The impact of land security and input allocation on farm household income

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Abstract:

China's rural reforms expose farm households to the risk of administrative land reallocation and adjustment. The possibility of land reallocation gives rise to the problem of tenure insecurity which reduces farm households' incentives to invest in the land and to use the labor forces efficiently and hence negatively affect farmers' income. In this study, the normalized quadratic profit function is used to analyze profit maximization problems in farm households in the Zhejiang and Hubei provinces of China from 1995 to 2002. Additional variables have been introduced to capture the effects of a series of institutional environment and factor market constraints, including land insecurity, crop cultivation structure, labor input and capital input allocations between agricultural and non-agricultural productions. Our results indicate that, although the official controls on rural labor mobility have been relaxed, the rural labor market has not yet reached the optimal level, and a less-than-optimal level of labor input is devoted to non-agriclutural activities for farm households in both provinces. Furthermore, the negative effects of land tenure insecurity on farmhousehold income through the interactions with the other three input allocations are observed in the Hubei province.

Key words: Land security, Input allocation, Farm household income, Rural China

JEL classification: Q12, Q15, Q18

1 Introduction

One major element of land reform implemented in rural China during the 1980s and the early 1990s highlights an extremely equal distribution of cultivated land, meaning that land security could not be guaranteed given the variation of household demographics, labor composition or land resources, etc (Brandt et al. 2002; Liu et al. 1998). After the expiration of the first round of land tenure, mainly in the later part of the 1990s, the government issued a policy that legally prohibited the transfer of land titles from one rural household to another to secure land use rights with the purpose of intensifying agricultural production (Kung 2000; Yao 2000). However, major differences exist between villages or even within villages in the measures implemented, the degree of implementation, and the overall effects of land security policies, etc (Zhang et al. 2011). Land periodically reallocated by local leaders is still observed to maintain egalitarianism despite the decrease of cultivated land per capita due to the population growth, the shifts of land planning and management, and the process of land degradation (Deng et al. 2006).

Land security reforms aiming to create optimal land institutions are running concurrently with reforms in other factor markets, which gradually allow us to diversify the factor allocations among alternative income-generating activities to improve the agent's welfare. When examining government statistics and studies in the literature, the metrics of employment, consistent with the classical two-sector development of the model, have shifted from agriculture to non-agriculture and from rural to urban in the evolution of land market and use (de Brauw et al. 2002; Fei and Ranis 1964; Glauben et al. 2008; Kreps 1990; Kung 2002; Lewis 1954). Ravallion and Van de Walle (2008) argued that one of the major barriers to prosperity in Asia is the willingness and capacity to invest in the usable assets that improve the productive accumulation of farmers when farmers face the uncertainty of land security due to the frequencies and magnitudes of land reallocation. China is no exception. Bowlus and Sicular (2003) attested that farm structures are endogenous instruments to the demand of on-farm labor, suggesting the existence of land allocation constraints in production. Kimura et al. (2011) pointed out that the perception of the land tenure insecurity determined by the market wage also influences the desired level of cultivated land which could be reached through the land rental market.

Well functioning factor markets, which are vital to making full use of scarce resources, are required for the successful transition process in agriculture (Swinnen and Rozelle 2006). To overcome the constraints caused by the lack of land security, the households' decision of whether and how much to allocate inputs such as labor and capital among the production activities is part of the interacted economic choices. Without well-functioning land sale or rental markets, a household makes simultaneous decisions about its production in both the short and long term (Benjamin 1992). Specifically, it makes decisions regarding its inputs, which affect its short-term production, and it decides on its investment in household resources, which affect long-term income capacity.

China's vast regional differences may complicate the relationship between land security and sustained income growth. China's economy is characterized by significant variations across space in the levels of wealth, factor endowment and markets, which may affect the decisions regarding factor allocations in profit-maximizing households (Nyberg and Rozelle 1999). For example, in the rapidly developing coastal areas and suburban areas around rapidly growing cities, farm households have become increasingly wealthy through off-farm employment opportunities or even by abandoning agricultural production altogether. In these situations, farmer's employment is only weakly tied to the land, and thus insecure access to land which may potentially be assigned an inferior quality in future reallocations are not essential to reduce the vulnerability against poverty. In areas that are well off, the factor markets, including the credit markets, are better developed although still imperfect (Findlay et al. 2003). Households in these areas could have many opportunities for non-agricultural investment concerning a trade-off between non-agricultural and agricultural income, which will be influenced by the shrinkage of cultivated land per capita due to the conversion of land to non-farm use.

The land insecurity implemented by Chinese local authorities and the evolution of the factor markets provide a unique opportunity to explore the sources of sustained income growth through a household's joint decisions in factor allocations. To achieve this target, a farm household analysis of income and its affecting factors has been done based on a panel dataset of rural household surveys conducted in the Zhejiang and Hubei provinces by the Ministry of Agriculture from 1995 to 2002. The rest of the paper is organized as follows: Section 2 presents the theoretical framework and the following section is devoted to the econometric model. Section 4 describes the data source and provides descriptive statistics of variables. Section 5 explains the empirical results obtained from the estimation of the normalized quadratic profit functions. The final section concludes the analysis and offers policy implications.

2 Theoretical framework

To study the impacts that land insecurity and farm households' input allocation decisions have on their income, we start from the profit maximization problem in which the household engages in two production activities: agriculture and non-agriculture. The variable profit function is then defined as:

$$\Pi = \Pi(p, z) \tag{1}$$

where p is a vector of netput (output or input) prices, and z is a vector of quasifixed inputs. In the neoclassical production theory setting, it is assumed that the objective of the farm household is the maximization of short-run profit and that the farm household is a price-taker in the output and variable input markets. If the profit function satisfies certain regularity conditions, it is dual to the production function, and its parameters contain sufficient information to describe the farm's production technology at profit-maximizing points in the production possibility set. These testable conditions of

regularity are that the profit function is continuous, twice differentiable, linearly homogeneous in prices, convex in all prices, concave in fixed inputs, decreasing in the prices of the input, increasing in the prices of the output, and non-decreasing in fixed inputs. Applying Hotelling's Lemma to equation (1), the supply functions of output and the derived demand functions of variable input can be obtained by differentiating the profit function with respect to netput prices as:

$$q_i = \frac{\partial \Pi(p,z)}{\partial p_i}, \qquad i = 1, \dots, n \tag{2}$$

where $q_i s$ are positive for outputs, and negative for variable inputs.

