Economic impact of farmers-driven vertical integration: the case of safe vegetable chains in Northern Vietnam

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Summary

The paper investigates the respective profitability of contractual arrangements, direct sales and spot marketing for "safe vegetable" farmers in Northern Vietnam. This is based on a survey of 137 peri-urban vegetable farmers, with a minimum of 30 farmers in each category. Selection biases are corrected using propensity score matching methods. The results show that direct sales have a positive significant impact on income relative to contractual arrangements and spot marketing when selection biases are corrected. Contractual arrangements have no significant impact on income compared with the other two categories after correction of selection bias. This may be due to the involvement of purchasers in the production process being still limited. The paper illustrates that direct relations between farmers and consumers, often described in the literature as efficient in the development of consumer confidence as regards quality, can indeed translate into higher incomes than anonymous exchange, or than contractual arrangements with retailing companies. Some limitations of the research and policy recommendations are given in the conclusion.

Key words

Contracts, direct sales, vegetables, Vietnam.

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Introduction

It is more and more widely acknowledged that access to high value chains have a positive impact on farmers' incomes and poverty alleviation (World Bank, 2008). Rising incomes and fast urbanization increases the demand for high value products, including fruits, vegetables and meat. They are also increasing consumer attention to food safety. This context, combined with the liberalization of foreign direct investment, favored the development of supermarkets in developing countries, starting in the mid-1980s in Latin America and then rapidly spreading to Asia and Africa in the 1990s (Reardon et al., 2003).

Like many countries of South-East Asia, Vietnam is characterized by a fast economic development and urban growth. The GDP growth rate was 8.5 per cent in 2007 (7.5 for Laos and 4.8 for Thailand). In 2005, the urbanisation rate was 26.4 per cent and the urban growth rate stood at 3.13 per cent (Wup, 2009). Food safety has become of primary importance for urban consumers, especially for vegetables, fruit and meat, together with the freshness of these products (Figuie et al., 2004). The growth rate of the value of the retail trade in USD is estimated at 10% per year for the period from 2001 to 2006, and of modern trade by 20% per year in the same period. The share of supermarkets in retail market is nevertheless still limited (around 14 percent) (Usda, 2009). Most of the food is still provided by retail wet markets, planned as well as spontaneous.

On the supply side, Vietnam is characterized by a dynamic agricultural sector which still faces structural constraints. Most vegetables available in Hanoi are produced in peri-urban zones where the limited size of land, generally smaller than 500 m², and the context of property speculation, result in farmers using increasing quantities of fertiliser and pesticides to maximise productivity per hectare. In 1995, public interest in the safety of vegetable products led the Vietnamese Ministry of Agriculture to implement an ambitious programme called "safe vegetables". The programme educated farmers in the reasonable use of fertiliser and pesticides, based on IPM principles as well as the use of water from wells and non-polluted rivers. Similar programmes were organized by NGOs. Some dynamic farmers established groups of neighboring farmers which benefited from the training, and engaged in various marketing strategies to promote their quality efforts. These include selling vegetables to canteens, shops or specific market stalls (with indication of vegetables being "safe"), and also to supermarkets. All these outlets offer premium prices to "safe vegetables", although these are highly variable. Shops and market stalls may be run by intermediate traders, or by farmer groups themselves. Supermarkets commonly sign contracts with safe vegetable groups, or buy from distribution companies which

contract their supply to farmer groups. These contracts specify the frequency of delivery, quality requirements (including visual criteria and the provision of certificate) and terms of payment (cash, 15 to 30 days after delivery). Certificates of production of safe vegetables are awarded by the Plant Protection Department of Hanoi municipality. In 2008, in Hanoi there were twenty-seven cooperatives holding a certificate of safe vegetable production, representing around 2 per cent of Hanoi vegetable area (while the safe vegetable program approximately covers 20 per cent of area).

Despite the growing demand for food safety, farmers frequently complain about the low profitability of vegetable production, and the strong variability of their incomes. Not all farmers are successful in finding traders providing premium prices to their vegetables. "Safe" vegetables can actually be sold through a variety of channels, in addition to the traditional chain of collectors, wholesalers and retailers. In some locations of peri-urban Hanoi, farmers have benefited from support by public programmes to get access to retailing points, or to contracts with distribution companies. In this paper, we address the following issue: what kind of vertical coordination is the most beneficial for farmers involved in quality efforts?

Changes in consumer demand and in the retailing sector provide market opportunities, but also new challenges for small-scale farmers, as the new markets have special requests in terms of quality and timely deliveries. Contractual arrangements between farmers or farmer groups and buyers, and more generally vertical integration in the chain, have been documented as efficient ways to overcome these challenges and bring additional incomes to farmers. Vertical integration involves participation of one firm in two adjacent stages in the vertical marketing channel from producers to consumers, in terms of decisions and/or ownership (Carlton et Perloff, 1994). The role of vertical integration in reducing transaction costs has been brought to the fore by Williamson (1987). Transaction costs are all the indirect costs occurred in the setting, the conduct and the monitoring of the transaction, i.e., the information costs of searching, screening, agreeing, implementing and enforcing contracts (North, 1990). Measurement costs of quality characteristics are specific types of transaction costs. The safety of food products is a quality attribute which is especially difficult to observe and measure. The consequences of quality measurement constraints on the supply of low-quality products (as good quality products do not get quality premium) and even disappearance of market transactions have been demonstrated by Akerlov (1970). Increased vertical integration is a response to increasing quality measurement errors (Barzel, 1982).

