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Impact of Contract Farming on Income: Linking Small Farmers, Packers, and Supermarkets in China

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Summary. — This study compares contract and non-contract growers of apples and green onions in Shandong Province, China in order to explore the constraints on participation and the impact of contract farming on income. We find little evidence that firms prefer to work with larger farms, though all farms in the area are quite small. Using a Heckman selection–correction model, we find that contract farming raises income even after controlling for observable and unobservable household characteristics. These results suggest that contract farming can help raise small-farm income, though questions remain regarding the number of farmers that can be brought into such schemes.

Key words — China, contract farming, horticulture, farmers, supermarkets, processors, exports

1. INTRODUCTION

The role of contract farming in developing countries has been a topic of interest and some controversy at least since the 1970s (Glover, 1984; Minot, 1986; Morrisey, 1974). Critics of contract farming argue that large agribusiness firms use contracts to take advantage of cheap labor and transfer production risk to farmers. Another concern is that smallholders will be marginalized because companies will prefer to work with medium- and large-scale growers, thus exacerbating rural inequality (Little & Watts, 1994; Singh, 2002). Others are less pessimistic, seeing contract farming as a means to incorporate small farmers into growing markets for processed goods and export commodities. Because the contracts often involve the provision of seed, fertilizer, and technical assistance on credit and a guaranteed price at harvest, this form of vertical coordination simultaneously solves a number of constraints on small-farm productivity, including risk and access to inputs, credit, and information. In this view, contract farming is an institutional solution to the problems of market failure in the markets for credit, insurance, and information (Grosh, 1994; Key & Runsten, 1999).

Contract farming usually involves a large-scale buyer, such as an exporter or a food processor that needs to ensure a steady supply of raw materials meeting certain quality standards. As such, contracting is rare for basic staple foods but relatively common for industrial crops (e.g., sugarcane, tobacco, and tea), poultry, dairy, and horticulture, particularly when produced for high-income consumers who are willing to pay a premium for quality and food safety (Jaffee & Morton, 1994; Minot, 1986).

There are few estimates of the prevalence of contract farming and no estimates of trends over time, but changes in global agricultural markets provide some hints. First, rapid income growth, particularly in Asia, is shifting consumption away from staple grains and toward high-value commodities such as meat, fish, dairy, and horticulture and toward processed foods (Minot & Roy, 2006). Second, income growth, urbanization, and foreign investment are driving a consolidation in retail food outlets, the supermarket revolution (Reardon, Timmer, Barrett, & Berdegué, 2003). Third, lower trade barriers and improved communication technology are expanding trade linkages, connecting small farmers in developing countries with high-income consumers in developing country cities and in industrialized countries. The growth in high-value agriculture, supermarkets, processing, and export-oriented agriculture suggest that the importance of contract farming is probably growing.

This study provides an empirical analysis of the impact of contract farming of apples and green onions on household income in Shandong Province, China. The issue is relevant to food policy decisions because if contract farming has a propoor impact, then policies and programs to support contract farming (such as cost-sharing in the provision of extension services) could be justified on equity grounds. If not, the policymakers would be better allocating resources to other agricultural development strategies. This study also has implications for the debate over whether small farmers will be able to adapt to globalization, which increases the need for various forms of vertical coordination, including contract farming. In China, the average farm size is less than 0.5 ha, which is much smaller than in other Asian developing countries such as India

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(1.5 ha), Thailand (3.4 ha), and South Korea (1.5 ha) (Fan & Chan-Kang, 2005).

More specifically, this paper addresses three related questions. First, to what degree do less educated and small-scale farmers participate in contract farming schemes? Second, does contract farming raise the income of participating farmers? Third, if contract farming raises income, how does it do so, through lower input prices, higher yields, better crop prices, or some other mechanism?

In Section 2, we review previous research that evaluates the distributional effect of contract farming schemes. Section 3 describes the farm survey data and the econometric methods used in this study. Section 4 provides the results in three parts: a description of the contract farming schemes, a comparison of contract and non-contract farmers, and an econometric analysis of contract participation and income. Section 5 provides some concluding comments and policy implications.

2. BACKGROUND

(a) *Previous studies of contract farming in developing countries*

In an early review of contract farming schemes, Minot (1986) finds that most of them improved the income of participants, although rigorous evaluations were rare and the failure rate of contract farming schemes is high. Little and Watts (1994) compile a set of seven case studies of contract farming in sub-Saharan Africa, focusing on conflicts between farmers and the contracting firms, the imbalance of power between the two parties, intra-household tensions over the allocation of new revenues, and the increasing rural inequality as contract farmers grow wealthy enough to hire farm laborers. Nonetheless, Little (1994, p. 221) concludes that "incomes from contract farming increased for a moderate (30–40%) to a high (50–60%) proportion of participants." In a review of the experience of contract farming in Africa in the early 1990s, Porter and Phillips-Howard (1997) conclude that farmers were generally better off as a result of their participation in contract farming, in spite of a number of social problems that arose in the communities. Singh (2002) identifies a series of problems associated with contract vegetable production in Punjab state in India: imbalanced power between farmers and companies, violation of the terms of the agreements, social differentiation, and environmental unsustainability. Nonetheless, his surveys reveal that most contract farmers have seen incomes rise and are satisfied with the contract arrangement.

