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Stochastic Frontier Analysis with Price Risk: An Application to Organic Tea Production in Vietnam

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Authors' contributions

This work was carried out in collaboration between all authors. Both authors NDT and JFY designed the study and wrote the protocol. Author JFY supervised the work and author NDT performed the all statistical analysis, managed the analyses of the study. Author NDT wrote the first draft of the manuscript. Author edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Traditionally, tea famers have been used chemicals to protect products. But an over usage of pesticides or preservation compounds has negatively affected on the environment and human health. When the living standard has been improved, consumers have changed into buying cleaner and safer products. Therefore, conventional tea production has been gradually converted into organic ones health requirement standards. However, lacks of researches about profit level as well as potential price risk for organic tea industries might be hard to pursue famers and policy makers about that movement.

Thai Nguyen province, one of Northern mountainous provinces, has been well-known for its high quality and quantity tea production in Vietnam for along time, which mainly contributes to make tea become one of the country's primary industrial exports. In this field, Stochastic Frontier Analysis (SFA) was applied to estimate profit levels for 180 tea growers selected from four representative

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communes of two tea producing districts of the Thai Nguyen province. A risk analytical model using the Monte Carlo method was developed to link risk levels to profit for organic tea producers when the premium price for organic tea and market conditions change.
This study shows that organic tea production has a higher profit efficiency level (0.836) than conventional tea production (0.454). If the price premium is removed, the probability that organic tea farmers incur a negative profit is about 22.5% and the probability that the farmers receive profits below the average observed profit increases by 42.5%. Maintaining the price premium is a policy option promoting a smoother transition to organic tea production by stabilizing income.

Keywords: Vietnam; organic tea; price premium; profit efficiency; price risk.

1. INTRODUCTION

Recently in Vietnam, tea has become one of the country's primary industrial export crops. However, excessive use of pesticides and agro-chemicals in tea production has had negative effects on the environment and to human health. In order to improve the quality of tea products that satisfy health requirement standards, there has been a movement toward converting conventional tea production to organic tea production [1]. According to Ngo, Do, Ha & Nguyen [2] "use of pesticides, particularly those of high toxicity has caused a great number of harmful impacts on human health and the environment." Hartman [3] and the U.S. EPA [4] also report that consumers generally prefer buying foods produced with less chemicals**.** Since organic farming prohibits use of synthetic pesticides, consumers perceive organic foods as having low chemical residue [3,5].

This research has the following objectives: (i) Determine profit efficiency of organic tea production for the Thai Nguyen province of Vietnam, (ii) Identify risky and uncertain factors affecting profitability and therefore income security of organic tea producers in Vietnam and (iii) Provide information to assist policymakers in determining whether organic tea production is a viable economic and environmental option for adoption by farmers in Vietnam and to (iv) Evaluate the role that the price premium plays for farmers transitioning from conventional to organic tea production.

2. METHODOLOGY

2.1 Methods for Analyzing Profit Efficiency

In the frontier-efficiency literature, there have been two primary frontier approaches used to analyze productive efficiency: The econometric approach and the mathematical programming approach [6]. Aigner, Lovell and Schmidt [7] and Meeusen and van den Broeck [8] introduced the stochastic frontier model which incorporates an error term composed of two components: A symmetric component capturing random variations of the frontier across firms and the effects of measurement error and a one-sided component capturing the effects of inefficiency relatively to the stochastic frontier. The econometric approach, often called Stochastic Frontier Analysis (SFA), is stochastic and the effects from noise can be distinguished from the effects from inefficiency.

There are two different approaches for estimating stochastic profit inefficiency: the primal production frontier approach and the dual variable profit frontier approach. In this research, the dual variable profit frontier approach was used to estimate profit efficiency for organic and non-organic tea production.