A typology of forms of coordination according to the degree of vertical integration can be found in various contributions of transaction costs economics including Williamson (1987) and Jaffee (1993). At two extremes lie market coordination and hierarchy (or firm). Market coordination generally refers to the coordination of operations of selling and purchase by the establishment and publicizing of prices, i.e. price incentives. The firm is a typical centralized, hierarchical organization, which

stands in contrast to classical market contracting. Hierarchy refers to the centralization of decisions, command-and-control approaches with coercive power translated into regulations. Hybrid forms are intermediary forms between markets and hierarchies, with some sharing of decisions between the two partners in the transaction. These include different forms of contracts. A contract can be defined as a set of commitments on the conditions of transactions, e.g., prices, volumes, quantities, input provision. Vertical integration increases from spot markets, market reciprocity, to contracts and hierarchy. Vertical integration reduces transaction costs, but on the other hand it increases governance costs, that is, costs of ensuring that the arrangements are enforced.

Empirical tests relating contractual arrangements to the reduction of transaction costs are numerous (see in particular Shelanski and Klein, 1995 for a review). Besides, in the last ten years, studies measuring the benefits for farmers of contractual arrangements have developed. A review of existing studies has been recently done by Miyata and al. (2009) showing the positive impact of contracts on farmers' incomes. Yet, most existing studies compare incomes of farmers with and without contracts, and do not provide for selection biases related to differences in characteristics (observable and non observable) between farmers participating and not participating in contracts. These selection biases can be reduced by various econometric methods, including propensity score matching (PSM) (Rosenbaum et Rubin, 1983). This technique was used by Miyata and al (2009) in their study of contracts for marketing apples and green onions in Shandong Province in China. Their conclusion is that contract farmers earn more than their neighbors growing the same crops even after controlling for observable and non observable characteristics. Another rigorous evaluation (based on PSM techniques) of the economic impact of different modes of coordination in food chains was conducted by Maertens and Swinnen (2009) in the case of vegetable exports in Senegal. A comparison of incomes was conducted between farmers contracted with export companies, farmers employed by exporters' estate farms and independent farmers. The study shows that contracted farmers earn more than vertically integrated farmers who themselves earn more than farmers outside export schemes (nor contracted nor vertically integrated).

Yet it is difficult to conclude from this study that contractual arrangements bring additional incomes relative to spot marketing. What are compared are incomes from green beans exported (through contracts) with incomes of farmers not involved in contracts, so it is the introduction of a new crop rather than the form of coordination which generates additional incomes. Besides, even when the same crops are considered, as is the case in the study by Miyata and al. (2009), the quality characteristics are different between the farmers selling through contracts and the ones without contracts, so that it is difficult to conclude about the impact of the contract versus the impact of quality upgrading. Finally, what would be interesting to compare is the effect of contractual arrangements versus other ways to coordinate transactions in a chain where specific quality attributes are involved, generating high

transaction costs. Existing studies mostly focus on vertical integration driven by the buyer, who provides inputs in exchange for the product purchase. Another possible situation of vertical integration is when farmers engage in retailing, which can be termed as farmers' driven vertical integration. The case of safe vegetables in Vietnam provides a good ground for evaluating the impact of different types of vertical coordination.

In the paper we will evaluate the impact on incomes of three different types of intra-chain coordination observed to market "safe" vegetables (defined as vegetables produced alongside IPM methods, be they certified or not): spot marketing, corresponding to marketing to collectors without commitments in terms of inputs or outputs; contractual arrangements with supermarkets; direct sales to consumers. Next section details the methodology used.

Method

Data collection

We conducted a survey from August to December 2008 of 137 peri-urban vegetable farmers, situated in safe vegetable production areas. They market their vegetables through three ways: (1) selling to collectors in spot markets (66 farmers); (2) selling directly to consumers in rented shops or market stalls (30 farmers); (3) selling to supermarkets or to companies through contracts (41 farmers). Besides we conducted interviews with the leaders of the nine farmer cooperatives where the farmers contracted or selling directly belong to better understand the specifications of the contracts and the strategies of the group as regards marketing.

It should be noted that farmers frequently combine different marketing strategies. We selected farmers selling more than one half of their vegetables through one channel to define them as belonging to the three respective groups of market coordination (spot marketing, direct sales, contracts). This condition explains the small size of sample for situations (2) and (3).

Besides, supermarkets and companies contract with farmer organizations rather than with individual farmers. But the interviews with the cooperative leaders show that the contracts are fulfilled by a small number of farmers in the group (two to five) who sell their own products plus the products of some neighboring farmers. Likewise, the shops of the farmer cooperatives are run by a small group of farmers who sell their vegetables and act as collectors for the rest of the group. Hence the strategies of marketing are individual rather than collective. The collective pattern of the farmer organizations mostly relate to quality development and labeling (Moustier et al., 2010).

The questionnaire provides details on household demographic characteristics, landholdings, planting pattern, inclusion in a group, vegetable production, household income, agricultural income from vegetable and non-vegetable production. As stated by Miyata and al. (2009), the

household income is a better indicator than vegetable income of the effect of the contract on the well-being because the contract may draw labour or land away from other activities.

