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Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labor market linkages in China

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Abstract

This study examines linkages between off-farm labor markets and the labor allocated by farmers to on-farm production of fruit crops. Using a stratified random sample of rural households in Shandong Province, we find that young and educated members of the labor force tend to work more frequently in the off-farm labor market, and that off-farm employment reduces the likelihood and intensity of fruit production. Fruit production is associated with lower levels of off-farm employment. Households and individuals who are less likely (or able) to find off-farm employment can benefit from shifting into fruit production. Although off-farm employment is an important avenue out of poverty, fruit production provides ways for the less educated and older households to raise their income.

JEL classification: D13, J21, J61

Keywords: Off-farm employment; Fruit production; Labor market; Linkages

1. Introduction

China's labor markets in the early part of the 21st century are undergoing rapid transformation in an extremely dynamic economic environment (deBrauw et al., 2002; Yang, 2004). In addition to tens of millions of wage-earning jobs in rural areas, it is thought that more than 150 million rural migrants are now living and working in China's urban areas. Rural entrepreneurs have also started nearly 100 million self-employed businesses that are becoming more sophisticated and capital-intensive (Zhang et al., 2006). Access to off-farm jobs has been linked to rising incomes and poverty alleviation and is known to exacerbate intrarural income inequality (Rozelle, 1996).

The pull off the farm by higher wages and more steady hours, however, is occurring exactly at a time when domestic structural change policies are being pushed by national agricultural leaders. The rise in off-farm employment is happening at a time when international trade liberalization is being implemented and there is a rising demand for high-value horticultural crops and livestock and aquaculture commodities. Barriers to horticultural production are being eliminated, which could raise the returns to farming (Wang et al., forthcoming). The rise of supermarkets and other shifts in the downstream segments of the marketing supply chain in rural China reinforce the demand for higher-valued fruits and vegetables (Reardon and Timmer, 2005). It has been shown (Huang et al., 2006) that changes in the horticultural sector lead to higher incomes for those who have shifted into the production of fruits and vegetables.

In such a dynamic environment, it is difficult to make policies that will enhance the performance of the economy, allow individuals to shift toward activities that will improve their family's

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Data Appendix Available Online

A data appendix to replicate main results is available in the online version of this article. Please note: Wiley-Blackwell, Inc. is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

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welfare, and provide opportunities to the more vulnerable in society, i.e., those with lower levels of human capital, those with lower levels of physical capital (or the poor), and those who are less mobile (e.g., the elderly). To begin to design the policies that can find such a balance, a great deal of information is needed about the nation's labor markets. For example, with the continuing decline in labor in agriculture due to rising off-farm employment, will China be able to continue to take advantage of its comparative advantage in labor-intensive agriculture (e.g., horticulture)? What are the likely impacts of off-farm employment on crop composition and technology adoption? Will the emergence of a high-value commodity sector affect the decisions of families to move off the farm? The answers to these issues are important as they will have significant implications not only on China's domestic production and the welfare of its rural population but also on other sectors, such as the industrial and service sectors (which will demand labor from the rural economy) and international markets (which are sending signals to China that it should produce and export larger volumes of labor-intensive fruits and vegetables).

The overall goal of our article is to try to begin to answer some of these questions on how changes to off-farm employment are affecting the emergence of horticulture, the labor-intensive segment of the agricultural sector in China—and vice versa—how the rise of the horticultural economy affects off-farm employment choices. To meet this broad goal, we will pursue three specific objectives. First, we will document the changes in China's labor markets—both off the farm and on the farm. Second, we will describe the linkages and interactions between off-farm and on-farm labor markets. Finally, we will seek to more rigorously disentangle the determinants of participation in the off-farm and on-farm labor markets by quantifying the effects of off-farm employment on horticultural production and the effect of participation in horticultural production on the choice of whether or not to go into off-farm employment. If we can understand who will benefit and who will not benefit from the new opportunities in China's rural labor markets, we can provide policy makers with information that can allow the nation's leaders to create a better environment for the rural population.

To meet these ambitious objectives, we necessarily have to narrow down the focus of our analysis. Our analysis in this article is based on data from a single province, Shandong Province. Although Shandong Province is the single largest horticulture-producing province in China, it is still only one region, and so we can really only definitively say anything about rural labor markets in Shandong.

In addition, we also decided to narrow down our focus to a subset of two fruit commodities, apples and grapes. Because we have a provincially representative data set, our study can make statistically significant statements about Shandong's apple and grape economies, which are two of the province's largest fruit sectors. We have no reason to believe the findings would not also hold true in the cases of other fruit and vegetable subsectors, but any statement about the overall horticultural economy is speculative. We chose apples and grapes randomly, after assigning a random number between 1 and 5 to Shandong's top five fruit commodities.

Finally, this is an empirical article that is seeking to understand and document what is happening in the field in rural China. As such, we do not seek to make any new theoretical contributions. For the interested reader, the work by Ahituv and Kimhi (2002) provides a theoretical model of the interaction between off-farm and on-farm labor.

The rest of the article is organized as follows. The next section discusses the data. The third section describes the trends in the off-farm and on-farm labor markets between 2001 and 2006. The linkages between the markets are also examined descriptively. The next two sections review the empirical framework that will be used to conduct the multivariate analysis of the relationship between off-farm and on-farm employment and examine the results. The final section concludes.

2. Sampling, data, and weighting scheme

The data for this study come from a stratified random sampling survey in Shandong Province. This survey is a representative sample of apple- and grape-growing villages (producers) in the province. The first step in conducting the survey involved creating two sampling frames of county-level apple production and county-level grape production. With the knowledge of the production environment in Shandong for each fruit, we ranked all 140 counties in Shandong by the level of apple or grape area per rural person. On the basis of the ranking from high to low for the farm production of each apple or grape county, we kept the top 70 counties for each of the apple and grape samples, which accounted for more than 90% of total apple or grape production in Shandong. We then divided these 70 counties into the following five groups (or five regions): two high-production county regions, two medium-production county regions, and one low-production county region. Each of the production regions, when ranked from high to low in terms of their cropped area, accounted for about 10%, 15%, 20%, 25%, and 30%, respectively, of rural farm population within the sampling population (70 counties). In addition, one county was randomly selected from each of the above five groups. In total, we had five sample counties for each crop (they were different for apples and grapes). The farm population in each set of counties provided data for our weighting system, which was used to create point estimates for 90% of apple and grape production in Shandong Province.

After the sample counties were chosen, a relatively similar stratified random process was used to select the townships and villages. The number of sample towns, however, differed by the "type" of county. Specifically, in each of the two high-production counties, five townships were selected (two high-production townships, two medium ones, and one low one). In each of the two medium-production counties, three townships were selected (one high-production township, one medium one,

and one low one). In the low-production county, only two townships were selected (one high-production township, the other a low-production township). In total, for each crop, the survey teams visited 18 townships. After the sample townships were selected, a similar stratified random process was used to select the sample villages.[1]

Finally, households were selected from the sample villages. Here, we use apple-producing villages as an example to show how the households were sampled. In each of 35 apple villages, first we divided *all households* in each village into two groups: households with and without apple production. Then we randomly selected seven apple-producing households and three non-apple producing households. However, there are a few exceptions. First, there are some villages where the total number of apple producers was less than 7. In these cases, we selected all of the apple households. In addition, we then randomly selected 3 non-apple households if the number of apple households was 5 or 6; we randomly selected 1 (2) non-apple-producing household(s) if the number of apple households was 3 or 4 (1 or 2). Second, for villages in which there were no or nearly no apple producers, we randomly selected 10 apple households. In total, we interviewed 340 households. We used 338 households in the final analysis because there were two households with incomplete information. For grapes, we interviewed 330 households. There was only one household that had incomplete records.[2]

2.1. Survey instruments and data

After choosing the villages and households, the enumeration team then visited each village and ran two data collection activities. First, one of the enumerators conducted a two-hour, sit-down survey with the village leader and accountant. During this interview, information was collected on the village's farming practices, its general economy, and the links of the village to local transportation and marketing infrastructure. We also collected information about local institutions. The respondents provided information on the village's horticulture-producing history as well as recounting information about policies and/or other government-initiated efforts to extend fruits (and apples/grapes) into the village. A profile of local labor markets as well as of labor markets in neighboring localities were also part of the survey. In general, the main task of the village leader survey was to collect information with which we could create a set of policy and instrumental variables for the econometric analysis to measure the impacts of off-farm and on-farm labor marketing choices of farmers.