In the dual variable profit frontier approach, the profit frontier is assumed as:

$$v\pi = v\pi(pe^{-u}, w, z; \beta) = v\pi(p, w, z;\beta).h(p, w, z;\beta) \quad (1)$$

Where $v\pi = py\text{-}w^{T}x = v\pi\{(pe^{-u})(ye^{u}) - w^{T}x\}$, $h(p, w, z;\beta) = v\pi(pe^{-u}, w, z;\beta)/ v\pi(p, w, z;\beta)$ is the ratio of profit with technical inefficiency and profit for corresponding points on the profit frontier. Variable descriptions include p as the output price; w is a vector of input prices; y is a scalar of output ($y > 0$); x is a vector of inputs; z is the normalized fixed costs; v is the normalized random effect; u is the normalized profit inefficiency, and β is a vector of estimated technology parameters.

To comply with "regularity conditions", Thompson and Mark [9], Goyal and Berg [10], FAO [11] and Kolawole [12] used a normalized profit function, formed by dividing profit, input prices, and other factors by output price.

As an extension of the profit function shown in equation 1, the Cobb-Douglas form of the profit function can be written as:

$$\ln\frac{v\pi}{p} = \beta_0 + \sum_n \beta_n \ln\frac{w_n}{p} + \sum_q \beta_q \ln z_q + v_\pi + u_\pi \quad (2)$$

Where v_π represents the random effect and u_π represents the inefficient effect which is a function of age of household head, education level, tea farming experience, distance from home to the closest local market, and tea farm size. Socio-economic variables are often included in the analytical model to determine their possible influence on profit inefficiency [12-14] for tea production. Conformity to Hotelling's Lemma, negative signs for input cost and input price coefficients would be expected [15]. It is hypothesized that the cost of inputs negatively affects profit efficiency [14,16]. Sigma^2_v (σ^2_v) and sigma^2_u (σ^2_u) are the variances of the random effect and of the inefficiency effect used to measure variation of profit from the frontier that can be attributed to profit inefficiency [17]. In this research, lnsigma^2_**v** and lnsigma^2_u will be used to replace σ^2_v and σ^2_u as suggested by Battese and Coelli [18].

2.2 Risk Analysis

Enger and Smith [19] reported that most risk assessments are statistical statements of the probability of negative effects. "Risk traditionally has been defined as uncertainty concerning the occurrence of loss and chance of loss is defined as the probability that an event will occur" [20].

According to Helton (2005), the underlying idea of sampling based approaches to uncertainty and risk analysis is that the analysis results in $Y(X) = [y_1(X),\ y_2(X)\ldots.\ y_n(X)]$ and are functions of the uncertainty analysis variables $X = [x_1, x_2\ldots..x_m]$. In turn, uncertainty in X results in uncertainty in Y(X). In our model, Y is a vector of profit for different tea production methods (e.g., organic and clean tea production) given changes in tea production and market factors of vector X (i.e., tea yield, input expenditures, and tea price) under different tea production methods**.** A risk analytical model using the Monte Carlo method will be developed to link risk levels to profit for organic tea producers when the premium price for organic tea and market conditions change. The intent is to see how values of the objective function (net returns) change when values of the decision variables vary around their means following fitted distributions of these variables as observed in the sample and to determine whether conversion to organic tea production will be a risky decision in terms of ensuring income security. Using the risk analytical program @RISK 4.5 [21], risk levels in terms of probabilities for having a negative profit (net return) are solved for under three different analytical scenarios. The first two scenarios deal with changes in prices alone (i.e**.**, with and without the premium price). The third scenario involves risk in tea production (by allowing all decision variables to vary simultaneously as observed in the sample). These scenarios are evaluated for both organic tea and clean tea production.