Data analysis

Descriptive analysis was used to show and compare the basic household characteristics. To estimate the impact of different forms of coordination in vegetable chains, regression and matching techniques from the average treatment effects literature were applied to correct the selection bias resulted from stakeholders decision and output (Jalan and Ravallion, 2003; Maertens and Swinnen, 2009). Taking farmers with contract or selling directly to consumers as treatment group and farmers selling in spot market as control group in the study, the value of average treatment effects (ATE) is defined as the average difference between household income with and without treatment for those who actually participated in treatment. Two treatments are considered: contracts with companies, and direct sales. These treatments are applied to farmers independently from their characteristics, as they mostly depend on the location of farmers, and on the fact that they were the first selected ones from what can be approximated to a "queuing list", as market stalls and shops are in a limited supply. Y_1 and Y_2 represent the income with treatments and Y_0 the income without treatment.

$$ATE_1 = E(Y_1 - Y_0) \quad \text{for} \quad T_1 = 1\text{: with contract}$$

$$ATE_2 = E(Y_2 - Y_0) \quad \text{for} \quad T_2 = 1\text{: selling directly}$$

The hypothesis is with that vertical coordination whether in the form of contracts or direct sales treatment coordination have positive impact on household income and therefore both ATEs are positive significantly. Observable covariates related to participation and family income as output were selected from the survey for the selection bias adjustment (Maertens and Swinnen, 2009; Caliendo and Kopeinig, 2008; Dehejia and Wahba, 1999; Heckman et al., 1997). The result is shown in Table 1. They are farmers' access to resources (including landholdings, labor and distance from nearest market), their skill and ability including age and education, and family preference identifying by family size. The number of motorbikes was not selected because of the potential endogenous problem although it is a typical variable in Vietnam to indicate their family assets. The number of motorbikes could be an endogenous variable related to income because it is difficult to identify whether farmers with higher income buy more motorbikes or more motorbikes help farmers increase the income by transportation and selling the products.

To compare the impact of different forms of coordination and identify the selection bias, there are three components in the econometric analysis. First, we use the covariate matching method to implement the regression on household income and the selection bias was controlled by including observable covariates. Farmers' participation is included as the covariates to estimate the average treatment effects. The ATEs can be estimated as the coefficients of covariates for treatment in the ordinary least squares (OLS) regression (Imbens, 2004; Wooldridge, 2002). The model I is specified as:

$$For(T_1 = 1): Y_i = \varphi + \alpha_1 T_1 + \beta X_i + \varepsilon_i$$

$$For(T_2 = 1): Y_i = \varphi + \alpha_2 T_2 + \beta X_i + \varepsilon_i$$

Secondly, a probit model is used to estimate the probability of a given household participating in the treatment and the estimated marginal probabilities are included as additional propensity score correction functions in the regression (Maertens and Swinnen, 2009). This is to control the participation bias correlated to unobservable characteristics. And the ATEs can be estimated using ordinary least squares (OLS) regression (Maertens and Swinnen, 2009; Imbens, 2004; Wooldridge, 2002).

The model II is specified as:

$$For(T_1 = 1): Y_i = \varphi + \alpha_1 T_1 + \theta P_1 + \beta X_i + \varepsilon_i$$

$$For(T_2 = 1): Y_i = \varphi + \alpha_2 T_2 + \theta P_2 + \beta X_i + \varepsilon_i$$

with $P_i = \hat{p}(T_i = 1 \mid X)$

The third econometric analysis is to estimate ATEs using the propensity score matching method because the counterfactuals are never directly observed. Non experimental studies differ from randomized experiments in that the probability of participating in coordination is not a fixed constant but influenced by unobserved and observed characteristics due to self-selection and selection made by related stakeholders (Aakvik, 2001). Selection bias due to correlation between observed variables and a households' participation is solved by either matching techniques or by including these covariates in regression analysis (Aakvik, 2001).

As regards the model to be used for the estimation, there is little advice on functional form and logit and probit models usually yield similar results for bivariate estimation (Caliendo and Kopeinig, 2008; Smith, 1997), probit model was used in the propensity score matching analysis. We use the single nearest neighbor algorithm with replacement to identify the best match for each treated farmer which is the most straightforward matching method and reduces bias (Caliendo and Kopeinig, 2008; Dehejia and Wahba, 2002). The propensity score matching method estimates ATEs is specified as Model III:

$$ATE_1 = \frac{1}{N_1} \sum (Y_{1i} - Y_j)$$

$$ATE_2 = \frac{1}{N_2} \sum (Y_{2i} - Y_j)$$

Results

Descriptive analysis

Farm characteristics

Characteristics of households selling directly to consumers and contracted by supermarkets or company are compared to those selling their vegetables in spot markets using T test (Table 2). The significant differences between the three groups relate to the following characteristics: the land area (largest for spot market, followed by contracts and direct sales); the distance from the nearest market (higher for direct sales than the other groups); the number of working persons (highest for spot market); the age (lower for contracted farmers than for the other groups); education level (highest for contracted farmers).

