urbanization	3450	32.54	16.74	6.585	98.25
Agricultural productivity(grain)	3450	0.731	0.520	0.007	3.842
Agricultural productivity(tobacco)	3450	0.842	0.259	0.001	1.650
GDP per capita	3450	9.44	0.729	7.415	11.58

EMPIRICAL RESULTS

Benchmark Regression Results

Table 2 reports the basic regression results, which are consistent with proposition 2. Agricultural productivity will significantly improve the level of urbanization. Specifically, during 2000-2014, on average, every 1 standard deviation increase in agricultural productivity will increase the urbanization level of prefecture-level cities by about 4 percentage points, an increase of about 12%.

Columns 1 to 3 of Table 2 show the regression results using average grain yield as a measure of agricultural productivity. Column 1 using mixed panel model estimation, the display agricultural productivity coefficient is 8.220, you can through the test of significance of 5% significance level, indicates that the agricultural productivity per 1 standard deviation, the urbanization rate increase by about 6%, compared with the average rate of urbanization, the increase of about 18%. The second column controls the time-fixed effect on the basis of the first column. The regression results show that the coefficient of agricultural productivity drops to 5.759, which can pass the significance test of 1‰, indicating that the positive correlation between agricultural productivity and urbanization is not affected by the time-fixed effect. Column 3 in column 2 to control urban fixed effects, on the basis of the regression results show that the efficiency of agricultural production coefficient is 5.528, you can through the test of significance of 5% significance level, indicates that the agricultural productivity per 1 standard deviation, the urbanization rate increase by about 4%, compared with the average rate of urbanization, the increase of about 12%. It means that agricultural productivity will significantly improve the level of urbanization. Proposition 2 has been verified.

Table. 2
Agricultural productivity and urbanization

	(1)	(2)	(3)	(4)	(5)	(6)
Explained variable	Urbanization					
Agricultural productivity	8.220*	5.759***	5.528*			
	(2.51)	(3.49)	(2.23)			
Agricultural productivity(tobacco)				3.152***	2.189**	1.868*
				(3.91)	(3.24)	(2.39)
GDP per capital	8.541***	4.973***	3.630*	2.846***	2.536***	2.471*
	(9.68)	(4.21)	(2.12)	(6.83)	(3.96)	(2.13)
Constant	Y	Y	Y	Y	Y	Y
Year Fixed	N	Y	Y	N	Y	Y
City Fixed	N	N	Y	N	N	Y
Observations	3450	3450	3450	3450	3450	3450
R2	0.131	0.254	0.332	0.158	0.236	0.328

Notes: (1) t statistics are reported in parentheses; (2) ***, ** and * represent the significance level of 1‰, 1% and 5% respectively.(3)All columns adopt clustering robust standard error at provincial level.

The measurement method of agricultural productivity is replaced in columns 4 to 6 of Table 2. Average agricultural tobacco output is used to measure agricultural productivity, which is recorded as agricultural productivity(tobacco).

Improving the efficiency of tobacco production and the agricultural technology and improve the efficiency of food production use depend on the natural climate is not the same, however, the increase of tobacco output or grain output can represent the improvement of agricultural production efficiency.The empirical study using tobacco production efficiency as an explanatory variable is not only a beneficial supplement to the previous empirical results, but also can further explore the impact of the improvement of cash crop production efficiency on urbanization. The empirical method used in columns 4 to 6 of Table 2 is the same as that used in columns 1 to 3, and only the explained variable is replaced by agricultural productivity(tobacco). The regression results show that in columns 4 to 6 of Table 2, the coefficients of average tobacco output are all positive and significant at the 5% significance level, which means that the improvement of grain production efficiency can promote urbanization level, and that of cash crops such as tobacco can also promote urbanization level.

The results of Table 2 preliminarily show that both efficiency of grain production and the efficiency of cash crops such as tobacco production can improve the level of urbanization. For every 1 standard deviation increase of agricultural productivity, the urbanization level of prefecture-level cities will increase by about 4 percentage points, with an increase of about 12%. It verifies proposition 2 of this paper. According to the results of theoretical model derivation in this paper, it can be concluded that in the process of agricultural technological progress in China, strong labor-saving technological progress plays a dominant role, which makes the improvement of agricultural productivity in China promote urbanization.