3. DATA, EMPIRICAL MODEL, AND ESTIMATION RESULTS

3.1 Study Area

The Thai Nguyen province is well-known for its high quality tea and ranks as the second largest province in terms of tea production area [1]. This province is also one of the provinces which participated in the International Global Changing Institute (IGCI) project which promotes adoption of organic tea production. These reasons support the selection of the Thai Nguyen province as the research site for this study. Total tea planted area for the Thai Nguyen province accounted for 13.8% of the total tea planted area for the country [1]. Representative tea growers selected for the sample include organic tea farms and non-organic tea farms (conventional tea farms and "clean tea"[1] farms) from four representative communes of two tea producing districts of the Thai Nguyen province.

3.2 Sample Size Determination

Johnson [22] and [23] described the approach used to determine sample size. This approach utilizes the variability of a key variable (crop yield was used for this study) to determine what would be an appropriate sample size that is representative of the population.

[1]*Clean tea production is a tea farming practice that minimize use of pesticides and other chemical inputs and adopts Integrated Pest Management (IPM) for pest and disease control in tea production. The products from the clean tea production method may be free of pesticide and chemical residues but are not classified as organic tea.*

$$n=\left[\frac{z(\alpha/2)\sigma}{E}\right]^2 \quad (3)$$

Where

n = sample size,
α = confident level,
z = the two tail z value with the corresponding confident level,
σ = population standard deviation, and
E = precision level (absolute acceptable error).

The pretest was performed using 15 tea growers, of which five were organic tea farms, five were conventional tea farms and the other five were clean tea farms. The standard deviations of key variables and their precision levels were then plugged in equation 3 using the automatic sample size calculator introduced by Arsham, [24]. The recommended sample size was 23 organic tea producers, 67 clean tea producers and 59 conventional tea producers. However, to increase the statistical convenience in conducting survey analysis comparing with and without scenarios, for each organic or clean tea producer selected in the sample, one conventional tea producer was randomly selected from the surrounding neighborhood. A total of 180 tea growers were interviewed in the survey (summing 23, 67 and 90 for organic, clean and conventional tea producers respectively). Of the 180 tea farmers interviewed, only 176 observations had complete information (outliers were excluded by using the Hadi method [25].

3.3 Empirical Model

The empirical model for profit efficiency can be written as:

$$\ln(profit/p) = \beta_0+\beta_1\ln(plabor/p)+\beta_2\ln(pfer/p)+\beta_3\ln(pecost/p)+\beta_4\ln(hcost/p)+\beta_5\ln(ocost/p) +\delta_1\ln texp+\delta_2\ln age +\delta_3\ln tare + \delta_4 distm + \delta_5 edu \quad (4)$$

Where profit is net returns (th.VND[2]/ha/year), p is the price of fresh tea (th.VND/kg), plabor is the price of labor[3] (th.VND/ man day), pfer is the price of fertilizer (th.VND/ kg of nitrogen equivalent), pecost is the expenditure for pest and disease control[4] (th.VND/ha/year), hcost is the expenditure for health care and hospitalization (th.VND/ha/year) as an indirect measurement of environmental cost, ocost is other variable costs (fuel, irrigation fee etc.,) in th.VND per ha per year, texp is tea growing experience (years), age is the age of the household head (years), tare is the tea farm size (m^2), distm is the distance from home to the closest local market (= 1 if < 1km, = 2 if from 1-2 km, = 3 if >3 km), and edu is the education level of the household heads (= 1 if elementary education,= 2 if middle school education, = 3 if high school graduate and = 4 if higher).

All variables in the model were corrected for normality problems (skewedness and kurtosis) by using the trans-log form as suggested by Sheskin (2004) (Table 1a and 1b). The heteroskedasticity problem was checked by using the Breusch-Pagan/Cook-Weisberg test. A correction for heteroskedasticity was done by standardizing variables (dividing each variable by its standard deviation) as suggested by Varian [26] and Kuosmanen et al. [27] before estimating the actual profit efficiency model.

3.4 Estimation Results

Profit efficiency is of interest to policy makers in developing government intervention programs. The dual method applied in this research to analyze tea profit efficiency provides information about factors influencing profit efficiency and the estimated magnitudes of these effects. Results from the profit efficiency estimation for organic tea production are presented in Table 2.

