

Does a higher minimum wage accelerate labour division in agricultural production? Evidence from the main rice-planting area in China

Lili Guo, Xiaoyu Duan, Houjian Li, Wanjiang Yang, Yanjun Ren & Yangli Guo

To cite this article: Lili Guo, Xiaoyu Duan, Houjian Li, Wanjiang Yang, Yanjun Ren & Yangli Guo (2022) Does a higher minimum wage accelerate labour division in agricultural production? Evidence from the main rice-planting area in China, Economic Research-Ekonomiska Istraživanja, 35:1, 2984-3010, DOI: [10.1080/1331677X.2021.1985573](https://doi.org/10.1080/1331677X.2021.1985573)

To link to this article: <https://doi.org/10.1080/1331677X.2021.1985573>



© 2021 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.



Published online: 12 Oct 2021.



Submit your article to this journal [↗](#)



Article views: 1525



View related articles [↗](#)



View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)

Does a higher minimum wage accelerate labour division in agricultural production? Evidence from the main rice-planting area in China

Lili Guo^a, Xiaoyu Duan^b, Houjian Li^c , Wanjiang Yang^d, Yanjun Ren^e  and Yangli Guo^f

^aCollege of Economics, Sichuan Agricultural University, Chengdu, China; ^bCollege of Economics, Southwestern University of Finance and Economics, Chengdu, China; ^cCollege of Economics, Sichuan Agricultural University, Chengdu, China; ^dChina Academy for Rural Development, Zhejiang University, Hangzhou, China; ^eLeibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle, Germany; ^fSchool of Economics and Management, Southwest Jiaotong University, Chengdu, China

ABSTRACT

Agricultural production outsourcing, a new means of agricultural production, can optimise the allocation of resources, reduce agricultural production costs, and improve agricultural productivity. However, farmers' outsourcing behaviours are strongly interfered with by many factors such as economics, technology and institutions. Using a farmer-level data set from 2014 to 2018 in China, we examine the effects of the minimum wage increase on rice farmers' production outsourcing behaviours. Our study relies on a Logit regression framework and uses the control function (C.F.) approach to address potential endogeneity concerns. Results show that the minimum wage increase significantly reduces the probability of farmers conducting production outsourcing. We also examine the heterogeneous effects of the minimum wage increase, and find that compared with other outsourcing services, the adverse effects on harvesting outsourcing are the strongest; the negative effects on production outsourcing are stronger for rice farmers with higher education. Our results provide new insights into understanding how labour regulation affects labour division in agricultural production.

ARTICLE HISTORY

Received 2 March 2021

Accepted 21 September 2021

KEYWORDS

production outsourcing; minimum wage; control function (C.F.) approach; China

JEL CODES

D1; D2; D24

1. Introduction

Agricultural production outsourcing refers to transfer some or all stages of agricultural production to some service providers or hire others to complete some production tasks (Mi et al., 2020). Existing literatures have concluded that agricultural production outsourcing is one of the most efficient measures to address the labour shortage in agricultural production (Igata et al., 2008; Picazo-Tadeo & Reig-Martínez, 2006; Wolf, 2003), improve agricultural productivity (Gillespie et al., 2010), reduce

CONTACT Houjian Li  14159@sicau.edu.cn

© 2021 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

agricultural production costs (Zhang et al., 2017), and enhance the welfare of small farmers (Gillespie et al., 2010; Mi et al., 2020; Picazo-Tadeo & Reig-Martínez, 2006). At present, more and more farmers begin to outsource their production tasks to others in China (Ji et al., 2017; Zhang et al., 2017). Previous research documents some evidence on the question: what are the factors that affect agricultural production outsourcing? Using the data on rice farmers in Zhejiang province, Ji et al. (2017) established an econometrics model to explore the factors affecting agricultural outsourcing, and found that labour force, government subsidies, planting area, and the number of farm machines owned by farmers are the main determinants of agricultural production outsourcing. Vernimmen et al. (2000) suggested that some critical factors affect agricultural production outsourcing, including the age of farmers, agricultural production scale and institutional environment. Importantly, it is found that non-farm income had a significant and positive effect on production outsourcing (Baiyegunhi et al., 2019; Zhang et al., 2017).

While various factors could affect farmers' decisions on agricultural production outsourcing, whether minimum wage could play a role in this process remains unclear. Some studies have concluded that a rise in the minimum wage increases the income expectations of migrant workers (Sun & Shu, 2011; Zhang & Yang, 2019), so that the opportunity cost of farmers engaged in agricultural production increases. However, other existing literature shows that an increase in the minimum wage would lead to a significant increase in the unemployment rate (Bhaskar & To, 1999; Burkhauser et al., 2000; Katz & Krueger, 1992; Kohen et al., 1982; Neumark & Wascher, 2002), especially for low-skilled workers (Stigler, 1946), thereby reducing the opportunities for farmers to go out to work, forcing most farmers to engage in local agricultural production, reducing farmers' demand for outsourcing agricultural production. Therefore, based on the existing theory, we cannot accurately judge the net impact of the minimum wage on agricultural production outsourcing. However, there has been little discussion about how the minimum wage increase affects agricultural production outsourcing. This article attempts to bridge this research gap.

Rice is one of the three major food crops in the world, as well as one of the most important food crops in China. With less than 7% of the world's arable land, China needs to support 22% of the world's population (Bryan et al., 2018; Deng et al., 2015; Jin et al., 2019). With rapid progress in urbanisation, the labour shortage in rural has become one of the most urgent issues threatening China's food security. Understanding how and to which extent minimum wage could affect agricultural production outsourcing has significant implications not only for farmers' welfare but also for sustainable agriculture production to ensure food security.

Using a farmer-level data set from 2014 to 2018 in China, this article focuses on the effects of the minimum wage increase on rice farmers' production outsourcing behaviours. Given that the rapid improvement of mechanisation and organisation sets up a solid foundation on the division of labour in small-scale farming, our results contribute to the literature on the relationship between labour market regulation and division of labour, and help differentiate changes in labour division due to technical factors, market reasons, institution factors as well as labour market regulation. With an increase in wages, large-scale farmers use more hired-in machines through

machine rental or specialised mechanisation service providers, which contributes to the mechanisation of agricultural production (Qiao, 2017; Wang et al., 2016; Yamauchi, 2016), and induces a division of labour between farmers and mechanisation service providers to take place (Zhang et al., 2017). Our results present an opposite perspective toward this view: raising the minimum wage would serve to retard the labour division in agricultural production, and this put farmers at a disadvantage. Second, the article has further deepened the understanding of labour division in small-scale agricultural production (a farming production form with one household as the production unit formed under the household contract responsibility system). Our results show that as minimum wage increases, agricultural production with limited resources and scale in a household cannot be as divisible as industrial production. The results are consistent with the traditional ideas about the division of labour, which means that even if some steps in the agricultural production process can be outsourced, the restriction of resources and scale on labour division will still not be erased due to the change of labour market institution. Although our article is about China's rice production, the research results may shed some light on how the labour market regulation affects division of labour and help us understand how to create the conditions for labour division in agricultural production from the perspective of the minimum wage system. Finally, understanding the role of minimum wages in improving the outsourcing of agricultural production is essential for policymaking. Compared with other countries in the world, China's agricultural production efficiency has been low (Cao & Zhu, 2019; Gao, 2015), which seriously limits the development of agriculture and threatens food security in China (Baležentis et al., 2021; Guo et al., 2020; Zhang et al., 2021). So the Chinese-related government has been working hard to improve the efficiency of agricultural production. In recent years, the population bonus has gradually disappeared, labour costs have continued to rise (Li et al., 2019; Qiao, 2017; Zhang et al., 2017; Zhang & Yang, 2019), also the minimum wage has been continuously raised in China (Du & Wang, 2020; Fan et al., 2018; Howell, 2020). At the same time, the level of agricultural mechanisation and organisation in China is relatively low (Jiang et al., 2020; Wang et al., 2016). In this context, does the increase in the minimum wage encourage farmers to adopt production outsourcing, thereby accelerating the division of labour in agricultural production, improving agricultural production efficiency? The existing literature does not provide a clear answer to this question. Therefore, our article attempts to fill this research gap and provide inspiration for further research and policymakers.

The rest of this study is organised as follows. Section 2 addresses the institutional background, Section 3 introduces data collection, and Section 4 explains the empirical strategy. Section 5 results analysis and discussion and robustness tests, while conclusions and policy implication of the study are furnished in Section 6.

2. Institutional background and hypothesis development

The minimum wage institution is a special provision made by the state to protect the fundamental interests of low-income groups and avoid excessive infringement of workers' rights by enterprises. In 1993, the minimum wage institution was officially

introduced as the former Chinese Ministry of Labour issued 'Enterprise Minimum wage Standards'. The 1994 Labour Law authorised that municipal governments could set their minimum wage standards according to local specific conditions. In 2004, the Ministry of Labour and Social Security issued a new 'Minimum Wage Standards Regulations', which made amendments and supplements to the old regulations. In 2008, the new Labour Contract Law strengthened the enforcement of minimum wage regulations, also further guaranteed the implementation of minimum wage institutions. In the second quarter of 2017, the Human Resources and Social Work Report, the Ministry of Human Resources and Social Affairs stated that by the end of July 2017, and minimum wage also increased by up to 10.8% in 11 regions. In China, the monthly minimum wage in Shanghai is the highest at 2,300 *yuan*, which is 3.7 times lower than its monthly average wage of employees; the monthly minimum wage in Beijing is 1890 *yuan*, which is five times lower than its monthly average wage of employees.

