Effect of contract farming on productivity and income of small holders: The case of tea production in north-western Vietnam

Yoshiko Saigenji[1] and Manfred Zeller[1]

[1]Department of Agricultural Economics and Social Sciences in the Tropics and Subtropics (490a), University of Hohenheim, 70593 Stuttgart, Germany
E-mail: saigenji@uni-hohenheim.de

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Abstract

This paper examines potential of contract farming as a rural development tool by revealing its effect on productivity and income of small holders in tea production in north-western Vietnam. In the present research, three economic analyses are applied. First, the technical efficiency of tea production is estimated by using stochastic frontier model. The results show that contract farming achieved significantly higher technical efficiency compared to non-contract farming. Second, logit model is investigated to determine the influential socio-economic characteristics of households for contract participation. The model indicates that social relationship of households, such as the membership in the communist party, play an important role in contract participation with 73% correct prediction. Finally, the impact of contract participation on income is estimated by applying Propensity Score Matching. A significant effect of contract participation on income by 8,000 VND daily per capita can be observed.

Keywords: Contract farming, Tea, Vietnam

1. Introduction

Since the Doi Moi [1] market reforms the Vietnamese economy has engaged in market liberalization characterized by increasing foreign investment, privatization of domestic companies, and reforming of state-owned enterprises. Additionally, rapid economic growth, along with a steadily increasing population, has augmented domestic demand for agricultural products. Furthermore, it is assumed that the WTO accession in 2007 has accelerated economic reform. In contrast to these massive political and economic changes, Vietnam still has an income poverty rate of 23% countrywide, with the highest rate of 52% in the north west region (GSO 2004).

The north west region, with its mountainous topography and temperate climate, is one of the main tea cultivation areas in Vietnam. Although state-owned enterprises used to control marketing and pricing of the final products in the Vietnamese tea sector, an increasing number of private companies have created new marketing channels that impact both the conventional tea market and farmers' livelihood. The participation of small holders in the new agricultural marketing system is an important consideration for rural development in the course of Vietnam's ongoing economic growth.

As observed during the survey, one of the common schemes for tea production in north-western Vietnam is contract farming. The contract system attempts to ensure a steady supply of quality products which is increasingly important given market liberalization, heightened consumer demands, and internationalization. Following the typology specified by Singh (2002), two types of contract farming can be observed in the surveyed area; the partial contract, where some inputs are provided by the contractor and the products are sold at a pre-agreed price; and the total contract, where the contractor supplies all the inputs and determines management decisions and the farmer supplies labour and land. Both production

[1] Significant economic reforms initiated by the Vietnamese Government in 1986.

schemes have been successfully applied in the region, however their effects on productivity and income of farmers have not been evaluated. Therefore, this study examines the effect of contract farming on productivity of tea production, and investigates its impact on income of tea farmers in the mountainous region of north-western Vietnam in order to evaluate the potential of contract farming as a tool for poverty alleviation.

2. Literature review

2.1. Contract farming

Contract farming has been the focus of many studies since the late 1980s. Minot (1986) discussed the role of smallholders in the course of economic growth and the influence of contract farming. By considering potentials and constraints of contract farming, he concluded that in almost all cases contract farming succeeded in improving income. Comparative case studies of African countries by Glover and Kusterer (1990) and Little and Watts (1994) attempted to develop an overall scheme for contract farming and to comprehensively assess its social impact.

Warning and Key (2002) determined how participation in the NOVASEN (a private company) program affected the agricultural income of 32,000 peanut growers in Senegal. Similarly, Miyata et al. (2007) examined the impact of contract participation on household income of apple and green onion farmers in China. Both studies controlled unobservable factors by applying selection correction models to contract participation and income models in order to obtain unbiased results of the impact of contract participation.

Ramaswami et al. (2006) focused on the efficiency factor in contract farming by Indian poultry producers. They found that producers involved in contracts reached a higher efficiency mainly due to a higher feed-conversion ratio. Moreover, by estimating the average returns of contract and non-contract producers, they concluded that the contract enables

farmers with poorer prospects to generate a comparable income to non-contract farmers with better prospects.

2.2. Production efficiency

When considering contract farming as a tool for rural development, it is necessary to clarify its production efficiency compared to other production schemes. There are a number of efficiency analyses applying stochastic production frontier model to the studies of agriculture in developing countries. Bravo-Ureta and Evenson (1994) examined technical, allocative and economic efficiency by estimating separate Cobb-Douglas production frontiers of peasant farmers in eastern Paraguay. They found that there is no strong relation between socio-economic characteristics and the productivity of farmers. Rawlins (1985) evaluated effects of the Jamaican Second Integrated Rural Development Project (IRDPII) on the level of technical efficiency for peasant farmers by using cross sectional frontier model. Although the results showed that non-contract farmers have higher average technical efficiency, it concluded that contract farming drives up the production frontier of contract farmers.

