China Economic Review 42 (2017) 155–165

Contents lists available at ScienceDirect

China Economic Review

Off-farm employment and agricultural specialization in China

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ARTICLE INFO

Article history:
Received 5 July 2015
Received in revised form 11 September 2016
Accepted 11 September 2016
Available online 13 September 2016

JEL classifications:
J2
Q12

Keywords:
Off-farm employment
Specialization
China

ABSTRACT

While it is well known that China's off farm labor market is emerging rapidly, less is known about the effect of movement off the farm on the farming practices of those that have continued to farm. The overall goal of this paper is to analyze the effects of changes in China's off farm employment on one aspect of the performance of China's agricultural sector: the emergence of specialization in farming. To achieve this goal, we have three specific objectives. First, we document the changes in the flow of labor out of China's villages. Second, we examine how specialization in farming has changed over time. Third, we examine the association between off farm labor flows and specialization. Using panel data from a national representative data collected by the authors between 1999 and 2008, the analysis finds that off farm employment is indeed rising rapidly. At the same time, specialization is occurring off and on the farm. There is a strong and robust correlation between off farm employment and on farm specialization. The results imply that China's agriculture has responded dynamically to the modernization happening elsewhere in the economy.

In recent years researchers have studied intensively the rise of China's rural labor markets in terms of employment outcomes and the effect on wages. Many papers that have sought to measure the flow of labor out rural areas into urban areas and the industrial labor force (de Brauw, Huang, Rozelle, Zhang, & Zhang, 2002; World Bank, 2007; Cai & Wang, 2010; Knight, Deng, & Li, 2011; Wang, Huang, Zhang, & Rozelle, 2011; Gong, Kong, Li, & Meng, 2008). The estimates of the flows of labor from rural villages to the cities range from 35% to 65% in 2008. Despite these differences, the papers have one element in common: the number of participants in China's off farm labor market is large and rising.

The literature has a number of papers in recent years that suggest that off farm labor markets have been rising fast and that village economies have been changing as a result. In one set of papers, it is reported that large share of rural individuals are outmigrating and creating sharp changes to the demographics in the villages (Li, Huang, Luo, & Liu, 2013; Huang & Ding, 2015). In another set of papers, there is a description of China's rapidly rising wage rate in the period after 2000 (Zhang, Yang, & Wang, 2011; Li, Li, Wu, & Xiong, 2012; Wang, Yamauchi, & Huang, 2016). This, of course, is evidence that—at least at some level—large numbers of rural individuals have entered the off farm labor market but that the scope of further rises is less optimistic. In other words, since the number of individuals in rural communities have stabilized and there are fewer workers who want to leave, there is upward pressure on the wage rate.

There is one part of China's off farm labor market literature, however, that has had less attention. Few empirical studies have analyzed the effect of the changes in off farm employment on the sector the workers left behind: agriculture. There are studies

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http://dx.doi.org/10.1016/j.chieco.2016.09.004
1043-951X/

that are interested in understanding how China's food economy and its food security agenda will evolve as China develops. These big picture studies, however, are based either on reviews of the literature (Fan & Agcaoili-Sombilla, 1997; Ash, 2011) or modeling (Huang, Yang, & Rozelle, 2010; OECD-FAO, 2011). There are also empirical studies that are interested in whether or not there are economies of scale in agriculture (Heerink, Qu, Kuiper, Shi, & Tan, 2007). Such research, however, has not been conducted in the context of changes of off farm employment. In sum, then, there is an absence of research on how the rise of off farm employment is affecting the strategies of households in allocating their labor across sectors and how these allocations are affecting farming. This lacuna of research, in part, may explain why both casual observers seem to suggest that China's food economy will suffer from China's ongoing industrialization and urbanization (Christiansen, 2009).

The nature of the shifts in off farm labor markets could very well also be associated with healthy changes in the agricultural sector that might produce a village economy that is more efficient. The mechanism, of course, would be specialization. In the literature it has been shown that in some economies when labor becomes more scarce and hired labor does not completely substitute the family labor, the households/individuals that remain in farming begin to specialize in order to more efficiently use their labor, farm more area and produce higher incomes (D'Antoni, Khanal, & Mishra, 2014). In the theoretical literature (which was initially examining developed countries), Roumasset, Setboonsarng, Wickramasinghe, Estudillo, and Evenson (1995) shows that outmigration of certain types of households also leads to changes in farming systems. These shifts are characterized as changing subsistence farming to specialized activities in farming, according to the comparative advantages of the families that are left behind.

There are clear examples where this has occurred in developed countries. For example in the United States, trend was oriented toward the cultivation of specialized commodities by farmers in counties that specialized in those commodities (Winsberg, 1982). Moreover, it is the counties that experienced the greatest outflow of labor during the post-World War II era that experienced the greatest shifts toward specialization. Their empirical findings are mirrored by the work of Kimhi and Bollman (1999) which demonstrated that changing labor markets off the farm were associated with more specialization in Canada's farming.

