Land Management Scale, Rural Labour Migration, and Agricultural Mechanization: Evidence from China

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Abstract. This paper based on the panel data of 31 provinces in China from 1999 to 2014. The three-stage least squares method is used in this paper to analysis the relationship between land management scale, rural labour migration and agricultural mechanization level. The analysis reveal that the rural labour migration and the scale of land management show a U-shaped relationship. The level of agricultural mechanization is positively affecting the transfer of rural labour. In addition, we find that the scale of land management, rural labour migration have promoted the level of agricultural mechanization. The proportion of the gross agricultural output value in the GDP has a negative impact on rural labour migration.

Keywords: Land management scale, Labour migration, Agricultural mechanization

1. Introduction

Agriculture is the short board of China's economic development. The agricultural development, peasants’ income and rural construction have always been the inevitable problems in the modernization construction.

In the context of fragmented agricultural production land and low agricultural production efficiency. The rural labour migration and land transfer can promote large-scale land management. Meanwhile, rural labour migration can improve the level of agricultural mechanization and adapt to medium-scale development. This is one of the current priorities for large-scale agricultural operations. Since the beginning of the 21st century, China's rural labour has accelerated its transfer to the non-agricultural sector, and agricultural mechanization has rapidly grown. Therefore, a large body of literature has committed to research rural labour migration, agricultural management scale and mechanization research. The existing literature believes that rural household income affected by the industrial structure, labour migration, agricultural technology, land and other factors (Yang Yuhong, 2009). Through combing the existing literature research, most scholars focus on the relationship between land scale and rural labour migration, rural labour migration and Agro-mechanization level. As reported above, none of the previous studies have related scale, rural labour migration and Agro-mechanization level. On the basis of previous studies, we using the panel data of 31 provinces in China since 1999 to 2014, basing on the 3SLS estimation of simultaneous equations. The aim of this paper is to study the relationship between land management scale, labor migration and agricultural mechanization.
2. Theoretical Framework
Since reform and opening-up, with the gradual improvement of the land and household contract management system, the per capita rural land area has shown an upward trend, and the scale of land has been increasing year by year. In recent years, with the progress of agricultural science and technology, the agricultural mechanization level has increased year by year. Finally, the speed of rural labor migration has accelerated, and the surplus rural labor has decreased.

Fig.1 1999-2014 Mechanical level, per capita arable land and labor migration trends in China

The paper extends the relationship between land management scale, labor migration and agricultural mechanization level in developing counties as a perspective. We try to put forward two hypotheses to define the reference frame of this paper. Then, the mathematical model is used to verify these hypotheses:

Hypothesis 1: There is a certain U-shaped relationship between land management scale and rural labor migration. In addition, the small scale of land management may increase the transfer of rural labor. Meanwhile, if capita land area is small, the labor restraint effect is small, and the greater possibility of labor migration. The farmers' income mainly comes from non-agricultural production, and the farmers' net income is high. However, these farmers are generally part-time workers, and they will not give up completely. The cultivation of the land, because the income from the land for the working family reduces the risk of their going out.

Hypothesis 2: The rural labor migration has a positive impact on the growth of agricultural mechanization. The transfer of rural surplus labor can promote the application and popularization of agricultural machinery. What’s more, orderly land transfer system is the key link to achieve large-scale land management, and promote agricultural mechanization level. Notably, the improvement of agricultural mechanization level can be an important external thrust for rural surplus labor migration. Rural labor migration will lead to a large number of cropland owned by a few capable farmers. In order to realize large-scale land management, reduce labor intensity and improve labor productivity. We should increase investment in agricultural machinery and comprehensively improve the agricultural mechanization level. Practice has proved that agricultural mechanization can not only promote the rural economy restructuring, improve agricultural industrialization level, but also provide security for transferred rural labor.

3. Data, Variables and Methodology
3.1. Data and variables
The panel data used in this study came from the 31 provinces in China since 1999 to 2014. The sample data were collected through the statistical yearbook of China (2000-2015), the statistical yearbook of all
provinces in China (2015), and the state statistical bureau etc. Including the land area, mechanization and agricultural employment in all provinces of China since 1999 to 2014. Using per capita farmland area (PFL) to measure land operations scale. According to the existing literature, there are two methods to measure the level of agricultural mechanization level: the first is to divide the total power of mechanization by the employees engaged in agriculture, forestry, animal husbandry and fishery (Xia Chunping et al., 2012); the second is to measure the mechanization level by the comprehensive mechanization rate of crop cultivation and harvest (Zhou Zhen et al., 2016). In this paper, we used the first method to construct per capita mechanization power (PMP) to represent mechanization level. In the existing literature, there are many methods to measure the rural labor migration. Basing on the statistical index of China statistical yearbook, the social working labor generally divided into two categories according to industry and urban and rural areas. We used rural workers (CL) minus agricultural, forestry, animal husbandry and fishery workers to represent rural labor transfer (TRL) (He Jianxin, 2013). In order to propose the population size effect of each province, this paper used the proportion of rural labor transfer (PTRL) to represent the level of rural surplus labor transfer.