The relationship between migrant workers and minimum wage originated from the dual economic structure in China. Since the Reform and Opening-up, the state has concentrated its efforts on developing urban industrial departments, and a lot of resources have been transferred to the urban. Meanwhile, the government has carried out the urban-rural household registration system to restrict a massive migration of rural residents to the cities. Eventually, the labour market was divided, forming a dual labour market (Piore, 1978), the primary and the secondary labour market. Most jobs in the primary labour market belong to some core departments with high technology, efficiency and welfare, mainly local urban labour forces. On the contrary, the secondary labour market includes those labour-intensive, unstable and inefficient secondary departments, where most migrant workers are employed in low-skilled occupations. In general, the minimum wage institution mainly plays a role in the secondary labour market. When the state raises the minimum wage standard, the labour cost of enterprises increases (Gindling & Terrell, 2009; Riley & Bondibene, 2017). To make up for the shortfall in its pay arising from the increment of minimum wage, enterprises may increase the prices of produced goods and services to transfer higher costs, extend workers' working hours, or use machinery to replace the labour force. However, according to the actual situation in China, the secondary labour market is dominated by labour-intensive enterprises, and the products or services produced by these enterprises are usually in a perfectly competitive market. In this kind of market, enterprises can only passively accept prices, and once they increase the prices of products or services, their market share will drop significantly. Therefore, these enterprises usually do not transfer the higher costs to the consumers by raising prices. In addition, we believe that these companies rarely alleviate the dilemma of rising labour costs by extending workers' working hours and increasing labour intensity. The reason is that such behaviour will not only reduce workers' motivation and productivity but also violate the labour law. Therefore, we consider that in the short term, enterprises mainly directly decide to lay off low-skilled workers, etc. In the long term, they mainly replace workers with machinery to reduce the cost of labour (Stigler, 1946), or improve labour productivity to earn more benefits to relieve the pressure of labour cost (Mayneris et al., 2018). In the end, the employment

opportunities for low-skilled migrant workers decrease (Fang & Lin, 2015; Jia, 2014; Sun et al., 2015). Under this condition, farmers continue to engage in agricultural production rather than search for a non-farm job in the labour market. Therefore, the demand for production outsourcing decreases. Based on the above discussion, we propose Hypothesis 1 as follows:

H1. The increase in minimum wage can reduce farmers' probability of conducting production outsourcing.

According to the theory of human capital, the education level of the employees usually affects their employment by affecting labour productivity and human capital. As discussed above, the secondary labour market can almost be called a competitive market of rural surplus labour, where higher-educated farmers are more likely to work in the formal sector, while less-educated farmers are more likely to be employed in the informal sector (Bose et al., 2017; Wu et al., 2020; Zhang et al., 2002). The existing literature indicates that formal sector employment suffers more negative effects when the minimum wage increases, while informal sector employment is less negatively affected. Gindling and Terrell (2007) find minor adverse employment effects in the formal sector but not in the informal one. Ham (2018) finds that employment in the formal sector falls and wages rise due to a minimum wage increase, while the opposite happens in the informal sector. Neumark and Munguía Corella (2021) suggest that when minimum wages are binding and enforced, it could reduce employment in the formal sector. Thus, compared with less-educated farmers who work in the informal sector, higher-educated farmers who participate in the formal sector are hit the hardest when minimum wage increases. The decrease in employment opportunities for the formal sector arising from a rise in the minimum wage could make higher-educated farmers allocate more time to engage in agricultural production, reducing the probability of outsourcing agricultural production. Therefore, we propose Hypothesis 2 as follows:

H2. The higher the education level of farmers is, the stronger the negative effect on their outsourcing behaviour is.

Based on the analysis of the above theoretical background, we then conduct empirical testing for these hypotheses in this article.

3. Data collection and description

3.1. Outsourcing data

We use data from an annual survey of Chinese rice farmers conducted by the Rural Economic Research Centre of Agriculture Ministry, and the period from November to December each year, the Rural Economic Research Centre of Agriculture Ministry conducts the surveys on farmers, and randomly selects 20–25 farmers from each village. A total of 5,403 observations were collected from Chinese main rice-planting areas involved in 70 counties of 30 cities belonging to 12 provinces during 2014–2018 (Figure 1). The collected data included information on rice production and management (e.g., input use, costs, output and technology adoption), marketing (e.g., price,

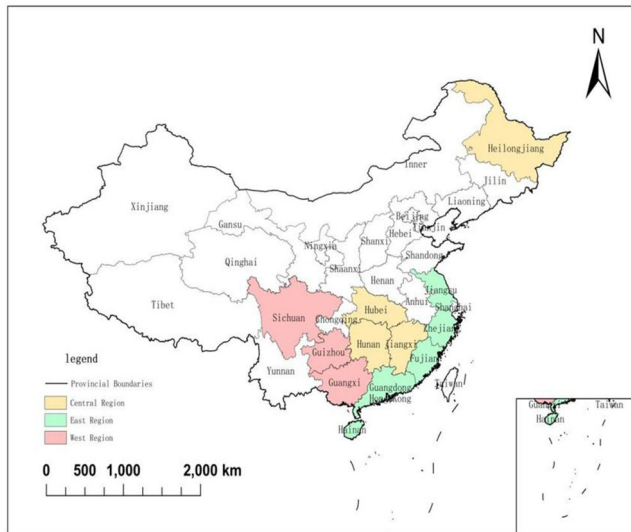


Figure 1. The distribution of selected rice production areas in China.

Source: Authors' estimation using the survey data from 2014 to 2018.

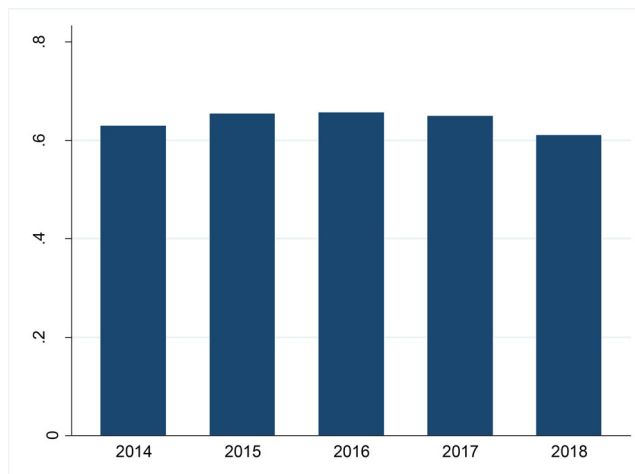


Figure 2. Outsourcing of farming in China.

Note: Outsourcing data in this figure refers to no less than one stage of outsourcing in the process of rice production.

Source: Authors' estimation using the survey data from 2014 to 2018.

sale channel and policy), as well as characteristics at the household and village levels (e.g., gender, health, incomes).

According to the process of rice production, we divide rice production outsourcing into five stages: farming outsourcing, planting outsourcing, field management outsourcing, harvesting outsourcing and drying outsourcing. Rice farmers make outsourcing choices based on their family conditions and external socio-economic factors. [Figure 2](#) presents the average ratio of rice outsourcing from 2014 to 2018. As the figure shows, the annual percentage of outsourcing is about 60%~70% from 2014 to 2018. The ratio of rice production outsourcing in China indicates a trend of rising

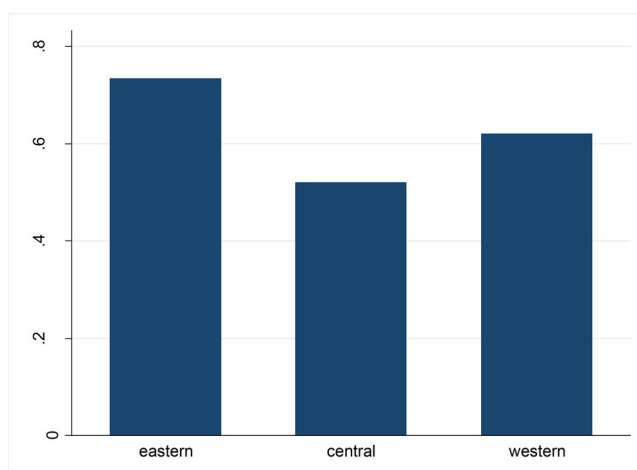


Figure 3. Regional outsourcing of farming in China.

Note: Outsourcing data in this figure refers to no less than one stage of outsourcing in the process of rice production. Source: Authors' estimation using the survey data from 2014 to 2018.

and then falling, but the overall level does not change much. The average ratio of outsourcing in 2016 is the highest, with about 65.6% of sample farmers choosing to outsource some or all stages of rice production. Figure 3 shows the ratio of rice outsourcing by region from 2014 to 2018. As indicated in Figure 3, there are regional differences in the proportion of rice production outsourcing in China. In the central, western and eastern regions, at least half of farmers choose to outsource some or all stages of rice production. The outsourcing ratio in the eastern region is 73.4%, which is significantly higher than that in the central and western regions. Compared with the western region, the percentage of outsourcing in the central region is lower, about 52%.

