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Analysis of Migration Decisions of Chinese Japonica Rice Farmers: Estimation of Internal Wage on Output Supply Using Agricultural Household Model

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Summary

This paper examines the migration decisions of Chinese Japonica rice farmers in terms of wage gaps. We use a non-separable agricultural household model to estimate the internal wages of the output supply. As a result, internal wages, which denote the reservation wages of Japonica rice cultivation, are substantially lower than market wages in Japonica rice production and the wage levels in township and village enterprises. Furthermore, we find that internal wages are substantially lower than the wage levels in the urban construction sector. Finally, we analyze the separation property in this agricultural household model. The test for equality of means between internal and market wages is rejected at a 1 % level of significance. We conclude that an efficient labor market does not yet exist in rural China.

JEL classification: J31, Q11, R23

Keywords: Migration, Wage gap, Internal wages, Agricultural Household Model

1. Introduction

After 1978, the decollectivization of the People's Commune System and the introduction of the Household Responsibility System enormously changed rural China. One of the biggest changes was the start of a massive migration of rural surplus labor. Under the collective farming system, redundant labor in agricultural production had been prohibited from leaving rural areas. However, in the early 1980's, after the introduction of the Household Responsibility System, rural labor rapidly flowed into urban industrial sectors and Township and Village Enterprises (TVEs). In the 1990's, as intense competition among TVEs occured, a number of TVEs exited the market. At the same time, surplus labor was allowed to migrate from villages to urban areas without changing household registration (*hukou*) status. As a consequence, rural residents who worked in urban areas rapidly increased. According to the National Bureau of Statistics of China,[1] the number of migrant workers exceeded 145.3 million at the end of 2009. On the other hand, a shortage of workers surfaced in the Pearl River delta region in 2004. After that, the entire eastern coastal region faced the same situation. Cai (2007a, and 2007b) argued that surplus labor had disappeared from the entire country, meaning that the turning point discussed in Lewis (1954) had been exceeded. The controversy grew concerning whether the Chinese economy had already reached its turning point.

The Lewis model assumes that surplus labor migrates from the rural agricultural

[1] http://www.stats.gov.cn/tjfx/fxbg/t20100319_402628281.htm

to the urban industrial sector. But migration also happens among rural agricultural sectors. In China, after 1998, *The Data Collection of the National Farm Production Costs and Returns* recorded the working hours of workers who migrate among rural agricultural sectors. Their hours have been increasing.

Why did migration occur from rural to various other sectors? In the empirical literature, analyses have been conducted in two different ways. First, a set of papers investigated wage gaps among sectors. Some used Lewis model to estimate wage gaps between rural and industrial sectors (e.g., Yang and Zhou (1999), Meng (2000), and Minami and Ma (2009)). Others used the agricultural household (hereafter AH) model to evaluate reservation wages in agricultural sectors (e.g., Cook (1999), Hoken (2000), and Zeng (2005)). The authors who utilized the AH model also analyzed the wage gap by comparing reservation wages with wage levels in industrial and non-agricultural sectors. Second, another set of papers analyzed the effect of relevant variables on migration decisions. Zhao (1997) and Zhang, Huang and Rozelle (2002) studied the effects of education on migration decisions. Zhu (2002) used published income data to examine the effect of income gaps between rural and urban areas on migration decisions. Wu and Yao (2003) analyzed the effect of the characteristics of Chinese institutions on migration decisions. Others analyzed the effects of education and such characteristics as family members, household, and community on migration decisions (e.g., Hare (1999, 2002), Zhao (1999), and Lu and Song (2006)).

This paper is most closely related to the estimation of the wage gap using the AH model. Papers conducted by the first method[2] use published macro and micro data to estimate farmer's on-farm wage levels. In macro data analysis, Yang and Zhou (1999) used panel data for 1987-1992 collected from the *China Statistical Yearbook (CSY)* and rural and urban household surveys and examined whether economic reforms reduced rural-urban segmentation. They employed the Lewis model to estimate the marginal value productivity of labor (MVPL) in the agricultural sector, TVEs, and state-owned enterprises (SOEs) at the national level. Their result shows that the MVPL in SOEs is higher than in the rural industries and agricultural sectors. This suggests that sectoral wage disparities cause migration from agricultural sectors to TVEs and SOEs. Consequently, they concluded that economic reforms failed to correct urban bias. Meng (2000) used panel data for 1984-1990 collected from *CSY* and a survey conducted by the Rural Development Center of China and the World Bank on 300 TVEs. He also employed the Lewis model to compare MVPL in TVEs with agricultural returns to labor. The comparison result indicates that the agricultural returns to labor is substantially lower

[2] In these papers, they refer to working in the non-agricultural sector without moving away from their place of residence as "non-farm work". On the other hand, work in the urban industrial sector by moving away from their place of residence is "migration". In this paper, we refer to both as "migration" in a broad sense.

than the wage level in TVEs. The wage gap was increasing. Minami and Ma (2009) used time series-cross section data for 1990-2005 from *the China Rural Statistical Yearbook (CRSY)*. They also utilized Lewis model to compare MVPL in agricultural sector with the level of subsistence wage. (the net per capita income for rural residents and per capita rural household expenditures) They showed that MVPL is substantially lower than subsistence wage. They concluded that agricultural sector in China still have surplus labor, which implies that the Lewisian turning point had not been yet exceeded.

In micro data analysis, Cook (1999) used household survey data conducted in Shandong Province in 1990 and employed an AH model to estimate production functions in agricultural and non-agricultural sectors. The household data included crops (wheat, corn, and cotton), fruit cultivation, and animal husbandry. She found the marginal return in agricultural sectors is substantially lower than the marginal returns in non-agricultural sectors. Furthermore, the result shows the marginal return in non-agricultural sectors approximate the non-agricultural wage rate and indicates that the labor market in this region might be efficient in the non-agricultural sector.