Incomes

The survey shows that the highest incomes are obtained for farmers selling directly to consumers, both as regards vegetable incomes and total household incomes. Second come incomes of contracted farmers, followed by farmers selling in spot markets (see Figure 1).

Vegetable production is an important income source for farmers, especially for the contract and direct sales groups farmers (more than half of the overall income), compared with less than one third of household income for those selling in spot markets.

The following section investigates whether the differences in incomes result from the resource or location characteristics of households or from their participation in contract and vertical integration after correcting selection bias.

Econometric analysis

In table 3 we show the result of model I, covariate matching method, by implementing OLS regression to estimate the ATEs. The estimate effect for direct sales is significantly positive at the 1% level. Household income could be raised by 32.5 million VND by selling directly to consumers which accounts for 51% of the total average household income and 56% of household income selling in spot markets. In contrast, the estimation indicates that there is no significant impact of contract on household income after controlling a set of observable covariates.

Taking the probability of a given household participate the treatment into account, Table 4 shows the results of model II. Similar with the results of model I, the estimate effect for direct sales is significantly at the 5% level and no significant impact for contracts. And the extent of income increasing is 32.37 million VND, 50% of the total average household income and 56% of household income selling in spot markets which is quite close to that of model I. This confirms the hypothesis that the vertical integration of selling directly to consumers can help raise small farm income. In contrast, the estimated effects for contract are not significantly positive in the regression.

The result of the bivariate probit in Table 5 shows that selling directly to consumers is biased toward household with bigger household size, less labor and less land and that with contract is biased toward those younger households and with less land. There is no significant effect of education on the probability of different forms of coordination. The result further indicates that households with less land are more likely to be involved in safe vegetable production through contract or direct sales.

After implementing the propensity score matching method to correct the bias, Table 6 shows the comparison of estimated treatment effect. Matching means the similar treatment and control units are paired in terms of their observable characteristics (Maertens and Swinnen, 2009; Abadie and Imbens, 2002; Dehejia and Wahba, 2002). The result of the estimated effect for direct sales is still significantly positive at the 1% level with the difference about 42 million VND which is higher than that of model I and II.

It is interesting that the estimate effect has significant impact for contracts which is different from that of model I and II. We present the result of comparison between and after match in Table 7, this indicates that there is possible selection bias before matching. And the null hypothesis that the previous matching techniques could avoid the selection bias is rejected. To make the results robust, we use "trimming" (Smith and Todd, 2005) to estimate the effect which impose the common support by dropping the treatment observations which has lowest propensity score density of the control observations. The results are the same. It confirms the hypothesis that contract farming can contribute to raising small farm income.

Robustness tests

The average treatment effect is only defined in the region of common support (Caliendo and Kopeinig, 2008). To estimate ATE requires sufficient overlap and region of common support between treatment and control group (Dehejia and Wahba, 2002; Imbens, 2004). ATE is difficult to be estimated by matching techniques if households with and without coordination differ substantially in observable characteristics (Maertens and Swinnen, 2009). There are two methods to check the overlap and common support. One is by comparing the minima and maxima of the propensity score and the other one is based on estimating the density distribution (Caliendo and Kopeinig, 2008). We use the first and Figure 1 shows the comparison. It indicates the sufficient overlap and common support where the propensity score of the treated group is not higher than the maximum propensity score of control group or less than that of the minimum one. Besides, the results of Table 8 show that there is a strong bias for most covariates. And the matching eliminates the bias so that there is a good balance of covariate distribution between treated and matched control units.

To test robustness and unmeasured bias, we also calculate Rosenbaum bounds for average treatment effects on the treated in the presence of unobserved heterogeneity (hidden bias) between treatment and control units and the results are shown in Table 9 and Table 10. The results suggest that the effects are still significant which corroborating the propensity score matching method.

Conclusion

The results show the profitability of farmers' direct sales relative to selling to collectors in spot markets, and even to contracts with supermarkets. Contracts with supermarkets actually show higher profitability than spot markets, but this does not appear significant after selection biases are corrected.

Direct sales provide economic benefits to farmers translated into higher income, because they enable farmers to better promote their efforts in terms of vegetable quality, especially safety. Food safety generates a number of information deficiencies and opportunism risks which are reduced by cutting intermediary stages between farmers and consumers. This also benefits consumers who are reassured in terms of the way food is produced, in addition to getting access to fresher and more affordable food. Yet direct sales may be constraining in terms of the access to a market stall or store (Moustier et Nguyen, A paraître).

The results are original because they show the profitability of vertical integration of retailing stages by producers, while many farmers rather investigate vertical integration of producing stages by traders. Yet some qualifications need to be made. The contracts observed in the safe vegetable chains have limited features of vertical integration. They are mostly systems of guarantee of purchase and sale, rather than the involvement of the purchaser in the stages of production. Purchasers do not provide inputs nor technical advice, and the extent of quality control is limited. It would be worthwhile to carry out a comparison of farmers-driven integration with retailer-driven integration in cases of more active involvement of retailers in the process of production, which may be more frequent in Southern Vietnam than in Northern Vietnam. Another situation is the one of retailing companies involved in production through salaried workers. The profitability of salaried work could be compared with the one of contracted and independent farmers – provided we could find a significant number of farmers in situation of salaried work.