3. Methodology and data

3.1. Methodology

The objective of this research is to investigate the effect of contract farming on production and income of tea farmers in north-western Vietnam. It includes three main research questions as follows:

- Does contract farming enhance production efficiency compared to non-contract farming?
- What are the differences in socio-economic characteristics of contract and non-contract farmers?
- How strong is the impact of contract participation on household income?

The analysis of production efficiency and impact on income are investigated respectively. Three components of economic analysis are applied.

3.1.1. Estimating technical efficiency

First, stochastic frontier production function (SFPF) model is used to estimate the technical efficiency of farmers.

SFPF was first proposed by Meeusen and van de Broeck (1977) and Aigner, Lovell and Schmidt (1977) independently, and has since been further developed in a number of studies related to production models and technical efficiency estimations. The model includes two stages of estimation with respect to two error components: one associated with the presence of technical efficiency and the other a conventional random error.

As approved by many studies, the Cobb-Douglas type production function equations are appropriate for functional analysis intended for agricultural activities and are applicable for small sets of data (Armagan and Ozden, 2007).

Technical efficiency has been defined in many ways. In this study it refers to farmers producing a given output with minimized inputs or maximizing the output with given inputs.

The stochastic frontier production function to be estimated is specified as follows:

$$(1)\ \ln Y_i = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + \sum_{k=1}^{5} \beta_k D_{ki} + V_i - U_i,$$

$$(2)\ U_i = \delta_0 + \sum_{m=1}^{7} \delta_m Z_{mi} + W_i.$$

ln*Yi* denotes natural logarithm of output of *i*-th farm (*i*=1, 2, ….., 162),

β are the unknown parameters to be estimated,

X_j is a vector of inputs,

D_k is a vector of dummy variables,

Vi is N (0, σ^2_v) distributed random errors,

Ui is the non-negative random variable representing technical inefficiency of production. It is assumed to be distributed independently, which can have either half-normal, exponential or truncated- normal distribution.

δ are the unknown parameter to be estimated,

Z_m is a vector of explanatory variables associated with technical inefficiency of production,

Wi is N (0, σ^2_u) distributed random variable.

The total variance of the production function, expressed as variances of two error components: $\sigma^2 = \sigma^2_v + \sigma^2_u$. $\gamma = \sigma^2_u / (\sigma^2_v + \sigma^2_u)$ is tested to be zero by performing log-likelihood ratio test.

The technical efficiency of production for *i*-th farmer is defined by

$$(3)\, TE_i = \exp(-U_i).$$

The maximum likelihood estimates of parameters in the equation were obtained by using software FRONTIER 4.1 following the instruction of Coelli (1996).

3.1.2. Determinant socio-economic characteristics of households to contract participation and impact of contract participation on income

The second part of economic analysis uses logit model to estimate the probability of contract participation assigned to socio-economic characteristics of households. The results obtained by this analysis address the differences of those characteristics between contract and non-contract farmers and the marginal effects of each independent variable.

The dependent variable is contract participation (1=yes, 0=no). Independent variables are household composition data such as a number of household members, proportion of adults, age, education and ethnicity of household head, and number of household members in associations such as farmer's union and communist party. The number of income sources in 1997 is also included as, among the surveyed households, the first contracts started in 1998.

The results from logit model are applied to estimate the effect of contract participation on income. Propensity score matching (PSM) first proposed by Rosenbaum and Rubin (1983), is a treatment effect correction model used to reduce bias when estimating the effect of treatments. PSM has been applied in many project and policy evaluation studies because it formulates comparison of treatment groups better than previous models and enables estimation of the reduced-biased treatment effect. To evaluate the impact of participation on income, all observable characteristics have to be same between the contract (treatment) and the non-contract (control) group.

The expected treatment effect of contract participation is the difference between the actual income and the income if they did not participate. This can be written as:

$$(4)\quad ATT_i = E(Y_{1i} - Y_{0i} \mid P_i = 1).$$

Where Y_{1i} denotes the income when i-th farmer participates in contract,

Y_{0i} is the income of i-th farmer when he does not participate in contract, and

Pi denotes the contract participation, 1=participate, 0=otherwise.

ATTi, so called conditional mean impact or Average Treatment effect on Treatment (ATT), is conditional on contract participation.