3.2. Minimum wage data

We manually collect the minimum wage data at the city level from the websites of local labour security departments and other relevant governments. Then, taking 2014 as the base year, we obtain a real minimum wage data set after removing the effect of the price level.¹ Figure 4 shows the average monthly real minimum wage across sample districts from 2014 to 2018. As presented in Figure 4, the average monthly real minimum wage increases from 943 *yuan* in 2014 to 1,170 *yuan* in 2018, an increase of 24%. Figure 5 presents the average hourly real minimum wage across sample districts from 2014 to 2018. As indicated in Figure 5, the average hourly real minimum wage increases from 9.4 *yuan* per hour in 2014 to 11.4 *yuan* per hour in 2018, an increase of 21%.

4. Empirical strategy

4.1. Empirical model

To investigate the effects of a minimum wage increase on rice production outsourcing at the micro-farm level, we establish the model as follows:

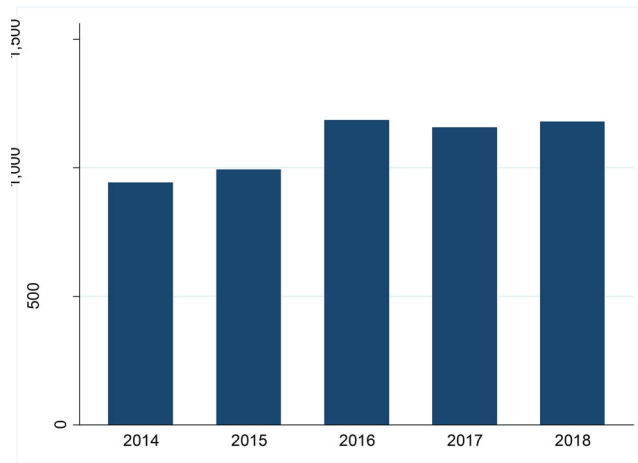


Figure 4. The real monthly minimum wage in China.

Source: Authors' estimation using the survey data from 2014 to 2018.

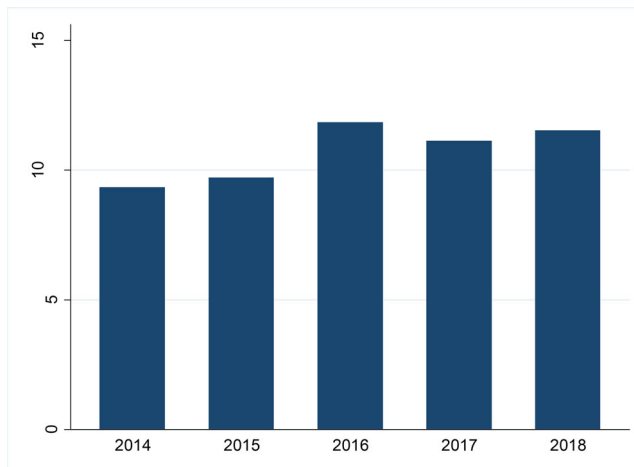


Figure 5. The real hourly minimum wage in China.

Source: Authors' estimation using the survey data from 2014 to 2018.

$$y_{it} = \beta_0 + \beta_1 \text{wage}_{it} + \beta_2 X_{it} + \text{area}_r + \varphi_t + \varepsilon_{it}, \quad (1)$$

where y_{it} is a dummy variable that takes a value of 1 if farmer i outsources any stage of rice production in year t , and takes a value of 0 otherwise. wage_{it} is the real minimum wage in the district where farmer i is located in year t , X_{it} is the control variables at the household level including the characteristics of household head (e.g., gender, age, education level, health level, rice-planting experience, rice planting preference, whether to join a farmer cooperative), family factors (e.g., whether to lease the land, the family population, the labour force population, the total area of rice field, the number of plots) and policy factors (e.g., the implementation of the agricultural technician system), area_r is the region fixed effects variable, φ_t is the year fixed effects variable, and ε_{it} is a random error term. For the binary dependent variable

(outsourcing dummy) model, we use the logit estimators. In Eq.(1), the main coefficient is β_1 , which measures the impact of minimum wage standard on rice production outsourcing. However, due to unobservable heterogeneity, reverse causality, or measurement errors, there may be a correlation between minimum wage ($wage_{it}$) and the random error term ε_{it} , which results in a biased estimate of β_1 . We use the control function (C.F.) approach to address endogenous bias, as described below.

4.2. Control function approach

Although the control variables affecting farmers' production outsourcing behaviour are added, there still exist endogenous problems due to omitted variables, such as cultural factors and other unobservable variables. We use a C.F. approach (Rivers & Vuong, 1988; Smith & Blundell, 1986; Wooldridge, 2015) to explore the impacts of the minimum wage increase on rice production outsourcing. In the C.F. approach, we could use instrument variables (I.V.) to correctly identify the causal effects. Compared with ordinary I.V. approaches, the C.F. approach is more flexible in terms of functional form and can efficiently address the endogenous explanatory variable in a relatively complex non-linear model (Wooldridge, 2015). To efficiently deal with the endogenous problem of core explanatory variable ($wage_{it}$) in the non-linear model, we choose the C.F. approach (Verkaart et al., 2017; Wooldridge, 2015).

Using a C.F. approach, we must find at least one instrument variable. To obtain the residual prediction value, we first use the I.V. to make the first-stage regression estimation of our model. The first-stage equation is as follows:

$$wage_{ct} = \alpha_1 X_{it} + \alpha_2 Z + \delta_{it} \quad (2)$$

where Z is the instrument variable vector of $wage_{it}$, and δ_{it} satisfies $\varepsilon_{it} = \theta\delta_{it} + \mu_{it}$. Subsequently, we introduce the residual prediction $\hat{\delta}_{it}$ in the second stage of regression,

$$y_{it} = \beta_0 + \beta_1 wage_{it} + \beta_2 X_{it} + area_r + \varphi_t + \theta\delta_{it} + \mu_{it} \quad (3)$$

where μ_{it} follows a normal distribution and is independent of $wage_{it}$ and δ_{it} . If the residual coefficient θ is statistically significant, which means that the minimum wage variable is endogenous. The regression with the residual term can make our estimation of the coefficient β_1 more effective.

In theory, a valid instrument variable should be related to the target variable and not correlated to the random error term. Therefore, we use two instrumental variables, namely the urban registered unemployment rate with a lag of one period and the average wage of employees at the city level in 1992 (Howell, 2020).

The first instrumental variable is the urban registered unemployment rate with a lag of one period. According to the 'Minimum Wage Regulations' issued by the Ministry of Labour and Social Security in 2003, the determination and adjustment of minimum wage standard should refer to local employment conditions. The government generally decides whether to increase the minimum wage based on the unemployment rate in previous years. Therefore, there is a correlation between the

Table 1. Solving endogeneity problem.

Test for the endogeneity of hourly minimum wage; H0: Variables are exogenous.
 Durbin (score) $\chi^2(1) = 9.8658$ ($p = 0.0017$)
 Wu-Hausman $F(1,5053) = 9.8364$ ($p = 0.0017$)
 Test for instruments' relevance; Ho: Instruments are weak.
 Variable hourly minimum wage instrumented by:

	R-sq.	Adj. R-sq.	Partial R-sq.	F(2, 5053)	Prob > F
-the urban registered unemployment rate with a lag of one period					
-the average wage of employees at the city level in 1992	0.5279	0.5257	0.1167	333.658	0.0000

Tests for instruments' validity; Ho: Instruments are not correlated with model residuals.
 Sargan (score) $\chi^2(1) = 0.0897$ ($p = 0.7646$)
 Basmann $\chi^2(1) = 0.0892$ ($p = 0.7652$)
Test for the endogeneity of monthly minimum wage; H0: Variables are exogenous.
 Durbin (score) $\chi^2(1) = 4.5012$ ($p = 0.0339$)
 Wu-Hausman $F(1,5053) = 4.4830$ ($p = 0.0343$)
 Test for instruments' relevance; Ho: Instruments are weak.

	R-sq.	Adj. R-sq.	Partial R-sq.	F(2, 5053)	Prob > F
-the urban registered unemployment rate with a lag of one period					
-the average wage of employees at the city level in 1992	0.5494	0.5473	0.0231	59.733	0.0000

Tests for instruments' validity; Ho: Instruments are not correlated with model residuals.
 Sargan (score) $\chi^2(1) = 0.8228$ ($p = 0.3644$)
 Basmann $\chi^2(1) = 0.8189$ ($p = 0.3655$)

Source: Authors' estimation using the survey data from 2014 to 2018.

urban registered unemployment rates with a lag of one period with minimum wage standards, which satisfies the correlation of the instrument variable. On the other hand, the urban registered unemployment rate with a lag of one period does not directly affect farmers' outsourcing decisions, so the exogenous of instrumental variable is satisfied. This instrumental variable is valid.