When it comes to the practice of production activities in China's farm households, the assumption of profit maximization needs careful discussion. The farmers are still assumed to be profit maximizers, but they will not always succeed in allocating resources in different sectors and choosing levels of outputs and inputs that will lead to a maximum level of profit due to a series of institutional environment and factor market constraints. The rural reform in China initiated in 1979, especially the implementation of household responsibility system (HRS), liberalized the rural labor force and similar production endowments to some extent. As a result, incentives for agricultural production have been greatly improved, and rural farmers' incomes have also increased correspondingly (Brümmer et al. 2006; Fan et al. 2002; Lin 1992). In addition to the decentralization of the production system, the united procurement and marketing system was reformed step by step. By the mid-1990s, China's agriculture had been transformed from a command-and-control system to a largely free-market one, with more than 90% of all agricultural products sold at market-determined prices. [1] In contrast to the impressive improvements in the functioning of product markets, constraints still exist in some important factor markets.

With the process of economic reform, the controls on rural labor mobility were relaxed and rural laborers were allowed to migrate for better paid jobs. But obstacles still exist that hinder the free mobility of rural labor. For instance, rural migrants are discouraged from bringing their families to the cities because of the household registration (hukou) system regulations which register rural and urban households separately and firmly determine access to public services, e.g. education, housing, or public welfare (Brosig et al. 2009; OECD 2009). There still exists a certain amount of local protectionism, in which village workers often earn much higher wages than outsiders (Yao 1999). The introduction of HRS granted land use rights to individual farm households, but left formal ownership of the land in the hands of the government or the local collective. Since the individual farm households do not have legal titles to the land, they face the risk of administrative land reallocation and adjustment. This induced land tenure insecurity reduces the incentives of farm households to invest in the land and hinder the efficient use of labor. Thus, the tenure insecurity may decrease agricultural

[1] The rural policy reform in the last 30 years has been reviewed in detail in Brümmer et al. (2006); Fan et al. (2002); OECD (2009); OECD (2009).

productivity and hence their income.[2] There is a great deal of relevant empirical research on these issues. As reported in Yang (2004), the relaxation of controls on production endowments permitted farm households to reallocate their inputs from agriculture to nonagricultural activities, and contributed significantly to household income growth. Using a hazard analysis approach, Jacoby et al. (2002) find that higher land expropriation risk significantly reduces the use of organic fertilizer, which has long-lasting benefits for soil quality. Applying a stochastic frontier analysis approach, Zhang et al. (2011) argue that in regions where land rental markets and other related factor markets are already relatively well developed, administrative land reallocation seems to distort the market mechanism, undermine market signals, and thus decrease technical efficiency. A study by Deininger and Jin (2005) suggests that land rental markets are more effective than administrative reallocation in reallocating land to those with lower endowments and have a bigger productivity-enhancing effect. Following these analyses, we further study the impact of land insecurity and input allocation and their impact on farm household income. In order to represent deviations from the "real" profit maximization, we add the restrictions related to the institutional environment and factor markets to the previous profit maximization model. Hence, the variable profit function in equation (1) is extended as:

$$\Pi^c = \Pi^c(p, z; c) \tag{3}$$

where $\Pi^c \leq \Pi$, and Π^c will be equal to Π if all the constraints are relaxed or deregulated; c is a vector of variables representing the effects of the institutional environment and factor market constraints which have been discussed above.

To illustrate, we analyze rural labor market in which farm households allocate their labor input (L) between agricultural (a) and non-agricultural (n) sectors. Then the household aggregate profit is the sum of profits from these two activities, and its profit function is written as:

$$\Pi = [f_a(L_a)p_a + f_n(L_n)p_n] - wx \tag{4}$$

where $L = L_a + L_n$; $f_a(L_a)$ and $f_n(L_n)$ are output quantities of agricultural and non-agricultural production, respectively; p_a and $p_n$are the associated output prices; x is a vector of variable inputs and w represents the associated input prices. Then equation (4) can be further expressed as:

$$\Pi = [f_a(L_a)p_a + f_n(L - L_a)p_n] - wx \tag{5}$$

differentiation with respect to L_a gives the following first-order condition for a constrained maximum:

$$\frac{\partial \Pi}{\partial L_a} = f_a^{'}(L_a)p_a - f_n^{'}(L - L_a)p_n = 0 \tag{6}$$

then we have:

[2]See Brandt et al. (2002); Deininger and Feder (2001); Kung (2000) for a more detailed discussions on land tenure security and land reallocation issues.

$$f_a^{'}(L_a)p_a = f_n^{'}(L_n)p_n \quad (7)$$

equation (7) means that, to achieve the goal of profit maximization, the household needs to adjust the level of its labor input between agricultural and non-agricultural production so that the marginal revenue (MR) of these two activities are equal. Graphically, L^* in Figure 1 represents the optimal point of the efficiently allocated labor input between these two sectors. Due to the rural labor market constraints which have been discussed above, we could expect that less-than-optimal level of labor input is devoted to non-agricultural production. As a result, the household's labor allocation will be at the point $L^{\sim}$, on the right side of L^*. And the shaded area ΔABC represents the household's loss of profit due to the misallocation of labor input between agricultural and non-agricultural production. This analysis on rural labor market also applies to the household's capital input allocation between agricultural and non-agricultural activities and its crop cultivation structure decision.

