Study on Separation of Factors of Production from Grain and Food Safety during the Evolution of Chinese Agricultural Structure

Kangkang SHAN*, **Anran WANG**

Southwest University, Chongqing 400715, China

Abstract   China is the world's largest food producer, and it also has the largest food demand. The stability of China's food production directly affects the supply and demand situation of the world food market. In the context of evolving Chinese agricultural structure, this paper studies the separation of factors of production from grain and issues concerning food safety. It is found that the arable land for food production within agricultural sector continues to flow to non-food production sector while the arable land is shrinking in China; the process of urbanization of population is the main reason for food production workforce reduction, resulting in a decline in the overall quality of the food production labor. By analyzing the panel data estimation results for food production function, it is found that arable land and labor are still important factors for food production in China at present, and their flow out of food production poses a major threat to food production and security.

Key words   Food production, "Separation from grain", Arable land, Population

1   Introduction

During most of the past decade, the global consumption of food was always higher than production. It is predicted that the food demand will increase by 30 - 40% in 2030, and the arrival of a new round of global food crisis seems to have been inevitable[1]. Because of the unbalanced economic development of the region, there are great differences in food production between different countries, and causing significant regional differences in the world food production[2]. At present, China has basically achieved self-sufficiency in food production, however, due to the accelerating Chinese urbanization and industrialization process, the allocation of resources and factors of production between the industries is constantly adjusted; capital, labor, arable land and other factors of production continue to flow from agricultural production to secondary and tertiary industries. In the process of industrialization and urbanization, the separation of factors of production from grain is an inevitable process, and the food production is restricted by land and technical factors. It is difficult to form the industrial or service-type explosive growth, and noticeably the food production is heavily dependent on natural factors, so the food production is facing great uncertainty[3]. In the previous political context of development in accordance with GDP, due to decreasing share of food output value in total value of production in national economy, various regions paid declining attention to food production and farmland occupied by industry became a common phenomenon[4]. A large number of labor forces transfer from rural areas to urban areas during Chinese urbanization, resulting in the loss of food production workforce. The factors of agricultural production con-

stantly flow out of food production and China's food production continues to achieve a new record high owing to continuous improvement of food production technology, but there is increasing pressure on stable food production with the outflow of factors[5]. In this paper, based on the phenomenon of "separation from grain" in the evolution of Chinese agricultural structure, we first analyze "separation of factors from grain" from arable land and labor, describe the changes in the allocation of factors in food production, and then use panel data model to analyze the input and output of China's food production factors.

## 2   The "separation of arable land from grain" in the factor flow

2.1   The non-farm trend of arable land in adjustment of agricultural structure   Since China's reform and opening, the economy has shown a rapid growth trend, and the economic development poses an increasing demand for land[6]. Under the limited land resources, the structure of land allocation between the agricultural sector and non-agricultural sector is gradually adjusted, and a lot of arable land flows out of agricultural sector to meet the needs for land resources during urbanization and industrialization. Fig. 1 shows the change in China's arable land area since 1996. As can be seen from Fig. 1, China's arable land area shows a downward trend. In 1996, the arable land area was 130.04 million mu, and then it showed a decreasing trend. In 2011, the arable land area was reduced to 121.73 million mu, a decrease of 6.3%. As China's farmland protection awareness has been gradually strengthened, the decline slowed after the sharp decline during 2000 - 2005, but the dramatic increase in non-agricultural land was still not reversed, and the arable land preservation was still faced with great pressure.