The second instrumental variable is the average wage of employees at the city level in 1992 because of the origins of minimum wage institutions. The Labour Law promulgated a formally minimum wage institution in 1994. On December 30, 2003, China issued the 'Minimum Wage Regulations' and carried it out nationwide from March 1, 2004. All areas in China Mainland are authorised to adjust minimum wage standards according to their situation. The average wage of employees in 1992 shows the difference in wage levels of various regions, which is an essential basis for determining the starting point of minimum wage. Thus, there is a correlation between the average wage of employees at the city level in 1992 and the city-level minimum wage standard, which satisfies the correlation of instrumental variable. On the other hand, the average wage of employees at the city level in 1992 does not directly affect farmers' rice production outsourcing decisions, so the exogeneity of instrumental variables is satisfied. This instrumental variable is also valid.

Table 1 shows the three-step test for endogeneity and addressed by the instruments. The test results in Table 1 show that the instrumental variables we selected are valid.

5. Results and discussions

5.1. Descriptive statistics

Table 2 presents the statistical characters of the main variables. In our sample, farmers' probability of choosing to outsource farming, planting, field management,

Table 2. Basic statistics of variables.

Variable	Obs	Mean	Std.Dev.	Min	Max
outsourcing1	5,078	0.443	0.497	0	1
outsourcing2	5,078	0.347	0.476	0	1
outsourcing3	5,078	0.281	0.450	0	1
outsourcing4	5,078	0.460	0.498	0	1
outsourcing5	5,078	0.087	0.281	0	1
outsourcing	5,078	0.640	0.480	0	1
rhwage	5,078	10.78	1.734	7.188	14.64
rmwage	5,078	10.92	1.650	7.954	14.71
unemployment	5,078	2.382	1.074	0.302	4.876
asalary92	5,078	2775	449.1	1767	3742
gender	5,078	0.912	0.284	0	1
age	5,078	52.74	9.448	18	85
agesq	5,078	2870	1006	324	7225
illiteracy	5,078	0.034	0.180	0	1
primary school	5,078	0.302	0.459	0	1
junior school	5,078	0.447	0.497	0	1
high school or above	5,078	0.217	0.412	0	1
universtiy	5,078	0.007	0.0851	0	1
health	5,078	0.974	0.159	0	1
experience	5,078	27.48	12.29	1	60
preference	5,078	0.882	0.322	0	1
membership	5,078	0.192	0.394	0	1
rentin	5,078	0.284	0.451	0	1
hhszise	5,078	4.469	1.614	1	15
rlabour	5,078	2.034	0.803	0	7
lnarea	5,078	2.324	1.439	-1.204	8.102
lnplots	5,078	1.675	1.128	-0.693	7.650
vtechnician	5,078	0.733	0.442	0	1

Source: Authors' estimation using the survey data from 2014 to 2018.

harvesting, and drying is 44.3%, 34.7%, 28.1%, 46.0%, and 8.7%, respectively. Farmers' probability of conducting harvesting outsourcing is the greatest, and the least that is drying outsourcing. About 64.0% of farmers outsource at least one production stage. The average hourly minimum wage is 10.78 *yuan*, while the average monthly minimum wage is 1,092 *yuan*. Due to the differences in economic development levels, there is a large gap in minimum wage levels between different districts. The minimum wage of the highest district is about twice that of the lowest district. From 2014 to 2018, the average unemployment rate in the districts of sample farmers is 2.382%, and the average worker's salary in 1992 is 2,775 *yuan*. In our sample, most of the respondents are male, accounting for 91.2%. Sample farmers are about 53-years-old on average. About 30.2% of respondents have a primary school education; 44.7% of respondents have a junior school education; 21.7% of respondents have a high school education or above. 97.4% of sample farmers are healthy. The average rice planting experience of sample farmers is about 27 years, with the highest even reaching 60 years. 88.2% of farmers prefer to grow rice, and only 19.2% of sample farmers join the rice cooperative. According to our statistical results, there are only 28.4% of farmers choosing to rent in land. The average family size of rice farmers is about 4.5 people, among whom the average labour force is only two people. The logarithmic value of the average rice planting area in our sample peasant households is 2.32, and the logarithmic value of the average number of households owned plots is 1.68. 73.3% of sample farmers are in rural areas where the rural technical staff institution is practised.

Table 3. Baseline results.

Variables	(1) outsourcing	(2) margins
rhwage	-0.1642*** (0.0248)	-0.0347*** (0.0052)
gender	0.3022*** (0.1055)	0.0639*** (0.0222)
age	-0.0858*** (0.0287)	0.0026** (0.0011)
age × age	0.0009*** (0.0003)	
primary school	-0.1624 (0.1767)	-0.0338 (0.0361)
junior school	-0.1580 (0.1797)	-0.0329 (0.0367)
high school or above	-0.1019 (0.1904)	-0.0211 (0.0390)
health	0.7001*** (0.1943)	0.1481*** (0.0409)
experience	-0.0099** (0.0043)	-0.0021** (0.0009)
preference	-0.2454** (0.1049)	-0.0519** (0.0221)
membership	0.9458*** (0.0949)	0.2000*** (0.0193)
rentin	0.0689 (0.0905)	0.0146 (0.0191)
hhsiz	-0.0305 (0.0211)	-0.0065 (0.0045)
rlabour	0.0367 (0.0432)	0.0078 (0.0091)
lnarea	-0.1156*** (0.0335)	-0.0245*** (0.0071)
lnplots	0.0939*** (0.0347)	0.0199*** (0.0073)
vtechnician	-0.0729 (0.0713)	-0.0154 (0.0151)
Year FE	Yes	Yes
Region FE	Yes	Yes
Constant	4.0754*** (0.8159)	
chi-squared	378.2	
pseudo-R-squared	0.0656	
Observations	5,078	5,078

Notes: (i) Standard errors in parentheses.

***p < 0.01.

**p < 0.05.

*p < 0.1. (ii) The unit of hourly minimum wage is 1 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

5.2. Impact of hourly minimum wage

In China, most migrant workers are low-skilled labour forces. They are usually part-time workers rather than full-time workers. Compared with the monthly minimum wage, migrant workers are more sensitive to the adjustment of the hourly minimum wage. Therefore, we use the hourly minimum wage as an independent variable in our benchmark regression. Table 3 indicates the estimation results of the effects on production outsourcing behaviours of farmers in equation (1). As Table 3 shows, the estimated coefficients on hourly minimum wage are negative and significant, indicating that the increase in the minimum wage reduces the probability of farmer's

Table 4. The estimation results of the C.F. approach.

Variables	(1) outsourcing	(2) margins
rhwage	-0.3739*** (0.0743)	-0.0789*** (0.0156)
resh	0.2389*** (0.0777)	0.0504*** (0.0163)
gender	0.3549*** (0.1045)	0.0749*** (0.0219)
age	-0.0841*** (0.0302)	0.0036*** (0.0012)
age × age	0.0010*** (0.0003)	
primary school	-0.2184 (0.1768)	-0.0446 (0.0351)
junior school	-0.2820 (0.1867)	-0.0580 (0.0371)
high school or above	-0.2059 (0.1877)	-0.0420 (0.0373)
health	0.8002*** (0.1871)	0.1689*** (0.0393)
experience	-0.0138*** (0.0047)	-0.0029*** (0.0010)
preference	-0.1379 (0.1112)	-0.0291 (0.0234)
membership	0.8597*** (0.0977)	0.1815*** (0.0202)
rentin	0.1356 (0.0911)	0.0286 (0.0192)
hhsiz	-0.0496** (0.0222)	-0.0105** (0.0047)
rlabour	0.0258 (0.0432)	0.0055 (0.0091)
lnarea	-0.1988*** (0.0416)	-0.0420*** (0.0087)
lnplots	0.1610*** (0.0410)	0.0340*** (0.0086)
vtechnician	0.0242 (0.0824)	0.0051 (0.0174)
Year FE	Yes	Yes
Region FE	Yes	Yes
chi-squared	433.8	
pseudo-R-squared	0.0670	
Observations	5,078	5,078

Notes: (i) Standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$. (ii) The standard errors for the C.F. estimates are based on 1000 bootstrap replications. (iii) The unit of hourly minimum wage is 1 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

participation in rice production outsourcing. As the second column of Table 3 shows, farmers have a 3.5 percentage point lower probability of participation in rice production outsourcing after increasing each unit of standard deviation in the hourly minimum wage.

Table 4 presents the estimated results using a C.F. approach. The signs of the C.F. estimated coefficients are consistent with our baseline regression results. Also, the estimated coefficients on the hourly minimum wage are significant. As presented in the second column of Table 4, farmers' probability of participation in rice production outsourcing is 7.9 percentage points lower after each additional standard deviation

unit in the hourly minimum wage. Meanwhile, the estimated coefficients on residual term are significant, so we could argue that variable ($wage_{ct}$) is endogenous. The estimated coefficients of the Logit regression β_1 are endogenously biased (Wooldridge, 2015). As indicated in Tables 3 and 4, compared with the Logit estimation results, the absolute values of estimates are larger when we use a C.F. approach. It means that the endogenous problem of minimum wage makes us underestimate its adverse effects on rice production outsourcing. Therefore, the C.F. estimates are more precise. Overall, Hypothesis 1 is supported by empirical evidence.