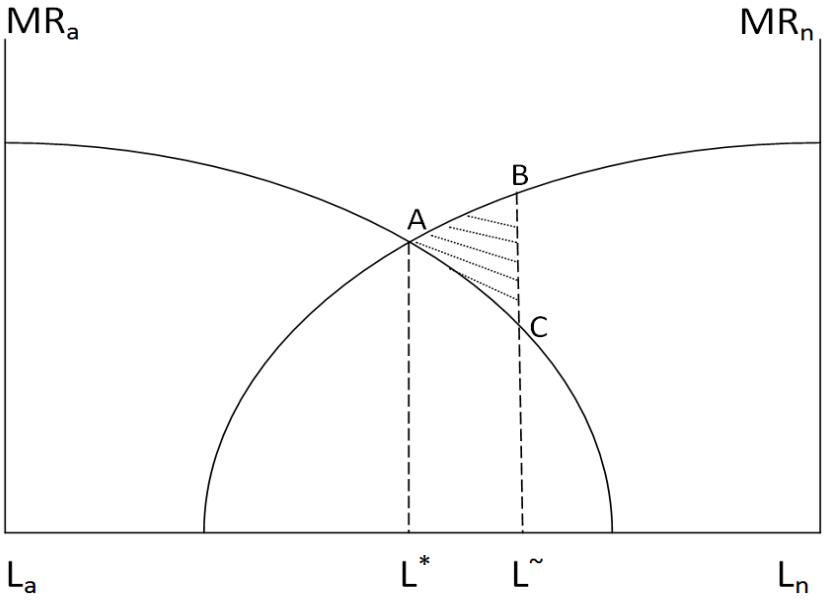

Figure 1: Profit loss due to misallocation of labor input

Source: Own figure.

3 Econometric model

A specific functional form is needed for the estimation of the profit function discussed in Section 2. In this study, the normalized quadratic profit function, from the class of second-order flexible functional forms, is applied. The quadratic functional form is locally flexible and its Hessian is a matrix of constants, which means curvature can be maintained globally without altering the flexibility of the function form. It takes the following form:

$$\Pi^c/p_1 = \alpha_0 + \sum_{i=2}^{m} \alpha_i(p_i/p_1) + \frac{1}{2}\sum_{i=2}^{m}\sum_{j=2}^{m} \alpha_{ij}(p_i/p_1)(p_j/p_1) + \sum_{i=1}^{n} \beta_i z_i$$
$$+\frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} z_i z_j + \sum_{i=2}^{m}\sum_{j=1}^{n} \gamma_{ij}(p_i/p_1) z_j + \sum_{i=1}^{w} \delta_i c_i \quad (8)$$

where Π^c/p_1 is the short-run profit (revenue minus variable costs) divided by the price of netput 1; (p_i/p_1)s are the prices of the variable netputs divided by the price of variable netput 1; z_is are the quantities of quasifixed factors and technology proxy; c_is are variables representing the effects of the institutional environment and factor market constraints; and $\alpha, \beta, \gamma, \delta$ are parameters to be estimated. Here the profit function is normalized by the price of netput 1 to ensure linear homogeneity in prices. Symmetry is maintained by requiring $\alpha_{ij} = \alpha_{ji}$ and $\beta_{ij} = \beta_{ji}$. Convexity and monotonicity will be checked after the estimation.

The expected values of parameters δ_is deserve more detailed discussions. Based on the theoretical framework, four variables (see Table 4) representing the effects of the institutional environment and factor market constraints are introduced in the model: a dummy variable with a value equal to 1 if the arable land of the farm household has been reallocated within the year (Land_real), a second variable representing the share of sown areas which are used for non-grain crops cultivation (Land_s), a third variable representing the share of household labor input which are allocated to non-agricultural production (Labor_s), and a fourth variable representing the share of fixed-capital assets which are allocated to non-agricultural production (Capital_s). As has already been discussed, frequent land reallocation, which induces land tenure insecurity, will have a negative effect on household income. To maintain food security, the government kept the grain quota procurement system until it was finally eliminated in 2001. But at the same time, the government raised procurement prices to increase farmers' incomes and to meet food security goals. So the impact of farmers' crop cultivation structure on their income depends on the game between market prices and government support policies. Because restrictions still exist that hinder the free mobility of rural labor, the effects of labor input share in non-agricultural production are expected to be positive. As for the effect of capital input share to non-agricultural production, it could be positive or negative. Given the expected positive effects of labor input share, it is positive if capital input and labor input are complementary in production, and it is negative if these two inputs are substitutable. As is discussed in the section on the theoretical framework, in addition to land tenure insecurity's direct effects, it might also have indirect effects on income through its interaction with other input allocations. As a result, the products of Land_real with the other three control variables are also introduced into the model.

Applying Hotelling's Lemma to equation (8), the supply functions of output and the derived demand functions of variable input can be obtained by differentiating the profit function with respect to the normalized netput prices as:

$$q_i = \frac{\partial(\Pi^c/p_1)}{\partial(p_i/p_1)} = \alpha_i + \sum_{j=2}^{m} \alpha_{ij}(p_j/p_1) + \sum_{j=1}^{n} \gamma_{ij} z_j \quad (9)$$

where q_i is positive for the supply of outputs and negative for the demand for variable inputs. The numeraire equation is quadratic in prices:

$$q_1 = \Pi^c/p_1 - \sum_{i=2}^{m} (p_i/p_1)\frac{\partial(\Pi^c/p_1)}{\partial(p_i/p_1)} = \alpha_0 - \frac{1}{2}\sum_{i=2}^{m}\sum_{j=2}^{m} \alpha_{ij}(p_i/p_1)(p_j/p_1)$$
$$+ \sum_{i=1}^{n} \beta_i z_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} z_i z_j + \sum_{i=1}^{w} \delta_i c_i \quad (10)$$

The uncompensated (Marshallian) price elasticities are computed as:

$$\eta_{ij} = \frac{\partial q_i}{\partial p_j} \times \frac{p_j}{q_i} = \frac{\partial q_i}{\partial (p_j/p_1)} \times \frac{(p_j/p_1)}{q_i} = \alpha_{ij}\frac{(p_j/p_1)}{q_i} \quad (11)$$

The price elasticities for the numeraire could then be calculated by applying the property of homogeneity of degree zero in prices for the supply functions of output and the derived demand functions of variable input.