For each sample household, we conducted a two-hour, sit-down survey. During the survey, information on a number of topics was enumerated. The survey collected information on each household's off-farm employment activities, including the participation of each family member (both those engaged in migration and those only working locally) and the percentage of their time worked in these jobs during the previous year (2006) and during the year five years prior to the survey (2001). The cropping structure, cultivated land, and other data were also enumerated for two years (2001 and 2006). Special attention was paid to the activities in apple and grape production and the inputs and technologies used in producing the horticultural crops. In addition, extensive information was collected on other aspects of the household's marketing, income, assets, family composition, etc.

2.2. Weights for analysis

Because we collected the cropped area and farm population data on all villages, townships, and counties, we were able to construct farm population-based weights to create point estimates of our variables that are provincial representative. In this study, in our descriptive analysis and the ordinary least squares (OLS) version of the multivariate analysis, we use these weights to make our findings provincial representative.[3] Descriptive

[1] In the high-production county and high-production township, three villages were selected (one a high-production village, one a medium one, and one a low one). In the high-production county, medium-production township, the medium-production county, high- and medium-production townships, and the low-production county, high-production township, we chose two sample villages (one high and one low). In the low-production township of all counties, we only chose one village per township. Therefore, in total, for each crop (for the 5 counties and 18 townships), we interviewed farmers in 35 villages (22 in high-production counties, 10 in medium-production counties, and 3 in low-production counties).

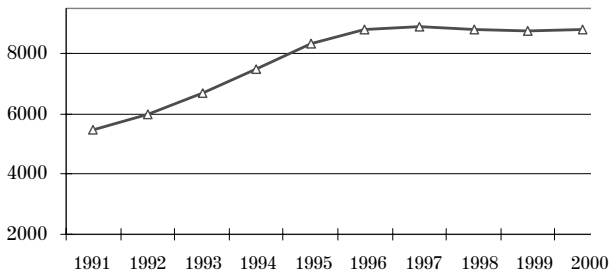
[2] The final summary of the final samples for the apple and grape producers in Shandong Province is:

Crop	County	Township	Village	Household	With the crop	Without the crop
Apple	5	18	35	338	279 (83%)	59 (17%)
Grape	5	18	35	329	232 (71%)	97 (29%)
Total	10	36	70	667	511	156

[3] Weights for whole sample are used to estimate a representative of all farmers in Shandong Province. The weight for *h*th households from *k*th village of *j*th township of *i*th county, P_{ijkh}, is defined as:

$$P_{ijkqh}=W_i \times W_{ij} \times W_{ijk} \times W_{ijkq} \times W_{ijkqh}$$

where W_i is the weight for *i*th category of counties, with values of 0.1, 0.15, 0.2, 0.25, and 0.3 for each of the five counties, ranging from highest to lowest ranked county using per capita production for the crop studied. The value of 0.1 here represents the farmers in the highest-production county, because they account for 10% of all farmers in the 70 counties of Shandong Province that we studied in this project. The sum of W_i over *i* equals 1; W_{ij} is the weight for *j*th township in *i*th county. Its values correspond to the shares of the farm population that belong to the *j*th category of township in the *i*th county. The sum W_{ij} over *j* equals 1; the symbol W_{ijk} is the weight for the *k*th village in the *j*th township of the *i*th county. Its values correspond to the share of the farm populations belonging to the *k*th category village in the *j*th township of the *i*th county. The sum of W_{ijk} over *k* equals 1; the symbol W_{ijkq} is the share of farmers who plant or not plant the crop (apple or grapes) in the *k*th village in the *j*th township of the *i*th county. The symbol, *q*, indexes two groups of farmers (those who plant and those who do not plant apples/grapes). Please note: $W_{ijk1} + W_{ijk2} = 1$. Finally, the symbol W_{ijkqh} is the reciprocal of *h*-type sample numbers in the *k*th village in the *j*th township of the *i*th county. The symbol indexes two groups



Source: Rozelle et al., 2007.

Fig. 1. Sown area of fruits in China, 1991–2000 (1,000 hectares).

statistics for the key variables in both the apple and the grape villages are presented in Table A.1.

3. On-farm and off-farm employment in rural China

Although China's entire agricultural economy has performed well in terms of growth over the past two decades, in response to rising demand by consumers and the new policy environment, China's fruit producers responded in a way that would have been difficult to predict. The changes in the sown area of fruits illustrate, more than anything, the responsiveness of producers (Fig. 1). Between 1990 and 2000, the sown area increased by nearly 100%, rising from 5 million to 10 million hectares. In the late 1990s, although the growth of the sown area slowed, farmers began to invest in upgrading their orchards through grafting, pulling and replanting, and improved agronomic care. Despite China being known as a country that is short of land, and despite its past policies that have emphasized cultivating grain ahead of all other crops, on a percentage basis, China has more than double the share of area (over 5%) allocated to fruits than other major countries (e.g., 2% in the U.S., 2% in the EU, etc.).

Although farmers in Shandong were among the first to expand into fruit production, like the trends for all of China (in the late 1990s), between 2001 and 2006, apple and grape producers in our sample households expanded at a slow, but steady, pace (Table 1). Apple and grape producers also expanded in different ways. Specifically, although the number of total apple producers in our sample remained relatively constant (expanding from 276 sample households in 2001 to 279 households in 2006, not shown in Table 1), the size of the average apple farm (in terms of cultivated land) rose slightly. All apple producers expanded their total cultivated area from 4.3 to 4.4 mu (1 mu = 1/15th of a hectare; column 1, rows 1 and 2). Of this total amount of cultivated land, they expanded fruit production (including apples and other types of fruits crops) from 1.6 to 1.8 mu (column 4); the apple area was expanded from 1.2 to 1.3 mu (column 5). In other words, like the rest of China, the production—which is all by small farmers (the largest apple farm was less than 1 hectare)—the apple area in our sample area expanded gradually, and mainly on the basis of existing farmers slightly increasing the size of their apple plantings.

Grape growers, like producers of apples, also expanded their total area of cultivated land from 4.9 to 5.1 mu (Table 1, rows 4 and 5, column 1). However, the production of grapes evolved slightly differently. The number of grape producers in our sample rose from 200 households in 2001 to 232 households in 2006. However, the existing producers actually saw the area under grape production contract, from 0.8 to 0.6 mu (column 5). Grape producers were not going heavily into other types of fruits (as their total fruit area remained at 1.7 mu; column 4). Interestingly, during this time, the average grape-growing household was shifting somewhat more into vegetable production, more than doubling its area from 0.09 to 0.20 mu.

There also were other changes occurring. For example, the total cropped area of farmers fell during this time for both apple and grape producers (on average, from 6.6 to 6.5 mu; column 3). The reduction in the cropped area was mainly because the production of other crops (which in this case was mostly maize, wheat, soybeans, and cotton) was falling (because cropping intensity fell; column 7). It should also be noted (though it is not shown in the table) that the yields of the sample horticulture crops rose during the study period. For example, average grape yields rose by 10% between 2001 and 2006, implying that production rose more sharply than total area.

3.1. Off-farm employment trends

At the same time that the production of horticultural crops rose gradually, off-farm employment was rising at a much faster pace (Table 2). Overall, 35.8% of rural laborers in our sample villages were participating in off-farm employment in 2001 (column 2, row 7). By 2006, this had risen to 41.7%, a rise of almost one percentage point annually (row 8). The rise occurred almost equally fast in both apple- (from 34.3 to 40.4) and grape-growing villages (from 37.2 to 43.1; rows 1 and 2 and 4 and 5). These trends are also consistent with the rest of China, which saw participation in the off-farm labor market (by those in the rural labor force) rise from 17% in 1981 to 45% in 2000 (deBrauw et al., 2002).

Participation in the off-farm sector, however, does not mean that an individual has to give up working on the farm. In fact, when looking at the time allocated to off-farm employment, the level of involvement in the off-farm sector appears slightly less (Table 2, column 3). For example, in all of our sample villages in 2001, our sample rural laborers allocated 25.5% of their time to off-farm activities (which was less than the 35.8% of individuals who had a job off the farm). Clearly, some individuals, while working part time off the farm, were also allocating part of their time to on-farm activities. The time

of farmers (those who plant and those who do not plant apples/grapes). For example, in a village with 10 sample households, there are 7 households that planted apples, and 3 households that did not plant apples. The weight, W_{ijkqh}, for each household that plants apples is 1/7; the weight is 1/3 for non-tomato households. The sum of P_{ijkh} over i, j, k, q, and h equals 1.