Robustness Test

Endogenous problems

Agricultural productivity and urbanization level may be mutually causal, agricultural productivity will promote urbanization, but the rapid development of urban industrial sector with the urbanization process may also feedback the rural agricultural sector, improve agricultural productivity. At this point, OLS regression may obtain biased empirical results.

This paper tries to introduce four instrumental variables to solve the possible endogenous problems. The first and second are the average urban topographic slope and average topographic relief. The local topographic slope and relief reflect the basic features of local topographic features, which directly affect the local agricultural productivity. The third instrumental variable is the latitude of a city. The latitude of a city determines its natural climate such as annual illumination and rainfall, which will have an impact on local climate and agricultural production. The fourth instrumental variable is the historical data of agricultural productivity. The historical agricultural productivity of the province where a city is located can capture other geographical information and human information that can affect agricultural productivity, such as soil suitability and agricultural cooperation spirit, which cannot be captured by terrain and latitude. Cities that are suitable for agricultural production not only have a higher initial level of agricultural production, but also have a greater increase in agricultural productivity after the emergence of new agricultural technologies (Bustos et al., 2016)[22]. On the other hand, the local agricultural productivity does not affect the urban topographic slope, topographic relief, latitude and historical agricultural productivity. Historical agricultural productivity is based on the 1978 measure of average agricultural grain yield of the provincial administrative unit where the city is located.

Table 3 shows the empirical results using instrumental variables and reports the contents of the second stage of 2SLS. The main explanatory variable in Table 3 is agricultural productivity. In column 1 and column 2, the average urban topographic slope and average topographic relief were used as instrumental variables. The regression results showed that after using topographic variables as instrumental variables, the coefficient of agricultural productivity increased significantly, and the significance level could still reach the significance level of 5% despite a decrease. In column 3 and column 4, the latitude of a city and the historical per capita grain yield are used as instrumental variables of agricultural productivity. The regression results also show that the coefficient of agricultural productivity increases significantly after using instrumental variables to solve the endogeneity problem, reaching the significance level of 1‰. In Column 5, the above four variables

were taken as instrumental variables of average agricultural grain yield at the same time. The regression results showed that the coefficient of agricultural productivity rose to 13.121, reaching the significance level of 1%. In Column 6, the above four variables are also used as instrumental variable, but the explanatory variable is replaced by agricultural productivity (tobacco). The regression results show that the coefficient of agricultural production efficiency is 1.340, reaching the significance level of 1%.Column 5 of Table 3 is used as the benchmark regression result in this paper.

Table 3
IV estimate

	(1)	(2)	(3)	(4)	(5)	(6)
	IV: Topographic slope and relief		IV: Latitude and historical per capita food production		IV: All	IV: All
Explained variable	Urbanization					
Agricultural productivity	11.594*	8.961*	12.329***	10.354***	13.121**	
	(2.43)	(2.01)	(5.89)	(5.87)	(3.26)	
Agricultural productivity(tobacco)						1.340***
						(5.75)
GDP per capital	8.995***	7.234***	6.703***	6.210***	6.256***	6.125***
	(8.59)	(7.63)	(7.78)	(6.80)	(7.51)	(4.15)
Constant	Y	Y	Y	Y	Y	Y
Year Fixed	N	Y	N	Y	Y	Y
City Fixed	N	Y	N	Y	Y	Y
Unidentifiable test	P=0.002	P=0.014	P=0.019	P=0.023	P=0.042	P=0.015
Overidentification test	P=0.142	P=0.098	P=0.648	P=0.235	P=0.103	P=0.128
Observations	3450	3450	3450	3450	3450	3450
R2	0.460	0.541	0.503	0.494	0.518	0.573

Notes: (1) t statistics are reported in parentheses; (2) ***, ** and * represent the significance level of 1‰, 1% and 5% respectively.(3)All columns adopt clustering robust standard error at provincial level. (3)IV in column 1 and 2 is topographic slope and topographic relief; IV of columns 3 and 4 are latitude and average grain yield in 1949; Column 5 nad 6 uses all four tool variables simultaneously.

The above analysis shows that after the use of instrumental variable method to correct the possible endogenous problems, the impact of agricultural productivity on urbanization will be greatly improved. For every 1 standard deviation increase in agricultural productivity, the urbanization level of prefecture-level cities will be increased by about 9.6 percentage points, an increase of about 30%. Proposition 2 has been further verified.

Introduce more control variables

Whether agricultural productivity can improve the urbanization rate may also be affected by other factors. This section attempts to further control the influence of these potential factors.