These estimation results are based on the stochastic frontier profit efficiency analysis and on the assumption that tea production can be approximated by a Cobb-Douglas production function. The organic tea results for the variance analysis (lnsigma^2_v for the random effect and lnsigma^2_u for the profit inefficient effect) show that the inefficiency effect for profit efficiency is negative and statistically significant. This result implies the significant presence of profit inefficiency in the profit model for organic tea production.

[2] th.VND: thousand Vietnam Dong, a monetary unit of Vietnam ($1USD = 16,600 VND in June, 2008).
[3]Labor in this research was treated as an aggregate variable consisting of family labor and hired labor for tea production per hectare (Yotopoulos and Lau, 1971; Sharma et al., 1997).
[4]For organic tea production, pesticide use is not allowed. Given this requirement, total expenditure for pest and disease control is used to replace pesticide and herbicide prices.

The negative and significant effect of pest and disease control costs for organic tea production conforms to hypothesized theory and observations made earlier by Ali and Flinn (1989), Kolawole [12], Abdulai and Huffman [28]. This reflects the fact that for organic tea production, pest control costs contribute significantly to reduced profit efficiency due to the application of a more costly pest control method to substitute for synthetic pesticides. The positive and significant effect of tea growing experience for organic tea production implies that more experience in tea growing will increase profit efficiency. These results are consistent with Ali and Flinn [16], Abdulai and Huffman [28] and Shuwu [14]. Note that labor and fertilizer prices do not have statistically significant effects on profit efficiency for organic tea production. This reflects the fact that most organic tea farms use family labor and apply domestic animal manures to substitute for chemical fertilizers. Therefore, changes in the price of hired labor and chemical fertilizer price do not significantly impact profit efficiency.

As defined by Vinatea [29], clean tea production is a tea farming practice that minimizes usage of pesticides and other chemical inputs and adopts Integrated Pest Management (IPM) for pest and disease control in tea production. The products from clean tea production are free of pesticides and chemical residues but are not certified as organic.

Table 1a. Descriptive statistics of variables of tea farming households

Statistics	Production method	Variables[1]				
		Age	**Tea area**	**Education**	**Tea exp.**	**Distm.**
Mean	Organic	43.2	1,545	2.3	19.1	1.6
	Clean	44.6	3,763	2.1	21.0	1.9
	Conventional	46.1	2,569	2.2	22.1	2.0
Standard Deviation	Organic	9.2	762	0.8	7.1	0.8
	Clean	10.6	2,105	0.5	8.2	0.7
	Conventional	9.3	2,505	0.6	10.1	0.8
Max	Organic	64.0	4,000	4.0	30.0	3.0
	Clean	75.0	10,100	3.0	43.0	3.0
	Conventional	65.0	20,000	3.0	50.0	3.0
Min	Organic	26.0	750	1.0	8.0	1.0
	Clean	27.0	720	1.0	5.0	1.0
	Conventional	21.0	450	1.0	5.0	1.0

Table 1b. Descriptive statistics of variables for profit efficiency analysis (2006)

Statistics	Production method	Variables[2] (Normalized variables)						
		profit	**plabor**	**pfer**	**pecost**	**hcost**	**hercost**	**ocost**
Mean	Organic	4510	2.25	1.19	111	83	0	799
	Clean	4632	2.69	1.43	415	174	222	736
	Conventional	3459	3.46	1.84	646	331	213	1163
Standard Deviation	Organic	1687	0.41	0.22	92	112	0	483
	Clean	1631	0.47	0.25	271	286	344	380
	Conventional	1742	0.98	0.53	501	1013	353	771
Max	Organic	7201	2.9	1.5	283	526	0	1769
	Clean	7400	3.6	1.9	1282	1808	1485	1941
	Conventional	6295	6	3.2	2333	8930	1489	4744
Min	Organic	214	1.5	0.8	0	0	0	0
	Clean	142	1.9	1	56	0	0	0
	Conventional	0	2.1	1.1	0	0	0	0