5.3. Impact of other variables

In addition to minimum wage, farmers' age, gender, physical health, planting experience, planting preference, whether to join the rice cooperative, the planting scale and the number of rice cultivated land plots, and whether to implement the rural technical staff institution in the village also significantly affect farmers' production outsourcing behaviours. The estimated coefficient on farmers' age is negative and significant at 1% level. The older farmers have less competitive advantages in the urban-rural dual labour market, so they are less likely to engage in non-agricultural works, which led to a lower probability of participation in agricultural outsourcing. Compared with female farmers, male farmers are more likely to outsource because male farmers have more opportunities to find off-farm jobs. The estimated coefficient on physical health is positive and significant at 1% level. The healthier farmers are, the more likely they are to outsource. The estimated coefficient on rice-planting experience is negative and significant at 5% level. The more experienced rice farmers are, the less likely they are to outsource their production. The dummy variable of planting preference has a significantly negative effect on rice production outsourcing. Farmers who prefer to grow rice are more reluctant to outsource the production process because they are experienced in rice farming. The dummy variable of whether or not to join a farmers' cooperative has a significantly positive effect on rice production outsourcing. Farmers who become cooperative memberships have more channels to learn about agricultural production outsourcing, and they trust the agricultural outsourcing service organisations more and are more enlightened. Hence, they are more likely to choose to outsource agricultural production. The planting area has a negative and significant effect on rice production outsourcing. This finding contradicts the previous study which suggested that limited by the labour force, farmers with large planting areas are more likely to outsource (Zhang et al., 2017). The reason for this may be that farmers with larger operation areas usually choose to buy machines such as ploughs, rice transplanters and reapers to achieve economies of scale. They are less likely to outsource. The number of cultivated land plots positively affects rice production outsourcing. The number of cultivated land plots measures land fragmentation level. The more cultivated land plots are, the greater the land fragmentation level is. A greater degree of fragmentation can reduce rice production efficiency. In order to give full play to their comparative advantages and improve productivity, farmers maybe search for individuals with higher

productivity in the market to realise the externalisation of internal production. The dummy variable of whether or not to implement the farm technical staff institution in the village has a negative and significant effect on rice production outsourcing. In the areas where the farm technical staff institution is practised, technicians provide technical training and door-to-door guidance to promote local specialised production and improve farmers' production efficiency. Farmers are less willing to outsource rice production.

5.4. Robustness test

5.4.1. Impacts on the production outsourcing in different stages

To test the robustness of our study results, regression analysis is carried out on the production outsourcing in various stages. Tables 5 and 6 demonstrate the impacts of the hourly minimum wage increase on production outsourcing in different stages. As Table 5 presents, for farming, field management, harvesting and drying, the coefficients on hourly minimum wage are negative and significant at 1% level. It means that a rise in the hourly minimum wage reduces farmers' probabilities of conducting farming outsourcing, field management outsourcing, harvesting outsourcing and drying outsourcing. Hourly minimum wage does not significantly affect planting outsourcing. We use a C.F. approach to address the endogenous problem of hourly minimum wage, and the results are presented in Table 6. For farming, planting outsourcing, field management, harvesting and drying, the coefficients on hourly minimum wage are negative and significant at 1% level, which means that the hourly minimum wage increase can reduce farmers' probability of conducting the production outsourcing in any links. The estimated results suggest that after an increase of each unit of standard deviation in the hourly minimum wage, farmers' probabilities of conducting farming outsourcing, planting outsourcing, field management outsourcing, harvesting outsourcing and drying outsourcing decrease by 11.6%, 6.4%, 4.6%, 16.8%, and 5.0%, respectively. Among them, the average marginal effect of hourly minimum wage on harvesting outsourcing is the strongest.

Table 5. The hourly minimum wage effects on different rice production link outsourcing based on Logit regression.

Variables	(1) Farming outsourcing	(2) Planting outsourcing	(3) Field management outsourcing	(4) Harvesting outsourcing	(5) Drying outsourcing
rh wage	-0.1598*** (0.0236)	-0.0267 (0.0253)	-0.0790*** (0.0260)	-0.0841*** (0.0233)	0.3307*** (0.0510)
Control-var	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Constant	1.9504** (0.7633)	2.4728*** (0.7546)	0.0518 (0.8103)	2.4423*** (0.7768)	-6.1623*** (1.3410)
Observations	5,078	5,077	5,078	5,077	5,078
chi-squared	428	372.6	236.3	479.5	436.3
pseudo-R-squared	0.0705	0.0652	0.0414	0.0814	0.164

Notes: (i) Standard errors in parentheses.

***p < 0.01.

**p < 0.05.

*p < 0.1. (ii) The unit of hourly minimum wage is: 1 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

Table 6. The hourly minimum wage effects on different rice production links outsourcing based on the C.F. approach regression.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Farming outsourcing	margins	Planting outsourcing	margins	Field management outsourcing	margins	Harvesting outsourcing	margins	Drying outsourcing	margins
rh wage	-0.5213*** (0.0665)	-0.1159*** (0.0144)	-0.3105*** (0.0717)	-0.0642*** (0.0147)	-0.2397*** (0.0774)	-0.0460*** (0.0148)	-0.7767*** (0.0775)	-0.1680*** (0.0161)	-0.7511*** (0.1701)	-0.0497*** (0.0109)
Control-var	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	5.2504*** (0.9348)	5.078	5.0624*** (0.9636)	5.077	1.5126 (1.0526)	5.078	8.8266*** (1.0275)	5.077	3.7173* (2.1826)	5.078
Observations	540.6	540.6	455	455	264.1	264.1	744.3	744.3	459.2	459.2
chi-squared	0.0751	0.0680	0.0680	0.0680	0.0423	0.0423	0.0976	0.0976	0.188	0.188

Notes: (i) Standard errors in parentheses.

***p < 0.01.

**p < 0.05.

*p < 0.1. (ii) The standard errors for the C.F. estimates are based on 500 bootstrap replications. (iii) The unit of hourly minimum wage is: 1 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

Table 7. The effect of monthly minimum wage based on a Logit regression.

Variables	(1) outsourcing	(2) margins
rmwage	-0.1064*** (0.0273)	-0.0226*** (0.0058)
Control-var	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
Constant	3.5796*** (0.8259)	
chi-squared	336.5	
pseudo-R-squared	0.0610	
Observations	5,078	5,078

Notes: (i) Standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$. (ii) The unit of monthly minimum wage is: 100 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

Table 8. The effect of monthly minimum wage based on a C.F. regression.

Variables	(1) outsourcing	(2) margins
rmwage	-0.4525** (0.1898)	-0.0962** (0.0403)
resm	0.3565* (0.1934)	0.0758* (0.0411)
Control-var	Yes	Yes
Year FE	Yes	Yes
Region FE	Yes	Yes
chi-squared	371.5	
pseudo-R-squared	0.0615	
Observations	5,078	5,078

Notes: (i) Standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$. (ii) The standard errors for the C.F. estimates are based on 500 bootstrap replications. (iii) The unit of monthly minimum wage is: 100 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

5.4.2. The effect of monthly minimum wage

Although migrant workers are more sensitive to the hourly minimum wage, we cannot rule out the impact of the monthly minimum wage on some migrant workers who are engaged in full-time jobs. In order to ensure the robustness of our results, this article replaces the hourly minimum wage with the monthly minimum wage to explore whether the increase in the monthly minimum wage has a negative impact on farmers' outsourcing behaviours. The results are shown in Tables 7 and 8. The results show that the increase in monthly minimum wage will significantly reduce the probability of farmers conducting production outsourcing.

The impacts of the monthly minimum wage rise on production outsourcing in different stages are reported in Tables 9 and 10. As evident from Table 9, the monthly minimum wage has a negative and significant impact on farming outsourcing. But it has a significantly positive effect on planting and drying outsourcing, yet not on field management outsourcing and harvesting outsourcing. We also used a C.F. approach to control the endogeneity of monthly minimum wage, and the estimated results are

Table 9. The monthly minimum wage effects on different rice production link outsourcing based on Logit regression.

Variables	(1) Farming outsourcing	(2) Planting outsourcing	(3) Field management outsourcing	(4) Harvesting outsourcing	(5) Drying outsourcing
rmwage	-0.0955*** (0.0264)	0.0559* (0.0285)	-0.0321 (0.0302)	0.0308 (0.0268)	0.2905*** (0.0470)
Control-var	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Constant	1.4315* (0.7736)	1.6922** (0.7650)	-0.3483 (0.8275)	1.3824* (0.7899)	-6.0494*** (1.3364)
Observations	5,078	5,077	5,078	5,077	5,078
chi-squared	405.2	370.7	230.3	475.7	453.1
pseudo-R-squared	0.0659	0.0656	0.0400	0.0798	0.163

Notes: (i) Standard errors in parentheses.

***p < 0.01.

**p < 0.05.

*p < 0.1. (ii) The unit of monthly minimum wage is: 100 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

given in Table 10. The increase in the monthly minimum wage significantly affects farming outsourcing, planting outsourcing, harvesting outsourcing and drying outsourcing, but it has no significant impact on field management outsourcing. After each additional unit of standard deviation in the monthly minimum wage, farmers' probabilities of conducting farming outsourcing, planting outsourcing, field management outsourcing, harvesting outsourcing and drying outsourcing decrease by 24.1%, 6.4%, 0.2%, 36.7% and 13.2%, respectively. Our results are not affected by the difference between the hourly minimum wage and the monthly minimum wage. It underlines the robustness of our study results.