Table 1
Household area of cultivated land and area devoted to cropping and fruit production in Shandong, 2001 and 2006

	Sample	Cultivated land (mu)	Cropping area (mu)				
			Total	Fruit area		Vegetables	Others
				Subtotal	Apples/grapes[a]		
Apple villages							
2001	338	4.3	5.8	1.6	1.2	0.23	4.0
2006	338	4.4	5.7	1.8	1.3	0.23	3.6
Average	676	4.3	5.8	1.7	1.2	0.23	3.8
Grape villages							
2001	329	4.9	7.4	1.7	0.8	0.09	5.7
2006	329	5.1	7.2	1.7	0.6	0.20	5.3
Average	658	5.0	7.3	1.7	0.7	0.14	5.5
All villages							
2001	667	4.6	6.6	1.6	1.0	0.16	4.9
2006	667	4.7	6.5	1.8	0.9	0.21	4.5
Average	1,334	4.7	6.6	1.7	0.9	0.19	4.7

Notes: All figures are weighted averages. 15 mu = 1 hectare. Among the 338 households in the sample apple villages, there were 276 households that produced apples in 2001; 279 households that produced apples in 2006. In the sample grape villages, among the 329 households, 200 households produced grapes in 2001; 232 household produced grapes in 2006.

[a]The numbers in this column in rows 1–3 refer to the apple area; those in rows 4–6 refer to the grape area; those in rows 7–9 are both apple and grade producers.

Table 2
Percentage of family labor participating in off-farm employment and the share of time allocated to off-farm work for the average household and by age cohort in Shandong, 2001 and 2006

	Sample	Percentage of labor participating in off-farm work (%)	Percentage of time allocated to off-farm employment by age cohort (excluding students)						
			Average, full sample	17–20	21–30	31–40	41–50	51–60	>60
Apple villages									
2001	338	34.3	22.9	36.2	69.4	19.4	14.8	6.7	14.3
2006	338	40.3	29.5	86.2	86.9	38.2	15.7	15.0	11.6
Average	676	37.3	26.2	67.3	79.1	27.3	15.1	11.6	12.6
Grape villages									
2001	329	37.2	28.0	58.9	65.0	37.3	18.1	7.7	2.7
2006	329	43.1	31.5	93.3	83.9	47.4	24.5	15.4	3.0
Average	658	40.2	29.8	71.8	74.5	41.7	21.0	11.8	2.9
All villages									
2001	667	35.8	25.5	49.6	67.1	29.3	16.2	7.3	9.3
2006	667	41.7	30.5	88.6	85.5	43.4	20.1	15.2	6.6
Average	1,334	38.7	28.0	69.4	76.9	35.3	17.9	11.8	7.5
Of all villages in 2006									
Apple and grape households	511	32.4	22.8	74.6	86.0	35.0	8.6	7.2	4.9
The rest of all households	156	47.3	35.1	94.5	85.2	47.4	29.6	20.6	7.1

Note: All figures are weighted averages.

allocated to off-farm employment, however, rose (similar to the case of participation). By 2006, 30.5% of the time of rural laborers was spent in off-farm activities (row 8). The share of time spent in off-farm employment by rural laborers rose in both apple- and grape-growing villages (rows 1 and 2 and 4 and 5).

The *average* share of time spent in off-farm employment activities hides sharp differences among age cohorts (Table 2, columns 4–9). Among younger cohorts of rural laborers (17- to 20- and 21- to 30-year-olds), there was a large rise in the percentage of time spent working off the farm between 2001 and 2006 (columns 4 and 5, rows 7 and 8). Indeed, by 2006, more than 85% of the entire rural labor force of those under 30 years was being allocated to off-farm employment. Such high rates of employment (for *both* men and women) have been shown by other work to be indicative of employment patterns for all of China (deBrauw et al., 2002). Our findings also are consistent with reports of rising wages and the entry into the off-farm labor force of older workers (columns 6 and 7).

Despite the entry of increasingly more number of laborers in the older cohorts, the share of time (in both 2001 and 2006) spent off the farm falls steadily as the age cohort increases (Table 2, columns 4–9). Even in 2006, only 20.1% of the time is spent by 41- to 50-year-olds in off-farm employment; the share of time in the off-farm sector is even less for those above 50 years (columns 7 and 8). The percentage of time spent by those older than 60 years actually fell between 2001 and 2006. These trends are consistent with the findings of deBrauw et al. (2002) that

Table 3
Percentage of time allocated to off-farm employment and fruit production for rural households in Shandong, 2006

	Sample	Cultivated land (mu/household)	Sown/planted area (mu/household)			
			Total	Fruits	Vegetables	Others
Apple villages	338	4.4	5.7	1.8	0.23	3.6
Off-farm = 0[a]	127	3.9	4.8	2.1	0.04	2.7
Off-farm >0[a]	211	4.6	6.1	1.7	0.32	4.1
0 < off-farm ≤ 40%[b]	136	4.8	5.9	2.2	0.24	3.4
40% < off-farm ≤ 60%[b]	56	5.4	7	2.1	0.63	4.2
Off-farm >60%[b]	19	3.3	5.8	0.1	0.24	5.5
Grape villages	329	5.1	7.2	1.7	0.2	5.3
Off-farm = 0[a]	102	3.7	4.7	1.9	0.27	2.6
Off-farm >0[a]	227	5.6	8.3	1.6	0.16	6.5
0 < off-farm ≤ 40%[b]	132	5.7	8.4	1.8	0.21	6.4
40% < off-farm ≤ 60%[b]	62	5.5	8.6	1.5	0.12	7
Off-farm >60%[b]	33	5.7	7.8	1.5	0.14	6.2
All villages	667	4.7	6.5	1.8	0.21	4.5
Off-farm = 0[a]	229	3.8	4.8	2	0.15	2.6
Off-farm >0[a]	438	5.1	7.2	1.7	0.24	5.3
0 < off-farm ≤ 40%[b]	268	5.2	7	2.1	0.22	4.7
40% < off-farm ≤ 60%[b]	118	5.5	8	1.7	0.31	6
Off-farm >60%[b]	52	4.5	6.8	0.8	0.19	5.8

Note: All figures are weighted averages.
[a]The comparisons between rows 2 and 3, 8 and 9, and 14 and 15 are between those households with no off-farm employment and those with any off-farm employment.
[b]The comparisons among rows 4–6, 10–12, and 16–18 are among households that have any off-farm employment.

documented the aging of the on-farm labor force. The on-farm labor force in Shandong's apple- and grape-growing villages also is aging.

When we divided the sample into those households that produced apples and grapes and those that did not, although there were differences in participation in the off-farm sector, most of the patterns across age cohorts were similar (Table 2, rows 10 and 11). Specifically, the rate of off-farm employment participation between households that participated in fruit production was lower (32.4%) than households that did not (47.3%). Moreover, with the exception of the 21- to 30-year-old age cohort (which has virtually identical levels of participation in the off-farm sector—85 and 86%), the level of participation in the off-farm sector is lower for all age cohorts in the case of households that produce apples and grapes than for households that do not. This pattern suggests (descriptively) that participation in off-farm and on-farm employment opportunities may be in some sense a substitute for one another.

3.2. Documenting the on-farm and off-farm linkages

When looking at the entire sample, we find that there are gradually rising trends for work on the farm and sharply rising trends for work off the farm. A closer examination of our data, however, shows that there is clearly a division of labor going on among our households when it comes to their decisions to move into the high-value fruit sector or the off-farm employment sector (Table 3). Households that make decisions to go into the off-farm sector are also endowed with different types of resources and allocate their resources differently.

Curiously, according to our data, in both apple- and grape-growing villages, households that allocate none of their labor to off-farm activities have less land than those households that have some level of involvement in the off-farm sector (Table 3, column 2, rows 2 and 3, rows 8 and 9, and rows 14 and 15). For example, in the case of apple villages, those with no off-farm employment have only 3.9 mu, whereas those with some off-farm employment have 4.6 mu. The differences are greater for grape-growing villages.