2.2   Change in the planting area of food crops   With the de-

Area (10⁴ mu)
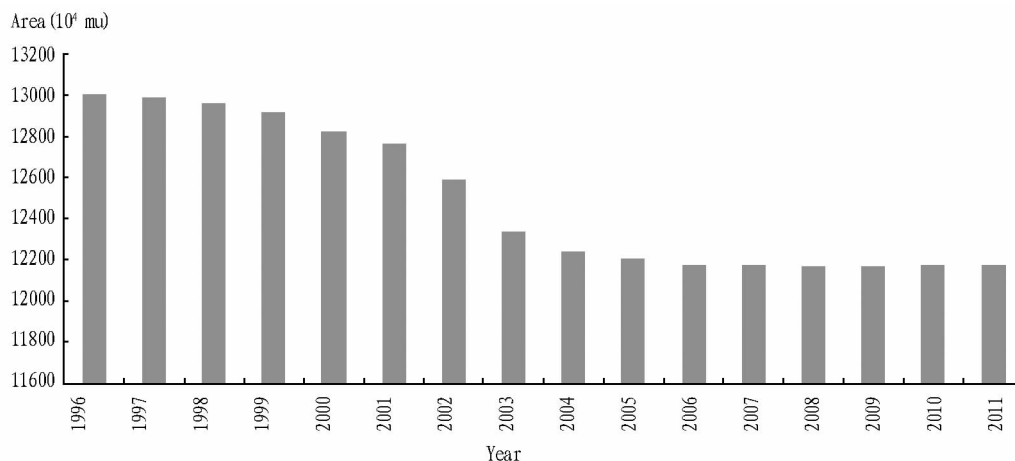
Fig. 1   The change in China's arable land area

creasing arable land area, the planting area of food crops in China also showed a downward trend (Fig. 2). In 1978, the planting area of food crops was 120. 59 million ha. With continuous economic development, there was a growing demand for land amid industrialization and urbanization, and the planting area of food crops showed a rapid decline. From the mid-1980s to the late 1990s, the planting area of food crops fluctuated within a certain range, but from 2000, there was a drastic decline in the area. In 2003, the growing area of food crops dropped to the lowest point (99. 41 million ha). After 2003, the growing area of food crops increased, and the planting area reached 111. 2 million ha in 2012.

2.3   Decreasing share of planting area of food crops in total planting area of crops   The change in share of planting area of food crops in total planting area of crops is shown in Fig. 3. In 1978, the planting area of food crops accounted for 80. 34% of total planting area of crops, and subsequently, the share continued to decline, reaching to the lowest point in 2003 (65. 22%). During 2004 – 2006, it rose to a certain extent, and since then it has been declining. From Fig. 2, 3, it is found that since the reform and opening up, the change in the share of planting area of food crops is consistent with the change in the planting area of food crops, both showing a downward trend, but there is a difference at different stages. This difference comes from the adjustment of the internal structure of farming[7].

3   "Separation of labor from grain" in the factor flow
3.1   Great transfer of rural population   Since the 1990s, "farmers' frenzied hunt for work in cities" has become a common phenomenon in China, and a lot of labor flows from rural areas to urban areas, from primary industry to secondary and tertiary industries. According to statistics, 160 million rural residents moved to urban areas in 2001, and transferred from agricultural production to construction and other sectors. In 2006, the number of rural migrant workers reached 132 million. The rural population in the early 1990s was 841. 38 million and it decreased to 601. 22 million in 2012, a decrease of 28. 8% ; it showed a rapid decline after 1995. The transfer of labor from food production, to a certain

extent, is conducive to economic development and the improvement of living standards, but it also brings some food safety risks. Therefore, how to well coordinate the relationship between labor outflow rate and food production is of great significance to healthy and stable development of the economy.

3.2   Declining quality of food production labor   In the composition of human capital, population and quality together determine the size of human capital. A recent survey by China Agricultural University on the rural population shows that China has 87 million left-behind population (20 million elderly people; 20 million children; 47 million women), the proportion of rural labor transferred to rural labor reached 39% , and 60% of rural labor transferred enters into secondary industry. This paper uses the level of education to measure the quality of food production labor. The level of education received by rural residents is very low. According to the data in 2012, rural population with education level of junior college or above accounted for only 3% ; rural population with education level of junior high school and primary school accounted for 53% and 26% , respectively; rural population with education level of senior high school and technical secondary school accounted for 10% and 3% , respectively; there were still 5% of illiterate or semi-illiterate people. In China's rural population, food production labor holds a large share, and the education level of rural population can basically reflect the quality of food production labor.