A number of studies examine the proportion of contract farmers that are smallholders. Guo, Jolly, and Zhu (2005) analyze the determinants of contract farming participation with farm-level survey data from China. They find that small farmers are less likely to participate in contract farming than larger farmers. In contrast, Runsten and Key (1996) find that multinational tomato processors in Mexico first contracted with large growers but then involved also the small growers because side-selling was a problem with their larger growers. Similarly, a horticultural exporter in Thailand started producing its own horticultural products on company land and later shifted to smallholder contract production (World Bank, 2006). Minot and Ngigi (2004) describe the evolution of several contract farming schemes in Kenya, including one (Del Monte pineapple) that gave up on contract production and others than have shifted from large-scale to small-scale production. In Senegal, green bean exporters switched from small-scale contract production to large-scale production (Maertens, 2006). These findings confirm that the comparative advantage of smallholders is not a static concept, but it can change as farmers and buyers experiment and learn from their experience. It also implies that there is no intrinsic advantage of large farmers, so that public policy may be able to play a role in supporting the participation of small farmers in these supply chains.

Other studies examine the effect of contract farming on gross margins, crop income, or total income. For example, Birthal, Joshi, and Gulati (2005) found that the gross margins for contract dairy farmers in India were almost double those of independent dairy farmers, largely because contract growers had lower production and marketing costs.

Some studies take into account the fact that contract farmers are generally not a random sample of the population; they may differ from the population in ways that also affect income. They may differ in *observable* characteristics, such as farm size or education, and/or in *unobservable* characteristics, such as industriousness or intelligence. In either case, the difference in income between contract farmers and other farmers will reflect both the effect of contracting *per se* and the effect of those characteristics. Standard regression analysis can control for the effect of observable characteristics, but to eliminate the bias associated with unobservable characteristics, it is necessary to use a Heckman selection–correction model or an instrumental variables model.

Warning and Key (2002) study contract farming in peanuts in Senegal. NOVASEN, a private company, contracted 32,000 growers and produced approximately 40,000 tons of peanuts annually. Using a two-step Heckman procedure, they find that the increase in gross agricultural revenues associated with contracting is statistically significant and large, equal to about 55% of the average revenue of non-contract farmers. Simmons, Winters, and Patrick (2005) examine contract growers of poultry, maize seed, and rice seed in Indonesia. Using a Heckman selection model, they find that poultry contracts and maize seed contracts resulted in improved returns to capital, while no significant impact was found in the case of rice seed. Contract seed growers were generally larger than the independent growers, but contract poultry growers tended to be smaller than independent poultry growers. They conclude that the contracts increase income and welfare, reducing absolute poverty.

(b) *Apple and green onion markets in Shandong Province*

This study examines contract and non-contract production of apples and green onions in Shandong Province, one of the most commercially-oriented agricultural regions in China. Fruit and vegetable production in China has increased dramatically over the past 25 years. Since 1980, the area planted with fruits and vegetables has increased at 7% per year. Vegetable production in China has increased from 2% of the planted area in 1980 to 11% in 2005, while the area planted with fruit trees has increased from 1% of the total to 6% over the same period (NBS, 2006). Fruit and vegetable exports started later, but have grown more rapidly, rising from US$ 1.2 billion in 1985 to US$ 6.4 billion. This represents an average growth rate of 9% per year (FAO, 2006).

China produces more than 20 million tons of apples per year, making it the largest producer in the world. Production has increased almost five-fold since 1990. Apple exports have expanded from US$ 20 million in 1992 to US$ 274 million in 2004, turning China from a net importer to a major exporter (FAO, 2006). The main markets for Chinese apples are Russia and Southeast Asia. In Southeast Asia, Chinese apples are displacing imports from the United States and New Zealand. Because just 4% of production is exported, the potential for expansion is large, but Chinese apple exports face a num-

ber of challenges, including low yields, inadequate cold storage and packing plant capacity, pesticide residues, and phytosanitary problems which prevent apple exports to some high-income markets such as the United States.

Shandong Province accounts for over half of China's apple exports. In addition, it is a major supplier of apples to Beijing and Shanghai. Apples are grown by independent farmers, farmers producing under contract to the packer/exporters, and by farms managed by packer/exporters. In the latter case, the company rents a block of land from all the farmers in a village and then hires farm laborers to work under the supervision of company technicians. [1]

Statistics for green onions [2] alone are not available, but China produces over 19 million tons of onions, green onions, and shallots, representing more than 30% of the world total. [3] Exports of these onions grew from 22,000 tons in 1990 to 579,000 tons in 2004 accounting for 10% of global export share (FAO, 2006). Shandong Province is the leading producer, with almost 4 million tons, and the leading exporter among the provinces (NBS, 2006). As in the case of apples, green onion production involves a mix of independent growers, contract growers, and large farms managed by packers/exporters.

3. DATA AND METHODS

This study uses data from a farm survey carried out by the International Food Policy Research Institute (IFPRI) and the Chinese Academy for Agricultural Science (CAAS) in Shandong Province, China. The 16-page farmer questionnaire includes questions on household characteristics, assets, crop production and marketing, other sources of income, input costs, credit, contractual details, and perceptions of changes over the previous five years. The sample included 162 farm households growing apples or green onions, including both contract farmers and non-contract farmers. The contract farmers were selected randomly by the survey team from lists provided by four firms, two apple packers and two green onion packers. The non-contract farmers were selected randomly from lists provided by village leaders. Farmers who did not grow apples or green onions were later removed from the list. The data collection was carried out over July and August 2005. The apple growers were interviewed in Qingdao district (Laixi county) and in Yantai district (Qixia county), while the green onion growers were interviewed in Weifang district (Anqiu county).