In more recent years, a literature has emerged that has examined this issue (rising off farm labor flows out of the village and specialization of farming of those left in the villages) in the context of developing countries. Theoretically, the household model frameworks derived by De Janvry, Fafchamps, and Sadoulet (1991) and De Janvry and Sadoulet (2006) demonstrates that when off farm labor does not flow (partly due to market failures in local labor markets), farming system tend to be remain subsistence in nature and not specialize. Empirically, Omamo (1998) presented data that show that small-scale farmers tend to shift away from diversified cropping to pure-stand (specialized) production as opportunities for off farm jobs rise (in Omamo's context this occurred as new roads shortened the distance to the market in Kenya).

Unfortunately, there is almost no work on documenting the rise of the specialization of agriculture in China's village or the effect of changes in labor markets. There is mention of changes in the ways that farmers are choosing their cropping patterns against the risk of the extreme weather events (Huang, Jiang, Wang, & Hou, 2014). There are also discussions of changing cropping patterns in villages (Chen, Sushil, & Ding, 2013). The only existing paper that has linked a rise in specialization with the better access to market is published by Yu and Zhang (2016), but their paper only exams several villages in Guizhou and is not focused on off farm labor flows per se. In fact, there is no paper—to our knowledge—that seeks to assess the relationship between changing off farm labor market trends and specialization.

The overall goal of this paper is to analyze how changes in China's off farm employment may affect one aspect of the performance of China's agricultural sector: the emergence of specialization. To achieve this goal, we will be looking to answer several specific questions: What are implications of rising off-farm employment for crop production? Has rising off-farm employment been associated with the specialization of households in farming? At the village level, is there more specialization occurring in villages with more off farm labor movement?

To meet this goal and answer these questions, we have three specific objectives. First, we document the changes in the flow of labor out of China's villages. Second, we examine how specialization in farming has changed over time. Third, we examine the associations between off farm labor flows and specialization. To meet this final objective, we exam data at both the household and village levels.

1. Data

The data used in this study are a subset of a dataset that was collected during two rounds of nationwide surveys. The authors carried out the surveys in December 2000 (collecting data for the year 2000) and early 2009 (collecting data for the year 2008). The dataset for the year 2000 includes information from 60 randomly-selected villages in 6 provinces representing China's major agricultural regions. The provinces selected include Hebei, Liaoning, Shaanxi, Zhejiang, Sichuan and Hubei. For each province five counties were selected. Two villages were randomly selected from each county. Twenty households were chosen from each village. Among a total of 1200 households investigated, 1194 records were complete. Importantly, in addition to collecting data for the year 2000, we also asked respondents to recall the information for the previous year (1999).

In the 2009 survey, we went back to the same villages that were surveyed in 2000. There were two exceptions. Because of the 2008 earthquake in Sichuan, we were not able to do the survey in two of the villages. As a consequence, the sample size (including those without complete records in 2001) was reduced from 1200 to 1160. Among the remaining 1160 households surveyed in 2000, we were able to re-investigate 1046 households in 2009. Of the 114 households that we could not find in the village, 89 of them had moved out of the village and resided in an urban area. The other 25 households either disappeared because all of the members had died (seven households) or were living in the village but were not engaged in farming activities (18

households—mostly because they were too sick to farm). In the 2008 wave of the survey, the 25 attrited households were replaced by other households that were randomly chosen from the village roster. In the end, we have 1194 households in 2000 and 1143 households in 2008. As in the case of the first wave of the survey (in 2000), in addition to collecting data for the year 2008, we also asked respondents to recall the information for the previous year (2007).

With the special attention to the crop production, we also constructed a sub-dataset for households who engaged in crop production. To measure crop production, we record the agricultural production structure measured by the area of crops from a plot by plot enumeration. Using this definition (and data set), in the years of 1999/2000, among 1194 households, around 90% of households (1071 households) were engaged in crop production. In the years of 2007/2008, among the 1143 households in the sample, around 78% of households were engaged in crop production. When aggregating into a single set of panel data (that is, combining the data from wave one and wave two of the survey), among the 897 farming households surveyed in 1999/2008, we were able to create a true panel dataset (805 households) with crop production in both waves of the survey (1999/2000 and 2007/2008). In other words, collected and merged this way, our data set allows us to set up the panel data for four years (1999, 2000, 2007 and 2008).

In order to examine the effect of the attrition that occurred when going from the full sample to the balanced panel, we examined the nature of the sample observations. The results are in the appendix (Table A1). While there are differences between the unbalanced and balanced panel, the differences are relatively small and not statistically significant. This means that attrition is not affecting the external validity of our results.

