Economic Analysis on the Rational Allocation of Agricultural Production Factors in Henan Province

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Abstract Based on the population floating theory under the Ranis-Fei dual economic structure, this paper designs an econometric model to study the isoquant curve and production factor substitution law. Finally, through the empirical analysis of labor-capital investment in Henan's agricultural production, combined with the principles of isoquant curve model, this paper determines the labor required for a certain scale of investment in agricultural production, and concludes that the fixed assets investment in Henan's agricultural production is not fully utilized, and too much labor is transferred. And this paper makes the corresponding policy recommendations for Henan's macroeconomic development.

Key words Isoquant curve, Allocation of production factors, Policy recommendations

1 Introduction

With the progress of science and technology, the economic development is accelerating, and China's dual economic structure is making the income gap between urban and rural residents continue to gradually expand, thereby forming a powerful pull for rural agricultural labor to transfer into urban areas. China's investment in agriculture is also increasing, and the fixed assets investment in agriculture increased from 165.23 billion yuan in 2003 to 1.347882 trillion yuan in 2013. Are such labor transfer and capital investment reasonable? Based on Ranis-Fei population migration model and the law of diminishing marginal rate of technical substitution, this paper uses econometric software Eviews3.1 for model regression analysis, in order to further discuss this issue.

2 Definition of related concepts

2.1 Ranis-Fei population flow model based on China's national conditions With the advance of China's agricultural modernization, agricultural labor productivity has been greatly enhanced, resulting in an increase of rural surplus labor force, which extends the Ranis-Fei "excess population" stage. Fig. 1 can illustrate this point, and in Fig. 1, *oa*-axis represents the labor input in the agricultural sector, *ob*-axis represents the total agricultural output, and *orcx* curve is the total output curve of the agricultural sector. *orc* segment is curved inwards, which means that with the increase of agricultural labor input, the marginal productivity of agriculture is diminishing; *cx* segment indicates that when the labor in the agricultural sector is increased to a certain extent, the marginal productivity is zero. This means that if we transfer the agricultural labor (*ad* segment) after point *c*, the total agricultural output will not be affected in any way, and such labor with marginal productivity of 0 is called "surplus labor". The wage of agricultural labor should be equal to the per capita level of output in the agricultural sector, and ox represents the wage in the agricultural sector. If a worker's income is lower than average, then his survival will be threatened, and in the agricultural sector, any labor with marginal productivity lower than the average income level is called "surplus labor"[4]. However, in China's rural areas, the population base is large and population is mushrooming, so this population migration model, as well as population growth, is elongated proportionally, thus postponing the arrival of Ranis-Fei population migration turning point. *oo'* segment is the growing population, and cc' is the extended surplus population. The land area and agricultural technology are constant within a certain period of change, so the total output value of the agricultural sector does not change much, and *o'b'* is equal to *ob*. The Ranis-Fei population migration model based on China's national conditions is shown in Fig. 1.

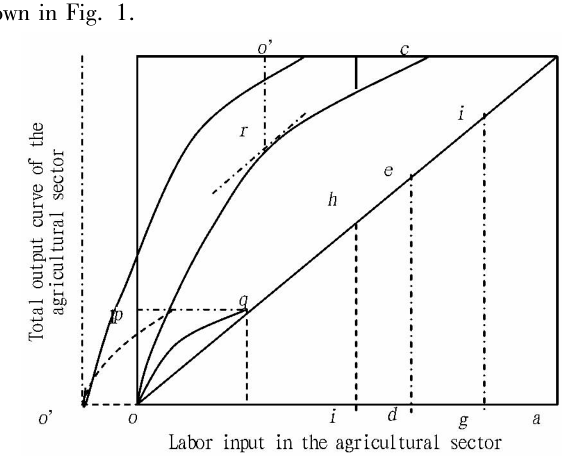

Fig. 1 Ranis-Fei population migration model

2.2 Isoquant curve At the same technical level, isoquant curve is the track of all the different combinations of input into two factors of production with the same output, and the corresponding production function is $Q = f(L, K)$. As shown in Fig. 2, *OL* and