The analysis focuses on the household characteristics associated with participation in a contract farming scheme and the impact of contract participation on *per capita* income [4]. We examine the impact of contract farming on *per capita* income rather than crop income or gross margins because our overall objective is to assess the potential of contract farming for poverty alleviation. If contract farming draws labor and land away from other activities, focusing on crop income or gross margins of the contracted crop may overstate the impact on household well-being.

There are three components to the econometric analysis. First, we use a probit model to estimate the probability that a given household will participate in a contract farming scheme. The regressors include household size and composition, the age and education of the head of household, and ownership of land and other assets. This analysis addresses the question of whether contract farmers tend to be better endowed than non-contract farmers.

Second, we use an ordinary least squares (OLS) model to estimate *per capita* income as a function of household and farm characteristics and a dummy variable representing participation in the contract scheme. By including household characteristics in the model, we control for observable differences between contract and non-contract farmers, such as differences in farm size, education, and the availability of family labor. However, this model does not take into account possible selection bias in contract participation. If contractors tend to be more industrious or more skilled than non-contractors, for example, they would have higher incomes regardless of whether they participated in the contract farming scheme. In this case, the coefficient on the participation dummy variable would include the effect of these unobservable characteristics in addition to the effect of contracting, thus over-estimating the effect of contracting. In econometric terms, if unobservable characteristics are correlated with both the dependent variable (*per capita* income) and a regressor (contract participation) then the coefficient on that regressor will be biased and inconsistent.

The third component of our analysis is the treatment effects model (also called the Heckman selection–correction model), which uses the participation probit model to calculate the inverse Mills ratio and includes this ratio as a regressor in the income model. This term corrects for possible selection bias and yields unbiased and consistent estimates in the income model. This analysis is implemented as a maximum likelihood estimation, in which all parameters in both models are estimated simultaneously, rather than as a two-step procedure. Identification is provided by the inclusion of a variable in the selection model that is not found in the outcome equation. Our identifying variable is the distance between the farm of a household and the farm of the village leader. Based on the field observations, the village leader plays an important role in selecting farmers for participation in the contract farming scheme. Therefore, proximity to the village leader is a good predictor of participation. We believe this distance does not have an independent effect on income, making it a useful identifying variable.

4. RESULTS

This section begins with a description of the apple and green onion contract farming schemes based on the farm survey and interviews with the four packers. Then we describe the differences between contract and non-contract farmers using simple means and *t*-tests. Finally, we present the results of the econometric analysis of the determinants of participation in a contract farming scheme and the impact of participation on household income.

(a) *Description of apple and green onion contract farming schemes*

Table 1 shows the characteristics of the firms that contracted the farmers in our sample. One of the apple packers is 100% Singapore-owned, but the others are majority locally-owned. The share of procurement from contract farmers ranges from 20% to 80%. All four packers rely partly on company-managed farms, and three of them also make spot-market purchases. Interviews revealed that the procurement strategy seems to be driven largely by the food safety and quality requirements of consumers. Export markets (particularly in Europe, Japan, and the United States) have the strictest standards, followed by large supermarket chains in Chinese cities. Pesticide residue is a major concern to the supermarkets because of intense sensitivity to food safety issues among

Table 1. *Characteristics of the packers Source: Firm interviews carried out by authors.*

Company	Longkou Fook Huat Tong Kee Refrigeration Co. Ltd.	Qindao San Feng Fruit Storage and Transport Co. Ltd.	Anqiu Dongfanghong Food Co. Ltd.	Anqiu Sanzhi Foodstuffs and Vegetables Co. Ltd.
Product	Apple	Apple	Green onion	Green onion
Ownership (% foreign)	100%	40%	24%	0%
Procurement				
Company farm	20%	5%	70%	30%
Contract farmers	20%	80%	30%	50%
Spot-market purchases	60%	15%	0%	20%
Total	100%	100%	100%	100%
Sales				
Export	67%	49%	91%	92%
Supermarkets	28%	41%	3%	2%
Wholesalers	0%	10%	4%	4%
Other domestic	5%	0%	2%	3%
Total	100%	100%	100%	100%
Share of farmers receiving inputs				
Seed	n.a.	n.a.	100%	100%
Fertilizer	50%	0%	0%	20%
Pesticides	100%	70%	60%	40%
Price determination	Market price plus premium	Market price plus premium	Fixed before planting	Market price plus premium

supermarket customers. Traditional markets in rural areas and secondary cities have the least restrictive standards.

Production on company farms allows the greatest degree of control over production methods and is mainly used for exports and sales to supermarket chains. Spot-market purchases tend to be less expensive and more flexible, and are used for sales to less discriminating local markets. Contract production is in an intermediate position, offering more flexibility than company farm production, but more quality control than spot-market purchases. By obtaining produce from multiple sources, the packers can supply a range of qualities and prices, while maintaining flexibility to respond to changes in demand over time.

The interviews with the packers revealed a trend of increasing coordination with foreign and domestic supermarket chains which distribute produce to the end consumer. Keeping pesticide residue to a minimum requires close monitoring during the production process. Carrefour, the world's second largest hypermarket/supermarket chain, buys from Sanfeng (one of the interviewed apple packers) and inspects the apples using its own quality verification system. Quality control focuses on soil, irrigation water, and the use of pesticides and chemical fertilizers. Sanfeng grows apples on its own farm as well as purchasing apples from third-party farmers. To ensure that the apples meet Carrefour's standards and avoid the costly rejection of the product at the point of delivery, Sanfeng closely monitors apple production, sending technicians directly to the farms to manage the farmers' use of pesticide and requiring that only the pesticides it supplies be used. In contrast, the company cannot verify the quality or trace the origin of apples purchased on the spot market, so these are sold in local wholesale markets where quality requirements are lower.