2. Key variables

We use two measures of specialization in farming (Table A2). The first is a count of the number of crops that a household planted in a single year. This information was taken from a plot by plot enumeration of all agricultural activities of each sample household. The second variable measures the share of sown area devoted to the largest crop. This was also taken from the plot-by-plot enumeration.

The use of these two variables has a basis in the literature. Specifically, when farm households are engaged in subsistence production, farmers tend to produce a range of crops and animals to feed themselves and their family without market exchange (Hayami & Ruttan, 1985). However, as shown in studies in the US in the post-World War II era, as the nation's farms shifted from subsistence agriculture to specialized farms, farms began to produce a more limited number of commodities/products (Winsberg, 1982). In a paper by Huang et al. (2014), the authors also used the "number of crops" as a proxy for the extent of a household diversified cropping structure. In that paper, the small the number of crops (in each household), the more specialization was the households in farming.

In other papers, authors have used an alternative, share-based measure. For example, in a paper by Omamo (1998), the research team defined specialization as the share of cropped area that was planted to a single crop. When the share of a family's area that was planted to a single crop was large, a household was thought to be specialized. A less specialized household was one in which only a small share of the household's area was focused on a single crop.

One of the strength of the paper lies in the nature of our data and use of the data. Off farm labor was measured for each individual in the household that was between the ages of 16 and 65 (for the same four years as the specialization variable). If a family member worked for at least 10 days on a job that was non-agricultural, he/she was counted as working off the farm. We also asked those individual who were working off the farm, if (when they were working off farm) they lived at home or if they live away from home. In the rest of the paper, if an individual was working off the farm and was not living at home, we call them a migrant. If an individual was working off the farm and was living at home, we call them a non-migrant, off-farm laborer.[1] While in most papers, other study teams will examine the effects/correlations of off farm labor (in general) and some other economic variable. In this paper, however, our data allow use to subdivide off farm labor into two parts: outmigration and employment in the local area. We then examine the effect of these different types of off farm labor on specialization.

Village-level measures of off farm employment intensity were created from aggregations of our household-level samples inside each village. In order to avoid endogeneity, when we created this village-level variable, we included all of the observations from the same village as the household, but, dropped that particular household. This same specification has been used in the development economics literature (see, for example, Benjamin, 1992).

The data also allowed us to measure several control variables for each year of our sample (1999, 2000, 2007 and 2008). We also use the variables to represent the demographic composition of the family including "share of population that is working-age (16–65)", "share of population that is above age 65" while share of population that is below age 16 as reference. The age and education attainment of households head and spouse are used to indicate his/her characteristics. We created measures for land per capita by taking each farm household total area of cultivated land and dividing it by the number of household members (*cultivated land*). The type of terrain for each village cultivated area (*terrain*) was measured as a dummy variable, either 1 for those villages in which most of the cultivated area was on a flat plain; and 0 for those villages in which most of the cultivated area was either hilly or mountainous.

[1] We are not able to define the off-farm hours by years. However, we are able to measure whether or not movement of labor off the farm was in the form of outmigration (long distant outside of the sample individual's local region); and employment off-farm but locally. We believe these two definitions are able to, at least in part, reflect the idea of working full-time and part-time off the farm.

3. Descriptive statistics and cross tabulations

In this section we look at two separate sets of trends and then examine the correlations between them. First, we report on the changes in labor market trends in our data between 1999/2000 and 2007/2008. Second, we review what our data say about how farming households are doing as these trends unfold. Finally, we produce cross tabulations, looking at the relationship between changes in off farm labor and the emergence of new farming practices.

3.1. Emerging off farm labor market trends after 1999/2000

As in the other papers that have been examining off farm employment trends in rural China, according to our data, there has been a steady surge of individuals that have moved off of the farm into the off farm employment sector (Table 1, row 1). In 1999 and 2000 between 21 and 27% of individuals (who were in the labor force) in the sample villages had a job off the farm. By 2007 and 2008, the share of those with off farm employment has more than doubled. In 2007, 54% of individuals in the labor force worked off farm; in 2008, 57% of individuals worked off farm. Clearly, the movement of labor off the farm is one of the defining features of village life in the 2000s.

Between 1999 and 2008, the flow of labor off the farm was steadily shifting more out of the village into the migrant labor force, though many of those in the off farm labor force were still living at home at the end of the sample period (Table 1, rows 2 and 3). For example, in 1999 of those in the off farm employment sector (21% of the total—column 1, row 1), 14 percentage points (or two-thirds—14/21) were working at non-migrant off farm laborers (that is, they were working off the farm but living at home). Only 8% of the total labor force worked at migrants. This means migrants made up only one-third of those working off the farm.