4 Data source and descriptive statistics

4.1 Data Source

The database used in this study is drawn from fixed-point survey data series across the Zhejiang and Hubei provinces in China, conducted annually by rural survey teams.[3] The two provinces covered were chosen to reflect the diversity of China's agricultural production. The Zhejiang province is located in the southern wing of the Yangtze River Delta in China, which was an early beneficiary of China's "open door" policies after 1978. In the Zhejiang province, the arable land accounts for 2.125 million hectares, or 1.6% of the country (NBSC, 2001). Since 1978, Zhejiang has experienced rapid growth and diversification of the economy. From 1978 to 2002, its GDP achieved a yearly growth rate of 13% on average, and thus it jumped in rank from 12th to 4th out of all 31 Chinese provinces in terms of economic performance. The GDP per capita rose to 16,570 Yuan (2,004 USD) in 2002 with an annual increase of 12.1%, while the per capita net income of rural residents reached 4,940 Yuan (597 USD) with an annual growth rate of 8.7%. The sectoral composition of the province's economy has changed dramatically compared to other provinces over the course of economic reforms. Agriculture accounts for only 33% of provincial employment compared to a national average of 64%. Tertiary industry accounts for 33% (NBSC, 2004). Zhejiang is developing

[3]The rural survey teams of the Ministry of Agriculture of China conducted the primary trial survey at the beginning of 1983 in nine provinces. After 1984, the survey was extended to 28 provinces (excluding Tibet and Taiwan; later the survey included Hainan and Chongqing after they separated from Guangdong and Sichuan provinces, respectively, as well as Tibet. Thus, the survey finally covers 31 provinces and is conducted annually), covering 71 counties, 93 townships, 272 villages and 37,422 rural households. For financial reasons, the survey was not conducted in 1992 and 1994. By agreement, we have obtained access to the household data of Zhejiang and Hubei provinces from 1995 to 2002.

rapidly, and today it is one of the richest provinces in China.

Hubei, which is often called the "Land of Fish and Rice", is a central province in China. Hubei is the traditional heartland of Chinese agricultural production whereas Hubei was chosen as one of the thirteen major trial grain production provinces to directly subsidize grain producers starting in 2004. The arable land in the Hubei province accounts for 4.950 million hectares, or 3.8% of the country (NBSC, 2001). 42.37% of those in the labor force still undertake some kinds of agricultural work in the Hubei province. Hubei's economy ranks 12th in the country and its nominal GDP for 2006 was 749.7 billion yuan (96.9 billion USD) with a per capita of 13,169 yuan (1,709 USD). It is expected that Hubei will benefit greatly after the completion of the "Three Gorge Dam" project conducted in the western part of Hubei.

Before summarizing the descriptive statistics of the variables used in the study, we provide a brief description of the fixed-pointed survey. The survey is based on a multistage, random-cluster process to attain rich information about the effect of rural reform on agricultural production and rural development. Counties, which are below province-level administrative units, were stratified by income level and selected according to a weighted sampling scheme. The villages within the counties were then randomly chosen according to geographic diversification (plain, hilly, or mountainous area), location (suburb of a city or not), and economic features defined as mainly agriculture, forestry, husbandry, fishery or others. Subsequently, the household data of the respective villages are randomly selected from the comprehensive household list kept by the village leader. To maintain longitudinal household information, the same households were interviewed each time the survey was conducted. If the household was dropped from the survey and was not recorded on the household list in the village, a new sample household was recruited from the same village with another ID and remained in the survey for the following years if it was qualified.[4] Local enumerators train assistants from the village and rural households to maintain daily diaries that completely record all economic activities. An enumerator assistant is then assigned to a group of ten households and helps the households complete their diaries. The assistants also check the diaries once a month. Every quarter of a year, the local enumerators collect and check the completed forms. At the end of the year, the forms are returned and entered into a nationally-designed coding program. Households receive payments of between 50 to 200 Yuan (around 6 to 24 USD) from the local government for their efforts. Close supervision of the data collection process and careful checks of consistency ensure that this dataset is of relatively high quality. Thus, the unbalanced panel data set includes 8,703 observations from 1995 to 2002, in which around 500 households from the Zhejiang province and 900 from the Hubei province participated .

4.2 Descriptive statistics

[4]The household was dropped from the survey either due to the emigration of the whole family from the village to an urban area or to another town or village, or because the family members died after several years in the survey.

The summary of statistics of the characteristics of farm households in Zhejiang (Table 1) and Hubei (Table 2) allow the comparison of the structure of households participating in agricultural and non-agricultural production over time. Total income per household is near the national average in 2002 in Hubei, while it is significantly above average in Zhejiang. Agricultural production activities generate by far the biggest component of household income in landlocked province Hubei-about 57%-while in the more diversified economy of coastal Zhejiang, it represents around 40% for the whole sample period. Even though the proportion of non-agricultural income has increased at a faster rate in Hubei than in Zhejiang, Hubei's non-agricultural income in 2002 was still far behindthe level seen in Zhejiang in 1995. In the pursuit of profit-maximization, households are more concerned with non-agricultural production activities in Zhejiang than in Hubei. On average, the share of labor input in non-agricultural production in Zhejiang is over 57% of the time allocation of a household's labor, measured in the unit of days; however, it is still less than 34% in Hubei, even though workers there have been more likely to engage in off-farm employment since 1995. Entering the 1990s, the impediments to non-agricultural activities had been largely relaxed, farm households could locate and maintain capital in non-agricultural business under their control. The fact that capital accumulation in non-agricultural business is much less in Hubei than that in Zhejiang is driven by the lower level of capital endowment and the smaller proportion of non-agricultural capital in Hubei.