In addition, the transfer of rural labor affected by economic development, the attraction of developed areas to labor is higher than underdeveloped areas. The proportion of the output value of the primary industry in GDP reflects the agricultural economic development level. The per capita wage income of rural family reflected the off-farm employment wage level. Generally speaking, the high energy of per capita wage income can promote rural labor migration. Therefore, the study introduced the control variables of rural per capita wage income (PWI), the proportion of agriculture to GDP (PGDP). Table 1 presents the definitions and descriptive statistics of the variables used in this paper.

| Variables                              | Mean  | S.D.  | Min  | Max  |
|----------------------------------------|-------|-------|------|------|
| Proportion of rural labor migration    | 0.41  | 0.16  | 0.09 | 0.85 |
| Per capita agricultural machinery power (KW) | 3.00  | 1.79  | 0.39 | 8.01 |
| Per capita cultivated land area (Mu)   | 2.31  | 2.44  | 0.20 | 13.77|
| Proportion of agricultural industry to GDP | 0.22  | 0.22  | 0.01 | 0.59 |
| Household per capita wage income (Yuan)| 2133.48 | 2251.57 | 54.23 | 15903.1|

- 1mu = 1/15 ha;

3.2. Methodology

The aim of this paper is the dynamic relationship and interaction among the land management scale, the agricultural mechanization level and the rural labor migration. According to the push-pull theory, the mechanization level is the result of the common "pull" of rural labor migration and land management scale.

The improvement of rural labor migration and agricultural mechanization level promoted land management scale. Furthermore, the increase in per capita wage income of farm household will promote the rural labor migration, and the proportion of agricultural industry in GDP affects the rural labor migration. In order to avoid the endogenous of the two core variables in this paper. We employed the square of per capita land management scale (PPFL), the logarithm of household wage income (lnPWI) and the proportion of agricultural output value to GDP (PGDP) as exogenous instrumental variables. The equations of the equations returned in turn, analyzing the dynamic impact of land management scale, agricultural mechanization level and rural labor transfer. The final simultaneous equations are as follows:

\[
PMP_{it} = \alpha_0 + \alpha_1 PPFL_{it} + \alpha_2 TRL_{it} + \alpha_3 PFL_{it} + \varepsilon_{PMP}^{it}
\]

\[
PFL_{it} = \beta_0 + \beta_1 TRL_{it} + \beta_2 PMP_{it} + \beta_3 lnPWI_{it} + \varepsilon_{PFL}^{it}
\]

\[
TRL_{it} = \gamma_0 + \gamma_1 PMP_{it} + \gamma_2 PGDP_{it} + \gamma_3 PPFL_{it} + \varepsilon_{TRL}^{it}
\]
where i represents the corresponding province, t represents the year, $\varepsilon_i^M$, $\varepsilon_i^L$, $\varepsilon_i^R$ represents the residual of the model, and $\alpha$, $\beta$, $\gamma$ respectively represents the parameters of the models that needs to be estimated.

4. Empirical and Results Analysis

Referring to the existing literature, this paper constructs a simultaneous equations model, and the related estimation methods are mainly from the following two aspects: First, single equation estimation (finite information estimation), mainly instrumental variable method (IV), indirect least square method (ILS) and two-stage least square method (2SLS), etc. These estimation methods are relatively simple to calculate, but the loss of random disturbance term information is easy to estimate (Cadot, 2006). Second, system estimation method or complete information estimation method which based on the whole system of equations. The method can be applied to structural equations with both coincidence and over recognition. It mainly includes full information maximum likelihood estimation (FIML) and three-stage least square method (3SLS) (Jiang Hanming, 2014). This paper is a large sample of data, usually with a normal distribution disturbance term, so 3SLS regression is used.

4.1 Data stationary test

The panel data used in this paper has a long span. Before investigating the regression of variables, avoid regression problems. Unit root test is required to determine data stability. The panel data considers the following AR(1) process:

$$y_{it} = \rho_i y_{i,t-1} + x_{it} \beta_i + \mu_{it}, \quad (i=1, 2, \ldots, N; t=1, 2, \ldots, T)$$

The random error term $\mu_{it}$ between different sections is a random disturbance independent of each other. If the autoregressive coefficient $\rho_i < 1$, it means that the sequence Yi is stable; if $\rho_i = 1$, it means that Yi contains unit root.