By 2008, although the absolute number of non-migrant laborers and migrants both rose, the share of migrants increased (Table 1, rows 2 and 3). In 2008 more than half (30 of 58) of all of those that worked off the farm worked as migrant. In contrast, the share of those that worked as non-migrant off farm laborers fell to less than one half (28/58).

3.2. Changes in farming practices

The rise of off farm employment in China—especially in migration—has also been accompanied by changing strategies of household labor (off farm) and land allocations (on farm). For example, our data shows that between 1999/2000 and 2007/2008 the share of households that stopped farming and allocated all of their labor to off farm employment more than doubled (Table 2, row 1). In 1999/2000 only 10% of rural households only worked in the off farm labor market, and not in farming. By 2007/2008, the share rose to 22%.

During this same period those households that remained farming also gradually began changing the strategy to one that, on average, appears to reflect a tendency to specialize (Table 2, row 2). In 1999/2000 farming households cultivated an average of 3.1 different crops per year. In 2007/2008 this number dropped to 2.4. The difference was statistically significant. The share of sown area allocated to the largest (main) crop also rose—from 59% of sown area in 1999/2000 to 67% in 2007/2008 (Table 2, row 3).

3.3. Off farm labor movement and specialization in farming

The data not only show the specialization off the farm and on the farm is occurring, when looking at village-level data, we see a correlation between specialization and working off the farm. When households are divided into groups according to the share of household members who are working off the farm (at any job), there is a relationship between specialization off the farm and specialization on the farm (Table 3, rows 1 to 3). As the share of family members working off the farm in a village rises from <8% to >25% (column 1, from rows 1 to 2 to 3), the number of crops falls from 3.6 to 2.5 (column 2). Likewise, as off farm employment in villages rise, the share of the family's land that is allocated to the main crop also rises from 56% to 66% (column 3, rows 1 to 3).

The same correlations appear when looking at the share of households in villages that sendoff farm labor into the migrant (Table 3, rows 4 to 6) and non-migrant off farm labor markets (Table 3, rows 7 to 9). Interestingly, the trends for household

Table 1
Trends of off-farm employment, including breakdown by migrant and non-migrant off farm laborer, among sample households in rural China, 1999 to 2008.
Source: Authors' own survey.

	1999	2000	2007	2008
Share of labor force with off-farm job (including both migrants and non-migrant off farm laborer)	21	27	54	57
— Share of labor force that has off-farm job in which the individual lives outside the village (migrant)	8	12	27	29
— Share of labor force that has off-farm job in which the individual can live at home inside the village (non-migrant off-farm laborer)	14	15	27	28
Number of households	1194	1194	1143	1143

Table 2
Overall trends of the specialization households in the off farm sector (that is, households that are not doing any farming) and the specialization trends of households that are in farming.

	1999/2000	2007/2008	*p*-Value of the difference
	Mean	Mean	
Percentage of households that that have stopped farming and are specializing in the off farm labor market	10	22	0.000
Farming households			
— Number of crops	3.1	2.4	0.000
— Share of largest crop's area	59	67	0.000
— Number of households in sample	1071/1088[a]	889/897[b]	

Source: Authors' own survey.

[a] This represents the number of households in 1999 and 2000, respectively.
[b] This represents the number of households in 2007 and 2008, respectively.

that have members in the non-migrant off farm labor market (and correlations the specialization of crops on farm) are sharper than in the case of households that send their members to the migrant labor market. For example, in villages in which >25% of households have members in the non-migrant off farm labor force the number of crops are less (2.4 crops) than in villages in which <8% of households in the non-migrant, off-farm labor force (3.4 crops).

4. Multivariate analysis

In this section, we define the econometric model that we use to better understand the correlations between specialization—both off-farm and on-farm—and off farm employment trends.

We first estimate a probit model to examine the correlates of those households that have decided to specialize in off farm employment (and stop farming). The model to be estimated is:

$$P^*_{i,t} = \alpha + \beta X_{j,t-1} + \gamma Z_{i,t} + \varepsilon_{i,t}$$
$$P = \begin{cases} 1 & if \quad P^*_i > 0 \\ 0 & otherwise \end{cases} \tag{1}$$

In Eq. (1), the subscript *i* represents the *i*th household and *j* represents the rest of the households in a village in which the *i*th household live; *t* represent year *t* (1999, 2000, 2007, 2008). The dependent variable is a dummy variable, P^*_i. The variable equals 1 if the household stopped farming and began to specialize in off-farm employment, and 0 otherwise. On the right hand side of Eq. (1) $X_{j,t-1}$ is a variable that measures the level of off farm employment in the sample villages (lagged one year, t-1). In other words, as in Table 3 above, it is a measure of the "Share of labor force that has an off-farm job." In the empirical specifications of Eq. (1), we actually split the variable into two, and include measures of the "Share of individuals in the village in the migrant labor force" and the "Share of individuals in the village in the non-migrant, off-farm labor force." The variables are lagged as a way to control, in part, for any unobserved heterogeneity (and/or simultaneity). The matrix, $Z_{i,t}$, are control variables, including share of

Table 3
Off-farm employment in the village and the specialization of households that are in farming 1999–2008.
Source: Authors' own survey.