Table 1: Summary statistics of characteristics of farm households in Zhejiang

Year	Share of households with land reallocation (%)	Capital (1000 yuan)	Share of capital in non-agriculture (%)	Labor (100 days)	Share of labor input in non-agriculture (%)	Total sown areas (mu)	Share of sown areas to non-grain crops (%)	Total income (1000 yuan)	Share of non-agricultural income (%)
1995	0.00	5.83	68.05	6.55	57.55	5.84	24.68	24.84	55.32
	(0.00)	(10.91)	(33.64)	(2.98)	(30.33)	(11.39)	(18.17)	(18.29)	(29.21)
1996	25.97	7.23	69.95	6.11	56.93	5.75	26.26	27.69	58.10
	(43.92)	(15.07)	(33.03)	(2.74)	(29.94)	(7.67)	(18.39)	(34.69)	(28.23)
1997	22.41	6.31	69.71	6.00	56.27	5.20	26.85	29.36	58.53
	(41.77)	(10.51)	(33.70)	(2.59)	(30.09)	(3.07)	(21.12)	(52.99)	(28.99)
1998	26.62	10.08	68.25	5.51	56.15	5.24	29.06	26.90	67.30
	(44.28)	(28.06)	(34.34)	(2.72)	(31.13)	(4.75)	(24.07)	(47.83)	(30.53)
1999	31.80	7.88	65.03	6.24	57.53	4.72	26.56	27.60	61.25
	(46.65)	(11.48)	(35.69)	(2.91)	(30.38)	(3.25)	(23.37)	(29.79)	(28.58)
2000	22.80	7.30	64.32	6.21	59.68	3.88	33.95	31.41	62.89
	(42.04)	(09.57)	(35.53)	(2.91)	(30.68)	(3.16)	(29.59)	(33.49)	(30.63)
2001	30.13	8.80	63.74	5.90	55.33	3.56	32.69	33.30	58.70
	(45.98)	(13.70)	(34.85)	(2.80)	(30.35)	(2.50)	(27.41)	(43.08)	(30.58)
2002	18.00	8.36	65.70	5.93	57.30	3.26	33.50	30.78	62.08
	(38.52)	(15.07)	(34.09)	(2.68)	(30.61)	(2.66)	(28.05)	(32.36)	(29.10)
Total	21.80	7.62	67.08	6.07	57.09	4.81	28.74	28.69	60.32
	(41.30)	(15.34)	(34.34)	(2.81)	(30.39)	(6.03)	(23.79)	(37.94)	(29.60)

Note: Standard deviations are in parentheses. Values of "Capital" and "Total income" are measured at constant 1995 prices.

Table 2: Summary statistics of characteristics of farm households in Hubei

Year	Share of households with land reallocation (%)	Capital (1000 yuan)	Share of capital in non-agriculture (%)	Labor (100 days)	Share of labor input in non-agriculture (%)	Total sown areas (mu)	Share of sown areas to non-grain crops (%)	Total income (1000 yuan)	Share of non-agricultural income (%)
1995	0.00	1.73	42.77	5.79	31.03	9.12	29.93	10.92	34.26
	(0.00)	(3.87)	(35.55)	(2.80)	(24.25)	(4.85)	(22.58)	(5.59)	(23.88)
1996	21.77	1.89	42.56	5.76	30.36	9.09	29.01	10.09	37.78
	(41.29)	(4.09)	(35.73)	(2.56)	(24.67)	(5.00)	(22.25)	(5.46)	(25.07)
1997	21.60	1.97	41.35	5.66	31.24	9.02	28.69	9.91	38.20
	(41.17)	(4.53)	(35.54)	(2.40)	(24.28)	(4.82)	(22.76)	(5.25)	(24.75)
1998	30.14	2.31	42.15	5.62	30.20	8.88	29.97	9.73	39.73
	(45.91)	(6.56)	(35.56)	(2.48)	(24.98)	(4.82)	(22.21)	(5.20)	(25.50)
1999	35.65	2.65	43.02	6.06	35.79	8.76	31.44	10.25	47.16
	(47.93)	(7.44)	(35.16)	(3.31)	(25.75)	(4.75)	(23.00)	(7.92)	(25.25)
2000	24.39	2.71	42.77	5.87	37.29	8.64	35.52	10.56	47.84
	(42.97)	(6.83)	(34.34)	(2.55)	(24.83)	(4.56)	(24.49)	(9.25)	(24.63)
2001	23.20	2.51	43.14	6.01	36.01	8.12	37.68	10.01	48.06
	(42.24)	(5.60)	(34.38)	(2.76)	(26.54)	(4.55)	(26.04)	(6.97)	(25.60)
2002	28.36	2.30	42.09	6.20	38.20	7.89	38.42	10.00	48.41
	(45.10)	(4.34)	(35.47)	(2.99)	(26.64)	(4.76)	(26.07)	(6.32)	(26.15)
Total	23.08	2.26	42.48	5.87	33.75	8.69	32.55	10.19	42.64
	(42.14)	(5.57)	(35.21)	(2.75)	(25.43)	(4.78)	(23.99)	(6.64)	(25.67)

Note: Standard deviations are in parentheses. Values of "Capital" and "Total income" are measured at constant 1995 prices.

It is well-known that agricultural sectors in China are dominated by small scale farms and that these farms face a certain risk of shrinkage of cultivated land and land insecurity. Average farm sizes in the sample reflect that average land area per household in South East China is below the national average of nearly 0.6 ha (NBSC, 2003). Average of total sown area is 8.69 mu[5] in Hubei and 4.81 mu in Zhejiang.[6] From 1995 to 2002, the reduction of sown area per household is 2.6 mu in Zhejiang, which is twice as much as that in Hubei. This also suggests that in the well-off areas, the farmers are less dependent on agricultural production. Agricultural production is also diversified into grain crops and other high-profit crops like oilseeds, vegetables, fruits and husbandry production. Our data also show that the non-grain cropping has been intensified in both Zhejiang and Hubei over time given the constraints of land endowment. The prevalence of land reallocation was reflected in our data in the two provinces because on average, more than 20% of households experienced land reallocation in the period of time 1995-2002. The dimension of land reallocation varied over time and between provinces with the evidence that more than 30% of sampled households have experienced land reallocation in different years. The land reallocation rate in our data is lower than that (75%) in the study by Kimura et al. (2011). This is because they recorded the land reallocation starting from the very beginning of the

[5] 1 mu = 1/15 hectare in China.