Another apple packer, Fufazhongji, one of the largest fruit exporters, sells to supermarkets such as the national chains Wal-mart, Hualian, and Yohan in Shanghai, and a fruit store chain in Singapore. To meet the quality and safety standards required by these supermarket clients, the firm tests the soil in the apple orchards to determine how much fertilizer is needed. The contract farmers are monitored by the firm to ensure that the apples meet the quality and the safety standards required by the supermarkets.

One of the green onion packers, Dangfanghong, has implemented a tracing system in collaboration with a Japanese import firm. This Japanese vegetable import firm supplies vegetables to Jusco, a supermarket chain found widely across Japan. The import firm assigns technicians from Japan to Dangfanghong in order to provide instructions in implementing the tracing technology. The tracing record identifies the farmer who produced each batch of green onions, as well as the types of pesticides used and the date of application. This enables supermarkets to trace any problems back to the grower.

The two green onion packers export over 90% of their output, while the apple packers both export and sell to domestic supermarkets. The green onion packers provide seed to all their contract growers in order to ensure an export-quality product. Most contract farmers receive pesticides on credit from the packers. By providing approved pesticides and sometimes offering spraying services, the companies reduce the risk of that the product will exceed maximum pesticide residue levels, a key motive for contracting production. One apple packer allows contract farmers to use only the pesticide designated by the firm to minimize residues.[5] Fertilizer is less commonly provided to contract growers.

The packers also provide technical assistance to their contract farmers. This assistance tends to focus on the correct use of inputs and the management practices needed to meet the quality and food safety standards of supermarkets and importers.

One firm offers a guaranteed price before planting, while the other three offer the market price plus a premium. The use of formula pricing reduces the risk of "side-selling" by farmers.

How do packers select contract growers? The packer first selects locations based on soil and water quality, proximity to the firm, road conditions, and the varieties grown.[6] Soil quality is one of the most important criteria as some agricultural land has been heavily contaminated with heavy metal or chlorine.[7] Once the packer identifies potential locations, it selects villages whose leaders are willing to cooperate. The village leader typically plays a key role in organizing the distribution of inputs and the collection of the harvest. Then, the packer asks the village head to identify farmers that meet certain conditions in terms of farm size, proximity, and contiguity which will facilitate quality control. All four firms have minimum

farm size requirements, but the minimum is quite small: 2 or 3 mu (0.13 or 0.20 ha).

The results of the farmer survey confirm the important role played by the village leader. When asked how they first got involved in contract production, about 70% of contract farmers reported being approached by local official (namely the village leader), 22% were approached directly by the packer, and 6% approached the packer to ask about contracting.

When farmers were asked for the main reason for contracting production, the most common responses were the stable or guaranteed fixed price (53%) and the high price (24%). Less common responses were access to information on improving quality (10%) and better access to inputs such as imported seeds (3%).

(b) *Comparison of contract and non-contract growers*

The sample of 162 farmers consists of 85 apple farmers and 77 green onion farmers. Of the total, 98 were contract farmers and 64 were not contract farmers, although 7 of the latter

Table 2. *Characteristics of contract and independent apple growers Source: IFPRI-CAAS Agricultural Marketing Survey, 2005.*

Variable	Independent farmers	Contract farmers	All farmers	*t* Test of difference	
				t-Stat.	Prob. > |*t*|
Household size (persons)	3.48	3.49	3.48	−0.05	0.96
Age of head (years)	45.0	44.6	44.8	0.19	0.85
Education of head (years)	8.26	8.49	8.38	−0.44	0.66
Education of spouse (years)	7.57	6.88	7.22	1.08	0.28
Household members between 15 and 65 (persons)	2.71	2.72	2.72	−0.03	0.97
Household members over 65 (persons)	0.21	0.09	0.15	1.25	0.22
Number of hh members away (more than 1 month)	0.45	0.44	0.45	0.07	0.95
Own a vehicle (%)	0.81	0.67	0.74	1.42	0.16
Area of house (m^2)	82.4	78.0	80.2	0.52	0.60
Value of house (Yuan)	16,000	24,163	20,129	−2.15	0.03**
Agriculture					
Land cultivated (ha)[a]	0.86	0.67	0.76	1.79	0.08*
Land irrigated (ha)	0.82	0.64	0.73	1.68	0.097*
Land rented (ha)	0.28	0.23	0.25	0.63	0.53
Value of agricultural assets (Yuan)[b]	1,579	4,044	2,826	−3.72	0.00***
Family labor, total farming (person days)	338	325	331	0.32	0.75
Hired labor, total farming (person days)	28.8	33.0	31.0	−0.41	0.68
Share of largest plot area (%)	48.1	55.9	52.1	−1.49	0.14
Share of non-farm income per hh income (%)	0.08	0.05	0.06	1.05	0.30
Distance to village head's land (m)	1,014	153	578	15.08	0.00***
Apple production					
Price of apple (Yuan/kg)	3.10	3.51	3.31	−0.72	0.47
Gross Margin of apple (Yuan/kg)	1.77	2.60	2.19	−1.45	0.15
Yield (kg/ha)	37,533	47,966	42,749	−3.58	0.001***
Apple planted area (ha)	0.35	0.27	0.31	1.50	0.14
Family labor for apple (days)	280	242	261	1.05	0.30
Family labor per land unit for apple (days/ha)	863	945	904	−1.27	0.21
Hired labor for apple (days)	23.4	26.8	25.1	−0.50	0.62
Total input cost for apple (Yuan)	7,265	6,314	6,784	0.91	0.37
Input cost for apple per kg (Yuan/kg)	1.21	0.80	1.00	1.13	0.26
Family labor productivity (Yuan/day)[c]	64.2	86.6	75.6	−2.28	0.02**
Land productivity of apple (Yuan/ha)	51,088	73,832	62,460	−3.84	0.0002***
Maximum years of apple tree owned (years)	15.3	19.4	17.4	−3.89	0.0002***
Years of tree owned before contracting (years)	15.3	17.4	16.4	−1.89	0.06*
Years of growing apple (years)	12.1	11.4	11.8	0.99	0.33
Income					
Total net household income (yuan)	21,366	26,558	23,993	−1.42	0.16
Net household income *per capita* (yuan)	5,907	7,557	6,742	−2.01	0.05**
Net crop income (yuan)	19,330	22,307	20,836	−0.92	0.36
Non-farm income (yuan)	1,551	1,305	1,427	0.39	0.69
Net income from apple (yuan)	17,361	20,119	18,756	−0.92	0.36
Income from livestock (yuan)	485	2,946	1,730	−1.51	0.14
Number of observations	42	43	85		