In terms of policy recommendation, our results indicate that public support for farmers to be able to directly sell their products could have beneficial impact on their incomes. This could involve micro-credit programmes, as well as facilitating the protection of areas available for farmers' sales, including farmer retail markets, which are still missing in Vietnam, in contrast with other countries. Besides, public food safety control needs to be improved to make the label "safe vegetables" more credible. At the moment, there is no strict control by an external authority of the origin of vegetables sold in the stalls and shops; the latter may well mix vegetables from various production areas and with incomplete certification. This could jeopardize the reputation – and hence incomes - of farmers involved in quality efforts.

The paper has some limitations and additional research is required. The issue of unobserved characteristics should be further investigated. Explanations should be further looked for as regards the unexpected direction of covariates. Besides, it would be worthwhile to carry out similar analyses with bigger samples per treatment, which would imply doing the research in other regions of Vietnam.

Table 1. Observable covariates for selection bias adjustment of ATEs

Covariate	Description	Household income	Selling directly to consumers	Contract with SM and company
Size	Household size (persons)	0.435***	-0.166	-0.146
Age	Average age of the family	-0.133	-0.085	-0.200**
Labor[a]	Household labor endowments	0.378***	-0.277***	-0.272***
Labor2	Square of labor	0.375***	-0.225**	-0.268***
Education	Average years of education in the family	0.141	-0.138	-0.211**
Land	Arable land area (ha)	0.118	-0.387**	-0.312***
Market	Distance from nearest market (km)	0.121	0.239**	-0.046
Road	Distance from nearest road (km)	0.101	-0.056	-0.097

[a]People aged from 15 to 65 were taken as labor.

Table 2 Comparison of household characteristics for different coordination forms

	Total	Selling in spot markets	Selling directly to consumers[c]	Contracted by supermarkets or company
Number of households	137	66	30	41
Household income (million VND)	64.24	57.93	81.42**	62.16 (*)[d]
Vegetable income (million VND)	29.38	19.03	44.32***	35.09***
Share of vegetable income (%)	45.96	36.23	56.22***	54.27***
Agriculture income[a] (million VND)	31.63	21.91	44.72***	37.62***
Agri. income per hectare (million VND/ha)	185.13	102.90	292.47***	238.09***
Household size (persons)	4.47	4.71	4.17	4.29
Male (persons)	2.31	2.47	2.13	2.20
Female (persons)	2.15	2.24	2.03	2.10
Number of labor [b]	3.48	3.86	3.07***	3.17***
Share of labors in the family	80%	85%	75%	75%
Age (years old)	34.58	36.22	34.32	32.13**
Education (years)	8.36	8.76	8.10	7.84**
Arable land area (ha)	0.22	0.26	0.16***	0.18***
Distance from nearest market (km)	0.94	0.88	1.26**	0.81(***)
Distance from nearest road (km)	0.25	0.27	0.24	0.21

[a] Agriculture income only refers to farming on the arable land, not including livestock feeding.

[b] Labor refers to a people in age from 15 to 65.

[c] Characteristics of farmers selling directly to consumers and contracted by supermarkets or company are compared to those selling their vegetables in spot markets using T test. Significant differences are indicated with *p<0.1, **p<0.05, ***p<0.01.

[d] The significance level indicated in the bracket is the comparison between selling directly to consumers and contracts.

Table 3. Regression on covariates by implementing OLS regression to estimate ATEs.

	T1: Selling directly			T2: With contract		
	Coefficient	Std. Err.	t	Coefficient	Std. Err.	t
Contract	32.50***	10.45	3.11	14.16	8.55	1.66
Size	16.50***	5.61	2.94	12.32**	4.84	2.55
Age	0.07	0.43	0.17	0.13	0.37	0.35
Labor	2.29	16.88	0.14	4.19	13.06	0.32
Labor2	-0.23	1.93	-0.12	-0.18	1.77	-0.10
Education	2.69	3.29	0.82	3.19	2.49	1.28
Land	-54.87	43.68	-1.26	-27.60	39.32	-0.70
Market	4.38	5.66	0.77	-0.70	4.93	-0.14
_cons	-40.46	43.95	-0.92	-38.12	38.13	-1.00

Table 4. Regression on propensity score to estimate ATEs

	T1: Selling directly			T2: With contract		
	Coefficient	Bootstrap Std. Err.	t	Coefficient	Bootstrap Std. Err.	t
Contract (0=spot)	32.37***	11.53	2.81	13.84	8.36	1.65
PS	-26.73	88.01	-0.30	81.23	213.95	0.38
Size	19.69	13.51	1.46	4.77	23.07	0.21
Age	0.02	0.46	0.03	0.90	2.00	0.45
Labor	-10.10	45.75	-0.22	15.81	23.38	0.68
Labor2	0.70	5.11	0.17	0.17	4.30	0.04
Education	3.81	5.54	0.69	2.05	4.85	0.42
Land	-89.11	126.72	-0.70	34.76	176.46	0.20
Market	7.21	10.99	0.66	0.31	5.16	0.06
_cons	-18.40	84.73	-0.22	-111.48	171.34	-0.65