Having more land, however, does not mean that households will necessarily allocate more of it to the production of fruits. In this case, there is clearly a strong negative trade-off between the decision to allocate time to off-farm employment and the area devoted to fruit production (Table 3, column 4). Although their total area is less, households in apple-growing villages with no off-farm employment have more apple area (2.1 mu) than those households with some of the labor in the off-farm sector (1.7 mu; rows 2 and 3). Conditional on the participation in the off-farm sector, the higher the share of time spent off farm, the lower the allocation of land to apple production (rows 4 to 6). Indeed, households that allocate more than 60% of their time off the farm only cultivate 0.1 mu (or almost nothing) of apples.

The same patterns are found in grape-growing villages (Table 3, column 4, rows 8–12). In grape-growing villages, households with no labor allocated off the farm have more grape area (1.9 mu) than those that are participating in off-farm activities (1.6 mu), despite the fact that farmers with activities off the farm have more land. Clearly, farmers who allocate some of their time to the off-farm sector are growing much higher levels

of less labor-intensive crops (6.5 mu of "other" crops; column 6, row 9) than households with no off-farm employment activity (only 2.6 mu; row 8).

From our descriptive statistics, at least, participation in the off-farm labor force is negatively correlated with the propensity of farmers to allocate land to labor-intensive fruit crops. One implication of this (if this is true for all of China; and if, as seen in Rozelle et al., 2007, incomes rise for those farmers who shift into the production of fruits and vegetables) is that the emergence of opportunities to produce fruits is in part offsetting the adverse intrarural inequality trends that once existed because not all households were able to enter the off-farm labor market. Perhaps the rise of the horticulture sector is in part responsible for the attenuation of intrarural inequality that has recently been noted in Riskin (2007). In other words, allocation of family labor to fruit production may be in some sense a viable alternative for households that are unable (or are unwilling) to shift their labor into the off-farm sector.

Further evidence of the trade-off between the on-farm and the off-farm labor decision is seen in the technology choice of farmers (Table A.2). From this table, the intensity of the use of capital and labor is highly correlated with the decision to work off the farm. When apple producers have no off-farm work, they use more capital per mu (2,097) and more labor per mu (109; columns 2 and 3, row 2). When they have a job off the farm, the intensity of the use of capital (1,924) and labor (89) falls. Capital and labor intensity also falls for those households that have off-farm employment as the share of their labor allocated to the off-farm sector rises (columns 2 and 3, rows 4 to 6). A similar set of patterns is found for grape-producing households (columns 2 and 3, rows 7 to 12), although the trend for capital use is not as clear.

Shaping our data in another way (Table 4) demonstrates (with our descriptive data) that the decision to shift area into fruits (apples and grapes are combined in this table) and vegetables influences the off-farm employment decision. It is clear that, in both apple and grape villages, there is a secular decline in the percentage of time that a farm household devotes to the off-farm sector as the area in fruits and vegetables rises. For example, when a household has less than 2 mu of its area devoted to fruits and vegetables, it allocates 25.5% of its time to the off-farm sector in apple villages and 30.6% in grape villages (columns 3 and 4, row 1). As the area devoted to fruits rises, the share of time falls to 16.5% in apple villages when the household produces more than 4 mu of fruits and vegetables (column 3, row 3). The share of time allocated to off-farm employment falls to 18.4% for grape producers who are cultivating more than 4 mu of fruits and vegetables (column 4, row 3). Similar trends arise when examining the production of fruits only (rows 4–6).

Table 4
Relationship between off-farm employment and fruit production in Shandong, 2006

		Percentage of time allocated to off-farm employment		
	Sample	Average	Apple villages	Grape villages
Fruit and vegetable area in 2001[a]				
Area <2	234	28.0	25.5	30.6
2 ≤ area < 4	196	24.7	19.3	29.5
Area ≥ 4	237	17.6	16.5	18.4
Fruit area only in 2001[b]				
Area <2	244	28.4	26.5	30.6
2 ≤ area < 4	192	22.9	14.3	28.9
Area ≥ 4	231	16.5	14.5	18.1

Note: All figures are weighted averages.

[a]Fruit and vegetable area includes area of all sample households that are planted with all fruit and vegetable crops (including apples and grapes).

[b]Fruit area includes area of all sample households that are planted with all fruit crops (including apples and grapes).

4. Econometric models and estimation

This section reviews the models used to test the statistical significance of the relationships discussed above: (a) when households allocate more of their land to fruit production, they reduce allocation of labor to the off-farm sector; and (b) when farm households allocate more labor to the off-farm sector, they systematically shift out of fruit production.

For the first research question, we define a farm household's off-farm labor allocation decision as L and specify an equation (Eq. (1)) that shows L is a function of several important variables:

$$L_{ijt} = \mathrm{f}(Fruit\ Area_{ijt-n}, Labor\ Share\ by\ Cohort_{ijt}, Household\ Characteristics_{it-n}, Other\ Shifters_{j}), \quad (1)$$

where, i, j, and t index household, village, and year. In Eq. (1), the dependent variable, L_{ijt}, is the percentage of time allocated by household i in village j in year t to the off-farm sector and $Fruit\ Area_{ijt-n}$ is our main independent variable of interest that measures the number of mu that household i in village j in year $t - n$ allocated to fruit production. In addition, we also hold constant: (a) the share of each household's total number of laborers that is in each age cohort (*Labor Share by Cohort*); (b) a number of other household characteristics, including the *Age* (measured in years) of the household head; the number of years of *Educational Attainment* (in years) of the household head, the number of people in the household's labor force (or the *Number of Family Laborers*), and *Per Capita Assets* (measured as the value of durable consumer goods per capita, including the value of the family's house, furniture, and major appliances); and (c) a number of village characteristics, including the *Village-Level Average Household Size of Cultivated Land in 2000* (measured in mu), the year that the mandatory grain delivery quota policy was eliminated (*Year of Grain Policy Change*), and the *Distance to the Nearest County Road* (in kilometers).

The question that we are interested in is whether or not, *ceteris paribus*, those households that decide to move into the

production of fruits will reduce the allocations of their time to off-farm labor markets. As such, our focus will be on the coefficient on the *Fruit Area* variable. This is important, because it is helping to explain one of the important determinants of entering the off-farm labor market (which is correlated with many positive outcomes and healthy economic indicators of development, e.g., higher incomes, reduced poverty, and falling inequality). If this is one reason why households are not entering the off-farm labor market, and not some other exogenous factor, such as lower human or physical capital (which are held constant), it means that the horticultural sector is providing an alternative outlet for rural households to improve their economic situation.

In addition, we are also interested in understanding the "flip side of the coin": Does a family's decision to work off the farm affect its decision to engage in the production of fruits? To examine this question, we specify the following model:

$$\begin{aligned} \textit{Fruit Area}_{ijt} = \mathrm{f}(&L_{ijt-n,}\textit{Labor Share by Cohort}_{ijt,} \\ &\textit{Household Characteristics}_{it-n,} \\ &\textit{Other Shifters}_{j}). \end{aligned} \tag{2}$$

In Eq. (2), the specification of the model is the same as Eq. (1) except that the dependent variable and the independent variable of interest ($\textit{Fruit Area}_{ijt}$ and L_{ijt-n}, respectively) "change places." In other words, we are going to explain the area that households allocate to fruit production in 2006 ($\textit{Fruit Area}_{ijt}$) as a function of the decision to move off the farm in 2001 (L_{ijt-n}), given that all of the other factors are held constant. The focus of the analysis of Eq. (2) is to understand if one of the main determining factors that enters into the family's decision to expand their production of fruits is the family's earlier decision to work off the farm. If so, this again is a positive factor in that it is the economics of the labor allocation decision (the family's determination of what is the better use of the household's labor) that is determining these major labor allocation decisions. In interpreting the results of Eq. (2), our focus will be centered on the coefficient of the off-farm labor allocation variable (L_{ijt-n}).

4.1. Estimation issues

Equation (1) can be estimated by OLS if it is assumed that the error term of the equation follows a normal distribution. Unfortunately, many of the sample's 338 (329) households in the apple (grape) study that are used in the regression did not produce apples (grapes). Specifically, in the case of the apple villages, 59 households did not produce apples; in the case of the grape villages, 97 households did not produce grapes. Statistically, this can be accounted for using a probit or tobit estimator to estimate the parameters in Eqs. (1) and (2). Therefore, we estimated Eqs. (1) and (2) in three ways. For probit and OLS (which can be used as a baseline case), we apply a weighted regression method, using the weights discussed above. Unfortunately, we are not able to run tobit with weights because there is no software available to do so. In all regressions, we use the entire sample, including households with and without apple (or grape) production.