Hoken (2000) used household surveys conducted in Hubei Province in 1979 and 1985 and employed an AH model to analyze the migration decisions of farmers from agricultural to non-agricultural sectors. One of his contributions is to estimate the husband and wife production function of crop cultivation. Using MVPL to calculate the annual income level of crop cultivation, he found that its income level in 1979 was higher than non-agricultural wages for both genders. However, in 1985, the income level in crop cultivation was substantially lower than non-agricultural wages. This is consistent with the rise of the Gini coefficient between 1979 (0.197) and 1985 (0.257) in this region. Hoken argues that the expansion of the non-agricultural sectors resulted from economic reform and a corresponding reallocation of labor, which caused an income disparity among households. On the other hand, he also analyzed the effect of education levels on crop cultivation and the non-agricultural labor supply and showed that education for both genders is not significantly positive in crop cultivation. But in the non-agricultural labor supply, the wife's level of education is significantly positive, but not the husband's level.

Zeng (2005) used a North and Northeast China Living Standard Survey coordinated by the World Bank in 1995. The data includes agricultural production and crop cultivation. He employed an AH model to analyze the effect of the non-agricultural labor supply on production efficiency and simultaneously analyzed the production efficiency of the non-agricultural labor supply. The result shows that variables related to the differences of human capital (e.g., education and job training) affect the labor supply of the non-agricultural sectors. Zeng also argues that a free transaction of farmland accelerates the labor supply in non-agricultural sectors.

Note that these studies employ the AH model with a separable property, which means that a farmer's production decision is independently determined regardless of his preferences and endowments. It assumes that a competitive market exists. However, we need to examine whether the assumption is appropriate. Cook (1999) carried out a equality test of the means between the marginal revenue product of labor in on-farm and off-farm work. The result shows that the returns to labor in agriculture are lower than the returns to labor in other non-agricultural activities. Hoken (2000) verified the effect of family characteristics on the non-agricultural labor supply. Consequently, since education and expanded family variables affect the non-agricultural labor supply, the separation property is rejected. Hoken concludes that efficient labor allocation is not always achieved in the sample region. Zeng (2005) also analyzed the effect of family characteristics on the non-agricultural labor supply and confirmed that the separation property is rejected because the variables of human capital affect the labor supply in the non-agricultural sectors.

As seen above, most previous literatures used data that included a broad agricultural sector, and assumed that migration decisions are homogeneous among various types of farmers. However, differences might exist in production technology and migration decisions among agriculture, forestry, fishery, and animal husbandry.[3] In micro data analysis, Hoken (2000) and Zeng (2005) estimated the production function of crop cultivation. But naturally differences are seen in production and consumption decisions among farmers of rice, wheat, corn and others. None of the papers analysed migration decisions in a specific crop cultivation. At the same time, these papers analyzed migration decisions from agricultural to non-agricultural and urban industrial sectors. None analyzed migration decisions from relatively poor agricultural to relatively rich agricultural sectors.

This paper utilizes the non-separable AH model constructed by Sonoda and Maruyama (1999) to analyze Chinese farmers engaged in Japonica rice cultivation.[4] Based on estimation of the production function, we calculate the reservation wages of Japonica rice farmers to examine migration decisions in terms of wage gaps among

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[3] In the definition of the Chinese statistics, "agriculture" in a broad sense includes not only agricultural production but also forestry, fishery, and animal husbandry. For example, in *CSY* "agriculture" describes *nong lin mu yu* (agriculture, forestry, animal husbandry and fishery). Additionally, "farmer" (*nong min*) indicates inhabitants in rural areas in all Chinese statistics. It does not always mean that "farmers" indicate labors who only engage in on-farm work. In recent years, *CRSY* published the classified data by sector.

[4] After the implementation of the household responsibility system for management (*bao gan dao hu*), farmers in China could voluntarily select which farm products to produce. Therefore, if we analyze farmer production decisions using micro data, we must consider sample selection bias. However, we ignore this problem, because we are examining aggregate production decisions at the provincial level.

sectors using macro data. To analyze this argument, we compare reservation wages with market wages in the production of Japonica rice, wages in TVEs, and wages in the urban construction sector. Sonoda and Maruyama (1999) demonstrated that the reservation wages on the output supply are lower than market wages of rice cultivation in Japan. The result provides a general explanation of migration decisions from agricultural to various sectors in terms of wage gaps.

In this paper, we assume that migration opportunities are constrained. Under this assumption, we can estimate the reservation wages on the output supply, and conduct a separability test of the AH model. The estimation method in the AH model and the separability test in our AH model are discussed below.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical background of the AH model and constructs an AH model based on Sonoda and Maruyama (1999). Section 3 describes the data and the compilation method of the variables. Section 4 presents the estimation method and the empirical results. Section 5 shows the calculation of internal wages of Japonica rice cultivation and the test results of the separable property of our AH model. Finally, Section 6 provides some concluding remarks.

2. Model

2.1. Theoretical background

The AH model prototype was formed by Tschajanow (1923), who argued that agricultural production decisions depend on consumption choices of peasant farmers. Under the influence of Tschajanow's analysis, Tanaka (1951) established the AH model as a subjective equilibrium model, which Nakajima (1956) extended to analyze imperfect agricultural input markets. Yori (1971) also developed an analysis of imperfect agricultural production markets. On the other hand, in western academic societies, based on the insightful work of Becker (1965), researchers constructed an AH model. Japanese papers had not been fully recognized because they were only published in Japanese. However, Singh et al. (1986) introduced early works written in Japanese as the founding work in the AH model that analyzed imperfect labor markets. Strauss and Thomas (1995) also described Tanaka (1951) and Nakajima (1957) as pioneering works that ranked with Becker (1965).