Table 5. Propensity score estimated using a bivariate probit model

Treatment	T1: Selling directly		T2: With contract	
Covariate	Coefficient	Std.Err	Coefficient	Std.Err
Size	0.129**	0.064	0.109	0.075
Age	-0.001	0.005	-0.009*	0.005
Labor	-0.451**	0.197	-0.040	0.235
Labor2	0.032	0.023	-0.024	0.036
Education	0.046	0.037	0.022	0.039
Land	-1.489***	0.563	-0.868*	0.475
Market	0.117*	0.060	-0.015	0.075

Table 6. Regression on propensity score to estimate ATEs

	T1: Selling directly			T2: With contract		
	Coefficient	Bootstrap Std. Err.	t	Coefficient	Bootstrap Std. Err.	t
Contract (0=spot)	32.37***	11.53	2.81	13.84	8.36	1.65
PS	-26.73	88.01	-0.30	81.23	213.95	0.38
Size	19.69	13.51	1.46	4.77	23.07	0.21
Age	0.02	0.46	0.03	0.90	2.00	0.45
Labor	-10.10	45.75	-0.22	15.81	23.38	0.68
Labor2	0.70	5.11	0.17	0.17	4.30	0.04
Education	3.81	5.54	0.69	2.05	4.85	0.42
Land	-89.11	126.72	-0.70	34.76	176.46	0.20
Market	7.21	10.99	0.66	0.31	5.16	0.06
_cons	-18.40	84.73	-0.22	-111.48	171.34	-0.65

Table 7. T-test of household income before and after matching

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
T1: Selling directly						
Income	Unmatched	85.13	57.30	27.83	10.45	2.66
	ATT	85.13	43.14	41.98	12.91	3.25
Income	Unmatched	85.12	57.30	27.83	10.45	2.66
	ATT	82.20	43.46	38.73	12.88	3.01
T2: With contract						
Income	Unmatched	62.16	57.30	4.86	8.16	0.60
	ATT	62.16	41.86	20.29	10.82	1.88
Income	Unmatched	62.16	57.30	4.86	8.16	0.60
	ATT	64.13	41.78	22.35	10.45	2.14

Table 8. Balancing properties of covariates in treated and control groups

Variable	Sample	Mean		%bias between treated and control	% Reduction in bias
		Treated	Control		
Treatment 1: Selling directly to consumers					
Size	Unmatched	4.16	4.64	-31.8	
	Matched	4.16	3.68	31.5	0.8
Age	Unmatched	33.42	36.33	-27.0	
	Matched	33.42	39.57	-57.1	-111.7
Labor	Unmatched	3.04	3.86	-61.1	
	Matched	3.04	2.88	11.9	80.6
Labor2	Unmatched	11.20	16.51	-50.2	
	Matched	11.20	9.28	18.1	63.8
Land	Unmatched	0.18	0.26	-80.7	
	Matched	0.18	0.19	-13.2	83.6
Education	Unmatched	8.03	8.81	-33.6	
	Matched	8.03	8.04	-0.5	98.5
Land	Unmatched	0.18	0.26	-80.7	
	Matched	0.18	0.19	-13.2	83.6

Market	Unmatched	1.31	0.92	53.9	
	Matched	1.31	2.02	-98.6	-83.0
Treatment 2: Contracted by supermarkets and companies					
Size	Unmatched	4.22	4.64	-30.3	
	Matched	4.22	4.84	-44.6	-46.9
Age	Unmatched	30.19	36.33	-62.0	
	Matched	30.19	28.55	16.5	73.3
Labor	Unmatched	3.00	3.86	-71.9	
	Matched	3.00	3.00	0.00	100.0
Labor2	Unmatched	10.25	16.51	-72.9	
	Matched	10.25	9.69	6.6	91.0
Education	Unmatched	7.75	8.81	-50.5	
	Matched	7.75	7.31	21.0	58.3
Land	Unmatched	0.17	0.26	-92.8	
	Matched	0.17	0.20	-34.1	63.3
Market	Unmatched	0.74	0.92	-27.4	
	Matched	0.74	0.85	-17.1	37.5

Table 9. Sensitivity analysis of propensity score matching for treatment of selling directly

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.0028	0.0028	33.4615	33.4615	10.8850	64.6815
1.05	0.0038	0.0020	32.1450	35.0430	8.7200	67.1815
1.1	0.0051	0.0015	30.5743	36.2687	8.2392	68.4955
1.15	0.0066	0.0011	29.6450	38.3380	7.0527	70.1925
1.2	0.0083	0.0008	28.8010	39.1520	6.8575	72.0740
1.25	0.0103	0.0006	27.5405	40.4125	5.5970	73.2605
1.3	0.0126	0.0004	26.6473	42.0113	5.0900	74.5210
1.35	0.0151	0.0003	26.3010	42.8063	2.9290	76.2785
1.4	0.0180	0.0002	25.5227	43.8683	2.3612	77.8650
1.45	0.0211	0.0002	23.8540	44.8565	1.3070	78.2275

1.5	0.0245	0.0001	23.5505	45.2380	0.6213	78.7930
1.55	0.0282	0.0001	23.0060	45.5700	-0.4150	79.3465
1.6	0.0322	0.0001	22.4965	47.2750	-1.6755	80.7275
1.65	0.0365	0.0000	21.7455	48.0700	-2.0604	81.8299
1.7	0.0410	0.0000	21.5366	49.3200	-3.1145	82.8840
1.75	0.0458	0.0000	20.5590	49.7750	-3.8470	83.2275
1.8	0.0508	0.0000	19.1625	50.5700	-4.7025	83.4900
1.85	0.0561	0.0000	18.5373	52.3241	-5.1065	86.5580
1.9	0.0616	0.0000	17.4130	52.4495	-6.3670	87.6810
1.95	0.0674	0.0000	17.2410	53.5370	-6.6070	87.9583
2	0.0733	0.0000	16.8149	54.6048	-7.5535	91.0263