There is one other issue that must be addressed when considering the estimation of Eqs. (1) and (2). To account for the simultaneity of labor allocations of household labor to the off-farm and on-farm labor markets, we always lag the right-hand variables of *Fruit Area* or *L* by five years. In other words, we are asking whether or not the decision of the household to produce fruits in 2001 is affecting its decision to move to the off-farm labor market in 2006 (and vice versa). The strategy here is to try to eliminate (or reduce) the effect of unobserved heterogeneity bias by lagging the potentially endogenous independent variable by five years. If there still is endogeneity that is unaccounted for, our results need to be interpreted with caution. However, if we find the correlations are strong, these results are equally as interesting.

5. Results of the multivariate analysis

The estimated results of Eq. (1) perform well. The results for the regression that regresses off-farm employment levels in 2006 in apple (grape) villages on the lagged (2001) values of the *Fruit Area* variable measured as the area planted with apples (grapes) are given in Table 5, columns 1–3 (columns 4–6). We present a set of regressions using an alternative measure of the lagged *Fruit Area* (measured as the area planted with all fruits, including apples/grapes and other types of fruit varieties) in Table A.3. In the OLS version of the estimated equations (Table 5, columns 2 and 5), the goodness-of-fit measure (adjusted R^2) is high for cross-section production regressions, ranging from 0.47 in the regression using the data from the grape-producing households to 0.61 in the regression using the data from the apple-producing households.

The coefficients of many of the control variables also perform largely as expected and are mostly consistent with the descriptive statistics. For example, the signs on the coefficient of the family labor variable (row 7) are positive in all of the regressions (and statistically significant in columns 2–4 and 6). Likewise, the signs on the coefficients of the education variable (row 9) are positive (and statistically significant in columns 1 and 4–6). In the villages in our sample areas, the point estimates of our coefficients suggest that families that have more labor and are relatively well educated will shift more of their labor into the off-farm sector. This result is consistent with the findings of Glauben et al. (2008), Yang (2004), and deBrauw and Rozelle (2008) who find positive and/or rising returns to education in the off-farm employment sector. Also similar to the findings in deBrauw et al. (2002), the negative signs on the coefficients of the cultivated land variable (row 10, which are statistically significant in columns 2, 3, and 6) suggest that those households with more land are those that allocate relatively less of their labor to the off-farm sector. This is what would be expected; households that are endowed with relatively more land will work relatively less off the farm.

Table 5
Estimated parameters from probit, OLS, and tobit regression analyses of the effect of fruit production on the share of time allocated to off-farm employment in Shandong, 2006

	Off-farm employment in apple villages			Off-farm employment in grape villages		
	Probit (with weights) (1)	OLS (with weights) (2)	Tobit (without weights) (3)	Probit (with weights) (4)	OLS (with weights) (5)	Tobit (without weights) (6)
Apple or grape sown area in 2001 or *Fruit Area* (mu)	−0.06	−1.50	−1.24	−0.10	−1.26	−0.68
	(0.05)	(0.76)**	(0.61)**	(0.05)**	(0.79)	(0.49)
Labor share by age (%)						
17–20	0.06	0.50	0.84	0.05	0.73	0.92
	(0.02)***	(0.21)**	(0.21)***	(0.02)**	(0.25)***	(0.24)***
21–30	0.05	0.39	0.85	0.04	0.67	0.87
	(0.01)***	(0.15)***	(0.16)***	(0.02)***	(0.16)***	(0.18)***
31–40	0.02	0.15	0.64	0.02	0.37	0.58
	(0.01)**	(0.14)	(0.12)***	(0.01)***	(0.14)***	(0.14)***
41–50	0.01	0.10	0.32	0.02	0.30	0.44
	(0.01)	(0.08)	(0.10)***	(0.01)**	(0.13)**	(0.11)***
51–60	0.01	0.11	0.23	0.02	0.23	0.37
	(0.01)*	(0.07)	(0.08)***	(0.01)***	(0.09)***	(0.09)***
Number of family laborers	0.33	8.25	11.66	0.66	3.75	6.57
	(0.29)	(2.71)***	(2.92)***	(0.34)*	(3.26)	(3.04)**
Household head's						
Age (years)	0.03	0.26	0.82	0.01	0.45	0.56
	(0.03)	(0.35)	(0.36)**	(0.03)	(0.42)	(0.38)
Education (years)	0.13	0.90	0.84	0.15	2.24	1.59
	(0.06)**	(0.55)	(0.72)	(0.06)***	(0.83)***	(0.74)**
Village-level average household's cultivated land in 2000 (mu)	−0.65	−9.76	−7.15	−0.12	−1.57	−6.88
	(0.40)	(5.46)*	(3.64)*	(0.23)	(3.72)	(2.80)**
Per capita assets in 2001 (10,000 yuan)	0.03	−1.30	3.93	0.04	0.52	1.80
	(0.15)	(2.36)	(1.21)***	(0.06)	(1.13)	(1.02)*
The year in which grain quota eliminated	−0.0006	−0.16	−0.15	−0.03	−0.20	−0.10
	(0.0154)	(0.13)	(0.20)	(0.03)	(0.43)	(0.40)
Distance to county road (km)	−0.12	−2.00	−1.49	−0.13	−1.02	−0.76
	(0.10)	(1.22)	(1.05)	(0.05)**	(0.58)*	(0.58)
Constant	−3.30	−10.09	−89.91	−3.48	−42.99	−72.20
	(1.70)*	(21.16)	(23.97)***	(1.75)**	(27.93)	(26.05)***
Number of observations	338	338	338	329	329	329
R^2		0.61			0.47	

Notes: Apple/grape area used as an explanatory variable of interest. All numbers in parentheses are robust standard errors. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

Consistent with the descriptive cohort analysis (reported in Table 2 and discussed above), age plays an important role in the determinants of access to employment off the farm (Table 5, rows 2–6). In nearly all of the regressions, regardless of the estimator that is used or whether the data are from apple or grape villages, the signs, magnitudes, and levels of statistical significance (29 of the 30 coefficients are statistically different from 0) of the age cohort coefficients suggest a robust set of linkages between age and off-farm employment. In all of our sample villages, individuals in rural households work relatively more off the farm when they are members of the younger cohorts. As the age cohort gets older, the magnitude of the coefficient monotonically falls. Clearly, these results are capturing a trend that is reflective of China's off-farm employment sector more generally (deBrauw et al., 2002). Interestingly, once the age structure of the household is held constant, the age of the household head does not appear to matter (row 8).

5.1. Linkages from horticulture to off-farm employment

Most importantly, our empirical results suggest that there is moderately convincing evidence of the link between a family's decision to engage in fruit production and its decision to allocate the labor of its members off the farm (Table 5 and Table A.3, row 1). In all six of the regressions in the apple-growing villages (in the probit, OLS, and tobit versions of the equations; columns 1–3), the signs on the coefficient of the apple/fruit planted area are negative. The estimated coefficients are significant in columns 2 and 3 in both Table 5 (the version of the regression using apple sown area) and Table A.3 (the version using total fruit area). These findings suggest that families with larger areas planted with apples participate less in off-farm labor employment activities.