As mentioned previously, the AH model has two types: a separable and a non-separable model. The former has a separable property in which production and consumption decisions are independently determined under the competitive markets. Imagine that the rice market is competitive. Then the results of the following two behaviors are identical in their consumption decisions: to consume goods produced by themselves and to consume goods purchased from markets. The price of rice is stabilized under a competitive market.

On the other hand, in the non-separable model, production decisions cannot be separated from consumption decisions under imperfect markets because household preferences influence the former. Non-separable models are frequently utilized by the analysis of agricultural households in developing countries because we can incorporate various types of markets failures and imperfect markets in this model.[5]

In this paper, we assume imperfect labor markets in China. Controversy continues whether a competitive labor market has already emerged in rural China.[6] But none of the papers show that an efficient labor market has emerged in the entire country. In reality, minimum wages among provinces remain unequal. Therefore, when we conduct macro data analysis, assuming that the labor market is not efficient might be practical.

We also assume that migrant wage employment is constrained. The first paper that incorporated constrained migrant employment into the AH model is Arayama (1986). He first assumes unconstrained off-farm employment under competitive labor and product markets to analyze the time allocation of Japanese farmers. Although the estimated result is consistent with the actual time allocation in off-farm employment, the separable property is strongly rejected. In response to the result, Arayama assumes constrained off-farm employment due to the following two reasons. First, farmers maintain a certain level of working hours in on-farm work. Second, there are few opportunities to find off-farm employment in some regions. Under these assumptions, the separable property is supported by the test.

Sonoda and Maruyama (1999) extend these studies to analyze the effect of internal wages on output supply using the AH model with constrained off-farm wage employment and show that a rise in the price of rice decreases rice output by the internal wage effect.[7]

As mentioned above, we assume that migrant wage employment is constrained, based on Sonoda and Maruyama (1999) and that migrant wage employment is constrained in China for the following reasons. First, farmers work in TVEs or urban

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[5] For example, Udry (1998) employs a non-separable AH model to analyze inefficient labor and land market. Kurosaki and Fafchamps (1998) also utilize a non-separable AH model to analyze market failures for which a complete set of contingent securities does not exist.

[6] For example, Parish, Zhe, and Li (1995) demonstrate that an efficient labor market has emerged around big cities and the east coastal region. On the other hand, Yao (1999) shows that farmers who want to work in the non-agricultural sector face entrance and time rationing in labor markets. Johnson (1995) argues that the entrance of the urban labor market is restricted for rural migrants, due to deficiencies in social benefits, medical services and educational systems for migrant workers.

[7] In this paper, we use internal wage as a synonym for reservation wage.

sectors in the off-farm season.[8] Second, the deficiencies in social benefits, medical services, and educational systems for migrant children discourage farmers from moving to urban areas. For these reasons, we consider that migrant wage employment of farmers is constrained.

2.2 Model

Next, we construct a AH model that deeply reflects Sonoda and Maruyama (1999). The welfare function of households presented as follows:

$$W = U(C_1, C_2, Z), \tag{1}$$

where $U(\cdot), C_1, C_2$, and Z denote the utility function, the amount of a home-produced good, purchased goods, and leisure, respectively. The welfare function is assumed to be well behaved in the usual sense. The household allocates its endowed time. We also assume the migrant wage employment is constrained:

$$L_2 = Te - Z - L_1 \leq L = \text{constant}, \tag{2}$$

where L_1, L_2, Te, and L denote the hours of on-farm work, migrant work, leisure, the endowed time, and the maximum hours of migrant work, respectively. The constrained household budget satisfies:

$$pC_1 + p'C_2 + wZ + S + TAX \leq M, \tag{3}$$

where $p, p', w, S,$ and TAX denote the price of a produced good, purchased goods, and the market wage, savings, and taxes, respectively. M denotes the entire income of the household defined as:

$$M \equiv wTe + \pi + V, \tag{4}$$

where $\pi = pX - wL_1 - qF - OC.$

Equation (4) shows that the household's entire income consists of the value of endowed time (wTe), the profit function of home-produced good (π), and unearned income (V). The revenue of home-produced good (π) is defined above. q, F and OC denote the price of material inputs, their quantity, and other costs. The household produces a quantity of Y. The quantity of produced good C_1 does not exceed the quantity of Y. Y is bounded by production possibility:

$$Y \leq f(L_1, F; K, T), \tag{5}$$

[8] In fact, the number of migrant workers who spend whole of the year working in another sector or district (including entire family exoduses (*ju jia li cun*)) is huge in micro level. According to the Department of Rural Surveys National Bureau of Statistics (2005), the number of entire family exoduses was 24.7 million in 2004. This accounts for about 20% of the number of migrant workers. But, we ignore the decision of year round migration in this paper. Because we consider aggregate production decisions, we don't assume that the hours of on-farm work equals zero.

where K and T denote the capital input and planting area of a home-produced good. Production function $f(\cdot)$ is assumed to be well behaved in the usual sense.[9]

The following are the Kuhn-Tucker Lagrange optimality conditions:

$$\partial\ell / \partial L_1 = \mu + \lambda(p\partial f / \partial L_1 - w) \le 0 \tag{6.1}$$

$$\partial\ell / \partial F = \lambda(p\partial f / \partial F - q) \le 0 \tag{6.2}$$

$$\partial\ell / \partial C_1 = \partial U / \partial C_1 - \lambda p \le 0 \tag{6.3}$$

$$\partial\ell / \partial C_2 = \partial U / \partial C_2 - \lambda p' \le 0 \tag{6.4}$$

$$\partial\ell / \partial Z = \partial U / \partial Z + \mu - \lambda w \le 0 \tag{6.5}$$

$$\partial\ell / \partial\lambda = pf(L_1, F, K, T) - wL_1 - qF - OC - pC_1 - p'C_2 - wZ - S - TAX \le 0 \tag{6.6}$$

$$\partial\ell / \partial\mu = L - Te + Z + L_1 \le 0, \tag{6.7}$$

where they are assumed to satisfy the nonnegative conditions in each variable. Equations (6.1), (6.3), and (6.5) imply that

$$p\frac{\partial U / \partial Z}{\partial U / \partial C_1} = w - \mu / \lambda = p\partial f / \partial L_1. \tag{7}$$