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OK denote the inputs of labor and capital, respectively; *y*-axis denotes the output *Q*. *OKQ'L* is the output curve. Any point on output curved surface represents an output height, and the vertical line between two axes from this point to the *L*-*K* surface indicates the production combination required for the output at this point. For example, *P* is a point on the output curved surface, and it represents output *PP'* = *RR'*. The vertical lines between two axes from *P* to the *L*-*K* surface indicate that the labor input is OL_1 and capital investment is OK_1 for output *PP'*, respectively. Similarly, we can find all factor combinations at the level of output *RR'* in the figure. Assuming *PP'* = *AA'* = *BB'* = *RR'* and using a surface to touch but not intersect the output curve *OKQ'L*, we can get a curve *APB*. *APB* curve represents the trajectory of points for the same output level *RR'* on the output curved surface. By projecting *APB* curve onto the *L*-*K* surface, we get the curve *A'P'B'*. *A'P'B'* curve is the trajectory of a variety of different combinations of two variable factors of production for the same output level *RR'*. For example, the labor and capital investment at point *A'*, *P'* and *B'* brings the same output level, namely *AA'* = *PP'* = *BB'* = *RR'*. *A'P'B'* is an isoquant curve. By converting the isoquant curve in three-dimensional graph into two-dimensional plane coordinates, we get the isoquant curve typically used for the analysis of long-term production function in Fig. 3. Similar to indifference curves, the distance between isoquant curve and the origin of coordinates represents the output level. Any two isoquant curves will not intersect on the same coordinates plane. The isoquant curve is convex to the origin.

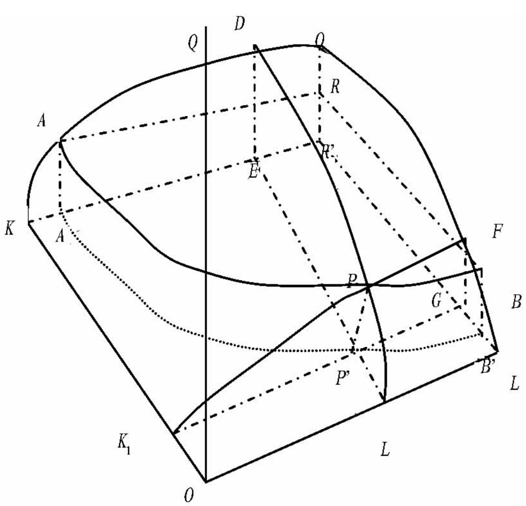

Fig. 2 Isoquant curve in three-dimensional graph

3 Empirical analysis

3.1 Data processing and analysis Before the establishment of the model, we first obtain the data concerning the rural labor engaged in agriculture in Henan Province during 1995-2014 (Table 1). It can be seen from the data that the total output value of the agricultural sector in Henan Province was 130.425 billion yuan in 1995, there were 28.08 million labor forces engaged in agricultural production, and the agricultural fixed assets investment reached 1.856 billion yuan; the total output value of the agricultural sector was 754.911 billion yuan in 2014, there were 24.3918 million labor forces engaged in agricultural production, and the agricultural fixed assets investment reached 126.48 billion yuan. The total output value in agricultural sector went through a 4.8-fold increase, the labor engaged in agricultural production underwent a 0.13-fold decline, and fixed assets investment presented a 68-fold increase, fully proving the effectiveness of large-scale land management and modernized agricultural operation. From the scatter plot of agricultural capital-labor input in Henan Province in Fig. 4, it can be found that over time, the agricultural science and technology have made progress, and the total output value in agricultural sector has continued to increase. During 1995-2003, the total output value in agricultural sector increased steadily; after the implementation of agricultural subsidies in 2003, it began to significantly climb, an increase of about 35.2%; due to the financial crisis in 2008, the export of agricultural products was hindered, but there was still a growing overall trend; at the end of 2014, the total output value in agricultural sector was 754.911 billion yuan, and there were 24.3918 million agricultural labor forces. The trend of total agricultural labor is relatively stable, and it declines at a rate of 2.5%. During 1995-2000, the agricultural labor increased, because the rural population growth rate was not affected by the family planning, rural population grew fast, the fixed assets investment in agriculture was relatively stable and grew at a rate of about 38.7%; from 2010, No. 1 Central Document paid special attention to issues concerning agriculture, farmers and countryside, and the subsidies for farm machinery purchase began to increase substantially. From the general trend of scatter plot, it can be found that the growth of fixed assets investment in agriculture is much faster than the reduction of labor. According to Ranis-Fei population flow model, the total output value in agricultural sector increases with the reduction of total agricultural labor over a certain range; according to the law of diminishing marginal returns, the total output value in agricultural sector is also negatively correlated with agricultural fixed assets investment (under certain conditions).