[1]Distm is a distance from home to a closest local market = 1 if < 1 km, = 2 if from 1-2 km, = 3 if > 3 km; Age: age of the household head (years); Education level of the household head: = 1 if elementary,= 2 if middle, = 3 if High school graduate and = 4 if higher; Tea exp is tea farming experience in years; tea area (m^2)

[2]Profit denotes normalized profit, plabor is normalized price of labor, pfer is normalized price of fertilizer, pecost is normalized pest control costs, hcost is normalized health care costs, hercost is normalized herbicide costs and ocost is normalized other variable costs (fuel, irrigation etc.,)

Table 2. Results from profit efficiency estimation

Variable	Organic tea	Clean tea	Conventional tea
Constant	7.5110	11.910***	8.298***
Labor price	-0.497	0.099	2.684
Fertilizer price	0.403	-0.397***	-4.194**
Pest control cost	- 0.023*	-0.048	-0.053***
Health care cost	-0.005	-0.006***	0.007
Other costs	-0.007	-0.009	-0.006
Tea farm size	-0.164	0.164**	0.516
Distance to market	-0.049	-0.121***	0.031
Farming experience	0.796**	0.064 ***	-0.456
Age of HH head	-0.392	-0.019	0.338
Education	0.320	0.085	0.047
Lnsigma^2_v	-32.797	-34.885	-28.23
Lnsigma^2_u	-0.667**	-0.735***	3.90***
Wald chi^2(11)	2e+7***	3e+08***	4+06***
R^2 for profit	0.53	0.36	0.35
Observation	23	67	86

**** = Statistically significant at the 1% level, ** = statistically significant at the 5% level, * = statistically significant at the 10% level; Source: computed from field data survey*

This can be thought of as an intermediate tea production method between the conventional and organic tea production methods.

Unlike the organic tea profit efficiency results shown previously, fertilizer price has a negative and statistically significant effect on profit efficiency for clean tea production which is consistent with previous studies [12,14,16,28].

The negative effect of distance (from home to the local market) on profit efficiency suggests that being farther away from the market, tea farmers will incur larger transportation costs resulting in lower profit efficiency. The positive and significant effects of the farm size variable is similar to results reported by Ali and Byerlee [30], Abdulai and Huffman [28] and Kolawole [12]. The tea growing experience variable has the same effect on profit efficiency for clean tea production as it does for the organic tea production.

Clean tea variance analysis for the random error (lnsigma^2_v) is statistically insignificant whereas the inefficiency element (lnsigma^2_u) is significant (at the 1% level). These results imply a significant presence of the inefficiency element but an insignificant presence of the random effect on profit efficiency for clean tea production in the sample.

Results from profit efficiency estimation for conventional tea production indicate that the coefficient of lnsigma^2_v (random error) is not statistically significant suggesting an insignificant effect from random factors in conventional tea production for the sample. However, the variance of the inefficiency effect (lnsigma^2_u) is statistically significant at the 1% level indicating a significant presence of inefficiency on profit efficiency for conventional tea production in the sample.

Among input price variables, fertilizer and pesticide prices have statistically significant effects on profit efficiency for conventional tea production. However, the negative signs for the coefficients of fertilizer price and pest control costs (expected signs as discussed in the methodology section) suggest that as the price of fertilizer and pest control costs increase, profit efficiency will decrease. These results are consistent with previous work done by Ali and Flinn [16], Abdulai and Huffman [28], Kolawole [12] and Shuwu [14]. The negative and large (in absolute value terms) coefficient on fertilizer price for conventional tea production illustrates a strong dependency on chemical inputs. To halt use of chemical inputs and pesticides will likely cause a large reduction in tea yield and, hence, conventional tea production profit.