Similar results are found in the grape-producing villages (Table 3 and Table A.3, row 1, columns 4–6). The signs on the

Table 6
Estimated parameters from probit, OLS, and tobit regression analyses of the effect of the share of time allocated to off-farm employment on apple/grape production in Shandong, 2006

	Apple area in apple villages			Grape area in grape villages		
	Probit (with weights) (1)	OLS (with weights) (2)	Tobit (without weights) (3)	Probit (with weights) (4)	OLS (with weights) (5)	Tobit (without weights) (6)
Share of off-farm employment in 2001 or *L* (%)	−0.01 (0.01)	−0.02 (0.01)***	−0.04 (0.01)***	−0.010 (0.004)**	−0.009 (0.003)***	−0.03 (0.01)**
Labor share by age (%)						
17–20	−0.03 (0.02)	−0.02 (0.02)	−0.04 (0.02)*	−0.02 (0.02)	−0.03 (0.01)**	0.002 (0.047)
21–30	−0.00002 (0.01202)	0.01 (0.01)	0.01 (0.02)	−0.004 (0.010)	−0.002 (0.009)	0.04 (0.04)
31–40	−0.001 (0.011)	0.01 (0.01)	0.004 (0.013)	−0.002 (0.007)	0.0004 (0.0048)	0.03 (0.03)
41–50	0.01 (0.01)	0.02 (0.01)**	0.02 (0.01)*	0.01 (0.01)	0.007 (0.004)*	0.05 (0.02)**
51–60	0.01 (0.01)	0.012 (0.004)***	0.02 (0.01)***	0.005 (0.004)	0.001 (0.002)	0.03 (0.02)**
Number of family laborers	0.04 (0.23)	0.07 (0.21)	0.64 (0.30)**	0.20 (0.18)	0.11 (0.16)	0.17 (0.63)
Household head's						
Age (years)	−0.03 (0.03)	0.004 (0.029)	−0.06 (0.04)	−0.04 (0.02)**	−0.03 (0.01)**	−0.07 (0.08)
Education (years)	0.03 (0.06)	0.10 (0.06)*	0.16 (0.07)**	−0.07 (0.05)	−0.04 (0.04)	0.15 (0.15)
Village-level average household's cultivated land in 2000 (mu)	0.45 (0.34)	0.38 (0.38)	0.37 (0.36)	0.39 (0.19)**	0.57 (0.21)***	0.37 (0.51)
Per capita assets in 2001 (10,000 yuan)	−0.19 (0.10)*	−0.14 (0.14)	0.08 (0.13)	0.01 (0.06)	−0.01 (0.06)	0.38 (0.21)*
The year in which grain quota eliminated	0.04 (0.01)***	−0.003 (0.010)	−0.02 (0.02)	0.04 (0.02)	0.04 (0.02)**	0.18 (0.08)**
Distance to county road (km)	0.08 (0.08)	−0.10 (0.07)	−0.18 (0.10)*	−0.03 (0.03)	−0.06 (0.02)***	−0.14 (0.12)
Constant	0.34 (2.17)	−0.37 (2.17)	2.17 (2.46)	0.71 (1.30)	1.74 (0.91)*	−0.82 (5.09)
Number of observations	338	338	338	329	329	329
R^2		0.19			0.10	

Notes: All numbers in parentheses are robust standard errors. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively. When probit model is used, dependent variable is 1 or 0.

coefficient of the *Fruit Area* variable are negative and statistically significant from 0 in 3 out of the 6 equations. These results, like those in the apple-producing villages, provide moderately convincing evidence of the negative trade-off that households face when they are deciding to plant grapes. When the households plant more grapes and when the households plant more fruits in grape-growing villages, they end up working less off the farm. Because there is no one forcing them into the production of apples or grapes, our results are consistent with the interpretation that the rise of the demand for horticultural commodities in China over the past decade has provided opportunities beyond the off-farm employment sector for certain households to link themselves into China's rapid development. Considering the results of the control variables (discussed above), these new opportunities are being taken up by relatively old and less-educated farmers. To the extent that these households have less of an opportunity to enter the off-farm labor market, the rise of horticulture is pro-poor, at least in a relative sense. These results are also consistent with the findings of Wang et al. (2007) who find that more involvement in agricultural activities reduces the allocation of labor to off-farm employment activities.

5.2. Reverse effect: Linkages from off-farm employment to horticulture

Although the goodness-of-fit measures are lower, when looking at the reverse effect, we find that the linkages between off-farm employment and horticulture appear in two ways. In the apple-growing villages, the negative sign on the off-farm labor share variable (*L*) suggests that those households that participated relatively more in the off-farm labor market in 2001 planted less area with apples in 2006 (Table 6 and Table A.4, row 1, columns 1–3). Although the coefficients in probit

Table 7
OLS estimates of the impact of off-farm employment on apple or grape capital and labor input in Shandong, 2006

	Apple villages		Grape villages	
	Capital input (yuan/mu) (1)	Labor input (day/mu) (2)	Capital input (yuan/mu) (3)	Labor input (day/mu) (4)
Share of off-farm employment in 2001 or *L* (%)	−6.12	−0.06	0.09	−0.24
	(3.64)*	(0.22)	(2.47)	(0.25)
Labor share by age (%)				
17–20	−10.73	−0.87	1.45	−1.84
	(8.57)	(0.45)*	(6.94)	(0.78)**
21–30	3.58	−0.33	2.69	−1.46
	(8.18)	(0.42)	(6.27)	(0.68)**
31–40	3.50	−0.15	−0.003	−1.26
	(7.38)	(0.41)	(5.059)	(0.53)**
41–50	5.22	−0.03	2.15	−0.96
	(5.05)	(0.27)	(4.30)	(0.46)**
51–60	−1.47	−0.29	−1.44	−0.50
	(3.47)	(0.23)	(3.26)	(0.36)
Labor	41.21	−2.30	−176.61	10.47
	(134.06)	(5.29)	(95.31)*	(11.44)
Household head's				
Age (year)	−1.41	−0.24	8.15	−0.77
	(23.66)	(1.15)	(12.59)	(0.95)
Education (year)	−86.44	−3.43	33.20	2.96
	(37.97)**	(2.57)	(19.95)*	(2.13)
Village-level average household's cultivated land in 2000 (mu)	−38.25	−0.14	139.22	−9.60
	(174.12)	(10.92)	(83.15)*	(8.37)
Per capita asset (10,000 yuan)	−124.03	−11.89	−36.27	2.02
	(62.07)**	(3.54)***	(39.83)	(4.74)
The year phased out grain quota	14.36	1.53	−2.87	−1.08
	(10.20)	(0.65)**	(9.24)	(1.01)
Distance to county road (km)	24.51	0.37	−15.77	−0.37
	(61.31)	(3.60)	(18.13)	(1.60)
Constant	2, 561.91	158.37	620.37	176.73
	(1, 463.21)*	(73.86)**	(814.46)	(86.39)**
Number of observations	275	275	224	224
R^2	0.15	0.19	0.17	0.25

Notes: All numbers in parentheses are robust standard errors. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively. Regressions use date with weights.

regression are not significant, those in the OLS and tobit regressions are.[4]

A similar set of results—if not stronger—is found in grape-producing villages. Regardless of the estimator, and regardless of the way we measure the area planted with grapes/fruits, the signs on the off-farm labor share variable are negative. In 5 of the 6 regressions, the coefficients are statistically significant from 0. Clearly, in both types of villages, the family's decision to move off the farm in an earlier period (e.g., 2001) appears to be fairly well linked to the decision of the family to produce fruits at a later time (e.g., 2006). These results also suggest that the rise of horticulture is giving households that were unable to access jobs off the farm in an earlier period a chance to move into activities other than subsistence agriculture.

5.3. Impact of off-farm employment on capital and labor inputs in horticulture

Although there was some hint in Table 4 that those households that had more of the labor of their family members allocated to off-farm labor used different inputs (among those households that produced apples/grapes), when looking at the multivariate analysis, almost all the effect disappears (Table 7). Except in column 1 (the regression result that examines the effect of off-farm labor share on the level of capital in apple villages), there is no significant effect in any of the rest of the regressions. In other words, when families work off

[4] In our regressions, we did not estimate the coefficients in the different equations simultaneously, because we found no procedure to do away with weights. However, it is possible that not accounting for the correlations across the error terms of the different equations could lead to inefficient results. Therefore, in Table A.5, we have included the results of a simultaneous equations model when we do not use weights. The results are fully consistent with the results of our original modeling work.

the farm relatively more (or less), the amount of labor and capital that are used on their apple and grape farms do not vary.