We define $w - \mu/\lambda = w* \le w$ and $w*$ as the reservation wages of the output supply.[10] Why is $w* \le w$ satisfied theoretically? Sonoda and Maruyama (1999) adopted the efficiency wage hypothesis proposed by Shapiro and Stiglitz (1984). The efficiency wage hypothesis in the context of the non-separable AH model means that employers pay workers higher wage (w) than their reservation wage ($w*$) for on-farm work to encourage workers not to shirk. If they are caught by shirking and fired, they have to pay a penalty between their reservation wage of on-farm work and their market wage. At the same time, imagine that workers follow suit. Now, workers who become unemployed are willing to work for wages lower than the market wage. But the employer doesn't want to hire at the lower wage, because he or she thinks that workers will inevitably shirk under the market wage level. Therefore, workers believe their employment is constrained by market wages including efficiency pay. It seems true that a wage gap exists between the agricultural sector and the non-agricultural and urban sectors in China.

The entire income and profit function based on reservation wages can be rewritten as follows:

$$M* \equiv w*Te + (w - w*)L + \pi* + V, \tag{4.1}$$

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[9] If we analyze the micro data, then we must consider the production minimum goal in a dual price system. Under the system, farmers receive incentive for higher cultivation, because they can freely sell their products after achieving the production target. We ignore this to consider aggregate production decision.

[10] Sonoda and Maruyama (1996) explain that μ / λ denotes the amount of discount that can be allowed. If they cannot utilize the opportunity of off-farm employment, they must input all their working hours in on-farm work. In this case, their marginal product of the labor or their demand wage level is lower than the market wage. The amount of discount turns out to be μ / λ.

$\pi^* \equiv pX - w^* L_1 - qF - OC.$

The second term of the right hand side in Equation. M^* presents the difference of the value of the maximum hours of migrant work in terms of w and w^*. Consequently, Equation (4.1) is identical with $M^* \equiv w^* L_1 + wL_2 + w^* Z$.[11] Finally, Equation (7) offers a useful device to test whether the household's migration employment is constrained, because when the migration hours are constrained, reservation wage w^* influences the household's production and consumption decisions.

3. Data Compilation Method and Sources

The data used in this paper are mainly taken from *the Data Collection of the National Farm Production Costs and Returns* and *the Data Collection of the National Farm Production Costs and Returns: After the Establishment of a Nation 1953-1997 Vol.2.* (FPCRS hereafter). According to Chen and Niu (1989), the aim of the national cost survey of farm production was to collect the cost data of inputs in agricultural production. After 1949, the survey was conducted by the State Development Planning Commission, because the data are essential to determine the prices of agricultural products. The survey is now continued by the National Development and Reform Commission. In the sampling method, they select typical prefectures in each product. Then in each prefecture, villages or groups of villages are selected. Finally, farm households are chosen among the villages.[12]

The observations cover periods from 1992 to 2008. The data compilation method of the variables is shown in Table 1. We used the data from Liaoning, Jilin, Heilongjiang, Hebei, Jiangsu, Anhui, Henan, and Yunnan Provinces. The sample size was 135.[13] The following variables were employed in the production decision; the output of Japonica rice is used as the explained variable. Explanatory variables include capital input, working hours, material input, and the planting area of Japonica rice.

4. Estimation Strategy and Empirical Results

We first estimate the production functions in each province and then conduct pooling regression using all observations. In these estimations, the production function is specified by the following form:

[11] We can also solve a non-separable AH model with internal wage. See Sonoda and Maruyama (1996, and 1999).

[12] In the early 1990's, Colby, Crook, and Webb (1992) pointed out that the reliability of the survey data has been questioned. For example, the sample size is extremely small for the non-randomness of the sample.

[13] The data of Jiangsu in 1992 is absent.

Table 1. Definitions of Variables in Production Decision

Variable	Unit	Symbol	Compilation method
Output of Japonica rice	Kilogram	Y	We use a category of output of Japonica rice.
Capital input		K	Capital input is evaluated by dividing its cost by the capital price index. The total cost is calculated by the sum of the costs of farm implements, farm machinery, and animal labor. The capital price index is constructed by weighing individual prices with their respective shares in the total cost.
Working hours	Hour	L_1	We used the published data of hours of family labor. But, before 1997, total hours of farm labor are only available. Total hours of farm labor include working hours of hired labor and family labor. For convenience, we constructed the data of hours of hired labor in the following manner. First, we annually calculated the ratio of hours of hired labor to total hours of farm labor from 1998 to 2008. Then we produced the hours of hired labor by multiplying the published total hours of farm labor from 1992 to 1997 by the average ratio of hours of hired labor. Finally, we generated hours of family labor by subtracting hours of hired labor from total hours of farm labor.
Material input		F	The material input is calculated by dividing the total cost of material input by the material price index. The total cost of material input is the sum of the costs of seeds and seedlings, pesticide, chemical fertilizer, agricultural film, and fuels. The material price index is calculated by weighing individual prices with their respective cost shares of the total cost. The price of seeds and seedlings is obtained by dividing the cost by the quantitiy in each year. The price of pesticide in 1994 is absent. Therefore, we used the price of pesticide and its appliances instead of the price of pesticide.
Planting area of Japonica rice	Hectare	T	We take the planted areas from the *Historical Outline of National Agricultural Statistics* (http://www.agri.gov.cn/sjzl/nongyety.htm). We can only use data for three years: 2001-2003. First, we calculated three-year averages of the ratio of the planting areas of Japonica rice to the planting areas of rice. Then we made absent data by multiplying the ratio by the planting area of rice.