* gamma: log odds of differential assignment due to unobserved factors.

sig+: upper bound significance level.

sig-: lower bound significance level

t-hat+: upper bound Hodges-Lehmann point estimate.

t-hat-: lower bound Hodges-Lehmann point estimate

CI+: upper bound confidence interval (a=0.95)

CI-: lower bound confidence interval (a= 0.95)

Table 10. Sensitivity analysis of propensity score matching for treatment of contracts

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.0046	0.0046	22.3958	22.3958	6.5378	37.6070
1.05	0.0064	0.0033	21.9205	23.0265	4.8383	38.3035
1.1	0.0086	0.0023	20.2757	23.7333	3.9420	39.9435
1.15	0.0112	0.0016	19.3407	24.9133	3.2500	40.9040
1.2	0.0144	0.0012	18.6250	25.4470	2.5085	41.2705
1.25	0.0180	0.0008	17.5700	25.8310	1.7060	42.1385
1.3	0.0223	0.0006	17.2682	26.8725	1.1810	42.3130
1.35	0.0270	0.0004	16.6475	26.9280	-0.1650	43.7850
1.4	0.0323	0.0003	15.6282	27.9705	-0.3600	44.9878
1.45	0.0382	0.0002	15.1675	28.8250	-0.7245	45.1235
1.5	0.0446	0.0001	14.6992	29.0870	-1.5400	45.7705
1.55	0.0516	0.0001	14.1920	29.5300	-1.7500	46.3490
1.6	0.0591	0.0001	14.1250	30.0080	-3.4740	47.4600
1.65	0.0671	0.0001	13.7615	30.5533	-4.5168	48.2500
1.7	0.0756	0.0000	12.9610	31.0425	-4.7468	49.5030
1.75	0.0846	0.0000	12.3900	31.9550	-5.2220	52.2115
1.8	0.0940	0.0000	11.6460	33.0183	-5.8520	52.5380
1.85	0.1038	0.0000	11.4060	33.4400	-6.4715	52.5750
1.9	0.1140	0.0000	11.0906	33.6817	-7.7435	52.5955
1.95	0.1246	0.0000	10.9670	33.7328	-8.1450	52.6400
2	0.1355	0.0000	10.7015	34.1119	-8.2188	52.9590

* gamma: log odds of differential assignment due to unobserved factors.

sig+: upper bound significance level.

sig-: lower bound significance level

t-hat+: upper bound Hodges-Lehmann point estimate.

t-hat-: lower bound Hodges-Lehmann point estimate

CI+: upper bound confidence interval (a=0.95)

CI-: lower bound confidence interval (a= 0.95)