First of all, we will introduce industrial structure and financial development level in column 1 of Table 4 to control the influence of economic development level of prefecture-level cities. Although we have controlled for the more important GDP per capita, other indicators are still important. Industrial structure can be measured in a region of industrial and service industry developm ent level, the higher the level of its development, the city's capacity to absorb rural labor force is stronger, the more likely a higher level of urbanization, this article reference Zhong(2011) study using the second industry difference/tertiary industry output value to measure various cities industry structure.[23] Chen et al.(2015) found that financial development was an important driving force for China's urbanization development, so we also controlled the level of financial development, which was measured by the proportion of bank deposits and loans in GDP.[24]

Secondly, in the second column of Table 4, we introduce the number of beds per 10,000 people, the number of books in the public library per 10,000 people, and the number of full-time teachers per 100 junior high school students to control the influence of the public service level of prefecture-level cities. Urban public service facilities are the basic carrier of urban economic and social activities and determine the attractiveness of a city. Wu and Sun (2010)[25]based on Chinese data, found that urban public service

facilities have a significant role in promoting urbanization. We use beds per 10,000 people as a proxy variable for public health services; The number of books in public library per 10,000 people and the number of full-time teachers per 100 junior high school students were used as proxy variables of public education services.

Then, we will introduce industrial sulfur dioxide emissions in column 3 of Table 4 to control the impact of environmental pollution in prefectural cities. Different from urban public services, environmental pollution will bring health damage to residents and reduce the benefits of living in cities. Therefore, this paper predicts that pollution will be detrimental to the process of urbanization. We used industrial sulfur dioxide emissions as a proxy variable of pollution. Column 3 of Table 4 shows the empirical results of introducing industrial sulfur dioxide emissions as a control variable on the basis of baseline regression.

Finally, we will introduce industrial sulfur dioxide emissions in column 4 of Table 4 to control the impact of population density. China's population is large and unevenly distributed, with most of the population concentrated in the eastern coastal cities. However, areas with high population density are more likely to have large cities with concentrated population, and the urbanization rate will be higher, so we control the impact of population density. Column 4 of Table 4 shows the empirical results of introducing population density as a control variable on the basis of baseline regression.

In column 5 of Table 4, all the above variables are simultaneously introduced as control variables on the basis of baseline regression. In column 6 of Table 4, the core explanatory variable is replaced by agricultural productivity(tobacco) based on column 5

Table 4
Introduce more control variables

	(1)	(2)	(3)	(4)	(5)	(6)
Explained variable	Urbanization					
Agricultural productivity	12.257**	10.888**	12.354***	12.598**	11.453*	
	(4.50)	(3.59)	(5.71)	(3.67)	(2.47)	
Agricultural productivity(tobacco)						4.464**
						(3.39)
GDP per capital	6.797**	6.830**	6.968**	6.185**	6.681**	2.959**
	(4.55)	(4.56)	(9.35)	(8.45)	(4.89)	(4.48)
industrial structure	0.553***				0.172*	0.120**
	(3.91)				(1.99)	(3.01)
financial development	1.469				2.428	-0.056
	(1.779)				(1.72)	(-0.30)
Beds per 10,000 people		0.672***			0.611*	0.445*
		(5.68)			(2.09)	(2.05)
Books per ten thousand people		0.061			-0.084	0.031
		(0.21)			(-0.38)	(0.18)
Number of full-time teachers per 100 secondary school students		0.193*			0.374*	0.164***
		(2.34)			(2.33)	(6.28)
Industrial So2 emissions			-0.512		-1.224*	-0.151
			(-0.22)		(-2.18)	(-0.58)
population density				0.587*	0.646*	0.556
				(2.22)	(2.17)	(1.02)
Constant	Y	Y	Y	Y	Y	Y
Year Fixed	Y	Y	Y	Y	Y	Y
City Fixed	Y	Y	Y	Y	Y	Y
Unidentifiable test	P=0.022	P=0.014	P=0.012	P=0.034	P=0.041	P=0.049
Overidentification test	P=0.256	P=0.168	P=0.120	P=0.130	P=0.270	P=0.370
Observations	3450	3450	3450	3450	3450	3450
R2	0.621	0.614	0.541	0.537	0.741	0.462

Notes: (1) t statistics are reported in parentheses; (2) ***, ** and * represent the significance level of 1‰, 1% and 5% respectively.(3)All columns adopt clustering robust standard error at provincial level. (3)IV is topographic slope and

topographic relief, latitude and average grain yield in history.