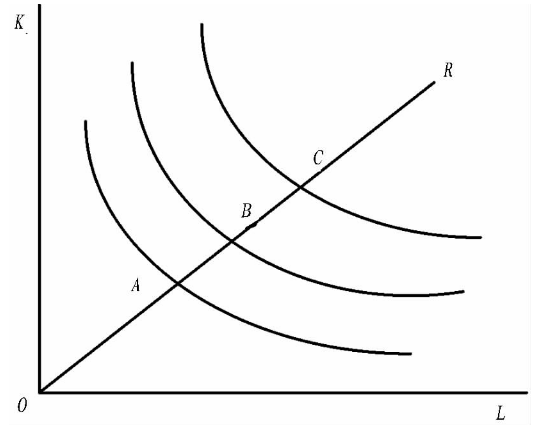

Fig. 3 Isoquant curve on two-dimensional plane

Table 1 The agricultural capital-labor input in Henan Province

Year	y (total output value in agricultural sector) // 10^8 yuan	x (total agricultural labor) // 10^4	x^2	z (fixed assets investment) 10^8 yuan	z^2
1995	1304.25	2808.00	7884864.000	18.56	344.4736
1996	1606.04	2815.80	7928729.640	21.22	450.2884
1997	1710.12	2902.65	8425377.023	22.35	499.5225
1998	1823.01	2940.30	8645364.090	32.16	1034.2660
1999	1906.75	3299.25	10885050.560	39.28	1542.9180
2000	1981.54	3558.55	12663278.100	43.51	1893.1200
2001	2102.79	3472.27	12056658.950	64.15	4115.2230
2002	2194.81	3392.97	11512245.420	54.73	2995.3730
2003	2193.09	3321.24	11030635.140	149.49	22347.2600
2004	2963.92	3234.98	10465095.600	129.51	16772.8400
2005	3309.70	3127.67	9782319.629	166.56	27742.2300
2006	3348.94	3039.48	9238438.670	193.35	37384.2200
2007	3879.93	2909.88	8467401.614	286.02	81807.4400
2008	4669.54	2837.24	8049930.818	256.54	65812.7700
2009	4871.51	2754.21	7585672.724	352.87	124517.2000
2010	5734.20	2698.45	7281632.403	311.47	97013.5600
2011	6218.64	2655.29	7050564.984	641.02	410906.6000
2012	6679.04	2611.18	6818260.992	783.84	614405.1000
2013	7198.08	2521.18	6356348.592	895.91	802654.7000
2014	7549.11	2439.18	5949599.072	1264.80	1599719.0000

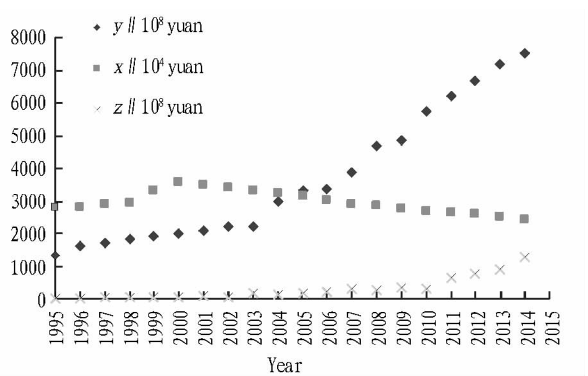

Fig. 4 Agricultural capital-labor input

3.2 Variable and model establishment The production function is $q = f(x, z, n...)$, and the variables represent output, labor input, capital input and land input, respectively. In accordance with the above analysis and Ranis-Fei population flow model, we can find a quadratic linear relation between the total output value in agricultural sector and rural labor, so this paper takes the technological advances and other factors of production as fixed variables, the total output value in agricultural sector as the dependent variable, and the total agricultural labor as the independent variable. We can suppose the model of impact of agricultural labor on production efficiency of agricultural sector as:

$$y = ax + bx^2 + c \quad (1)$$

where y is the total output value in agricultural sector; x is the rural labor engaged in agriculture; a, b, c are the parameters to be estimated.