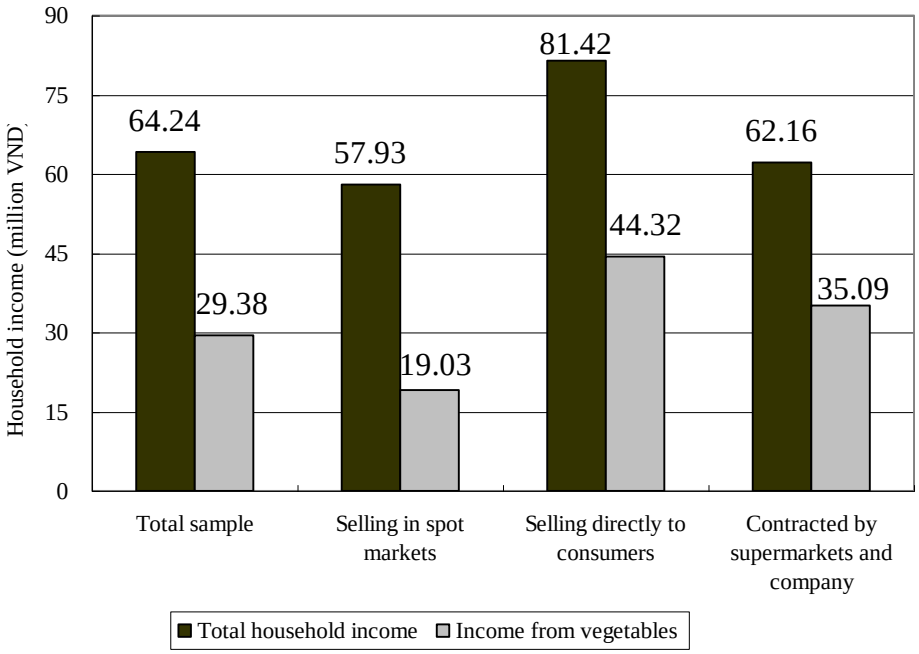
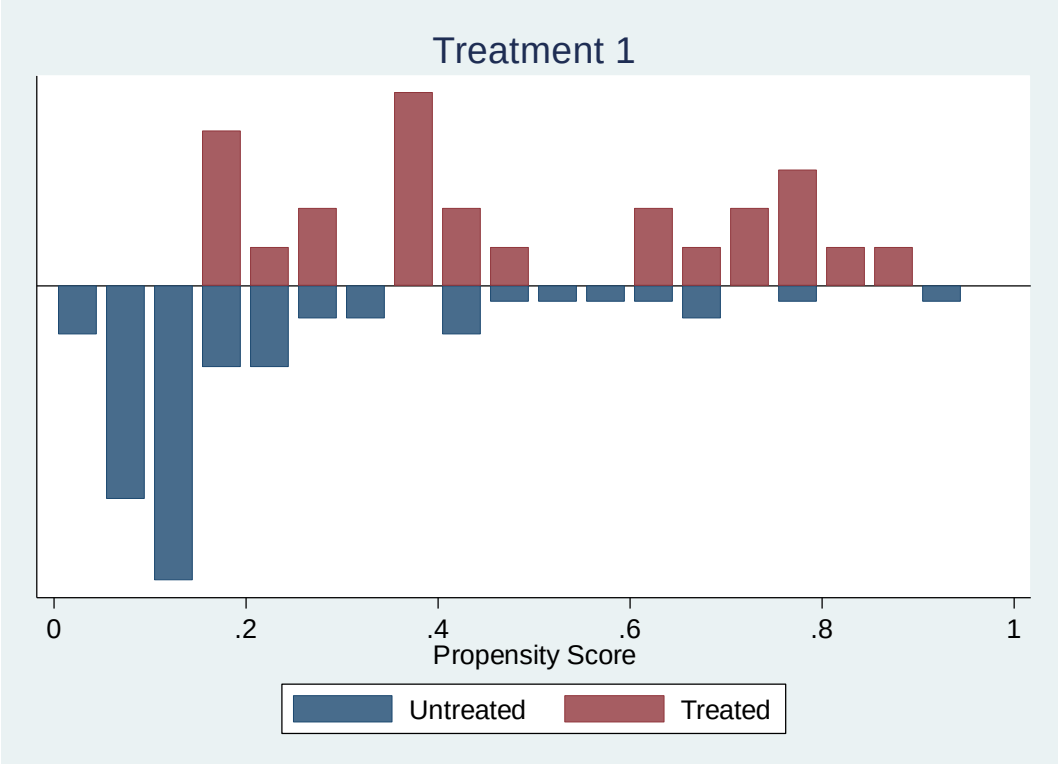
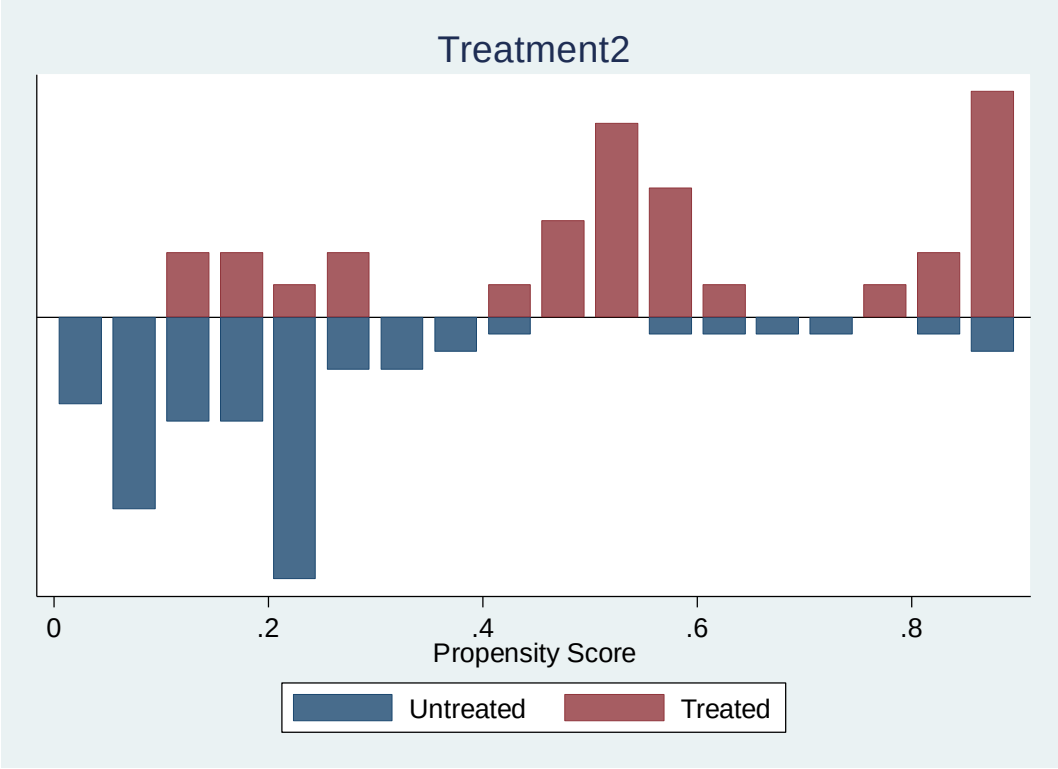


Figure 1. Household income and income from vegetables




Treatment2
0
.2
.4
.6
.8
Propensity Score
Untreated
Treated

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