The unit root test method of panel data includes LLC method proposed by Levin, Lin and Chu (2002), IPS test proposed by IM, Pesearn and Shin (2003), Fisher test, etc. We need to eliminate the possible effects of heteroscedasticity and avoid the occurrence of pseudo-regression problems. First, logarithmically process the panel data, logarithmically process the data per capita rural wage income (PWI) and record it as lnPWI, and square the per capita land size (PFL) to indicate PPFL.

We used stata14.0 for LLC and ADF tests to derive statistics and associated probability values (Table 2). It is found that the unit root does not exist in the inspection result, and the results of the two methods are the original hypothesis that the concomitant probability rejects the existence of unit root at the same time, indicating that there is no unit root in the variable, and all variables have “first-order single-integration”.

| Test | PTRL | PFL | PMP | PPFL | PGDP | lnPWI |
|------|------|-----|-----|------|------|-------|
| LLC  | -9.03032*** | -6.4965*** | -5.7754*** | -7.9082*** | -7.9082*** | -9.3513*** |
| ADF  | 173.32*** | 128.84*** | 115.53*** | 157.13*** | 156.65*** | 192.45*** |

*p<0.1. ** p<0.05. *** p<0.01.

4.2 Panel data co-integration relationship test

After deriving that, the panel data does not have a unit root, further check whether the data has a co-integration relationship. Two co-integration test methods are used: One is Fisher test based on Johansen co-integration test (Maddala and Wu, 1999). Fisher (1932) successfully used the independent test results of multiple individuals to conduct the overall joint test. The other one is Pedroni test (1999) and Kao test (1999) which based on Engle-Granger (EG) two-step test.

In this paper, Fisher panel co-integration test is used to determine whether there have co-integration relationship between explanatory variables and interpreted variables. The obtained statistics and associated
probability showed that there is a long-term equilibrium stable relationship between LC and LI, which is shown in Table 3. The results of trace statistic test with constant and practice trend indicated that there are at least four linearly independent co-integration vectors; the maximum eigenvalue test also showed that the original hypothesis of co-integration can be accepted at 1% level. It shows that there is a long-term stable equilibrium relationship between variables. And the equation regression residuals are stable. On this basis, the original equation can be regressed directly, and the regression result is accurate.

Table 3. Results of fisher co-integration test

| TEST          | Trace Statistic | Max Statistic |
|---------------|-----------------|---------------|
| None          | 111.1(0.0000)***| 111.1(0.0000)***|
| At most 1     | 485.9(0.0000)***| 485.9(0.0000)***|
| At most 2     | 557.0(0.0000)***| 455.2(0.0000)***|
| At most 3     | 204.1(0.0000)***| 163.9(0.0000)***|
| At most 4     | 142.7(0.0000)***| 142.7(0.0000)***|

4.3 Estimation results and analysis of simultaneous equation models

We used stata14 to conduct the regression of 3SLS simultaneous equations on the processed data. The identification of simultaneous equations must be considered before estimation. In equations (1) ~ (3), PTRL, PMP and PFL are endogenous variables, and the rest are exogenous instrumental variables. As the external objective conditions of the model are given, according to the order conditions and rank conditions of model recognition, it can be known that the set model can be effectively identified, and the results are shown in Table 4.

4.3.1 Quantitative analysis of agricultural mechanization level

Table 4 presents the regression results of quantitative analysis of agricultural mechanization. In the estimation equation, the following variables are used: PPFL, PTRL and PFL which are important factors affect agricultural mechanization. The OLS regression showed that all variables passed the significance test at the 1% level, and the coefficients are -0.034, 6.742 and 0.764, indicated that the influence of all factors on the agricultural mechanization level are stable. The results of two-stage least squares (2SLS), three-stage least squares (3SLS) and iterative 3SLS are not much different. The rural labor transfer ratio (PTRL) and per capita arable land area (PFL) pass the significance test at 1% and 5% respectively, and the coefficients are respectively 7.71, 0.60. With the increase of 10% of rural labor transfer ratio, the per capita agricultural mechanization level would increase 0.771kw. If per capita land area increase 1 mu, the per capita mechanical power would increase 0.60 kW. The finding shows that large-scale land management can promote the agricultural mechanization level. If the other factors remain unchanged, the agricultural mechanization level affected by both land management scale and rural labor migration. With the increase of the transfer proportion of rural labor, the surplus labor in rural areas will be reduced, and the demand for mechanization to replace labor would increase, which has a significant positive impact on improving agricultural mechanization level in China.
### 4.3.2 Analysis of land management scale