Note: The exchange rate was USD 1 = 8.2 yuan at the time of the survey (IMF, 2006).

[a] Cultivated area is calculated as the sum of areas cultivated in summer and winter seasons.

[b] Agricultural assets include water pump, irrigation and harvesting equipment, building, tractor, trailer, *etc*. The values of assets are based on the purchase prices depreciated to the current values using straight-line depreciation.

[c] Family labor productivity is the gross margin for apple production divided by the total family labor days devoted to apple production.

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

group had previously grown under contract with the surveyed firms. [8]

The characteristics of contract and independent apples growers are shown in Table 2. The average household has 3.5 members, the average age of the heads of household is 45 years, and the average amount of schooling of the heads of households was 8 years. The farms in both groups are quite small, with less than one hectare of cultivated land. About half of their cultivated land is dedicated to apple production. None of these variables differs between contract and non-contract growers at the 5% level of statistical significance.

There are some differences between contract and non-contract apple growers that are significant at the 5% level: contract growers have more agricultural assets, their trees are older, and they live closer to the village leader than independent growers. More importantly, contract growers have 28% higher yields, 35% higher family labor productivity, and 28% higher *per capita* income compared to independent apple growers, all of which are statistically significant differences.

Table 3 shows the characteristics of contract and non-contract green onion growers. Green onion growers appear to be fairly similar to apple growers in many respects: they have

Table 3. *Characteristics of contract and independent green onion growers Source: IFPRI-CAAS Agricultural Marketing Survey, 2005.*

Variable	Independent farmers	Contract farmers	All farmers	t test of difference	
				t-statistic	Prob.>|t|
Household size (persons)	3.86	3.82	3.83	0.19	0.85
Age of head (years)	44.73	44.84	44.81	−0.04	0.96
Education of head (years)	8.00	7.60	7.71	0.60	0.55
Education of spouse (years)	6.81	6.17	6.35	0.77	0.44
Household members between 15 and 65 (persons)	2.68	3.13	3.00	−1.62	0.11
Household members over 65 (persons)	0.36	0.13	0.19	1.96	0.05*
Household members away more than 1 month (%)	0.36	0.44	0.42	−0.40	0.69
Vehicle owned	0.55	0.60	0.58	−0.43	0.67
Area of house (m^2)	62.05	73.60	70.30	−1.52	0.13
Value of house (yuan)	19,159	23,527	22,279	−0.88	0.38**
Agriculture activity					
Land cultivated (ha)[a]	0.32	0.46	0.42	−2.98	0.004***
Land irrigated (ha)	0.32	0.45	0.41	−2.75	0.01***
Land rented (ha)	0.03	0.03	0.03	−0.08	0.93
Value of agricultural assets (yuan)[b]	1,544	1,802	1,728	−0.44	0.66
Family labor, total farming (person days)	119	169	154	−2.44	0.02**
Hired labor, total farming (person days)	2.95	3.36	3.25	−0.28	0.78
Share of largest plot area (%)	40.35	40.16	40.22	0.05	0.96
Share of non-farm income per hh income (%)	0.22	0.24	0.24	−0.21	0.84
Distance to village head (m)	838	225	400	9.20	0.000***
Green onion production					
Price of green onion (Yuan/kg)	0.45	0.64	0.59	−3.60	0.001***
Gross margin of green onion (yuan/kg)	0.24	0.39	0.35	−3.18	0.002***
Yield (kg/ha)	56,951	56,124	56,360	0.27	0.79
Green onion planted area (ha)	0.09	0.15	0.14	−2.68	0.01***
Family labor for green onion (days)	50.0	69.7	64.1	−1.87	0.07*
Family labor per 1 ha of land (days/ha)	537	477	494	1.23	0.22
Hired labor for green onion (days)	3.0	3.1	3.0	−0.08	0.93
Total input cost for green onion (yuan)	827	1,331	1,187	−2.98	0.00***
Input cost for green onion per kg (yuan/kg)	0.17	0.22	0.20	−1.86	0.07*
Family labor productivity (yuan/day)[c]	36	50	46	−1.29	0.20
Land productivity (yuan/ha)	14,263	18,242	17,105	−1.71	0.09*
Years of growing green onion (years)	3.82	3.76	3.78	0.15	0.88
Income					
Total net household income (yuan)	9,795	13,644	12,544	−1.40	0.17
Net household income *per capita* (yuan)	2,662	3,526	3,279	−1.20	0.23
Net crop income (yuan)	6,582	9,344	8,555	−1.26	0.21
Non-farm income (yuan)	2,982	3,318	3,222	−0.24	0.81
Net income from green onion (yuan)	1,119	2,751	2,284	−3.23	0.00***
Net income from livestock (yuan)	231	982	767	−1.44	0.15
Number of observations	22	55	77		