[6] In the two provinces, the cropping pattern generally involves sowing twice per year on one plot of cultivated land, for example, harvesting wheat in summer and rice in autumn.

implementation of HRS, while our statistics were obtained later, even after the expiration of the first round of land tenure contracts.

The dependent variable used in the normalized quadratic profit functions is the net income from the non-agricultural employment and agricultural production, which aggregates the profit of producing physical products from crop, livestocks and other agricultural products. A time trend is included to capture technological progress. The descriptive statistics of the variables presented in Table 3 reveal several important variations of output and inputs across provinces. It is reported that the rural household in Zhejiang earns more income, on average, from both agricultural and non-agricultural activities. The former include outputs from farming, forestry, husbandry and fishery while the latter are obtained from the diversified off-farm employment such as manufacturing, construction, transportation and other services, etc. In agricultural production, households in Zhejiang have less land than those in Hubei in the unit of mu and use the same level of intermediate input. This implies that the technologies applied in agricultural production are to a larger extent region-specific due to the different constraints of land endowment. Here, intermediate inputs in the value term include grain and cash crop seeds, fertilizer, agricultural diesel oil, plastics and pesticides in agricultural production. The labor input is the total number of annual working days of all of the rural labor, including both on- and off-farm employment activities. Capital input measured in the unit of yuan is defined as fixed-capital assets of the household at the end of the year and includes draught animals, production tools, production buildings, and machinery for agriculture, industry and transportation. Capital input and quantities of the three composite netput categories are measured at constant 1995 prices.

Divisia price indexes are calculated for the three composite netput categories (two outputs and one input). The producer price indexes of each netput within the three composite netput categories are drawn from the China Statistical Yearbook (NBSC, various years) and the China Rural Statistical Yearbook (NBSC, various years), and have been converted into cumulative (chained) indexes with the base year 1995 equal to 1. The Divisia price indexes are then computed with value shares of netputs as weights.

Table 3: Descriptive statistics of the variables

Variables	*Symbol*	Zhejiang		Hubei	
		Mean	Std. Dev.	Mean	Std. Dev.
Total household net income for the year (1000 yuan)	$Income$	16.433	8.782	7.469	3.912
Technology (year 1995 = 1)	t	4.178	2.243	4.480	2.291
Price indexes (base year 1995)					
Agricultural products	p_1	0.916	0.094	0.882	0.118
Non-agricultural products	p_2	0.964	0.047	0.959	0.057
Intermediate inputs	p_3	0.929	0.090	0.915	0.107
Quantities (prices of year 1995)					
Agricultural products (1000 yuan)	q_1	11.082	20.146	5.399	3.943
Non-agricultural products (1000 yuan)	q_2	12.298	32.130	3.308	5.594
Intermediate inputs (1000 yuan)	q_3	-0.743	0.861	-0.727	0.614
Quasifixed inputs					
Labor input of the household (100 days)	a	6.073	2.811	5.869	2.751
Arable land of the farm household (mu)	l	2.765	2.240	4.964	2.808
Fixed-capital assets of the household (1000 yuan)	k	7.624	15.344	2.258	5.569
Other control variables					
Share of labor input in non-agricultural production (%)	*Labor_s*	57.092	30.395	33.746	25.433
Share of sown areas in non-grain crops cultivation (%)	*Land_s*	28.735	23.793	32.555	23.991
Share of fixed-capital assets in non-agricultural production (%)	*Capital_s*	67.079	34.338	42.482	35.206
Whether land was reallocated within the year (dummy, 1 = yes)	*Land_real*	0.218	0.413	0.231	0.421
No. of observations		2170		6533	

5 Estimation results

Before the estimation, in order to avoid numerical difficulties in the maximum likelihood estimations and to facilitate the interpretation of the parameter estimates, the normalized profit, the two normalized netput prices and the three quasifixed input variables are scaled to have a mean of zero, respectively. As a result, at the sample mean, the transformed variables take the value zero. Hence, in the estimation results, the first-order coefficients of the normalized netput prices variables can be interpreted as quantities of the supply of output or the derived demand of variable input, and that of the quasifixed input variables can be interpreted as their shadow prices at the sample mean. Because a panel dataset is used in this study, the fixed effects (FE) model and the random effects (RE) model have been estimated separately, and the results of the Hausman test strongly reject the random effects model at the 1% significance level, suggesting that the unobserved time-invariant farm household effects are correlated with the explanatory variables in the estimations. Consequently, the following discussions are based on the results from the fixed effects model estimation. The estimated results of the normalized quadratic profit functions for the Zhejiang and Hubei provinces are presented in Table 4.