5.4.3. The effect of minimum wage on the number of outsourced rice production stages of farmers

We use a Zero-inflated Poisson regression model² to explore the relationship between the minimum wage and the number of outsourced rice production stages of farmers,³ and the estimated results are shown in Table 11 below. As Table 11 indicates, both monthly minimum wage and hourly minimum wage have a significant negative correlation with the number of outsourced rice production stages of farmers. After each additional unit of standard deviation in the monthly minimum wage, the number of outsourced rice production stages of farmers will decrease by 39.6%; After each additional unit of standard deviation in the hourly minimum wage, the number of outsourced rice production stages of farmers will reduce by 22.2%. This once again confirms the robustness of our conclusions.

5.4.4. Heterogenous effect of minimum wage by education

Other complex factors might influence the relationship between minimum wage and production outsourcing. An examination of heterogeneous effects caused by the minimum wage increase will be carried out in this section. Hypothesis 2 predicts the negative effects of the minimum wage increase on production outsourcing to be stronger for farmers with higher education. To analyze the heterogeneous effects of

Table 10. The monthly minimum wage effects on different rice production link outsourcing based on the C.F. approach regression.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Farming outsourcing	margins	Planting outsourcing	margins	Field management outsourcing	margins	Harvesting outsourcing	margins	Drying outsourcing	margins
rmwage	-1.0779*** (0.1642)	-0.2411*** (0.0361)	-0.3110* (0.1825)	-0.0644* (0.0378)	-0.0115 (0.1985)	-0.0022 (0.0382)	-1.6863*** (0.2012)	-0.3668*** (0.0424)	-1.9648*** (0.4017)	-0.1317*** (0.0264)
resm	1.0018*** (0.1673)	0.2241*** (0.0369)	0.3717*** (0.1820)	0.0770** (0.0376)	-0.0210 (0.1969)	-0.0040 (0.0379)	1.7580*** (0.2017)	0.3824*** (0.0425)	2.2166*** (0.3943)	0.1486*** (0.0259)
Control-var	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	10.9927*** (1.7446)		5.2579*** (1.9450)		-0.5479 (2.0720)		18.1413*** (2.1177)		15.9149*** (4.2137)	
Observations	5,078	5,078	5,077	5,077	5,078	5,078	5,077	5,077	5,078	5,078
chi-squared	524.9		445.7		241.8		690.6		457.6	
pseudo-R-squared	0.0706		0.0663		0.0400		0.0938		0.176	

Notes: (i) Standard errors in parentheses.

***p < 0.01.

**p < 0.05.

*p < 0.1. (ii) The standard errors for the C.F. estimates are based on 500 bootstrap replications. (iii) The unit of monthly minimum wage is: 100 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

Table 11. Minimum wage effects on the number of outsourced rice production stages of farmers.

Variables	(1) CF + OLS outsourcings	(2) CF + ZIP outsourcings	(3) CF + ZIP IRR	(4) CF + OLS outsourcings	(5) CF + ZIP outsourcings	(6) CF + ZIP IRR
rmwage	-0.8319*** (0.1384)	-0.5039*** (0.0613)	0.6042*** (0.0370)			
rhwage				-0.4681*** (0.0543)	-0.2505*** (0.0199)	0.7784*** (0.0155)
resid	0.8712*** (0.1415)	0.5289*** (0.0614)	1.6971*** (0.1042)	0.4707*** (0.0578)	0.2577*** (0.0238)	1.2939*** (0.0308)
control-var	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes
Region-FE	Yes	Yes	Yes	Yes	Yes	Yes
Inflate		-1.0626*** (0.0428)	-1.0626*** (0.0428)		-1.0810*** (0.0432)	-1.0810*** (0.0432)
Vuong test of zip		14.35***	14.35***		13.99***	13.99***
Observations	5,078	5,078	5,078	5,078	5,078	5,078
R-squared	0.1117			0.1193		

Notes: (i) Standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$. (ii) The standard errors for the C.F. estimates are based on 500 bootstrap replications. (iii) The unit of monthly minimum wage is 100 yuan; the unit of hourly minimum wage is 1 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

education, we include interactions between minimum wage and education dummies in both the logit model and the C.F. approach. The estimation results are shown in Table 12. As Table 12 indicates, compared with illiterate farmers, educated farmers' production outsourcing behaviour is more significantly and negatively affected by the minimum wage increase. The margin treatment effects (M.T.E.s) on the outsourcing behaviour of farmers with different education levels are presented graphically in Figures 6 and 7. As the figures show, the M.T.E. of the minimum wage rise on the outsourcing behaviour of illiterate farmers is insignificant, but the negative M.T.E. on the outsourcing behaviour of farmers with Primary school or above education becomes significant. And the negative impact of the minimum wage increase on the rice production outsourcing probability of farmers with higher education is stronger. This result applies to both the monthly minimum wage and the hourly minimum wage. Thus, it is true that the increase in the minimum wage has different effects on farmers with varying levels of education. These results provide evidence to certify Hypothesis 2.

In conclusion, we find that the lower possibility of rice production outsourcing is related to a rise in the city-level minimum wage. This finding is consistent with that of He (2019), who found the increase in minimum wage can affect farmers' grain production behaviours by affecting their employment and income status. Also, our research results are in line with the expected theory of the labour market in China. According to the demand for labour model of Stigler (1946), in the competitive labour market, the minimum wage set above the equilibrium price will reduce the demand for labour, due to the output effect (a rise in labour costs increases the price of the product, and the demand for the product will lessen, finally causing the demand for labour to decrease) and the substitution effect (enterprise will increase the input in other factors of production, thereby replacing the demand for labour). Some studies on the employment effect of minimum wages (Fang & Lin, 2015; Jia,

Table 12. Results by education.

Variables	(1) Logit	(2) CF	(3) Logit	(4) CF
rmwage	0.2341** (0.0996)	-0.1547 (0.2479)		
primary school × rmwage	-0.2951*** (0.1025)	-0.2929** (0.1153)		
junior school × rmwage	-0.3724*** (0.1023)	-0.3760*** (0.1141)		
high school or above × rmwage	-0.4091*** (0.1065)	-0.4215*** (0.1177)		
resm		0.4041** (0.2059)		
rhwage			0.1465* (0.0845)	0.0447 (0.1055)
primary school × rhwage			-0.3138*** (0.0876)	-0.3122*** (0.0988)
junior school × rhwage			-0.3386*** (0.0877)	-0.3376*** (0.0969)
high school or above × rhwage			-0.3100*** (0.0926)	-0.3146*** (0.1031)
resh				0.1479*** (0.0540)
Control-var	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	5,078	5,078	5,078	5,078
chi-squared	343.1	424.1	389.7	581.9
pseudo-R-squared	0.0635	0.0643	0.0678	0.0693

Notes: (i) Standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$. (ii) The unit of monthly minimum wage is: 100 yuan; the unit of hourly minimum wage is: 1 yuan.

Source: Authors' estimation using the survey data from 2014 to 2018.

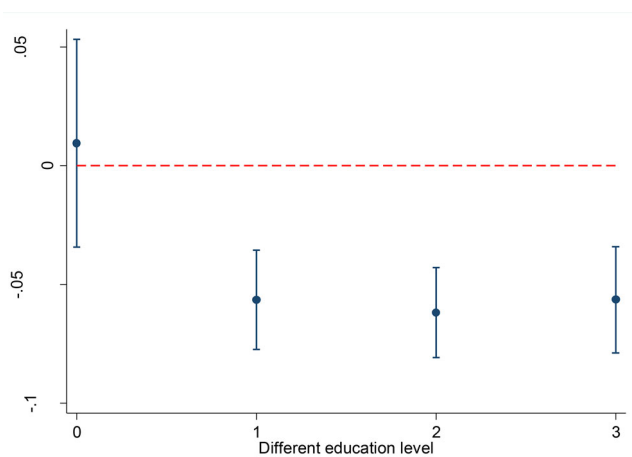


Figure 6. The moderation effect of education on the effect of hourly minimum wage.

Source: Authors' estimation using the survey data from 2014 to 2018.