Note: Exchange rate was USD 1 = 8.2 yuan at time of the survey (IMF, 2006).

[a] Cultivated area is calculated as the sum of areas cultivated in summer and winter seasons.

[b] Agricultural assets include water pump, irrigation and harvesting equipment, building, tractor, trailer, *etc*. The values of the assets are based on the purchase prices depreciated to current value using straight-line depreciation.

[c] Family labor productivity is the gross margin for green onion production divided by the total family labor days devoted to green onion production.

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

similar household sizes, the age and education of the head of household are comparable, and both are quite specialized in crop production, which represents at least two-thirds of total income in both cases. However, green onion growers have even smaller farms than apple growers (0.42 ha compared to 0.76 ha), and they have substantially lower *per capita* incomes (3,279 yuan or US$ 400 compared to 6,742 yuan or US$ 828 [9]).

Contract green onion growers differ from independent green onion growers in several respects. Contract green onion growers are somewhat larger farms and more irrigated land (both differences are small but statistically significant at the 5% level). Unlike the case of apple growers, there is no statistically significant difference in yields between contract and independent growers. However, contract green onion growers have larger green onion plots and they receive higher prices for their green onions. The combined effect of larger plots and higher prices is that contract farmers earn more than 2.4 times as much from green onion production compared to independent growers. The total and *per capita* household income of contract green onion growers is 32% greater than that of independent green onion growers, but the difference is not statistically significant.

(c) *Econometric analysis of participation and its effect on income*

The econometric analysis that we carry out uses the pooled sample of apple and green onion growers. This was necessary because of the relatively small sample for each commodity. The implicit assumption is that the effect of each explanatory variable is the same for apple growers as it is for green onion growers.

The first part of the econometric analysis examines differences in the characteristics of contract and independent growers. We use a probit model to estimate participation in a contract farming scheme. The results, shown in Table 4, indicate that the model is able to correctly "predict" which farms will have contracts in 93% of the cases in the sample. Contract growers have a somewhat smaller proportion of older household members, probably reflecting the labor intensity required for contract production. [10] The education of the head of household is weakly related to contract participation, but the relationship is U-shaped so there is no evidence of bias against less educated farmers. [11] The distance to the house of the village head is a strong predictor of participation in the contract farming scheme: farmers living near the village head are significantly more likely to participate. This probably reflects a smaller "social distance" between the farmer and the village leader, as well as the interest of the packer in concentrating production in a small area. Overall, these results suggest that there is some selection (or self-selection) in becoming a contract farmer, but it is in terms of labor availability and location, rather than farm size.

The second part of our econometric analysis is an ordinary least squares (OLS) regression of *per capita* income as a function of various household characteristics and a dummy variable representing contract growers. Table 5 presents the results of the model, which "explains" about 40% of the variance in *per capita* income across the sample. *Per capita* income is positively affected by the share of working-age family members, farm size, being an apple grower, and being a contract farmer. The coefficient on the contract variable implies that contracting raises *per capita* income by 1,476 yuan, equivalent to 22% of the average income of apple growers and 45% of the average income of green onion growers.

The third part of our econometric analysis repeats the estimation of *per capita* income, but, instead of OLS, it uses the treatment effects model, also called the Heckman selection-correction model. As described above, this model involves two equations: the selection equation estimates the probability of participating in contract production and the outcome equation estimates *per capita* income as a function of various household characteristics, the contract dummy variable, and the inverse Mills ratio (IMR). The IMR, calculated from the selection equation, adjusts the outcome equation for selection

Table 4. *Probit model of participation in contract production Source: Analysis of the IFPRI-CAAS Agricultural Marketing Survey, 2005.*

Variable	Coefficient	SE	$P[\|Z\| > z]$
Dependent variable: contract participation dummy			
Household size (persons)	−0.09	0.23	0.70
Age of head (years)	−0.19	0.20	0.35
Age of head squared	0.00	0.00	0.42
Education of head (years)	−0.80	0.41	0.05*
Education of head squared	0.05	0.02	0.07*
Proportion of adult between 15 and 65 (%)	0.58	1.29	0.65
Proportion of adult over 65 (%)	−4.23	1.95	0.03**
Farm size (ha)	1.05	0.75	0.16
Proportion of irrigated land (%)	−1.55	2.02	0.44
Apple dummy	−0.67	0.47	0.15
Distance to village head's land (m)	−0.01	0.00	0.00***
Constant	12.05	4.94	0.02**
Probability value > F	0.0000		
% correct predictions	93%		

		Predicted 0	Predicted 1	Total
Actual	0	57	7	64
	1	5	93	98
Number of observations	Total	62	100	162

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

Table 5. *Regression analysis (OLS) of per capita expenditure Source: Analysis of the IFPRI-CAAS Agricultural Marketing Survey, 2005.*