The regression results in Table 4 show that after introducing more control variables on the basis of the benchmark regression, the positive correlation between agricultural productivity measured by average agricultural grain yield and urbanization is still very significant, reaching the significance level of 5%, which verifies the robustness of the empirical results of the benchmark in this paper. In column 5, the agricultural productivity coefficient is 11.453, can pass a statistical test with a significance level of 5%; In column 6, the agricultural productivity(tobacco) coefficient is 5.300,can pass a statistical test with a significance level of 1%.The above results indicate that the improvement of agricultural production efficiency can significantly improve the urbanization rate, in particular, agricultural productivity per one standard deviation, the urbanization rate is 8.4%, compared with the average urbanization rate, increase of about 26%.

The above empirical results show that, after the use of instrumental variables to correct the possible endogenous problems and the introduction of many control variables, there is still a significant positive correlation between agricultural productivity and urbanization, which verifies proposition 2 of this paper. The empirical results of this paper reveal that the improvement of Agricultural productivity in China from 2000 to 2014 has significantly improved the level of urbanization in China. Implementing the rural revitalization strategy and improving the efficiency of agricultural production is not only conducive to the high-quality development of agriculture and rural areas, but also conducive to improving the level of urbanization and thus promoting the high-quality development of the overall economy. Given that China's agricultural productivity is far below the average level of high-income countries, China can further improve its urbanization rate by adopting more labor-saving agricultural technologies to improve its agricultural productivity and promote high-quality economic development.

CONCLUSION

Research on how to improve the level of urbanization is essential to promote high-quality economic development. China's urbanization rate and agricultural productivity are both relatively backward in the world. This makes us wonder whether there is an internal connection between China's low level of urbanization and low agricultural productivity. Can the improvement of agricultural productivity improve the level of urbanization? If so, how much? Based on this, this paper explores the impact of agricultural productivity on urbanization rate from both theoretical and empirical aspects.

Theoretically, this paper adopts CES production function to construct a small open economic model containing two sectors, and allows factor bias in technological progress of agricultural sector. Based on the factor bias of technological progress that leads to the improvement of agricultural productivity, this paper puts forward relevant prediction of the impact of agricultural productivity on urbanization. It is found that the impact of agricultural productivity on urbanization depends on the direction of technological progress. When technological progress is neutral, the improvement of agricultural productivity will hinder the process of urbanization. When technological progress is land-enhanced technological progress or labor-enhanced technological progress and labor and land are not strongly complementary, the improvement of agricultural productivity will also hinder urbanization. Only when technological progress is labor-enhanced technological progress and labor and land are strongly complementary, the improvement of agricultural productivity will enhance the level of urbanization.

Empirically, this paper uses panel data of 230 cities in China for 15 years from 2000 to 2014 to empirically investigate the impact of agricultural productivity on urbanization. Empirical analysis found that is consistent with the theoretical predictions, the prefectural agricultural productivity and the urbanization, there is significant positive correlation between mean, to promote the efficiency of agricultural production will significantly enhance the level of urbanization and agricultural productivity per 1 standard deviation, prefectural level of urbanization will increase about 4-9.6%, increase of about 12% to 30%. The above findings are very robust, and the benchmark conclusions of this paper are still valid after using instrumental variables, replacing the

measurement method of agricultural productivity, and introducing more control variables.

The results of this paper show that the improvement of agricultural productivity(both efficiency of grain production and efficiency of cash crops such as tobacco) can improve the urbanization rate. The research results of this paper also implicitly reveal that the technological progress that promotes the improvement of China's agricultural productivity belongs to labor-saving technological progress. Under the conditions of open economy, only such technological progress may release rural labor force into cities and promote the process of population urbanization. China's agricultural productivity is much lower than in high-income countries average, therefore, under the background of economic growth falling, implement the strategy of rejuvenating the country, improve the efficiency of agricultural production, not only is beneficial to the high quality development of agriculture and rural areas, but also to enhance the level of urbanization and to promote the high quality development of the economy as a whole.

Acknowledgements

Ma Jing thanks the the Youth Project of Guangdong Social Science Fund(Grant No.GD21YYJ01) for support. Qing Li thanks the Major Program of National Social Science Foundation of China (Grant No. 20&ZD085) for support.

Author Declaration

This research is not funded by any organization related to tobacco production.

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