4   Food production factor input and output
4.1   Model selection   Food production issue falls within the category of input-output study, and Douglas production function (also known as the CD production function) is often used in the input-output model[9]. The main factors affecting food production include capital input, labor input, technical level and grain growing area. Due to great correlation between capital input and technical level, we combine them in the research process as fixed capital stock of food production, so the model can be set as follows:
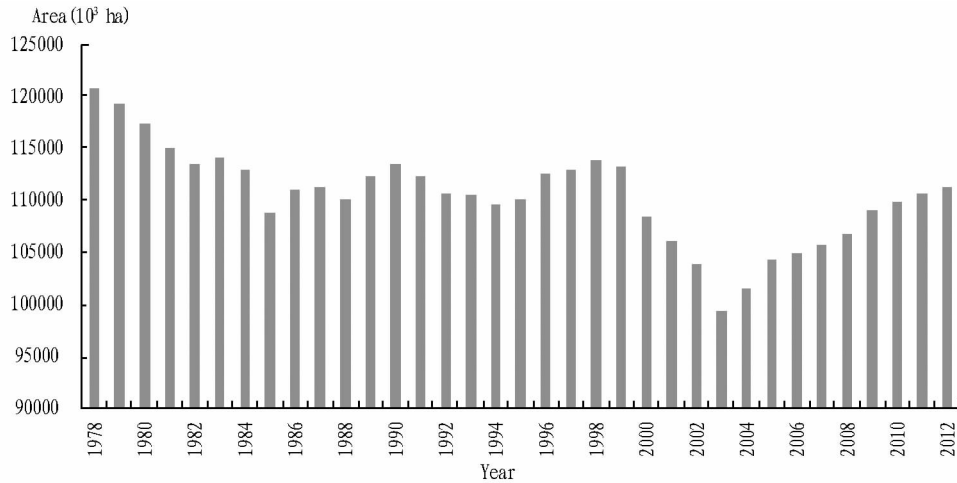
Fig. 2   Change in the planting area of food crops
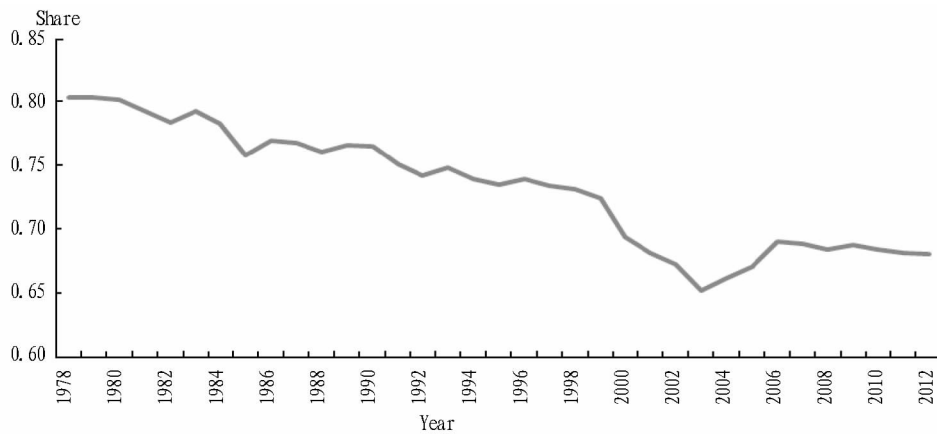
Fig. 3   The share of planting area of food crops in total planting area of crops

$$Y = L^{\alpha} K^{\beta} S^{\gamma} \tag{1}$$

To eliminate heteroscedasticity of model, we take the logarithm on both sides of equation (1):

$$LN(Y) = \alpha LN(L) + \beta LN(K) + \gamma LN(S) \tag{2}$$

Human capital depends on population and education level, so this model can be further grouped as:

$$LY = \alpha LHC + \beta LK + \gamma LS \tag{3}$$

where LY is the logarithm of total food production; LHC is the logarithm of human capital stock; H is the number of people engaged in food production; C is the average level of education of the rural population; LK is the logarithm of fixed capital stock of food production; LS is the logarithm of planting area of food crops.

4.2   Data sources   The study sample is the food production of 13 major grain producing areas (Liaoning, Hebei, Shandong, Jilin, Inner Mongolia, Jiangxi, Hunan, Sichuan, Henan, Hubei, Jiangsu, Anhui, Heilongjiang), and the data time span is 2004 – 2012. Data are from *China Statistical Yearbook*, *China Agricultural Yearbook*, *China Rural Statistical Yearbook*, *Chinese Food Yearbook* and *Statistical Yearbook of China's Fixed Asset Investment*. The fixed capital stock of food is calculated using the perpetual inventory method, and the formula is as follows:

$$K_{it} = (1 - \delta) K_{it-1} + k_{it}$$

where i is the province; t is the year; k_{it} the agricultural fixed capital investment in various regions.