According to the three-stage model quantitative analysis of panel data in China, we found that the per capita farmland area (PFL) is significantly affected by rural labor migration ratio (PTRL) and per capita agricultural machinery power (PMP), while the per capita wage income of rural households has no significant impact on land management scale. The least square (OLS) regression of model 2 shows that the PTRL and PMP coefficients of rural labor are -10.18, 0.61. The coefficients of the two-stage least squares (2SLS), the three-stage least squares (3SLS) and the iterative 3SLS estimates have little difference in coefficients. Rural labor migration ratio (PTRL) and per capita agricultural machinery power (PMP) passed the significance test at the 1% level, and coefficients are 22.97 and 2.49 respectively. It means that land management scale is significantly affected by rural labor migration and mechanization level. The estimated results show that for every 10% increase in the proportion of labor migration, he per capita land management scale will increase by 2.297 mu. In particular, the speed of land migration will be accelerated, and the smaller the constraints of land management scale on rural labor. For every 1 kilowatt-hour increase in the power of agricultural machinery per capita, the operating area of land per capita will increase by 2.49 mu. The degree of mechanization promotes the concentration level of rural land management to improve, per capita arable land area also increased. In the 2SLS and 3SLS regression, the control variable of rural household wage income does not significantly affect the land scale, which shows that the land management scale little affected by wage income.
4.3.3 Analysis of rural labour migration

According to model 3 (Table 4) estimation results of rural labor migration, per capita farmland area (PPFL), per capita agricultural machinery power (PMP) and the proportion of agricultural output value in GDP have a positive and significant impact on rural labor migration (PTRL).

The results of model 1 indicates that the proportion of local agricultural output in GDP negatively affects rural labor migration. Meanwhile, with the increase of local agricultural output value, the transfer of rural labor will decrease. According to the estimation of OLS, 2SLS and 3SLS models, the agricultural mechanization level (PMP) is significant at 1% level and the coefficient is 0.2044. The results show that if the per capita agricultural machinery power increase 1 unit, the proportion of rural labor migration would increase by 20.44%. If agricultural mechanization level is improved, it would be conducive to the large-scale operation of agriculture, and replace labor to improve labor efficiency. The better to promote the rural labor migration. When other variables remain unchanged, the coefficient of PPFL is 0.006, the proportion of labor transfer increased by 1 mu per capita cultivated land area increases by 1.2%. The results show that per capita land scale and labor migration have a U-shaped opening-up secondary change relationship. While the business area reaches the scale operation, the rural labor will increase in the form of marginal decline until the labor of each industry reaches saturation.

5. Conclusions and Implications

This Study aimed to explore the impacts of land management scale, rural labor migration and agricultural mechanization level in China. Specifically, drawing upon panel state from 31 provinces since 1999-2014. The research mainly draws the following conclusions:

The results of model 1–3 estimation show that agricultural mechanization level affected by rural labor migration and land management scale. With the increase of the proportion of rural labor migration, the rural surplus labor decreases, which led to the replacement of labor by agricultural machinery. Therefore, promoting rural labor migration has a positive impact on improving agricultural mechanization level in China.

We concluded that land management scale is significantly affected by rural labor migration and agricultural mechanization. The expansion of land management scale would increase the binding on rural labor. However, labor migration will accelerate land transfer speed. What’s more, the improvement of agricultural mechanization speed up the process of intensive management of rural land. Therefore, improving agricultural mechanization level is conducive to large-scale and intensive development of land.

Finally, the agricultural mechanization level has a significant impact on rural labor migration. If agricultural mechanization level is improved, it would be conducive to the large-scale operation of agriculture, and replace labor to improve labor efficiency. The better to promote the rural labor migration. The results show that per capita land scale and labor migration have a U-shaped opening-up secondary change relationship. While the business area reaches the scale operation, the rural labor will increase in the form of marginal decline until the labor of each industry reaches saturation.

Therefore, in order to improve agricultural mechanization level in China, we propose following enlightenment according the above findings and conclusions: First, the policy design should give priority to speed up the process of land titling to ensure improve land production efficiency. Second, we should provide more opportunities for rural labor which will increase farmers’ income. In addition, to improve the level of agricultural mechanization, we should concentrate resources on continuous use, and adapt to the local conditions to adapt to the power chassis and working machinery in hills and mountains.

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