Table 4: Results of the normalized quadratic profit functions with fixed effects model estimates

	Zhejiang		Hubei	
p_2^*	8.893*	(4.278)	12.324***	(1.072)
p_3^*	-6.847	(5.996)	-4.519***	(1.327)
t	0.839***	(0.133)	0.060	(0.043)
a	1.484***	(0.088)	0.491***	(0.029)
l	0.085	(0.195)	0.296***	(0.040)
k	0.120**	(0.046)	0.230***	(0.025)
Land_real	-0.164	(1.180)	-0.370	(0.228)
Land_s	-0.003	(0.009)	0.004	(0.004)
Capital_s	0.009	(0.010)	-0.006*	(0.003)
Labor_s	0.060***	(0.009)	0.025***	(0.003)
Land_real×Land_s	-0.009	(0.016)	-0.010*	(0.004)
Land_real×Capital_s	0.006	(0.011)	0.008**	(0.003)
Land_real×Labor_s	-0.007	(0.012)	0.010*	(0.004)
$0.5p_2^* \times p_2^*$	248.725	(167.968)	40.360	(23.857)
$0.5p_3^* \times p_3^*$	38.705	(90.483)	34.614***	(9.303)
$p_2^* \times p_3^*$	30.677	(85.531)	0.879	(12.967)
0.5t×t	0.219	(0.125)	0.078	(0.041)
0.5a×a	-0.052	(0.029)	-0.027***	(0.006)
0.5l×l	0.002	(0.012)	0.018*	(0.008)
0.5k×k	-0.002	(0.002)	-0.005***	(0.001)

t×a	0.079	(0.042)	0.038**	(0.014)
t×l	0.103	(0.071)	0.010	(0.014)
t×k	0.024*	(0.011)	0.012*	(0.006)
a×l	-0.042	(0.032)	0.009	(0.007)
a×k	0.004	(0.005)	-0.004	(0.002)
l×k	0.017	(0.012)	-0.012**	(0.004)
p_2^* ×t	-5.664	(4.039)	0.434	(0.841)
p_2^* ×a	1.759	(1.446)	-0.257	(0.343)
p_2^* ×l	-6.650**	(2.296)	-0.314	(0.336)
p_2^* ×k	-0.636	(0.335)	-0.167	(0.148)
p_3^* ×t	-1.137	(3.721)	-1.409*	(0.714)
p_3^* ×a	0.153	(1.578)	-0.614	(0.331)
p_3^* ×l	-0.265	(2.501)	-0.877**	(0.331)
p_3^* ×k	0.616*	(0.301)	0.025	(0.139)
# Observations	2170		6533	
sigma_u	8.855		2.608	
sigma_e	6.171		2.981	
rho	0.673		0.433	
log likelihood	-6795.890		-15845.555	
Endogeneity test of endogenous regressors				
H_0: Land_s can actually be treated as exogenous				
χ^2	$\chi^2(1) = 0.085$		$\chi^2(1) = 0.029$	
P-value	0.771		0.865	
H_0: Capital_s can actually be treated as exogenous				
χ^2	$\chi^2(1) = 2.578$		$\chi^2(1) = 0.603$	
P-value	0.108		0.438	
H_0: Labor_s can actually be treated as exogenous				
χ^2	$\chi^2(1) = 0.240$		$\chi^2(1) = 2.094$	
P-value	0.624		0.148	

Note: p_2^* and p_3^* are normalized prices, where $p_2^* = p_2/p_1$ and $p_3^* = p_3/p_1$.
Standard errors are given in parentheses.
* p < 0.05, ** p < 0.01, *** p < 0.001

Given the structure of the model, the three share variables (Land_s, Capital_s and Labor_s) reflect household production choices and might cause endogeneity problems in the estimation. Although the use of the fixed effects model estimation could partially overcome these problems, the instrumental variables estimations have been done to test for the endogeneity of the potentially endogenous regressors. In the model, a one-year lag of these three variables is used as an excluded instrument in the estimation considering the potential endogeneity problem, and the test results are given in the lower part of Table 4. The test statistics suggest that all of the three share variables (Land_s, Capital_s and Labor_s) can be treated as exogenous in the Zhejiang

and Hubei provinces. As was already discussed in the econometric model, one merit of the quadratic functional form is that the Hessian matrix of its second-order partial derivatives only contains constants and hence its curvature properties are global. Eigenvalues of the Hessian for the Zhejiang and Hubei provinces are checked and the results are listed in Table 5. Since the Hessian is positive semidefinite for both provinces, the normalized quadratic profit function is convex at all points of the sample.

Table 5: The Hessian matrix and its eigenvalues

Zhejiang			Hubei		
The Hessian		Eigenvalues	The Hessian		Eigenvalues
248.725	30.677	253.115	40.360	0.879	40.491
30.677	38.705	34.316	0.879	34.614	34.483

Since the two normalized netput prices and the three quasifixed input variables have been scaled, the coefficients of p_2^* can be interpreted as quantities of the supply of non-agricultural products; the absolute value of the coefficients of p_3^* can be interpreted as quantities of the derived demand for intermediate inputs, at the sample mean. From the estimation results, the two normalized prices p_2^* and p_3^* all have correct signs, and they are strongly significant at a level of 5% except for p_3^* of the Zhejiang province. The coefficients of technology (t) are both positive, and the significant effect on farm household income is only observed in the Zhejiang province.

As for the three quasifixed inputs, the coefficients, which can be interpreted as their shadow prices at the sample mean, all have correct signs, and they are strongly significant at a level of 5% except for arable land input (l) in the Zhejiang province. The shadow price of labor in the Zhejiang province is much higher (almost threefold) than that in the Hubei province, which is in accordance with the economic development level of the two provinces. In China, the Zhejiang province is located on the coast and is one of the richest provinces, while the Hubei province represents the middle-income region in the central part of the country. Rural enterprises, especially restructured township and village enterprises (TVEs), have always been privileged in the coastal provinces, since they have relatively easy access to both export markets and to large domestic markets in the densely populated and relatively rich eastern provinces (OECD 2009). Therefore, the concentration of rural enterprises in the Zhejiang province is much stronger than that in the Hubei province in terms of employment, value of production, and assets. The same story applies to the interpretation of the difference in shadow price of capital input for the two provinces. For farm households in China, non-agricultural incomes are very important to their level of net incomes. In our sample, on average roughly 60% of total income comes from non-agricultural activities for farm households in the Zhejiang province, while the number is 43% in the Hubei province. So in the estimated results, it is not very surprising to see that the shadow price of arable land in the Zhejiang province is small and not statistically different from zero at the 5% significance level.