Using the method of Griliches (1980), the fixed capital stock of food in 2004 is calculated as follows:

$$K_{i2004} = k_{i2004} / (g + \delta)$$

where g is the average growth rate of annual agricultural fixed capital investment at each section during 2004 – 2012; δ is the depreciation coefficient of agricultural fixed capital (depreciation rate of 4.24%) (Fan Shenggen, 2002).

The human capital in each province = food production population (H) × per capita level of education (C); per capita level of education (C) = 6 × primary school education rate + 9 × junior high school education rate + 12 × (senior high school education rate + vocational secondary school education rate) + 16 × education rate of junior college and above.

4.3   Regression result analysis   During panel model estimation, the sample data used include section, period and variable information. In terms of the choice of estimation model, the fixed effects model should be used for estimation, and the unit root test should be performed on each variable. Through LLC test, IPS

test, ADF test and PP test, it is found that there is integrated of order one for the four variables at the 1% significance level, and the panel data analysis can be conducted directly on the data. By eviews6. 0, we estimate the fixed effects model, and the estimation results are shown in Table 1. The estimation results of panel data model show that the estimation results of various variable coefficients pass the significance test at the 1% significance level; the goodness of fit of the model is 0. 8352 and the adjusted goodness of fit is 0. 8309. The estimation results have good fitting effect, and can reflect the relationship between food production and human capital stock, fixed capital stock or planting area. The coefficients of human capital stock (LHC), fixed capital stock (LK) and

planting area (LS) are 0. 1454, 0. 0701 and 0. 6605, respectively, and the increase in the three factors can significantly improve food production. It can be seen that under current economic, social and institutional environment of China, arable land and labor are still important factors to boost China's food production. With continuous improvement of China's food production technology, it can offset the effects arising from the outflow of arable land and labor to a certain extent, but the improvement of technological level is cumulative[9], and it is difficult to make great strides in the field of grain cultivation. Therefore, in the process of decreasing arable land and labor, there is a limit on the use of science and technology to ease the pressure on food production[10].

Table 1   Model estimation results

Variable	Coefficient	Standard deviation	T statistic	P value
C	1. 018554	0. 276933	3. 677983	0. 0004
LK	0. 070076	0. 016304	4. 298022	0. 0000
LHC	0. 145434	0. 025452	5. 714151	0. 0000
LS	0. 660495	0. 041852	15. 78171	0. 0000
R^2	0. 835235			
Adjusted R^2	0. 830860			
F − statistic	190. 9413			

5   Conclusions and recommendations

In this paper, we study the phenomenon of "separation from grain" during China's industrialization and urbanization, and find that there is a significant phenomenon of "separation from grain" in arable land and labor in recent years. The arable land is shrinking, and the growing area of food crops is also decreasing; within the agricultural sector, the share of growing area of food crops is decreasing, and arable land constantly flows from planting of food crops to other crops. The "separation from grain" in population means that during China's urbanization process, a lot of people flow from village to city, from agricultural sector to non-agricultural sector. In addition, the "separation from grain" in population is also reflected in the declining quality of rural left-behind population. The input-output analysis of food production shows that under current economic, social and institutional environment of China, arable land and labor are still important factors to boost China's food production, and the flow of arable land and labor out of food production poses a significant threat to food safety. Under market conditions, arable land and labor flow from low value-added food production to high value-added secondary and tertiary industries. In order to ensure the stability and sustainability of China's food production, it is necessary to give full play to the government's regulation, increase food production subsidies, and improve food production services, to attract factors of production to flow into food production. When the food production technology realizes no great leap, there is a need to ensure the stability of amount and level of arable land and resolutely put an end to any farmland occupation behavior. In response to the outflow of population during food production, the most effective way is to continuously promote mechanized food production and reduce the requirements of human resource, but in the context of household contract

responsibility system, farmers only have the contract rights, and food production has a small scale, all hindering the implementation of large-scale mechanized production. Therefore, the Chinese government must accelerate the design and implementation of rural land transfer system, and eliminate obstacles to agricultural production services and mechanization process, to promote stable growth of China's food production.

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