The mean difference from sample estimation between observable treatment and control is written as:

$$(5)\quad D = E(Y_1 \mid P_i = 1) - E(Y_0 \mid P_i = 0) = ATT + \varepsilon .$$

Term ε denotes bias given by

$$(6)\quad \varepsilon = E(Y_0 \mid P_i = 1) - E(Y_0 \mid P_i = 0) .$$

The middle equation of (5) is the difference between the counterfactual mean of contract participation and the mean output of non participation.

The true parameter of ATT is only identified if the outcome of treatment and control under the absence of contract are the same. This is written as:

$$(7)\quad E(Y_0 \mid P_i = 1) = E(Y_0 \mid P_i = 0) = 0.$$

The situation expressed by equation (6) might be possible by randomization of contract participation as long as it provides same mean and equal whole distribution between participant and non participant (Ravallion, 2001). However, there are no "perfect" random samplings due to the sampling error in practice.

The procedure in PSM starts by obtaining probability of participation for all samples through either probit or logit model. In the next step, the matched controls for each treatment are explored using selected matching algorithms over the estimated probability as a propensity score. To estimate the participation probability, logit model with maximum likelihood method is often preferred due to the consistency of parameter estimation associated with the assumption that error term *v* in the equation has a logistic distribution (Ravallion 2001, Baker 2000). The ratio of number of treatments to controls has to be considered. This study oversamples treatment compared to control so that choice based sample method is applied for

matching to correct this condition. In choice based sample method, odds ratio[2] is used instead of propensity score for matching (Baker 2000, Heckman 2008).

After estimating propensity score, the next procedure is matching the controls to each treatment using selected matching algorithm. The matching algorithm for this study is Nearest- neighbour matching with replacement due to the nature of the dataset.

3.2. Data

The data used in this study was obtained in a field survey of Moc Chau district[3], conducted by the author from June to October 2007. It consisted of a quantitative household survey of 170 tea farmers (including 50 non-contract tea farmers) and 77 non tea farmers, and in-depth interviews with integrators, farmers, and village representatives. The household survey consisted of 20 pages of questions including indicators of household characteristics, dwellings, assets, social capital, short-cut expenditure[4], social capital, land use, income source and tea production. The samples used in this paper are 50 non-contract farmers and 78 contract farmers (40 households contracted with state-owned enterprises and 38 with private companies).

The sampling frame followed random sampling. One state-owned enterprise and one private company were chosen as representative of contracts with farmers. Farm households were then selected randomly from the lists of those companies. The independent tea farmers were randomly selected from household lists from villages where the contract farmers had been identified previously and also represent non tea farmers.

[2] Odds ratio: p/(1-p) where p denotes propensity score.
[3] Administrative level below province level.
[4] The questionnaire uses 13 questions to determine the total household consumption expenditure. It has been tested in four different countries by University of Maryland together with University of Göttingen, and obtained the very high coefficient with a true measure of per-capita daily expenditures measured by LSMS- type questionnaire.

4. Empirical Results

4.1. Technical efficiency of tea production

Table 1 shows the maximum likelihood parameter estimation of the stochastic frontier model of tea production in Moc Chau district together with the mean value of each parameter. The parameters Xi in stochastic frontier in equation (1) are general inputs for tea production such as land, costs of pesticides, labour spent for tea production, and all other costs. At the time of the survey, all the inputs had been spent over the previous 12 months. All the inputs are assumed to have a positive coefficient to the yield. In the inefficiency model, defined in equation (2), specifies household characteristics that affect technical efficiency. Note that the negative sign of coefficients variables indicate negative effect on technical inefficiency. In other words, those variables with a negative coefficient affect technical efficiency of production positively. All the variables in inefficiency model, except for motorbike use, have negative coefficient to inefficiency. Total land owned by household, distance to collecting point of tea leaves and use of motorbikes to the collecting point are estimated with high significance. In whole sample, average distance from tea field to collecting point is 880m, and 28% of farmers use motorbikes and 65% walk to carry there. As the result, motorbike use does not contribute to the technical efficiency that motorbike use is not necessary and even can lead to inefficient production. Insignificance of poverty index measured by five dimensions of poverty (human and social capital, assets, dwellings and food security) indicates that production efficiency does not depend on poverty status of farmers.