Share of labor with off-farm job in the village	Number of crops per household (no.)	Share of largest crop's area in the household (%)
	Mean	Mean
Share of labor force with off-farm job (including both migrants and non-migrant off farm laborer)		
≤8%	3.6	56
(8–24%]	3.2	59
>25%	2.5	66
Share of labor force that has off-farm job in which the individual lives outside the village (migrant)		
≤8%	2.9	62
(8–24%]	2.8	63
>25%	2.8	63
Share of labor force that has off-farm job in which the individual can live at home inside the village (non-migrant off-farm laborer)		
≤8%	3.4	55
(8–24%]	2.7	63
>25%	2.4	69

Note: Data on off-farm employment in the village are generated using based on whole sampled households (about 20) except for own household in each village.

population that is working-age (16–65); share of population that is above age 65); age and education attainment of household's head; and age and educational attainment of his/her spouse; cultivated land and terrain (as defined above).

In addition to the standard probit model, we also use a canonical dynamic probit model (Heckman, 1981; Orme, 1996; Wooldridge, 2005). This model is fundamentally the same as the standard probit except it has an additional variables, $P_{i,t-1}^{*}$ and $P_{i,t-3}^{*}$, added into the model. The canonical dynamic probit model is:

$$P_{i,t}^{*} = \tau P_{i,t-1}^{*} + \beta X_{j,t-1} + \gamma Z_{i,t} + \delta P_{i,t-3}^{*} + \varepsilon_{i,t}$$
$$P = \begin{cases} 1 & if \quad P_i^{*}>0 \\ 0 & otherwise \end{cases} \tag{2}$$

where all variables in Eq. (2) are the same as in Eq. (1) (the standard probit model described above), except we have added an additional variables. $P_{i,t-1}^{*}$ is the variable referring to the value of the outcome at *t-1*, $P_{i,t-3}^{*}$ is the value of the outcome in the first (initial) wave observed for each observation. The purpose for adding these additional variables are that with its inclusion the results cannot be interpreted to mean that specialization not only depends on village level off farm employment behavior, but, also the farmer's past path (of specialization).

In order to estimate the correlates of specialization with a focus on off-farm employment, we specify the following empirical model:

$$Y_{i,t} = \alpha + \beta X_{j,t-1} + \gamma Z_{i,t} + \delta_i + \varphi_t + \varepsilon_{i,t} \tag{3}$$

In Eq. (3), subscripts *i*, *j* and *t* are defined as above. The right hand side independent variables, $X_{j,t-1}$ and $Z_{i,t}$, also are defined as above. In the estimation of Eq. (3), we use two different measures of the dependent variable, Y_{it}. In one set of estimations, we measure specialization as the number of crops. In the other specification, we measure specialization as the share of the largest crop in the *i*th household's sown area.

Table 4
Standard and dynamic probit estimations of specialization in off-farm employment in the years of 1999, 2000, 2007 and 2008.
Source: Authors' own survey.

	Standard probit	Dynamic probit
	Marginal effects	Marginal effects
	(Sta. Err.)	(Sta. Err.)
Specialization in off-farm employment (t-1) (1 = yes, 0 otherwise)		1.722***
		(0.131)
Share of labor force that has off-farm job in which the individual lives outside the village (t-1)[a]	0.026***	0.011***
	(0.004)	(0.003)
Share of labor force that has off-farm job in which the individual can live at home inside the village (t-1)[a]	0.016***	0.022***
	(0.003)	(0.003)
Share of population that is working-age (16–65)	0.011***	0.007**
	(0.003)	(0.003)
Share of population that is above age 65	0.020***	0.013***
	(0.004)	(0.004)
Age of household's head (year)	−0.024	−0.011
	(0.019)	(0.015)
Education attainment of household's head (year)	0.070***	0.021
	(0.018)	(0.016)
Age of head's spouse (year)	0.022	0.000
	(0.019)	(0.015)
Education attainment of head's spouse (year)	0.054***	0.020
	(0.017)	(0.014)
Land per capita (mu/capita)	−0.232***	−0.197***
	(0.032)	(0.030)
Type of terrain for each village's cultivated land (1 = plain; 0 otherwise)	0.294	−0.279**
	(0.363)	(0.114)
Specialization in off-farm employment (t-3) (1 = yes, 0 otherwise)		0.520**
		(0.222)
Constant	−2.497***	
	(0.709)	
Log likelihood	−1360.373	−953.62778
Wald chi^2	306.95	542.74 (12)
No. of obs	4674	3422

The symbols ***, ** and * mean the coefficients are significant at the levels 1%, 5% and 10%, respectively.
[a] Data on off-farm employment in the village are generated based on whole sampled households (about 20) except for own household in each village.