These results have several implications for our understanding of the operation of China's capital and on-farm labor market. First, such a result (i.e., no impact of the family's off-farm labor decision on the on-farm capital input decision) suggests that families are not going into off-farm employment as a way to earn cash that can be used to finance their fruit enterprises. Those families with high levels of off-farm employment and those families with low levels of off-farm employment both employ the same level of capital in their farming operations. Such a finding is also consistent with the findings of Park et al. (2004) that farmers in China are not much constrained by capital when it comes to agricultural production. This might be another reason that modern supply chains have been relatively slow in penetrating to the farm level (Wang et al., forthcoming); farmers do not need the capital (at least in the current labor-intensive ways of producing fruits) to the extent that farmers in other countries do (Swinnen et al., 2001). Alternatively, it could be that there are other ways to access capital, e.g., through formal or informal capital markets.[5]

6. Conclusions

In this article, we have explored the linkages between the off-farm labor market and the on-farm production of horticulture crops. In doing so, we find that there is evidence of the linkages between off-farm labor employment and horticulture production. In both the descriptive results and the multivariate analysis, we find that the decision to participate in fruit production is influenced by (or correlated with) previous decisions of the family to shift part or all of its labor off the farm. In addition, the decision to shift family members into off-farm employment is influenced by previous decisions to plant part or all of its area with either apples or grapes (or fruits in general). As in Wang et al. (2007), the decisions in both of these cases appear to involve trade-offs. Decisions to move into fruit production lead to lower levels of participation off the farm; decisions to shift family members into off-farm employment reduce the likelihood and intensity of fruit production.

One of the remarkable findings of our article is that—although we examine the cases of both apples and grapes, and we know that these are two different commodities—the results in terms of the trade-off of the household between labor allocated to fruit production and labor allocated to the off-farm sector are similar. In other words, in the case of either apples or grapes, households that do not seek employment (or do not want to seek employment) off the farm have an option: fruit production. This is one of the key messages of the article. There appears to be real opportunities in the fruit-producing sector for households that might not otherwise be able to enter the off-farm employment sector.

These findings are important to policy makers for a number of reasons. In the past, it has been noted that those families that have members who are educated and young are the ones that have been able to join the relatively more lucrative off-farm labor market. There is a great deal of documentation that shows that higher incomes and falling poverty rates are associated with shifts into off-farm employment. Although these tendencies bring benefits to those households that have educated and young family members, they also mean that incomes and incidences of poverty are likely to be higher for those families without such human capital. Our results suggest that, for those families that face difficulties in moving off the farm, shifting their efforts into fruit production may be a viable opportunity. At the very least, it is an option, and households in our sample area are making the trade-offs.

When the opportunities for shifting into the fruit-producing sector are coupled with the results of other studies that suggest that fruit production is moving into areas that are relatively poor, and that fruit production leads to higher income (Wang et al., forthcoming), another one of the roles of fruit production can be seen. In other words, fruit production may be an option for those who have difficulties moving off the farm because they lack the education and youth that are being demanded in off-farm labor markets. When less-educated households with older members (who are, by definition, relatively poorer in China) move into fruit production, it may help raise incomes and alleviate poverty. If this is so (and more research is needed to confirm this), policy makers may have one additional reason to encourage the expansion of fruit production.

Because of this the government should continue to do what they are doing. In our other works (Wang et al., forthcoming), China's fruit markets are shown to be relatively unregulated. Traders are shown to be moving across the landscape on increasingly improved road networks. Farmers, traders, wholesalers, and others are trading restriction-free in a larger and larger number of wholesale markets. This system, which is intermediating between China's consumers who are demanding increasing volumes of fruits and the small farmers in China's countryside, should be maintained. It is giving a whole new cohort of farmers a way to tie to China's rising economic prosperity. If this is truly happening, efforts should be made to continue the current system in the same way as it is operating.

Last, but not least, the significantly negative impact of off-farm employment on fruit production and the fact that more of the younger cohorts in the labor force are moving out of agriculture suggest that the expansion of horticulture may face challenges as off-farm employment continues to increase. For China to retain its comparative advantage in horticulture production in the long run, labor-saving technology and effective rental markets for farm size expansion will be essential.

[5] This does not imply that on-farm labor markets function well. As shown in Bowlus and Sicular (2003), there were imperfections in rural on-farm as well as off-farm labor markets, at least through the 1990s.

Appendix

Table A.1
Descriptive statistics of major variables used in the analysis

Variable	Apple villages			Grape villages		
	Observation	Mean	Standard deviation	Observation	Mean	Standard deviation
Share of family labor allocated to off-farm employment in 2001 (%)	338	22.9	22.2	329	28.0	25.2
Share of family labor allocated to off-farm employment in 2006 (%)	338	29.5	27.5	329	31.5	26.5
Planted area in 2001 (mu)						
Apple or grape area[a]	338	1.2	1.8	329	0.8	1.6
All fruit area	338	1.6	2.7	329	1.7	2.2
Planted area in 2006 (mu)						
Apple or grape area[a]	338	1.3	1.9	329	0.6	1.7
All fruits area	338	1.8	3.0	329	1.7	2.7
Labor share by age cohort in 2006						
17–20 years	338	6.3	12.3	329	3.1	8.9
21–30 years	338	14.0	18.1	329	13.4	19.4
31–40 years	338	12.8	30.1	329	14.6	29.1
41–50 years	338	20.0	31.1	329	20.1	30.6
51–60 years	338	29.1	36.4	329	28.9	35.8
>60 years	338	17.6	36.3	329	20.0	35.3
Household characteristics in 2006						
Household head's age (years)	338	52.6	9.2	329	54.2	9.7
Household head's education (years)	338	7.3	2.7	329	7.4	2.4
Number of family laborers	338	2.9	1.2	329	2.8	1.0
Per capita assets in 2001 (yuan)	338	8,797	11,183	329	11,790	16,534
Input variables in 2006						
Capital (yuan/mu)	275	1,992	1,072	224	929	581
Labor (days/mu)	275	97	65.0	224	79	54.1
Village characteristics						
Cultivated land of average household in 2000 (mu)	338	1.3	0.4	329	1.3	0.6
The year in which grain quota procurement eliminated	338	1,997	13.5	329	2,000	5.5
Distance to nearest roadway in 2005 (km)	338	1.8	1.9	329	2.6	3.0

Note: 15 mu = 1 hectare.
[a]The numbers under the apple columns are denominated apple area and those in the grape columns are dominated grape area.

Table A.2
Share of family's labor allocated to off-farm employments and inputs in fruit production in Shandong, 2006

	Sample	Inputs used in apple/grape production	
		Capital (yuan/mu)	Labor (days/mu)
Apple villages	279	1,992	97
Off-farm = 0[a]	109	2,097	109
Off-farm >0[a]	170	1,924	89
0 < off-farm ≤ 40%[b]	117	2,041	92
40% < off-farm ≤ 60%[b]	48	1,701	84
Off-farm >60%[b]	5	1,523	74
Grape villages	232	929	79
Off-farm = 0[a]	71	1,004	103
Off-farm >0[a]	161	893	67
0 < off-farm ≤ 40%[b]	100	905	67
40% < off-farm ≤ 60%[b]	43	865	66
Off-farm >60%[b]	18	912	65
All villages	511	1,460	88
Off-farm = 0[a]	180	1,605	107
Off-farm >0[a]	331	1,380	77
0 < off-farm ≤ 40%[b]	217	1,460	79
40% < off-farm ≤ 60%[b]	91	1,262	75
Off-farm >60%[b]	23	1,071	67

Notes: All figures are weighted averages.
[a]The comparisons between rows 2 and 3, 8 and 9, and 14 and 15 are between those households with no off-farm employment and those with any off-farm employment.
[b]The comparisons among rows 4–6, 10–12, and 16–18 are among households that have any off-farm employment.