Notes: (1) We use 1992 as the base year by which the price indices of the capital and material input were calculated. The price data are obtained from the *Market Statistical Yearbook of China (1993-2003) and CRSY* (2004-2008).

(2) The data were adapted from *FPCRS*. In these data, all variables are deflated by unit planting areas. To use planting area as a variable, we multiplied each variable by the planting areas of Japonica rice.

(3) Farm machinery and animal labor are only utilized in agricultural production.

$$\log Y = \beta_0 + \beta_1 \log L_1 + \beta_2 \log K + \beta_3 \log F + \beta_4 \log T + u, \quad (8)$$

where β_0 denotes a constant term and u an error term.

Second, we analyze the panel fixed and random effects with the following estimation model:

$$\log Y_{it} = \alpha + \beta \log L_{1it} + \gamma \log K_{it} + \delta \log F_{it} + \eta \log T_{it} + \nu_i + \xi_t + \varepsilon_{it}, \quad (9)$$

where i and t show indices of provinces and years, α means a constant term, ν_i a unobserved time invariant province effect, ξ_t a common regional trends and ε_{it} an error term. We carry out a Hausman (1978) specification test on the panel data to determine whether to employ a fixed or a random effect.[14]

The estimated coefficients are shown in Tables 2 and 3. In Table 2, the OLS results in each province show that the small sample size seriously affects the regression. In Table 3, it shows that all coefficients are statistically significant in the pooling regression. In this estimation, the negative effects caused by the shortage of observations are seemingly avoided. The coefficients of β_1 and β , which are significant in this regression are positive. Table 4 shows the estimated result in previous studies that utilized macro panel data for comparison. The elasticitiy of working hours in two-way fixed effect model is close to the results of Tian and Wan (2000) and Zhang and Fan (2001). We briefly describe the general condition of Japonica rice production in present China to understand the estimated result. The output of Japonica rice gradually rose during the observation period. On the other hand, the working hours of Japonica rice farmers in on-farm work have decreased due to the increase of migrant work. Material input rose rapidly because of the infertile land in China. In particular, the input of agricultural chemicals rose greatly. In recent years, agricultural machines replaced draft animals. It might improve production efficiency of capital. However, capital input increased during the period, because agricultural machinery, which is suitable for natural conditions in China, has been underdeveloped. Finally, the planted area of Japonica rice cultivation decreased. Under these circumstances, the estimated elasticities of each explanatory variable in a two-way province fixed effect model seem reasonable.[15]

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[14] We calculated robust Hausman test statistic proposed by Wooldridge (2002).

[15] We conducted a Hausman specification test as a pretest of the random effects specification. The result supports a fixed effect model. In addition, Guggenberger (2010) showed that the size distortion is caused mainly by the poor power properties of the test. In that sense, it is reasonable to use the coefficient of two way fixed effect model.

Table 2 Estimated Results of Equation (8)

	Liaoning		Jilin		Heilongjiang		Hebei	
Constant	-1.4464	(2.2080)	3.7216***	(0.5132)	1.5244	(0.9436)	1.8071***	(0.5343)
Log (working hours)	0.0647	(0.1489)	-0.1892**	(0.0741)	-0.0035	(0.1176)	-0.2447	(0.4227)
Log (capital input)	-0.0534	(0.1139)	0.077	(0.0457)	0.2068**	(0.0830)	0.2536	(0.2551)
Log (material input)	0.0542	(0.0752)	0.0237	(0.0438)	-0.0165	(0.1031)	0.1303	(0.1731)
Log (planting area)	1.4845***	(0.3742)	0.8306***	(0.0906)	0.8746***	(0.1809)	1.0022	(0.6391)
Observation	17		17		17		17	
R-squared	0.9228		0.9848		0.9891		0.8871	
Adjusted R-squared	0.8970		0.9797		0.9854		0.8494	
	Jiangsu		Anhui		Henan		Yunnan	
Constant	1.2358	(0.8367)	0.352	(1.1963)	-3.5461	(2.4761)	-2.1326	(2.3714)
Log (working hours)	-0.4325	(0.3801)	-0.0065	(0.2193)	0.157	(0.1580)	0.242	(0.1824)
Log (capital input)	-0.1686	(0.1842)	0.1806**	(0.0731)	-0.1947	(0.1841)	0.3867***	(0.1128)
Log (material input)	-0.2725	(0.2033)	-0.089	(0.1328)	0.1242	(0.1829)	-0.0535	(0.1505)
Log (planting area)	1.9914**	(0.7168)	1.1822***	(0.3019)	2.0339**	(0.6761)	1.1042***	(0.3575)
Observation	16		17		17		17	
R-squared	0.9398		0.9372		0.6920		0.7989	
Adjusted R-squared	0.9179		0.9163		0.5894		0.7319	

Note: Significance: * 10 percent, ** 5 percent, and *** 1 percent.
Standard errors are shown in parentheses.