As a robustness check, we also estimate (4), which is the exact same specification as Eq. (3), but, we add one addition variable, $X_{i,t-1}$:

$$Y_{i,t} = \alpha + \beta X_{j,t-1} + \vartheta X_{i,t-1} + \gamma Z_{i,t} + \delta_i + \varphi_t + \varepsilon_{i,t} \quad (4)$$

In Eq. (4), $X_{i,t-1}$ is a measure of the *i*th household's off farm labor force participation in the previous year. In this equation, the variable of interest is defined as the "Share of the labor force of household *i* that has a job off the farm." This household-level variable, like the village-level variable in Eqs. (3) and (4), is split into two measures of off farm labor force participation: participation in the migrant labor force and participation in the non-migrant, off farm labor force.

In our estimation of Eqs. (3) and (4), our identification strategy—in addition to using lagged variables on the right hand side—is to use a fixed effect approach. This means, in essence, that we are examining within household's heterogeneity in specialization as household respond to differences in off farm employment opportunities within a village.

5. Results of multivariate analysis

5.1. Specialization on off farm employment

Table 4 includes the results of the multivariable analysis for standardized probit (column 2) and canonical dynamic probit models (column 3). The focus of the empirical analysis is to identify the correlates of which households specialize in off farm employment.

According to the results, we find that there is a clearly a tendency for villages with higher levels of off farm employment activity to produce households that specialize in off farm labor. In the regression findings, we see that as the share of migrants in a village rises, the number of households that move full time off the farm also rises. The coefficient is 0.026 and is statistically significant. Although the coefficient on the non-migrant off farm employment variable is smaller (0.016), it is also statistically significant. This means that in villages with high levels of non-migrant off farm employment, there is also a tendency for more

Table 5
Fixed effects estimations of specialization in farming for balanced panel data in the years of 1999, 2000, 2007 and 2008.
Source: Authors' own survey.

Variables	Number of crops		Share of largest crop's area	
	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)
Share of labor force that has off-farm job in which the individual lives outside the village (t-1)[a]	−0.015*** (0.002)	−0.013*** (0.002)	0.137*** (0.032)	0.109*** (0.034)
Share of labor force that has off-farm job in which the individual can live at home inside the village (t-1)[a]	−0.007*** (0.002)	−0.005** (0.002)	0.094*** (0.034)	0.087** (0.035)
Share of household's labor force that are migrants (t-1)		−0.003*** (0.001)		0.045** (0.019)
Share of household's labor force that are non-migrant laborers (t-1)		−0.003*** (0.001)		0.007 (0.015)
Share of population that is working-age (16–65)	−0.002 (0.001)	−0.001 (0.001)	0.010 (0.024)	0.001 (0.024)
Share of population that is above age 65	0.000 (0.002)	0.001 (0.002)	−0.014 (0.036)	−0.018 (0.036)
Age of household's head (year)	0.003 (0.013)	0.004 (0.013)	−0.007 (0.209)	−0.017 (0.209)
Education attainment of household's head (year)	0.014 (0.014)	0.012 (0.014)	−0.448** (0.218)	−0.416* (0.218)
Age of head's spouse (year)	−0.026** (0.013)	−0.027** (0.013)	0.336 (0.208)	0.343* (0.208)
Education attainment of head's spouse (year)	−0.019 (0.012)	−0.018 (0.012)	0.651*** (0.197)	0.658*** (0.197)
Land per capita (mu/capita)	−0.015*** (0.004)	−0.015*** (0.004)	0.286*** (0.064)	0.287*** (0.064)
Type of terrain for each village's cultivated land (1 = plain; 0 otherwise)	−0.451*** (0.107)	−0.462*** (0.107)	9.528*** (1.720)	9.694*** (1.720)
Constant	4.616*** (0.251)	4.570*** (0.250)	37.351*** (4.042)	37.715*** (4.044)
Hausman test: (fixed vs. random effects)	Chi2(10) = 41.24	Chi2(12) = 42.68	Chi2(10) = 28.26	Chi2(12) = 24.81
Adj. R^2	0.061	0.065	0.025	0.025
No. of obs.	3220	3220	3220	3220

***, ** and * represent the significant level at 1%, 5% and 10%, respectively.
[a] Data on off-farm employment in the village are generated based on whole sampled households (about 20) except for own household in each village.

households to move off the farm. The control variables (unsurprisingly) suggest that land scarcity is also a factor in inducing households to specialize in off farm employment.