Variable	Coef.	SE	$P[\|Z\| > \|z\|]$
Dependent variable: household income *per capita*	−136	301	0.65
Household size (persons)	−439	315	0.17
Age of head (years)	5	3	0.17
Age of head squared Education of head (years)	−80	378	0.83
Education of head squared	36	24	0.13
Proportion of adult between 15 & 65 (%)	3,111	1,542	0.05**
Proportion of adult over 65 (%)	3,325	2,662	0.21
Farm size (ha)	2,486	721	0.00***
Proportion of irrigated land (%)	1,423	1,798	0.43
Apple dummy	2,755	582	0.00***
Contract	1,476	520	0.01***
Constant	5,852	6,860	0.40
Adjusted R^2		0.357	
Probability value > F		0.0000	
Number of observations		162	

** Significant at the 5% level; *** Significant at the 1% level.

Table 6. *Treatment effect model of per capita income Source: Analysis of the IFPRI-CAAS Agricultural Marketing Survey, 2005.*

Variable	Coef.	SE	$P[\|Z\| > z]$
Selection equation			
Dependent variable: contract participation dummy			
Household size (persons)	−0.08	0.23	0.74
Age of head (years)	−0.23	0.21	0.28
Age of head squared	0.00	0.00	0.33
Education of head (years)	−0.83	0.41	0.05**
Education of head squared	0.05	0.03	0.07*
Proportion of adult between 15 and 65 (%)	0.66	1.29	0.61
Proportion of adult over 65 (%)	−4.54	2.08	0.03**
Farm size (ha)	1.18	0.78	0.13
Proportion of irrigated land (%)	−1.72	2.02	0.39
Apple dummy	−0.73	0.47	0.12
Distance to village head's farm land (m)	−0.01	0.00	0.00***
Constant	13.20	5.27	0.01**
Outcome equation			
Dependent variable: *per capita* income			
Household size (persons)	−125	291	0.67
Age of head (years)	−454	304	0.14
Age of head squared	5	3	0.14
Education of head (years)	−73	364	0.84
Education of head squared	35	23	0.12
Proportion of adult between 15 and 65 (%)	3,170	1,488	0.03**
Proportion of adult over 65 (%)	3,197	2,571	0.21
Farm size (ha)	2,467	695	0.00***
Proportion of irrigated land (%)	1,368	1,734	0.43
Apple dummy	2,722	563	0.00***
Contract	1,276	593	0.03**
Constant	6,268	6,638	0.35
ath(ρ)	0.15	0.25	0.53
LR test of independent equations			
Chi-squared (1)		0.40	
Probability > chi-square		0.52	
Number of observations		162	

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.

bias associated with the fact that contract farmers and independent farmers may differ in unobservable characteristics (such as industriousness, skills, or intelligence). We implement this analysis with maximum likelihood estimation in which all parameters are estimated simultaneously rather than in a two-step process.

The results of the treatment effects regression are presented in Table 6. The selection equation, which predicts participation in a contract farming scheme, gives results quite similar to those of the probit model presented in Table 4.[12] Likewise, the results of the outcome equation, which predicts *per capita* income, are very similar to those of the OLS model in Table 5. The coefficient on the contract variable in this model (1276) is somewhat smaller than the contract coefficient in the OLS model (1476). At the bottom of Table 6, the parameter "ath (ρ)" is related to ρ, the correlation between the error terms in the selection equation and the outcome equation.[13] The fact that this parameter is not statistically significant implies that there is no selection bias, so it is not necessary to estimate *per capita* income using the treatment effect regression model. Nevertheless, it is reassuring to know that both versions of the model yield similar results: that the effect of contracting on *per capita* income is positive and statistically significant.

It should be noted that in some alternative specifications of the model, the contract variable was not statistically significant, particularly in models with a larger number of independent variables. This is partly attributable to the relatively small sample. However, the results of qualitative questions in the farmer survey provide some confirmation that the effect of contracting on income is positive. When the farmers in our sample were asked how their income had changed since they began contract farming, a majority reported that their income has increased: 51% of contract farmers reported a small increase and 25% perceived a large increase, while 21% said there was no change and 3% reported a small decrease. The survey also asked about how these changes in income were reflected in spending patterns. Of the farmers who felt their income had increased, the most common response was that they were able to spend more on schooling and keep their children in school longer (38%). Other reported effects were being able to improve their house (28%), spend more on health care (13%), eat better (10%), rent more land, and reduce debt.

5. CONCLUSIONS

In summarizing the results of this study, we return to the three questions posed in the introduction. First, to what degree are small-scale and less educated farmers able to participate in contract farming? The probit analysis of our farm survey of apple and green onion growers in Shandong Province, China, suggest that there is some selection (or self-selection) of contract farmers but it is by location (proximity to the village head) and by labor availability rather than by farm size or level of education. Thus, there does not seem to be a bias toward larger farmers in these contract farming schemes. However, it should be noted that even "large" farms in the sample are relatively small. Furthermore, the results suggest that contract farmers tend to have more agricultural assets than non-contract farmers, but our analysis does not allow us to determine whether this is a cause or an effect of contract farming.

Second, does contract farming raise the incomes of farmers? Our results suggest that contract farmers earn more than their neighbors growing the same crops even after controlling for household labor availability, education, farm size, share of land irrigated, and proximity to the village leader. Furthermore, the treatment effect regression model suggests that there is no selection bias caused by unobserved differences between contract and non-contract farmers such as industriousness or intelligence. Finally, direct questions to contract farmers revealed that three-quarters of them perceived an increase in income since they began contracting.