Table 3 Estimated Results of Equations (8) and (9)

	(1)		(2)		(3)	
Constant	2.1085***	(0.2088)	1.3529**	(0.4239)	1.8407***	(0.2797)
Log (working hours)	0.1103**	(0.0393)	0.0534	(0.0367)	0.0504	(0.0314)
Log (capital input)	0.2438***	(0.0674)	0.1430**	(0.0430)	0.1654***	(0.0458)
Log (material input)	0.0956**	(0.0347)	-0.0072	(0.0342)	-0.0015	(0.0364)
Log (planting area)	0.5588***	(0.1123)	0.9269***	(0.0752)	0.8247***	(0.0711)
Province fixed effects	No		Yes		No	
Province random effects	No		No		Yes	
Province year effects	No		No		No	
Observation	135		135		135	
R-squared	0.9866		0.9836		0.9844	
Robust Hausman test					F(4, 7)=16.37 Prob>F=0.0012	

	(4)		(5)	
Constant	0.8840*	(0.3925)	1.4221***	(0.3431)
Log (working hours)	0.1547**	(0.0624)	0.1253**	(0.0534)
Log (capital input)	0.05	(0.0423)	0.0758	(0.0511)
Log (material input)	0.0477	(0.0491)	0.054	(0.0558)
Log (planting area)	0.9093***	(0.0594)	0.8242***	(0.0647)
Province fixed effects	Yes		No	
Province random effects	No		Yes	
Province year effects	Yes		Yes	
Observation	135		135	
R-squared	0.9847		0.9859	
Robust Hausman test			F(4, 7)=16.40 Prob>F=0.0012	

Notes: Significance: * 10 percent, ** 5 percent, and *** 1 percent.

Standard errors are shown in parentheses. We compute standard errors that are robust to clustering by provinces.

Table 4 Estimated Result of Production Function in Previous Studies

Authors	Data source	Dependent variable	Period	Estimated elasticity capital	labor	material	land
Tian and Wan	FPCRS	Yield of Japonica rice per 1 mu.	1983-1996		0.021～0.086	0.139～0.238	
Zhang and Fan	CRSY, etc.	Adjusted VA of grain cultivation	1979-1997	0.167, 0.247	0.173, 0.234	0.081, 0.140	0.408, 0.143
Kang and Liu	FPCRS	Output of Japonica rice	1992-2002	-0.17	-0.05	0.2	0.96

Sources: Tian and Wan (2000, p.167 Table 3), Zhang and Fan (2001, p.386 Table 5), Kang and Liu (2005, p.29 Table2).
Notes: (1) VA is an abbreviation for Value Added.
(2) 1 mu equals one-fifteenth hectare.
(3) Zhang and Fan (2001) use a generalized maximum entropy approach. Kang and Liu (2005) estimate the stochastic frontier model. In terms of specifications of the production function, Zhang and Fan use translog and Cobb-Douglas types, and Tian and Wan, and Kang and Liu translog type.

5. Estimation of Internal Wages and Test of Separable Property of AH Model

5.1 Estimation of internal wages

Internal wages are estimated by the following relation:

$$w^* = \hat{\beta}\ p\hat{Y}/L_1, \qquad (10)$$

where $\hat{Y}$ is a theoretical value of Y. As a result of a Hausman specification test, we adopted the estimated coefficients in a two-way fixed effect model. The estimated results are shown in Table 5. The estimated internal wages on Japonica rice production supply are substantially lower than market wages in each province. The internal wages in the east coastal and northeastern regions are relatively higher than those of the central and internal regions. Since planted areas are extensive in northeastern China, relatively capital intensive farming is conducted. In the east coastal regions, relatively capital intensive farming might also be conducted because of the lower capital input prices.

Table 6 compares the estimated internal wages in the previous studies. The internal wages of Japonica rice production are higher than the internal wages of agricultural production and crop cultivation. One possible reason why the internal wages of Japonica rice production supply are relatively higher than other crop cultivation is that the unit price of Japonica rice is higher than other crops.

Next, we examine the migration of peasants from Japonica rice cultivation to TVEs and the urban sector. As proxies of the wage levels in TVEs and the urban sector, we utilize the annual wages of TVEs and the urban construction sector. For wages in the urban construction sector, we chose Beijing, Shanghai, and Guangdong because they are the major destination cities for migrant labors. For convenience, we calculated the annual maximum internal wage level by multiplying the estimated internal wage by 365 (days) minus 62 (holidays) times 8 (hours). Table 7 shows the results. Consequently, the internal wages are substantially lower than the wage levels in TVEs and the urban construction sector except Heilongjiang.[16] [17]

Table 5 Estimated Internal Wage (unit:Yuan/hour)

Province	Internal wage		Market wage(*)	
Liaoning	1.640	(0.771)	3.357	(0.800)
Jilin	1.605	(0.933)	2.782	(1.089)
Heilongjiang	2.060	(1.101)	3.490	(1.674)
Hebei	1.177	(0.366)	3.206	(1.801)
Jiansu	1.589	(0.741)	3.314	(1.169)
Anhui	0.913	(0.378)	3.512	(1.191)
Henan	0.927	(0.515)	2.432	(1.418)
Yunnan	0.648	(0.280)	2.384	(0.794)
All	1.318	(0.811)	3.058	(1.329)
Minimum	0.207		0.925	
Maximum	4.446		8.650	

Source: (*) We adopted market wages from the data published in *FPCRS*. But since the data are unavailable for 1992 to 1997, we estimated them by deflating existing market wages by the rural residents consumer price index. The consumer price index is obtained from *CRSY*.
Note: Standard errors are shown in parentheses.

Table 6 Estimated Results of Internal Wages in Previous Studies (unit: Yuan/hour)

Author	Data	Area	Year	Internal wage	Std.Dev	Min	Max
Cook	agiruculture	Zouping county, Shandong	1990	1.231	1.032	0.239	9.91
Zeng	agriculrure, crop	Northern Hebei, northeast Liaoning	1995	1.13, 0.33	1.56, 0.56	0.02, 0.003	18.57, 6.13

Sources: Cook (2000, p.32 Table 5), Zeng (2005, p.148 Table 6-7).
Notes: (1) Cook (2000) used agricultural data, including wheat, corn, cotton, vegitables, fruit, and animal husbandry. Zeng (2005) used agricultural data, including crop, vegitables, fruit, and animal husbandry.
(2) The elasticities of working hours are 0.097 in Cook (2000), 0.16 (agriculture) and 0.03 (crop) in Zeng (2005).