Based on the data in Table 1, Eviews3.1 is used for model regression, and the regression results are shown in Table 2. From the regression results, it is found that p value of the independent variables x, x^2, and constant regression coefficient is less than 0.05 at the 5% level, indicating that the independent variables x, x^2 are significantly correlated with the dependent variable y. We get $y = -56.1565\,7x + 0.008\,560x^2 + 94\,058.28$, and the adjusted R^2 is 0.679 361, close to 1, indicating that the goodness of fit is high, and this model is reasonable in economic theory. Then according to the law of diminishing marginal returns, it can be found that there is a quadratic linear relationship between the total output value in agricultural sector and agricultural fixed assets investment. Without considering the impact of technological advances and other factors, we can assume the model of impact of agricultural fixed assets investment on production efficiency in agricultural sector as:

$$y = \alpha z + \beta z^2 + u \quad (2)$$

where y is the total output value in agricultural sector; z is the variable of agricultural fixed assets investment; α, β, u are the parameters to be estimated.

The regression is conducted again on the data, and the regression results are shown in Table 3. From the regression results, the p value of independent variables z, z^2 and constant regression coefficient is less than 0.05 at the 5% level, indicating that the independent variables z, z^2 are significantly correlated with the dependent variable y. We get $y = 11.37\,057z + -0.00\,533z_2 + 1448.929$, and the adjusted R^2 is 0.952336, close to 1, indicating that the goodness of fit is high, and this model is also reasonable in economic theory.

3.3 Calculation of agricultural labor According to economic theory, when the marginal productivity is equal to zero, the actual output reaches maximum. Formula (1) is a linear function, on which we can calculate the first-order derivative, to get x value when there is maximum output. The formula is $dy/dx = (a + 2bx)/dx = 0$, and in formula (1), by calculating the first-order derivative of x, we get $y' = -56.15657 + 0.01712x$. When the first-order derivative is equal to 0, the value of x is calculated to be 32801735, indicating that without taking into account technological advances in agriculture, when there are 32801735 people engaged in agricultural production, the total agricultural output reaches a maximum value of 195665240000 yuan, and the per capita output is 5965.088 yuan. The reality is that as of the end of 2014, the total output value in agricultural sector in Henan Province reached 754911000000 yuan, but there were only 24391800 agricultural labor forces, with per capita output level of 30949.376 yuan. Obviously, the data of agricultural labor and per capita output obtained through model are larger than the actual data in 2014. Firstly, this model does not take into account land area changes, and land abandoning, land reclamation, land leveling and land planning will affect the scale of land operation; secondly, this model does not consider the impact of industrialization and urbanization on rural surplus labor; thirdly, this model does not consider the advances in technology; fourthly, there are many factors that affect the transfer of rural surplus labor, such as rural labor preferences and rural labor aging trends[9]; fifthly, the 1995-2014 time data are selected as the model data, and the total output value in agricultural sector and rural labor transfer are vulnerable to national policies and natural disasters. Due to these factors, the calculated number of the labor force engaged in agriculture is 8409935 more than the number of the labor force engaged in agriculture in 2014, and there is a need to calculate the labor required by the agricultural modernization in Henan Province.

Table 2 Model regression results

	Coefficients	Standard error	t-statistic	p-value
Intercept	94058.28	16.17729	-3.471321	0.0029
x variable	-56.15657	0.002685	3.188206	0.0054
x^2 variable	0.00856	24153.60	3.894173	0.0012
R^2	0.713112			
Adjusted R^2	0.679361			

Table 3 Model regression results

	Coefficients	Standard error	t-statistic	p-value
Intercept	1448.929	166.461	8.704312	1.14E-07
x variable	11.37057	0.9854	11.53904	1.83E-09
x^2 variable	-0.00533	0.000855	-6.23493	9.06E-06
R^2	0.957353			
Adjusted R^2	0.952336			

3.4 Calculation of agricultural fixed assets In formula (2), by calculating the first-order derivative of z, we get $y' = 11.37057 - 0.01066z$. When the first-order derivative is equal to 0, the value of z is calculated to be 106665760000 yuan, indicating that without taking into account technological advances in agriculture, when the agricultural fixed assets investment reaches 106665760000 yuan, the total agricultural output reaches a maximum value of 751318170000 yuan. The reality is that as of the end of 2014, the total output value in agricultural sector in Henan Province reached 754911000000 yuan, and the agricultural fixed assets investment reached 126480000000 yuan, with a difference of 19814200000 yuan, and the fixed assets output level was 5.97 yuan, indicating that a large amount of capital has not been fully utilized.