The coefficients of Land_real, which index land tenure insecurity, are negative

but not statistically significant for both provinces. Direct effects of administrative land reallocation on farm household income are therefore not observed in our sample. The coefficients of Land_s are also not significant, which indicates that farmers' choice of crop cultivation structure has not significantly affected their income in our sample. The coefficient of Capital_s is not statistically significant for the Zhejiang province, but it is significant and negative for the Hubei province. The insignificance of Capital_s in the Zhejiang province indicates that, statistically, a one percent increase of capital input share in non-agricultural activities or a one percent decrease of that in agricultural activities will not bring any more profit at the 5% significance level. In other words, the sectoral allocation of capital input between agricultural and non-agricultural production could be seen as already at the optimum for farm households in the Zhejiang province. In contrast, the negative sign for the Hubei province shows that a less-than-optimal level of capital input is devoted to agricultural production, and farm households' income will increase if they allocate more capital from non-agricultural activities to agricultural use. The coefficients of Labor_s are positive and statistically significant at a 0.1% level for both provinces. The results indicate that the rural labor market has not yet reached the optimum, and a less-than-optimal level of labor input is devoted to non-agricultural activities, which is consistent with the findings from Yang (2004). Judged from the magnitude of the coefficients, the same adjustment level of labor from agricultural to non-agricultural activities will bring more profit to farm households in Zhejiang than in Hubei.

As for the indirect effects of land tenure insecurity on rural income through the interactions with other input allocations, the coefficients of the interaction terms are all not statistically significant at 5% level for the Zhejiang province, which means that there are also no indirect effects of land tenure insecurity on the farm household income observed in our sample. In contrast, the coefficients of the interaction terms are all statistically significant for the Hubei province. The effect of the interaction term of Land_real with Land_s is negative, which means that allocating more arable land from non-grain crops to grain crops production will bring additional profit to farm households whose lands have been administratively reallocated compared to those whose lands have not. The effects of the interaction terms of Land_real with Capital_s and Labor_s are both positive. The results could be interpreted that an adjustment of labor and capital inputs from agricultural to non-agricultural activities will bring additional profit to farm households whose lands have been administratively reallocated compared to those whose lands have not.

After the estimation, the uncompensated or Marshallian price elasticities of outputs and variable inputs are calculated and reported at the sample means for both provinces in Table 6. Under the assumption of profit maximization, own price elasticities of output supply must be positive and own price elasticities of input demand must be negative. From Table 6 we can see that all own price elasticities have the correct sign except for the non-agricultural products in the Hubei province. Since roughly 24% of the observations in the Hubei province have zero non-agricultural products, we suspect this might be the source of the wrong sign of the non-agricultural products supply elasticity. To control for the effects of those farm households who do not have non-agricultural

activities, we introduced a dummy variable into the model with value equal to 1 if positive non-agricultural products are observed for the farm household and the interaction term of the dummy variable with the normalized price of non-agricultural products. Yet after the re-estimation, the calculated own price elasticity of the non-agricultural products is still negative. The results indicate that own price elasticities for agricultural products are elastic while own price elasticities for non-agricultural products and intermediate inputs are inelastic for both the Zhejiang and Hubei provinces.

Table 6: Uncompensated (Marshallian) price elasticities of outputs and variable inputs at the sample means

	Zhejiang			Hubei		
	p_1	p_2	p_3	p_1	p_2	p_3
q_1	1.120	-0.940	-0.179	2.568	-2.202	-0.366
q_2	-0.348	0.277	0.071	0.164	-0.163	-0.001
q_3	0.165	-0.139	-0.026	0.006	0.015	-0.021

6 Concluding remarks

In this study, the normalized quadratic profit function is used to analyze profit maximization problems in farm households in rural China. Additional variables have been introduced to capture the effects of a series of institutional environment and factor market constraints, including land insecurity, crop cultivation structure, labor input and capital input allocations between agricultural and non-agricultural productions. A panel dataset covering two distinct provinces and eight years allows us to study factors affecting farm household income and do some regional comparisons.

Our results indicate that, although the official controls on rural labor mobility have been relaxed, the rural labor market has not yet reached the optimal level, and a less-than-optimal level of labor input is devoted to non-agricultural activities for farm households in both provinces. The estimated results suggest that those government policy choices which help further facilitate the outflow of labor from agriculture into other economic sectors, through outmigration for example, will bring significant income effects to farm households. In contrast to the optimized rural capital market for farm households in the Zhejiang province, households in the Hubei province have not efficiently allocated their capital input between agricultural and non-agricultural productions, and their income will increase if they allocate more capital from non-agricultural to agricultural use. At the same time, the finding that the farmers' choice of crop cultivation structure has no significant effect on their income reflects that the united procurement and marketing system has been largely deregulated during the research period and farmers could adjust their crop cultivation structure according to the market prices. Although the grain quota procurement system still existed until 2001,

the government had concurrently raised procurement prices for grain substantially to increase farmers' income and to meet food security goals.

In the Zhejiang province, we observe that land tenure insecurity, which is induced by administrative land reallocation, has neither direct nor indirect effects on farm household income through the interactions with other input allocations. The explanation for this is that, on the one hand, off-farm income has accounted for a large proportion of household net income, as is already shown in the descriptive statistics, so income dependence on land has decreased to some extent. On the other hand, according to the research results from Zhang et al. (2011), the development of the land rental market can serve as a substitute for administrative land reallocation in optimizing the distribution of land resources, and the Zhejiang province is a case with a relatively well developed land rental market. So we could say that the negative effects of land tenure insecurity have been largely offset by the positive effects of a relatively well functioning land rental market. In the Hubei province, although the direct effects of land tenure insecurity are not observed, the indirect effects through the interactions with the other three input allocations are all significant. The negative effects of the interaction term of Land_real with Land_s indicate that administrative land reallocation will disturb farm households' decisions regarding the adjustment of crop cultivation structure and hence affect their income growth. Similarly, frequent land reallocation, which induces land tenure insecurity, will further distort the market mechanism, reinforce farm households' misallocations of the inputs, impede their adjustment process to the optimal allocation of inputs and hence hinder income growth.

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