[16] The higher internal wages in Heilongjiang seem reasonable, because large scale and mechanized farming is prevalent there.

Table 7 Estimated Internal Wages and Wages in TVEs(*) and Urban Construction Sector(**) (unit: Yuan/year)

	Liaoning		Jilin		Heilongjiang		Hebei		Jiangsu	
1992	1358.2	1910.1	1131.1	1428.3	1524.5	1852.1	1803.9×	1689.8		
1993	1505.4	2302.8	1278.4	1813.7	1693.6	2181.1	1178.3	1935.4	1347.0	2449.8
1994	2949.2×	2891.6	2020.6	3142.0	3027.3×	2388.3	2472.1	2500.9	2304.2	3110.1
1995	3782.6×	3462.7	3472.3×	3116.1	3556.5×	3043.5	3455.7	3541.8	2789.3	3991.6
1996	3699.1	3864.0	3208.3	3051.1	3502.0	3623.0	3161.2	4026.7	2813.2	4843.2
1997	3041.3	4167.8	2777.2	3151.0	3611.5×	3706.8	3017.9	4024.3	3025.5	4513.6
1998	3279.5	4392.9	3024.5	10081.0	5459.1	4173.5	2798.9	4404.3	3195.9	4960.7
1999	3209.8	4462.1	2872.5	3741.5	4484.4	5796.8	2624.4	4718.9	2865.5	5515.7
2000	2809.5	4638.2	2766.7	3830.7	4291.7×	3524.7	2046.0	4890.0	2427.1	5852.0
2001	3259.5	5184.3	2916.7	4244.4	3269.7	3600.9	2296.8	4951.0	2906.4	6172.4
2002	2865.9	5884.4	2436.0	4744.7	3315.4	4215.0	1954.1	5491.1	2703.5	8117.1
2003	3353.5	6803.0	2623.6	5279.4	4531.6×	4485.1	2420.4	5653.8	3866.5	8973.5
2004	4989.3	6943.4	6533.1×	5495.9	6533.6×	5690.9	3680.8	5604.6	5707.8	9465.5
2005	6084.9	8147.4	6483.1×	6265.2	7076.7×	5657.9	3063.2	6240.3	5806.6	12025.0
2006	7135.1	8821.9	7881.8×	6497.2	9291.5×	6043.3	4172.0	6723.8	5999.9	14759.7
2007	6384.2	11882.9	6804.5	8482.4	8925.8×	7788.8	3927.1	8862.4	6668.4	14867.6
2008	7865.1	13632.6	7917.2	11290.4	10777.6×	10666.1	4414.2	10257.9	7218.0	17741.5
Ave.	4056.0	5846.6	3213.6	5038.5	3321.3	4614.0	2917.7	5030.4	3852.8	7959.9

	Anhui		Henan		Yunnan		Beijing	Shanghai	Guangdong
1992	807.4	1362.1	779.3	1471.9	502.1	1486.2	3558.0	4448.0	4627.0
1993	1177.0	1694.8	1040.8	1808.0	677.2	1930.1	4677.0	5861.0	5846.0
1994	1697.6	2346.3	1765.1	2341.4	984.3	2000.0	6820.0	8296.0	7198.0
1995	1855.1	3525.8	2133.4	3049.3	1268.6	2607.9	8451.0	9996.0	8110.0
1996	1896.4	4530.2	1887.1	3586.3	1562.7	2697.0	9642.0	11666.0	8614.0
1997	1960.8	4466.4	1502.3	4198.8	1392.5	3291.5	10111.0	12722.0	8982.0
1998	2249.4	4970.2	1547.7	4165.0	1604.1	4006.4	10777.0	12458.0	9239.0
1999	2090.2	5550.2	1716.8	4168.2	1361.3	4282.7	11644.0	13689.0	9738.0
2000	1397.5	5068.4	1105.6	4445.5	1158.2	4726.9	12275.0	14332.0	10922.0
2001	1547.7	5429.3	1584.2	4549.2	1223.3	4863.5	13840.0	16270.0	11592.0
2002	1790.1	5620.4	1366.2	4816.8	1345.1	4937.4	14455.0	18361.0	12365.0
2003	2138.0	6147.3	1554.0	5470.4	1386.1	5181.0	16730.0	20801.0	13961.0
2004	2837.2	6915.7	3852.6	6307.4	2067.5	20081.8	20606.0	24330.0	14980.0
2005	3062.9	7282.0	3600.9	7028.2	2095.8	5931.5	23300.0	25972.0	16795.0
2006	3020.8	9436.4	4076.9	7867.0	2313.3	6412.9	27830.0	27440.0	18842.0
2007	3884.9	10551.2	4117.6	10356.4	2754.0	5858.2	34015.0	30075.0	20906.0
2008	4207.6	10550.7	4566.3	11747.6	3007.0	11415.1	39320.0	31686.0	22917.0
Ave.	2213.0	5614.5	2246.9	5139.9	1570.8	5394.7	15767.7	16964.9	12096.1

Sources: (*) *CSY*, *China Town and Village Enterprises Yearbook*, *China Town and Village Enterprises and Agricultural Products Processing Industry Yearbook.*

(**) *Statistical Yearbook of Beijing, Statistical Yearbook of Shanghai and Guangdong Statistical Yearbook.*

Notes: (1) We present the annual internal wages of Japonica rice cultivation in the left and annual wage level in TVEs in right, respectively. The annual wage levels in TVEs are obtained by dividing the amount of wages by total number of workers.