The technical efficiency of individual households is computed by equation (3). The means of contract and non-contract households are shown in table 2. Comparison of means by ANOVA shows significant differences among each group. Compared to both types of contract farming, non-contract farming results in low technical efficiency. What is remarkable is that state-owned company contracts achieve slightly higher technical efficiency than private and cooperative contracts despite country wide criticisms of state-owned enterprises for their

inefficient productivity (USAID, 2002). The inputs and extension supply of both contracts had no significant difference. However, as the evaluation of the actual quality of the extension supply could not be performed by the quantitative questionnaires, differences in technical efficiency might be caused by different recommendations such as the timing of certain management measures. Table 3 presents the test of null hypotheses of model applicability by likelihood ratio tests. First test concerns $\gamma = \sigma^2_u / (\sigma^2_v + \sigma^2_u) = 0$ which means there are no technical inefficiency effects in the model and strongly rejected. Test statistic for this hypothesis test follows mixed χ^2 distribution and the critical value is obtained from Kodde and Palm (1986). Second test is performed for the null hypothesis that coefficients of the inefficiency model are jointly zero and also strongly rejected.

Table1 Maximum- likelihood Estimates for the Parameters in the Cobb-Douglas Stochastic Frontier Production Function of Tea production

Variables [a]	Parameter	Mean [d]	Maximum Likelihood estimate (S.E.) [e]	
Dependent variable: Logged total amount of tea harvested in year 2007 (kg)		4101.69		
Constant	β_0		1.762 (0.668)	***
Logged land planted with tea (m^2)	β_1	4265.46	0.761 (0.172)	***
Logged pesticides used (000VND [b])	β_2	718.44	0.669 (0.078)	***
Logged family and hired labour spent for tea production (days)	β_3	483.17	0.000 (0.000)	***
Logged capital costs spent in tea production (000VND)	β_4	557.96	0.165 (0.036)	***
Inefficiency effects				
Constant	δ_0		13.572 (5.049)	***
Total land owned by household (m^2)	δ_1	12685.92	-0.000 (0.000)	**
Number of plots (tea)	δ_2	1.44	-0.881 (0.502)	*
Age of tea tree (year) weighted by area	δ_3	17.65	-0.000 (0.000)	*
Number of extension usage(per year)	δ_4	1.35	-1.163 (0.642)	*
Distance to the collecting point of tea leaves(m)	δ_5	876.13	-0.000 (0.000)	**
Use of motor bike to the tea leaves collecting point (1=yes, 0=no)	δ_6		0.000 (0.000)	**
Poverty Index [c]	δ_7	-0.021	-1.245 (0.841)	
Variance Parameters	σ^2		1.661 (0.685)	***
	γ		0.953 (0.028)	***

a) Dummy variables for village are included.
b) The exchange rate was US$1=16,000VND at the time of survey.
c) Poverty Index of each household is computed by using Principal Component Analysis (PCA) in author's previous study. More about PCA on Poverty Assessment see Henry, C., et al. (2003).
d) Mean value of variables are not logged.
e) *Significant at the 10% level, ** 5% level, and *** 1% level.
Source: Own data

Table2 Mean Technical Efficiency of tea production

Contract with state-owned	0.69
Contract with Private/ Cooperative	0.58
Non-Contract	0.47
Average	0.60
F- value	13.129***

***Significant at the 1% level
Source: Own data

Table3 Likelihood ratio test of hypothesis for parameters of the inefficiency frontier model for tea farmers in north-western Vietnam

	Crit. χ^2 value	Test value λ
$H_0 : \gamma = 0$	27.13[a)]	61.83***
$H_0 : \delta_1 = ... = \delta_7 = 0$	24.32	39.77***

***The Null hypothesis is rejected at the 0.1% level of error probability.
[a)] Mixed χ^2 distribution.
Source: Own data

4.2. Determinant socio-economic characteristics of households to contract participation

As the results in the previous chapter showed, production under contract farming has a higher technical efficiency than farms without contracts. Now the question might be raised, if all farmers are eligible to participate in contract farming, why does one farmer participate and the other not? Are contract farmers better-off than non-contract farmers? To answer those questions, the study applies logit model on contract participation to determine the socio-economic characteristics of sampled households. Table 4 displays the descriptive statistics of explanatory variables in logit model. There are no strong significant differences in characteristics between contract and non-contract farmers except for the years of experience.

Table4 Descriptive of household characteristics

	Mean		
	Contracted	Non-contract	F-value
Age of household head	45.32	42.94	1.21
Education of household head (year)	6.42	5.68	2.24
Number of household member	4.72	4.46	1.82
Proportion of adults age between 15 to 65	0.71	0.73	0.27
Number of household member in:			
Farmer's Union	0.74	0.90	2.27
Women's Union	0.82	0.82	0.00
Youth Union	0.67	0.62	0.10
Veteran Union	0.28	0.22	0.49
Fatherland Front	0.10	0.02	3.21*
Communist party	0.13	0.04	2.81*
Number of income source in 1997	1.99	1.94	0.12
Experience in tea production (year)	12.90	7.90	10.11***
Daily income per capita (expenditure proxy, 000VND)	28.08	23.54	2.02

*Significant at the 10% level, and *** 1% level.
Source: Own data

After the logit regression, only three variables are found to significantly influence the contract participation as shown in table 5; household located in Moc Chau commune (1=yes, 0=no), the number of household members in farmer's union, and the number of household members in communist party.