4 Isoquant curve model analysis

According to isoquant curve model concept, the isoquant curve can be divided into two types. One is the relationship between the constant proportion combination of factor input and variable output, and the other is the relationship between the constant output level and the variable proportion combination of factor input. Now we analyze the first kind of relationship. Using the econometric model, we calculate the number of agricultural labor forces in Henan Province to be 32801735, the agricultural total output value reaches a maximum value of 195665240000 yuan, and the per capita output is 5965.088 yuan. In 2014, the total output value in agricultural sector was 754911000000 yuan in Henan Province, but there were only 24391800 people engaged in agricultural labor, and the per capita output level is 30949.376 yuan. Obviously, the labor decreases and the total output value increases, indicating that the capital-labor input is not in the constant proportion combination, so it does not fall within the first relationship. We assume that the proportion of capital-labor input into agricultural production is variable, the isoquant curve represents different output levels, and the longer the distance from the origin, the higher the output levels. The MRTS can be expressed as the ratio of marginal output between the two factors, namely:

$$-dk/dl = MPL/MPK \quad (3)$$

where K and L represent labor and capital, respectively.

Under the constant output levels, the total output increase brought about by labor input increase must be equal to the total output decrease brought about by capital decrease, so $|\triangle LoMPL| = |\triangle KoMPL|$. By putting the first-order derivative of formula (1), (2) into formula (4), we get $\triangle x/\triangle z \approx 1/2000$. Therefore, based on the fixed assets investment in 2014, it requires about 63240000 labor forces, while there are only 24391800 people engaged in agricultural labor, indicating that the agricultural fixed assets investment is not fully utilized in Henan Province, and too much rural labor is transferred. In reality, a large area of abandoned rural land, conversion of agricultural land to non-agricultural land, and agricultural production reduction caused by soil and water pollution, fully demonstrate this point.

5 Conclusions and recommendations

5.1 Conclusions Based on the population floating theory under the Ranis-Fei dual economic structure, this paper designs an econometric model to study the isoquant curve and production factor substitution law. Finally, through the empirical analysis of labor-capital investment in Henan's agricultural production, combined with the principles of isoquant curve model, this paper determines the labor required for a certain scale of investment in agricultural production, and concludes that the fixed assets investment in Henan's agricultural production is not fully utilized, and too much labor is transferred.

5.2 Recommendations It is necessary to improve agricultural land management system, and rationally utilize arable land resources; regulate land consolidation measures, and make rational land use plan; strictly supervise agricultural investment projects, and rationally use agricultural investment funds; vigorously improve the ecological environment, and enhance land productivity effectiveness; innovate upon labor reflux policy, cultivate new occupational farmers, improve agricultural productivity, and promote agriculture to a new level.

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prehensive functions of existing towns in the process of animal husbandry industrialization and strengthen radiation force and area of towns. Specifically, it is required to fully realize functions of small rural towns in promoting industrialized operation of animal husbandry, formulate pertinent incentive and preferential conditions, create favorable environment, actively cultivate secondary and tertiary industrial development of rural towns, cultivate technology, information, management, operation, and education functions of rural towns, to realize their rapid development. (ii) It is recommended to pay attention to organic integration of small rural town construction with local areas in relatively developed areas and areas with higher industrialization level of animal husbandry. The animal husbandry industrialization is in fact marketization. Whether it can realize specialized large-scale production and operation on principle of market labor division lies in marketization of superior livestock and poultry products with regional characteristics. Therefore, for small rural town construction in developed breeding areas, it is required to adapt to industrialized development of animal husbandry, integrate overall distribution of rural towns, and make reasonable plan to satisfy demands of urban economic development and residents' living standards for livestock and poultry products, and build small rural towns integrating various characteristic functions, livestock and poultry product production, processing, and circulation with reasonable and scientific distribution.

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