2014; Sun et al., 2015) are consistent with this theory. In addition to the adverse impact on employment, Sun et al. (2015) also found that a rise in the minimum wage can lessen the working hours of workers. The above analysis confirms that the minimum wage increase might reduce employment opportunities. The employment effect

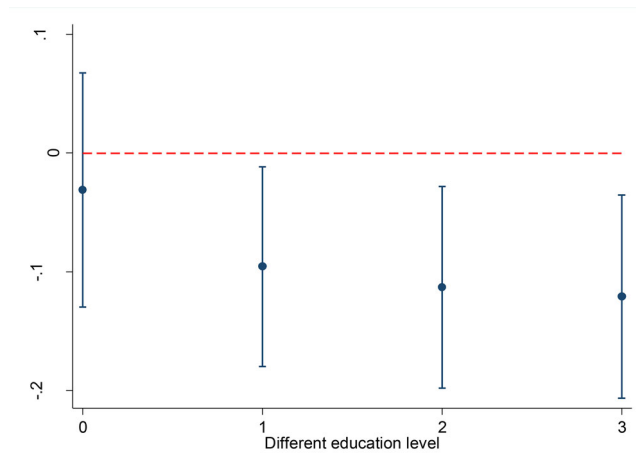


Figure 7. The moderation effect of education on the effect of monthly minimum wage.
Source: Authors' estimation using the survey data from 2014 to 2018.

of the minimum wage mainly occurs in the secondary labour market dominated by migrant workers (Sun et al., 2015). The rise in the minimum wage causes employment opportunities of migrant workers to decrease, so they have more time and energy to engage in agricultural production, reducing outsourcing in agricultural production. Our study results are in line with China's current situation that uses machines to replace labour forces to make up for the shortage of funds caused by rising labour costs.

6. Conclusion

Agriculture development is crucial for all countries, especially for China, a traditional farming country. However, the high degree of fragmentation and small land, and small-scale household farming methods limit the efficiency of agricultural production. Agricultural production outsourcing, a new means of agricultural production, not only benefits agricultural productivity growth, but also optimises the allocation of agricultural production resources, which indicated that agricultural production outsourcing is a crucial way to promote agricultural scale management and modern agricultural development. This research of rice farmers in China examines whether and how a rise in the minimum wage can affect farmers' probability of conducting production outsourcing. The Baseline results indicate that increasing each unit of standard deviation in the hourly minimum wage can reduce farmers' probability of conducting production outsourcing by 3.5%. We then use the C.F. approach to address potential endogeneity concerns, and the results indicate that an increase of each unit of standard deviation in the hourly minimum wage can reduce farmers' probability of conducting production outsourcing by 7.9%. We prefer the estimated results using a C.F. approach because of their more efficient estimates. In a word, the increase in the minimum wage reduces farmers' probability of conducting production outsourcing. One possible reason is that a rise in the minimum wage raises

enterprises' labour costs and forces enterprises to downsize their low-skilled staff in response to rising production costs. Hence, employment opportunities for migrant workers decrease, causing more farmers to undertake agricultural production on their own, reducing production outsourcing. Finally, we also notice that as the education level of farmers improves, the negative impacts of the minimum wage increase on agricultural production outsourcing by farmers is also increasing; the effect of the minimum wage increase on harvesting outsourcing is the strongest. Our research results provide empirical evidence for exploring a connection between labour market regulation and the division of labour. From the perspective of the minimum wage system, it provides inspiration for how to promote labour division in agricultural production. In reality, policymakers often worry that the minimum wage rise attracts more farmers to work in the city, which may be aggravated by rural ageing and abandoned land. But according to our findings, this concern is unnecessary. In order to weaken the negative impact of higher minimum wages on labour division in agricultural production, policymakers need to fully consider its impact on agricultural production when raising the minimum wage standard, and should not raise the minimum wage excessively first; Second, while increasing the minimum wage, it is necessary to create other employment opportunities for them to promote the reemployment of migrant workers. As one of the new models of modern agricultural production, more future studies should focus on agricultural production outsourcing.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Funding for this research from National Natural Science Foundation of China with ratification number 71603177, and National Social Science Foundation of China with ratification number 20CMZ037.

ORCID

Houjian Li  <http://orcid.org/0000-0003-4852-8042>

Yanjun Ren  <http://orcid.org/0000-0002-8384-8925>

References

- Baiyegunhi, L. J. S., Majokweni, Z. P., & Ferrer, S. R. D. (2019). Impact of outsourced agricultural extension program on smallholder farmers' net farm income in Msinga, KwaZulu-Natal, South Africa. *Technology in Society*, 57, 1–7. <https://doi.org/10.1016/j.techsoc.2018.11.003>
- Baležentis, T., Li, T., & Chen, X. (2021). Has agricultural labor restructuring improved agricultural labor productivity in China? A decomposition approach. *Socio-Economic Planning Sciences*, 76, 100967. <https://doi.org/10.1016/j.seps.2020.100967>

- Bhaskar, V., & To, T. (1999). Minimum wages for Ronald McDonald monopsonies: A theory of monopsonistic competition. *The Economic Journal*, 109(455), 190–203. <https://doi.org/10.1111/1468-0297.00427>
- Bose, N., Das, S., Review, A., & Duflo, E. (2017). Women's inheritance rights, household allocation, and gender bias. *American Economic Review*, 107(5), 150–153. <https://doi.org/10.1257/aer.p20171128>
- Bryan, B. A., Gao, L., Ye, Y., Sun, X., Connor, J. D., Crossman, N. D., Stafford-Smith, M., Wu, J., He, C., Yu, D., Liu, Z., Li, A., Huang, Q., Ren, H., Deng, X., Zheng, H., Niu, J., Han, G., & Hou, X. (2018). China's response to a national land-system sustainability emergency. *Nature*, 559(7713), 193–204. <https://doi.org/10.1038/s41586-018-0280-2>
- Burkhauser, R., V., Couch, K., A., & Wittenburg, D., C. (2000). Who minimum wage increases bite: An analysis using monthly data from the SIPP and the CPS. *Southern Economic Journal*, 67(1), 16–40. <https://doi.org/10.2307/1061611>
- Cao, B., & Zhu, N. (2019). Study on paths of agricultural supply side reform from the perspective of labor productivity. *Journal of China Agricultural University*, 24(1), 175–183. (In Chinese)
- Deng, X., Huang, J., Rozelle, S., Zhang, J., & Li, Z. (2015). Impact of urbanization on cultivated land changes in China. *Land Use Policy*, 45, 1–7. <https://doi.org/10.1016/j.landusepol.2015.01.007>
- Du, P., & Wang, S. (2020). The effect of minimum wage on firm markup: Evidence from China. *Economic Modelling*, 86, 241–250. <https://doi.org/10.1016/j.econmod.2019.10.012>
- Fan, H., Lin, F., & Tang, L. (2018). Minimum wage and outward FDI from China. *Journal of Development Economics*, 135, 1–19. <https://doi.org/10.1016/j.jdeveco.2018.06.013>
- Fang, T., & Lin, C. (2015). Minimum wages and employment in China. *IZA Journal of Labor Policy*, 4(1), 1–30. <https://doi.org/10.1186/s40173-015-0050-9>
- Gao, F. (2015). International experience to improve agricultural productivity and China's policy choice. *Fudan Journal (Social Sciences)*, 57(1), 116–124. (In Chinese)
- Gillespie, J., Nehring, R., Sandretto, C., & Hallahan, C. (2010). Forage outsourcing in the dairy sector: The extent of use and impact on farm profitability. *Agricultural and Resource Economics Review*, 39(3), 399–414. <https://doi.org/10.1017/S1068280500007401>
- Gindling, T. H., & Terrell, K. (2007). The effects of multiple minimum wages throughout the labor market: The case of Costa Rica. *Labour Economics*, 14(3), 485–511. <https://doi.org/10.1016/j.labeco.2006.01.004>
- Gindling, T. H., & Terrell, K. (2009). Minimum wages, wages and employment in various sectors in Honduras. *Labour Economics*, 16(3), 291–303. <https://doi.org/10.1016/j.labeco.2008.10.001>
- Guo, B., He, D., Zhao, X., Zhang, Z., & Dong, Y. (2020). Analysis on the spatiotemporal patterns and driving mechanisms of China's agricultural production efficiency from 2000 to 2015. *Physics and Chemistry of the Earth, Parts A/B/C*, 120, 102909. <https://doi.org/10.1016/j.pce.2020.102909>
- Ham, A. (2018). The consequences of legal minimum wages in Honduras. *World Development*, 102, 135–157. <https://doi.org/10.1016/j.worlddev.2017.09.015>
- He, Z. (2019). The economic impact of minimum wage standard on grain production mechanization – literature review and research prospect. *Grain Science and Technology and Economy*, 44(5), 39–42. (In Chinese)
- Howell, A. (2020). Minimum wage impacts on Han-minority Workers' wage distribution and inequality in urban china. *Journal of Urban Economics*, 115, 103184. <https://doi.org/10.1016/j.jue.2019.103184>
- Igata, M., Hendriksen, A., & Heijman, W. J. M. (2008). Agricultural outsourcing: A comparison between the Netherlands and Japan. *Applied Studies in Agribusiness and Commerce*, 2(1–2), 29–33. <https://doi.org/10.19041/APSTRACT/2008/1-2/4>
- Ji, C., Guo, H., Jin, S., & Yang, J. (2017). Outsourcing agricultural production: Evidence from rice farmers in Zhejiang Province. *PLOS One*, 12(1), 1–16. <https://doi.org/10.1371/journal.pone.0170861>