When running the analysis using the dynamic probit model, we see the results are similar to those obtained from standardized probit estimation. According to the results in column 3 (Table 4), the level of off farm employment is a determinant of specialization. We also see that past employment history also has an independent impact on specialization. In summary, there is a close relationship between movement of employment off farm and the nature of specialization of farming.

5.2. Specialization on the farm

The empirical analysis, using the balanced panel for rural households who engaged in farming, also suggests that the rise of off farm employment is changing the nature of farming. The estimates of Eq. (3) are found in Table 5, columns 1 and 3. The estimates of Eq. (4) are found in Table 5, columns 2 and 4. The estimates for the analysis using the first proxy for specialization, the number of crops, are in Table 5, columns 1 and 2. The estimates for the analysis using the second proxy for specialization, the share of the labor crop's area, are in Table 5, columns 3 and 4.

According to the findings, in all specifications and using the two alternative measures of agricultural specialization there is a strong and robust association between off farm employment at the village level and on farm specialization (Table 5, rows 1 and 2). In the two specifications using the number of crops as the dependent variable the coefficients on both the migrant and non-migrant off farm employment village-level variables are negative and statistically significant (columns 1 and 2). Likewise, in the two specifications using the largest crop's share as the dependent variable the coefficients on both the migrant and non-migrant off farm employment village-level variables are positive and statistically significant (columns 3 and 4). Clearly in villages in which there are higher numbers of individuals working off the farm—both as migrants and as non-migrant off farm laborers, those left in farming are specializing by planting fewer crops and planting a higher share of area to the most important crop in the household's planting plan.

In our estimation of Eqs. (3) and (4) we also find evidence of the association between movement of household members off the farm and the specialization on farm activities of individuals from the same household who were left farming. The coefficients on the household-level off farm employment variables in columns 2 and 4 are both negative and significant except the variable representing household's labor force that are non-migrant laborers (Table 5, rows 3 and 4, columns 2 and 4). This implies that in addition to the specialization that is associated with off farm employment at the village level, households are also specializing themselves. The results by using the unbalanced panel, which is consistent with the findings in Table 5, are presented in appendix Table A3.

6. Conclusions

In this paper we are attempting to examine the relationship between off farm employment and the production behavior of those left in the farm sector. There is no doubt that off farm employment is rising fast. The labor literature in China demonstrates this repeatedly. Our data also show off farm employment rose rapidly during the 2000s. There also was considerable specialization in the off farm labor market. Nearly one-quarter (22%) of households in rural China worked solely off the farm and were not engaged in farming by 2008.

Unlike some of those that have suggested that farming will be hurt during this surge of labor into the off farm employment market, our paper suggests that those left behind in farming are responding, too. Overall between the early 2000s and the late 2000s, specialization is occurring—both in the number of crops and the share that each household allocates to the most important crop. There is strong and robust evidence that this move to specialization is occurring in those villages in which off farm labor is rising the fastest. There are statistically significant correlations when measuring the relationship between off farm employment and agricultural specialization.

While this study does not directly speak to food security, there is certainly an argument to be made that the rise of specialization will help dampen the impact of rising off farm employment on food production. Labor will necessarily fall as off farm employment rises and the wage rises with it. If specialization increases efficiency and overall output, the specialization effect can help offset or attenuate the loss of labor effect.

The rise of specialization may also have other longer term effects. In the past China's fragmented farming systems did not facilitate the development of contracting and the emergence of more sophisticated supply chains. If households—and in turn villages—naturally begin to specialize as off farm labor continues to rise, the benefits of developing safer and more reliable farm commodity supply systems could rise and help rationalize China farm-to-consumer food chains.

Of course, more research is needed. Assessing the ultimate impact of the rise of specialization is beyond the scope of this paper. Using longer time series data would also help. It is our hope that this paper helps build a more complete picture of how China's agriculture will change as the country continues to modernize and develop.

Acknowledgement

The authors acknowledge funding supports provided by National Natural Sciences of China (71373255; 71333013), the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences (2012RC102; KSZD-EW-Z-021-1; Y02015004).

Appendix A

Table A1
The distribution of sample in the years of 1999, 2000, 2007 and 2008.
Source: Authors' own survey.

	1999	2000	2007	2008
Number of households	1194	1194	1143	1143
— With crop production	1071	1088	889	897
— Balanced panel data for households with crop production	805	805	805	805

Table A2
Descriptive statistics of variables used in the estimations.
Source: Authors' own survey.