Table A.3
Estimated parameters from probit, OLS, and tobit regression analyses of the effect of fruit production on the share of time allocated to off-farm employment in Shandong, 2006

	Off-farm employment in apple villages			Off-farm employment in grape villages		
	Probit (with weights) (1)	OLS (with weights) (2)	Tobit (without weights) (3)	Probit (with weights) (4)	OLS (with weights) (5)	Tobit (without weights) (6)
Fruit sown area in 2001 or *Fruit Area* (mu)	−0.04 (0.03)	−0.91 (0.52)*	−0.84 (0.45)*	−0.13 (0.04)***	−0.85 (0.63)	−1.06 (0.38)***
Labor share by age (%)						
17–20	0.06 (0.02)***	0.51 (0.22)**	0.85 (0.21)***	0.04 (0.02)**	0.72 (0.27)***	0.87 (0.24)***
21–30	0.05 (0.02)***	0.39 (0.15)***	0.85 (0.16)***	0.04 (0.02)**	0.64 (0.17)***	0.84 (0.18)***
31–40	0.02 (0.01)**	0.15 (0.14)	0.64 (0.13)***	0.02 (0.01)***	0.35 (0.14)**	0.57 (0.14)***
41–50	0.01 (0.01)	0.10 (0.08)	0.32 (0.10)***	0.02 (0.01)**	0.28 (0.13)**	0.44 (0.11)***
51–60	0.01 (0.01)*	0.11 (0.07)	0.23 (0.08)***	0.01 (0.01)**	0.22 (0.09)**	0.36 (0.09)***
Number of family laborers	0.32 (0.29)	8.26 (2.71)***	11.65 (2.93)***	0.75 (0.35)**	3.96 (3.35)	7.04 (3.02)**
Household head's						
Age (years)	0.03 (0.03)	0.29 (0.36)	0.84 (0.36)**	−0.004 (0.025)	0.40 (0.43)	0.49 (0.38)
Education (years)	0.14 (0.06)**	0.90 (0.55)	0.82 (0.72)	0.14 (0.06)***	2.15 (0.82)***	1.63 (0.74)**
Village-level average household's cultivated land in 2000 (mu)	−0.63 (0.40)	−9.60 (5.53)*	−7.30 (3.65)**	−0.07 (0.23)	−1.73 (3.88)	−6.08 (2.78)**
Per capita assets in 2001 (10,000 yuan)	0.03 (0.15)	−1.24 (2.34)	3.90 (1.22)***	0.02 (0.06)	0.44 (1.11)	1.87 (1.01)*
The year in which grain quota eliminated	−0.0001 (0.0154)	−0.15 (0.13)	−0.12 (0.20)	−0.03 (0.03)	−0.19 (0.44)	0.02 (0.40)
Distance to county road (km)	−0.11 (0.10)	−1.98 (1.23)	−1.40 (1.05)	−0.11 (0.05)**	−0.90 (0.60)	−0.77 (0.58)
Constant	−3.39 (1.70)**	−12.25 (21.52)	−91.23 (24.01)***	−2.83 (1.79)	−38.32 (28.50)	−69.33 (25.89)***
Number of observations	338	338	338	329	329	329
R^2		0.61			0.47	

Notes: Total fruit area used as an explanatory variable of interest. All numbers in parentheses are robust standard errors. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

Table A.4
Estimated parameters from probit, OLS, and tobit regression analyses of the effect of the share of time allocated to off-farm employment on total fruit production in Shandong, 2006

	Apple areas in apple villages			Grape area in grape villages		
	Probit (with weight) (1)	OLS (with weight) (2)	Tobit (without weight) (3)	Probit (with weight) (4)	OLS (with weight) (5)	Tobit (without weight) (6)
Off-farm time share in 2001 (%)	−0.01 (0.01)	−0.02 (0.01)**	−0.05 (0.01)***	0.01 (0.01)*	−0.0002 (0.0068)	−0.04 (0.02)**
Labor share by age (%)						
17–20	−0.03 (0.02)	−0.03 (0.03)	−0.05 (0.03)	−0.04 (0.02)**	−0.06 (0.02)**	−0.05 (0.05)
21–30	0.001 (0.012)	0.004 (0.018)	−0.01 (0.02)	−0.02 (0.01)*	−0.03 (0.02)*	−0.004 (0.041)
31–40	−0.001 (0.011)	0.002 (0.013)	−0.01 (0.02)	−0.02 (0.01)**	−0.01 (0.01)	0.002 (0.030)

(*continued*)

Table A.4
Continued

	Apple areas in apple villages			Grape area in grape villages		
	Probit (with weight) (1)	OLS (with weight) (2)	Tobit (without weight) (3)	Probit (with weight) (4)	OLS (with weight) (5)	Tobit (without weight) (6)
41–50	0.01	0.02	0.01	−0.001	−0.002	0.03
	(0.01)	(0.01)*	(0.01)	(0.007)	(0.008)	(0.02)
51–60	0.01	0.01	0.02	−0.01	−0.01	0.01
	(0.01)	(0.01)**	(0.01)**	(0.01)**	(0.01)	(0.02)
Number of family laborers	−0.003	0.14	0.82	0.19	0.34	0.54
	(0.239)	(0.30)	(0.43)*	(0.22)	(0.37)	(0.70)
Household head's						
Age (years)	−0.02	−0.02	−0.11	−0.07	−0.11	−0.18
	(0.03)	(0.04)	(0.05)**	(0.03)***	(0.03)***	(0.09)**
Education (years)	0.04	0.13	0.24	−0.17	−0.07	0.19
	(0.06)	(0.09)	(0.10)**	(0.06)***	(0.08)	(0.16)
Village-level average household's cultivated land in 2000 (mu)	0.52	1.17	0.46	−0.39	0.48	0.63
	(0.36)	(0.56)**	(0.51)	(0.25)	(0.43)	(0.57)
Per capita assets in 2001 (10,000 yuan)	−0.16	−0.08	0.09	−0.16	−0.18	0.30
	(0.11)	(0.17)	(0.18)	(0.07)**	(0.10)*	(0.23)
The year in which grain quota eliminated	0.05	0.02	0.02	0.06	0.07	0.24
	(0.02)**	(0.02)	(0.03)	(0.04)	(0.05)	(0.08)***
Distance to county road (km)	0.14	−0.06	−0.12	0.08	0.02	−0.19
	(0.08)*	(0.09)	(0.14)	(0.05)*	(0.06)	(0.13)
Constant	0.08	−0.17	4.13	5.64	7.68	7.43
	(2.24)	(2.88)	(3.51)	(1.84)***	(2.16)***	(5.68)
Number of observations	338	338	338	329	329	329
R^2		0.17			0.10	

Notes: All numbers in parentheses are robust standard errors. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively. When probit model is used, dependent variable is 1 or 0.

Table A.5
Estimated parameters from three-stage least squares regression analyses of the effect of apple/grape production on the share of time allocated to off-farm employment and the effect of the share of time allocated to off-farm employment on apple/grape production in Shandong, 2006

	Apple villages		Grape villages	
	Share of off-farm employment	Apple sown area	Share of off-farm employment	Grape sown area
Apple or grape sown area in 2001 (mu)	−1.60		−0.79	
	(0.41)***		(0.36)**	
Share of off-farm employment in 2001 (%)		−0.04		−0.03
		(0.01)***		(0.01)**
Labor share by age (%)				
17–20	0.53	−0.03	0.56	0.00
	(0.14)***	(0.02)*	(0.17)***	(0.03)
21–30	0.54	0.01	0.55	0.03
	(0.10)***	(0.01)	(0.13)***	(0.03)
31–40	0.39	0.01	0.29	0.02
	(0.08)***	(0.01)	(0.09)***	(0.02)
41–50	0.19	0.02	0.21	0.03
	(0.06)***	(0.01)**	(0.07)***	(0.02)*
51–60	0.12	0.01	0.16	0.02
	(0.04)***	(0.01)**	(0.05)***	(0.01)
Number of family laborers	7.98	0.44	4.54	−0.04
	(1.96)***	(0.25)*	(2.18)**	(0.45)
Household head's				
Age (years)	0.65	−0.03	0.34	−0.02
	(0.24)***	(0.03)	(0.26)	(0.05)

(*continued*)

Table A.5
Continued

	Apple villages		Grape villages	
	Share of off-farm employment	Apple sown area	Share of off-farm employment	Grape sown area
Education (years)	0.66	0.15	1.12	0.14
	(0.45)	(0.06)**	(0.53)**	(0.11)
Village-level average household's cultivated land in 2000 (mu)	−4.19	0.36	−3.69	0.28
	(2.33)*	(0.30)	(1.81)**	(0.38)
Per capita assets in 2001 (10,000 yuan)	3.19	0.10	1.22	0.28
	(0.83)***	(0.11)	(0.74)	(0.15)*
The year in which grain quota eliminated	−0.14	−0.02	0.08	0.12
	(0.13)	(0.02)	(0.28)	(0.06)**
Distance to county road (km)	−0.91	−0.14	−0.47	−0.11
	(0.67)	(0.09)*	(0.41)	(0.09)
Constant	−49.18	1.65	−28.98	−0.18
	(15.79)***	(2.03)	(17.67)	(3.67)
Number of observations	338	338	329	329

Notes: All numbers in parentheses are robust standard errors. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

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