- Jia, P. (2014). Employment and working hour effects of minimum wage increase: Evidence from China. *China & World Economy*, 22(2), 61–80. <https://doi.org/10.1111/j.1749-124X.2014.12062.x>
- Jiang, M., Hu, X., Chunga, J., Lin, Z., & Fei, R. (2020). Does the popularization of agricultural mechanization improve energy-environment performance in China's agricultural sector? *Journal of Cleaner Production*, 276, 124210. <https://doi.org/10.1016/j.jclepro.2020.124210>
- Jin, G., Chen, K., Wang, P., Guo, B., Dong, Y., & Yang, J. (2019). Trade-offs in land-use competition and sustainable land development in the North China Plain. *Technological Forecasting and Social Change*, 141, 36–46. <https://doi.org/10.1016/j.techfore.2019.01.004>
- Katz, L. F., & Krueger, A. B. (1992). The effect of the minimum wage on the Fast-Food Industry. *Industrial and Labor Relations Review*, 46(1), 6–21. <https://doi.org/10.2307/2524735>
- Kohen, A., Brown, C., & Gilroy, C. (1982). The effect of the minimum wage on employment and unemployment. *Journal of Economic Literature*, 20(2), 487–528.
- Li, L., Wang, X., Jiang, D., & Fang, S. (2019). Has the rising minimum wage in China led to the exit of foreign enterprises? *The Journal of World Economy*, 42(8), 97–120. In Chinese)
- Mayneris, F., Poncet, S., & Zhang, T. (2018). Improving or disappearing: Firm-level adjustments to minimum wages in China. *Journal of Development Economics*, 135, 20–42. <https://doi.org/10.1016/j.jdeveco.2018.06.010>
- Mi, Q., Li, X., & Gao, J. (2020). How to improve the welfare of smallholders through agricultural production outsourcing: Evidence from cotton farmers in Xinjiang, Northwest China. *Journal of Cleaner Production*, 256, 120636. <https://doi.org/10.1016/j.jclepro.2020.120636>
- Neumark, D., & Munguía Corella, L. F. (2021). Do minimum wages reduce employment in developing countries? A survey and exploration of conflicting evidence. *World Development*, 137, 105165. <https://doi.org/10.1016/j.worlddev.2020.105165>
- Neumark, D., & Wascher, W. (2002). Do minimum wages fight poverty? *Economic Inquiry*, 40(3), 315–333. <https://doi.org/10.1093/ei/40.3.315>
- Picazo-Tadeo, A. J., & Reig-Martínez, E. (2006). Outsourcing and efficiency: The case of Spanish citrus farming. *Agricultural Economics*, 35(2), 213–222. <https://doi.org/10.1111/j.1574-0862.2006.00154.x>
- Piore, M. J. (1978). Dualism in the labor market: A response to uncertainty and flux. the case of France. *Revue Économique*, 29(1), 26–48. <https://doi.org/10.3406/reco.1978.408371>
- Qiao, F. (2017). Increasing wage, mechanization, and agriculture production in China. *China Economic Review*, 46, 249–260. <https://doi.org/10.1016/j.chieco.2017.10.002>
- Riley, R., & Bondibene, C. R. (2017). Raising the standard: Minimum wages and firm productivity. *Labour Economics*, 44, 27–50. <https://doi.org/10.1016/j.labeco.2016.11.010>
- Rivers, D., & Vuong, Q. H. (1988). Limited information estimators and exogeneity tests for simultaneous probit models. *Journal of Econometrics*, 39(3), 347–366. [https://doi.org/10.1016/0304-4076\(88\)90063-2](https://doi.org/10.1016/0304-4076(88)90063-2)
- Smith, R. J., & Blundell, R. (1986). An exogeneity test for a simultaneous equation tobit model with an application to labor supply. *Econometrica*, 54(3), 679–685. <https://doi.org/10.2307/1911314>
- Stigler, G. J. (1946). The economics of minimum wage legislation. *The American Economic Review*, 36(3), 358–365.
- Sun, Z., & Shu, b. (2011). The standard of the minimum wage, and the wages of Peasant-workers: A case study based on Zhujiang delta. *Management World*, (8), 45–56. In Chinese)
- Sun, W., Wang, X., & Zhang, X. (2015). Minimum wage effects on employment and working time of Chinese workers—Evidence based on CHNS. *IZA Journal of Labor & Development*, 4(1), 19. <https://doi.org/10.1186/s40175-015-0046-2>
- Verkaart, S., Munyua, B., Mausch, K., & Michler, J. D. (2017). Welfare impacts of improved chickpea adoption: A pathway for rural development in Ethiopia? *Food Policy*, 66, 50–61. <https://doi.org/10.1016/j.foodpol.2016.11.007>

- Vernimmen, T., Verbeke, W., & Van Huylenbroeck, G. (2000). Transaction cost analysis of outsourcing farm administration by Belgian farmers. *European Review of Agriculture Economics*, 27(3), 325–345. <https://doi.org/10.1093/erae/27.3.325>
- Wang, X., Yamauchi, F., Otsuka, K., & Huang, J. (2016). Wage growth, landholding, and mechanization in Chinese agriculture. *World Development*, 86, 30–45. <https://doi.org/10.1016/j.worlddev.2016.05.002>
- Wolf, C. A. (2003). Custom dairy heifer grower industry characteristics and contract terms. *Journal of Dairy Science*, 86(9), 3016–3022. [https://doi.org/10.3168/jds.S0022-0302\(03\)73900-9](https://doi.org/10.3168/jds.S0022-0302(03)73900-9)
- Wooldridge, J. M. (2015). Control function methods in applied econometrics. *Journal of Human Resources*, 50(2), 420–445. <https://doi.org/10.3368/jhr.50.2.420>
- Wu, W., Chen, Z., & Yang, D. (2020). Do internal migrants crowd out employment opportunities for urban locals in China?—Reexamining under the skill stratification. *Physica A: Statistical Mechanics and Its Applications*, 537, 122580. <https://doi.org/10.1016/j.physa.2019.122580>
- Yamauchi, F. (2016). Rising real wages, mechanization and growing advantage of large farms: Evidence from Indonesia. *Food Policy*, 58, 62–69. <https://doi.org/10.1016/j.foodpol.2015.11.004>
- Zhang, L., Huang, J., & Rozelle, S. (2002). Employment, emerging labor markets, and the role of education in rural China. *China Economic Review*, 13(2–3), 313–328. [https://doi.org/10.1016/S1043-951X\(02\)00075-5](https://doi.org/10.1016/S1043-951X(02)00075-5)
- Zhang, S., & Yang, Z. (2019). Can minimum wages raise rural migrant workers' wages in the long run? *Finance & Economics*, 380(11), 95–108. (In Chinese)
- Zhang, X., Yang, J., & Thomas, R. (2017). Mechanization outsourcing clusters and division of labor in Chinese agriculture. *China Economic Review*, 43, 184–195. <https://doi.org/10.1016/j.chieco.2017.01.012>
- Zhang, Q., Zhang, F., Wu, G., & Mai, Q. (2021). Spatial spillover effects of grain production efficiency in China: Measurement and scope. *Journal of Cleaner Production*, 278, 121062. <https://doi.org/10.1016/j.jclepro.2020.121062>

Table A1. The selection and definition of major variables.

Variable	Definition
Farming outsourcing	Equals 1 if the HH head outsources farming task, and equals 0 otherwise
Planting outsourcing	Equals 1 if the HH head outsources planting task, and equals 0 otherwise
Field management outsourcing	Equals 1 if the HH head outsources field management task, and equals 0 otherwise
Harvesting outsourcing	Equals 1 if the HH head outsources harvesting task, and equals 0 otherwise
Drying outsourcing	Equals 1 if the HH head outsources drying task, and equals 0 otherwise
outsourcing	Outsourcing at any task: equals 1 if the HH head outsources any rice production task, and equals 0 otherwise
rhwage	Taking 2014 as the base year, real hourly minimum wage in the district where the HH head is located (RMB)
rmwage	Taking 2014 as the base year, real monthly minimum wage in the district where the HH head is located (100RMB)
unemployment	Urban registered unemployment rate in the district where the HH head is located (%)
asalary92	The average wage of employees in 1992 in the district where the HH head is located (RMB)
gender	The gender of the HH head: equals 1 if the HH head is male 0 if it is female
age	The age of the HH head (years)
agesq	The square of the HH head's age
illiteracy	Equals 1 if the highest school level achieved by the HH head is illiteracy, and equals 0 otherwise
primary school	Equals 1 if the highest school level achieved by the HH head is primary school, and equals 0 otherwise
junior school	Equals 1 if the highest school level achieved by the HH head is junior school, and equals 0 otherwise
high school or above	Equals 1 if the highest school level achieved by the HH head is high school or above, and equals 0 otherwise
health	The health level of the HH head: equals 1 if the HH head is healthy 0 if it is unhealthy
experience	The rice-planting experience of the HH head (years of planting rice)
preference	The rice planting preference of the HH head: equals 1 if the HH head love planting rice, and equals 0 otherwise
membership	Whether the HH head joins the farmers' cooperative: Equals 1 if it is yes, and equals 0 otherwise
rentin	Whether the HH head rents his land: Equals 1 if it is yes, and equals 0 otherwise
hhszise	The total family population of the HH head (number)
rlabour	The labour force population of the HH household (number)
lnarea	Natural logarithm of the total area of rice field in the HH household
lnplots	Natural logarithm of the number of plots operated by the HH household
vtechnician	Whether to implement the system of 'one agricultural technician to one village': equals 1 if it is yes , and equals 0 otherwise