The marginal effect of regional dummy of Moc Chau commune indicated that probability of contract participation of those who live in Moc Chau is 32% higher than those who live in other communes. Moc Chau is located closest to the district centre of the sampled communes, so that it might be easier to access information on contract farming in terms of absolute distance to the information.

The education of household head seems to be no influential factor regarding contract participation as those variables are not statistically significant. However, the marginal effect of education 0 deserves attention. It indicates that the probability of contract participation of household heads that received no education at all is 28% less compared to household heads that received at least primary education. That membership in the communist party has the

highest marginal effect on participation indicates strong linkages between politics and economics in the rural society of north-western Vietnam.

Table5 Logit model of Participation in contract

Variables			Coefficients	S.E.	Marginal Effects
Dependent Variable: Contract participation (1=yes, 0=no)					
Household locate in Moc Chau commune [a] (1=yes, 0=no)			2.392*	1.432	0.319
Household locate in To Mua commune (1=yes, 0=no)			0.324	0.750	0.071
Household head is Dao/Muong minority (1=yes, 0=no)			-0.826	0.737	-0.192
Age of head			0.134	0.137	0.030
Age of head squared			-0.001	0.001	0.000
Education of head [b] 0 (1=yes, 0=no)			-1.139	0.849	-0.275
Education of head 2 (1=yes, 0=no)			-0.517	0.496	-0.115
Education of head 3 (1=yes, 0=no)			0.064	1.299	0.014
Number of households member			0.265	0.260	0.059
Proportion of adults age between 15 to 65			-0.341	1.093	-0.076
Household owns red book (land title, 1=yes, 0=no)			1.110	0.954	0.267
Number of household member in:					
Farmer's Union			-0.722*	0.436	-0.160
Women's Union			-0.196	0.470	-0.044
Youth's Union			0.141	0.316	0.031
Veteran's Union [c]			0.326	0.562	0.072
Fatherland Front's Union [d]			2.049	1.286	0.454
Communist Party			2.081**	0.999	0.462
Number of income source in 1997			-0.186	0.360	-0.041
Experienced years of tea production			0.068	0.042	0.015
Constant			-4.011	3.214	-
$\chi^2 = 37.10$			Predicted		Total
Significance level = 0.0077			0	1	
% correct predictions = 72.7 %	Actual	0	28	22	50
		1	13	65	78
Number of observations			41	87	128

a) Commune is the administrative level below province.
b) Education of village head is classified into 4 levels: 0-no education, 1-primary education, 2-secondary education, and 3- high school education completed respectively.
c) Mass organization mainly for retired solders.
d) Mass organization for heads of unions, villages and other organizations.
e) *Significant at the 10% level, and ** 5% level.
Source: Own data

From the last economic analysis, the impact of contract participation on income is revealed. Income is determined as expenditure daily per capita proxy obtained from the household survey.

Table 6 shows the results before and after matching the controls. The income difference per capita and day between contract and non-contract farm households is 8,000 VND (US$0.5) on average, which is computed as the average treatment effect. The average daily income of controls after matching was 20,097VND (US$1.3), so that on average contract participation increases daily income by nearly 40%. Contract farming has a significant impact on the income of participating tea farmers.

Table6 Average Treatment effect on Treatment

	Effect of contract participation ('000VND)	S.E.	t-value
Unmatched	4.543*	3.193	1.42
Matched by PSM	7.984**	4.004	2.00

*Significant at the 10% level, and ** 5% level.
Source: Own data

5. Conclusions

In considering contract farming as a useful tool to accelerate rural development in developing countries, empirical results from field surveys play an important role not only for increasingly popular experimental studies, but especially for designing, implementing, and evaluating different contract farming systems.

As it has been shown in the three economic analyses, contract farming of tea production in Moc Chau district provides higher technical efficiency and slightly higher income to households. However, the main influencing factor to contract participation, and as a consequence a higher probability to gain higher income, is membership in the communist party. It seems that even more than 20 years after the implementation of the Doi Moi, linkages between politics and economy are still very strong and can influence opportunities for advancement in rural north-western Vietnam. The obvious question, which should be examined further, is: what exactly causes the advantages of members of the communist party?

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