Third, what explains the income differences between contract and non-contract farmers? In the case of apple growers, contract farmers benefit from higher yields, presumably due to the technical assistance and specialized inputs provided by the packers. In contrast, the yields of contract green onion growers are no larger than those of independent green onion growers, but the prices contract farmers receive from the packers are higher. Although their per-unit input costs are also higher, the higher price more than compensates for this, resulting in higher gross margins. It is likely that these higher prices received by contract growers reflect the higher quality made possible by the contract relationship.

On the other hand, it is important to recognize that Shandong Province enjoys good soils and adequate rainfall, as well

a major port and proximity to the Japanese and South Korean markets. As a result, Shandong is one of the more prosperous provinces in China with an advanced, commercially-oriented agricultural sector. The two crops considered in this study, apples and green onions, are perishable, high-value commodities, and thus more likely to require the vertical coordination that contract farming provides. Furthermore, only some of the apple and green onion production is contracted, specifically the portion to be supplied to upscale domestic markets (e.g., supermarket chains) and export markets. International experience suggests that contract farming much less likely to be viable for farmers growing staple foods or horticultural crops for local consumption. By extension, contract farming is likely to have more limited application in western China, which is poorer, drier, and more distant from potential markets.

One implication of these results is that public policy should support the establishment and maintenance of contract farming, particularly where it involves small-scale farmers. This support could take the form of establishing a clear legal framework for contracts between farmers and agribusiness firms, helping firms identify potential contract farmers, allowing extension agents to provide technical assistance under the guidance of the firm, and mediating conflicts between farmers and buyers. Chinese agricultural policy already provides some incentives for contract production, establishing conditions under which contracting firms can be certified as "Dragon head" companies to benefit from tax concessions or access to preferential loans (Gale & Collender, 2006). All four of the packers interviewed for this study have been designated "Dragon head" companies.

However, it is important for policymakers to be realistic about the potential scope of contract farming. Because of the costs associated with contracting, it tends to be limited to high-value commodities (including meat, milk, fish, fruits, vegetables, and cash crops) being grown for processors and exporters who sell into a quality-sensitive market. Thus, policymakers should not think of contract farming as a solution to the problems of credit, information, and market access for all small farmers in developing countries. Contract farming can be very effective in raising small-farm income, but it is only applicable in certain circumstances.

NOTES

1. Packers and other agro-industrial firms cannot own farm land, but they can lease it from groups of farmers with contiguous parcels. This requires considerable negotiation with village leaders and involves long-term leases.

2. Green onions (*Allium fistulosum*) are known by a wide variety of names, including bunching onions, spring onions, salad onions, scallions, Japanese/Chinese scallions, Japanese leek, *negi* in Japanese, and *da cong* or *tsung* in Chinese.

3. There is a discrepancy between Chinese statistics and FAO statistics. According to the NBS, Chinese production of green onions was 17 million tons in 2003 rather than 19 million tons. The difference may come from different definitions used for onion group category.

4. In our analysis, net income is calculated as the value of crop production (including home production) minus the cost of purchased inputs, income from animal product sales and net animal sales minus the cost of purchased inputs, net income from non-farm businesses, wages, and transfers.

5. The level of pesticide residue is partly affected by the type of pesticide used. Some less expensive domestic pesticides leave more residues, making it difficult for the product to meet pesticide residue requirements set by the contracting firms in response to the demands of supermarkets and export markets.

6. The apple varieties grown include Red Star, Golden Delicious, and Red Fuji (a Japanese variety for Japanese market). The apple varieties grown in Shandong province have shifted in response to export demand. Shandong province plans to increase Red General, Gala and other mid-maturity and mid-and-early maturity apple varieties, as well as apple variety mainly for processing. The companies require all farmers to grow same variety, but non-contract farmers also grow these varieties so variety does not seem to be the main factor distinguishing contract and non-contract growers.

7. The Ministry of Land and Resources estimates that about 12.3 million hectares, more than 10% of arable land in China, has been contaminated by pollution (China Daily News, 2007, April 23). Heavy metal contamination also comes from heavy use of pesticides.

8. The six farmers who used to contract are green onion growers. They withdrew from contracting after finding that their income declined or in order to reduce their workload.

9. In July 2005, the exchange rate was 8.2 yuan/US$ (IMF, 2006).

10. We would expect contract production to be somewhat more labor intensive, given the higher quality and food safety standards that they are expected to meet, compared to independent growers. For example, contract apple growers may be asked to prune more frequently to produce fewer high-quality apples rather than a large volume of lower-quality apples. However, the results of our survey do not show any statistically significant differences in the amount of family labor devoted to the crop on a per farm or per hectare basis.

11. The education coefficients imply a U-shaped relationship with the lowest probability of participation at about 8 years of education. Even if we accept the weak statistical significance of these coefficients, it implies a bias against farmers with average education, not a bias against those with less education.

12. The slight differences are related to the fact that, in the treatment effects model, the selection model parameters are estimated simultaneously with the income model parameters, while in the original probit model there is no interaction with the income model.

13. Treatment effect regression model does not estimate ρ directly, but rather the hyperbolic arctangent of ρ ("ath (ρ)"). However, the test of the hypothesis that ath (ρ) = 0 is equivalent to the test that $\rho = 0$, which tests the presence of correlation of the error terms and thus selection bias.

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