(2) Annual wages in TVEs consist of the following firms: TVEs (1992-1996), collective and private firms (1997), collective and private firms and individual businesses (*getihu*) (1998- 2001), and domestic and foreign enterprises (after 2002). We can see abnormal values for wages in TVEs (Jilin in 1998 and Yunnan in 2004). The others seem reasonable.

(3) We selected the annual wages in the urban construction sector as the annual average wages in the construction sector.

(4) If estimated internal wage outperform wage in TVEs, we mark with a symbol ×.

5.2 Separable property test in AH model

Tablel 8 Tests of the Equality of Internal Wages and Market Wages Received by Market Participants

Internal wage vs market wage

$$\log w_{i\,hourly}* = -1.0862 + 1.1482 \log w_{i\,market} \qquad R^2 : 0.5870$$
$$(0.092) \quad (0.083) \quad F(2,133) = 404.67$$

Internal wage vs wage levels in TVEs

$$\log w_{i\,yearly}* = 1.7401 + 0.727 \log w_{i\,TVEs} \qquad R^2 : 0.4675$$
$$(0.571) \quad (0.067) \quad F(2,133) = 126.17$$

Note: Standard errors are shown in parentheses.

Following the method of Sonoda and Maruyama (1999), we first estimate the following equation presented by Skoufias (1994):

$$\ln w_{ij}* = a + b \ln w_{ik}, \tag{11}$$

where $w_{ij}*(i = 1...n, n = 135)$ stands for the internal wages of Japonica rice cultivation on hourly and yearly bases, j = hourly and yearly, w_{ik} is the market wages of Japonica rice cultivation and wages in TVEs, k = market and TVEs. Then we conducted the joint hypothesis test as follows: null hypothesis $H_0 : a = 0$ and $b = 1$, alternative hypothesis $H_1 : a \neq 0$ or $b \neq 1$. We obtained the estimated equations shown in Table 8. The F statistics of both equations rejected the null hypothesis at a 1 % level of significance.

Next, we tested whether the averages of the internal wages are statistically lower than the market wage averages in Japonica rice cultivation and TVEs. The difference between the two wages is defined as $D_i = w_i - w_i*$. The test statistic for paired sample is [18]:

$$t = n^{\frac{1}{2}}(\overline{D}/s_D) \sim t(n-1), \tag{12}$$

where $\overline{D}$ and s_D show sample means and sample standard errors of D_i. These statistics are 21.86 and 10.32, which are rejected at a 1 % level of significance. Therefore,

[18] We conducted the test of whether two groups of wages are statistically independent. The test statistic is $T = \rho(n-2)^{\frac{1}{2}}/(1-\rho^2)^{\frac{1}{2}}$ which is distributed as $t(n-2)$, where ρ denotes correlation between two wages. These statistics are, 12.25 and 8.37, which are rejected at a 1 % level of significance. It indicates that two groups of wages are not statistically independent.

the mean of the internal wages proves to be significantly lower than that of the market wages.[19]

6. Conclusion

In this paper, we estimated the internal wages of Chinese Japonica rice production supply in eight provinces and analyzed the cause of migration in China in terms of wage gaps among sectors. We found that the means of internal wages is significantly lower than that of market wages in Japonica rice cultivation and TVEs. The result shows that the separable property is rejected in this AH model. As for the comparison of wages in each sector, we also discovered that internal wages are substantially lower than market wages in the urban construction sector. We showed that migration to each sector is caused by the wage gap.

These results show that Japonica rice farmers in eight provinces still have surplus labor, so that they chose migration to earn a higher income than the Japonica rice cultivation. On the other hand, the working hours in Japonica rice production have been decreasing, and output has been increasing because of the large input of agricultural chemicals and the replacement of animal labor by agricultural machinery. If agricultural machinery suitable to China's natural conditions is developed and spread over the entire country, the output could be further increased. Farmland improvement is also important. For example, soil conservation and land irrigation would enhance production efficiency. The most important aspect of the Chinese agricultural sector is to develop efficient labor markets. Optimal allocation of labor forces will accelerate labor productivity and develop capital intensive agricultural industries in the near future. To establish efficient labor markets, the immediate concerns are to allow migrant workers to have permanent residences in urban areas. The central government needs to create a new system in which migrants have the same social benefits, medical services, and educational systems for migrant children as urban residents.

[19] We also conducted paired sample Wilcoxon signed rank test which is the nonparametric methods to test whether median of the difference of two groups are equal. The test statistics are 9.18 and 10.08, which is rejected at a 1 % level of significance. Therefore, the null hypothesis of no difference between the two wages is strongly rejected.

Table 9 Descriptive Statistics of Production Decision

	Output		Working hours		Capital		Material		Planting area	
Province	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev	Mean	Std.Dev
Liaoning	8.311	0.167	6.438	0.128	5.519	0.336	5.813	0.257	6.272	0.115
Jilin	8.269	0.204	6.408	0.195	5.683	0.410	5.474	0.210	6.281	0.197
Heilongjiang	9.084	0.468	6.917	0.179	6.658	0.707	6.385	0.204	7.217	0.371
Hebei	6.844	0.277	5.311	0.337	4.017	0.217	4.727	0.307	4.727	0.262
Jiansu	9.481	0.210	7.646	0.243	6.902	0.581	7.298	0.279	7.395	0.178
Anhui	7.663	0.283	6.259	0.154	5.016	0.582	5.257	0.400	5.849	0.176
Henan	6.418	0.185	5.272	0.248	3.350	0.423	4.296	0.179	4.548	0.109
Yunnan	8.084	0.187	7.224	0.195	5.101	0.305	5.295	0.190	6.110	0.087
All	7.929	0.922	6.357	0.753	5.206	1.137	5.466	0.870	5.990	0.889

Note: We set 1992 as the base year. All variables take logarithms.

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