Variables	Total	With crop production	
		Unbalanced panel data	Balanced panel data
	Mean (Sta. Dev.)	Mean (Sta. Dev.)	Mean (Sta. Dev.)
Dependent variables			
Specialization in off-farm employment (1 = yes, 0 = no)	0.16 (0.36)		
Number of crops (no.)	2.37 (1.62)	2.81 (1.37)	2.83 (1.36)
Share of largest crop's area (%)	52.84 (31.07)	62.61 (23.07)	61.77 (22.55)
Independent variables			
Share of labor force that has off-farm job in which the individual lives outside the village (t-1)[a]	16.16 (14.01)	15.53 (13.73)	16.56 (14.06)
Share of labor force that has off-farm job in which the individual can live at home inside the village (t-1)[a]	19.50 (14.28)	18.09 (13.38)	17.82 (13.28)
Share of household's labor force that are migrants (t-1)	16.16 (27.11)	15.69 (22.74)	14.78 (23.14)
Share of household's labor force that are non-migrant laborers (t-1)	19.50 (31.83)	17.23 (29.13)	16.65 (28.61)
Share of population that is working-age (16–65)	75.45 (24.00)	75.54 (23.14)	76.29 (23.02)
Share of population that is above age 65	8.36 (20.27)	7.71 (18.50)	7.53 (18.25)
Age of household's head (year)	48.28 (11.46)	48.01 (11.21)	48.28 (11.01)
Education attainment of household's head (year)	6.42 (3.41)	6.38 (3.41)	6.38 (3.42)
Age of head's spouse (year)	46.23 (11.15)	46.01 (10.81)	46.37 (10.55)
Education attainment of head's spouse (year)	4.47 (3.78)	4.41 (3.75)	4.40 (3.71)
Land per capita (mu/capita)	2.60 (6.95)	2.87 (7.48)	2.94 (6.90)
Dummy of village land (1 = plain, 0 otherwise)	0.36 (0.48)	0.37 (0.48)	0.39 (0.49)
No. of obs.	4674	3945	3220

[a] Data on off-farm employment in the village are generated based on whole sampled households (about 20) except for own household in each village.

Table A3
Fixed effects estimations of specialization in farming for the unbalanced data in the years of 1999, 2000, 2007 and 2008.
Source: Authors' own survey.

Variables	Number of crops		Share of largest crop's area	
	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)
Share of labor force that has off-farm job in which the individual lives outside the village (t-1)[a]	−0.016*** (0.002)	−0.013*** (0.002)	0.149*** (0.030)	0.112*** (0.032)

(continued on next page)

Table A3 *(continued)*

Variables	Number of crops		Share of largest crop's area	
	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)	Coefficients (Sta. Err.)
Share of labor force that has off-farm job in which the individual can live at home inside the village (t-1)[a]	−0.005** (0.002)	−0.003 (0.002)	0.067** (0.032)	0.051 (0.033)
Share of household's labor force that are migrants (t-1)		−0.004*** (0.001)		0.055*** (0.018)
Share of household's labor force that are non-migrant laborers (t-1)		−0.003*** (0.001)		0.023 (0.014)
Share of population that is working-age (16–65)	−0.002 (0.001)	−0.001 (0.001)	0.010 (0.023)	−0.002 (0.023)
Share of population that is above age 65	0.000 (0.002)	0.001 (0.002)	−0.015 (0.034)	−0.021 (0.034)
Age of household's head (year)	0.011 (0.012)	0.011 (0.012)	−0.132 (0.199)	−0.139 (0.199)
Education attainment of household's head (year)_	−0.010 (0.013)	−0.010 (0.013)	−0.043 (0.203)	−0.023 (0.203)
Age of head's spouse (year)	−0.034*** (0.012)	−0.034*** (0.012)	0.461** (0.199)	0.463** (0.199)
Education attainment of head's spouse (year)	−0.013 (0.012)	−0.012 (0.012)	0.576*** (0.188)	0.576*** (0.187)
Land per capita (mu/capita)	−0.010*** (0.003)	−0.010*** (0.003)	0.205*** (0.054)	0.207*** (0.054)
Type of terrain for each village's cultivated land (1 = plain; 0 otherwise)	−0.439*** (0.101)	−0.451*** (0.101)	9.009*** (1.632)	9.180*** (1.630)
Constant	4.634*** (0.237)	4.575*** (0.237)	37.413*** (3.841)	38.098*** (3.840)
Hausman test: (fixed vs. random effects)	$Chi^2(10) = 61.63$	$Chi^2(12) = 57.98$	$Chi^2(10) = 25.93$	$Chi^2(12) = 24.63$
Adj. R^2	0.047	0.052	0.018	0.018
No. of obs.	3945	3945	3945	3945

The symbols ***, ** and * mean the coefficients are significant at the levels 1%, 5% and 10%, respectively.

[a] Data on off-farm employment in the village are generated based on whole sampled households (about 20) except for own household in each village.

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