The results shown in Table 3 illustrate the mean comparison of profit efficiency for the three different tea production methods (i.e., organic, clean and conventional tea production) using the Stochastic Profit Frontier Analysis (SFA). The results show that the highest profit efficiency (0.836) is obtained from organic tea production whereas conventional tea production has the lowest mean profit efficiency (0.454). Also, clean tea producers have a significantly higher mean profit efficiency level as compared to conventional tea producers.

Profit efficiency analyses for the three different tea production methods in the Thai Nguyen province indicate that organic tea farmers have the highest efficiency level (an average of 0.836). Also, the results show a significantly lower profit efficiency level for conventional tea producers (an average of 0.454).

3.5 Risk and Profits for Organic tea Production

The basic profit equation used in the profit efficiency analysis for tea production

$$\pi = py - w^T x$$

The profit equation for organic tea production per hectare can be re-written as:

$$v\pi = py - labcost - fercost - pecost - hercost - hcost - ocost \quad (5)$$

Where vπ is profit for tea production (th.VND/ha/year), p is fresh organic tea price (th.VND/kg), y is fresh tea yield (kg/ha/year), labcost is labor expenditures[5] (th.VND/ha/year), fercost is fertilizer expenditures (th.VND/ha/year), pecost is expenditures for pest and disease control[6] (th.VND/ha/year), hercost is herbicide expenditure (th. VND/ha), hcost is expenditures for health care and hospitalization (th.VND/ha/year) as an indirect measurement of environmental cost, and ocost is other costs in th.VND/ha/year (fuel, irrigation fee etc.,).

This profit equation was used as the objective function for the risk analysis involving organic tea production. The cumulative distribution functions (CDF) depicted in Fig. 1 are the results of simulations conducted for 500 trials using a Monte Carlo risk analytical model discussed in the earlier methodology section. The risk involved in organic tea production was examined in scenario (1) By allowing a change in tea price when other production factors are fixed at their means (see graphs a and b in Fig. 1) and in the scenario (2) When allowing changes in all decision variables following their fitted distributions as observed for organic tea production in the sample (see graph c Fig.1). The cumulative probability distribution functions in this figure show how a change in the tea price and changes in all production factors (Fig. 1.) for organic tea production would affect profitability of organic tea growers. As Haldar and Mahadvan [31] and Rejda [20] defined risk objectives in terms of output uncertainty characterized by a probability distribution function and as uncertainty concerning the occurrence of loss and chance of loss. Mahadevan and Smith [34] also report that "a probabilistic optimization will characterize uncertainty objectives and constraints in terms of probability distribution and statistics" [34]. Thus, in this research, the risk involved in organic tea production is depicted by the change in the probability that organic tea farmers will receive negative profits or the increased probability that organic tea farmers will receive profits that fall below the average observed profit in the sample.

In the first simulation (scenario 1), only organic tea price is allowed to vary (all other variables are kept constant). The graphs a and b in Fig. 1 plot the simulations for tea price changes (i.e., with and without the premium price). This figure shows that given currently observed socio-economic conditions for organic tea farms in the Thai Nguyen province, if the premium price is removed, the cumulative probability density function for profit shifts to the left in parallel fashion and the probability of profit being less than average (i.e., average profit from tea production in the sample of VND 11, 314,000) increases from 2.4% to 64.2% (61.8% increase). By removing the premium price[7] for organic tea products, the probability that organic tea farmers will have negative profits is about 30%. This result shows how sensitive profitability of organic tea production is to the premium price for organic tea products.

In the second analysis, all variables including organic tea price are allowed to change as observed in the sample (i.e., all decision variables follow their fitted distributions in the sample for organic tea production).

[5]Labor in this research was treated as aggregate labor consisting of family labor and hired labor for tea production per hectare (Yotopoulos and Lau, 1973; Sharma et al., 1997).
[6]Since pesticides are not allowed in organic tea production, for convenience in calculations and analyses, total expenditures for pest and disease control were used to replace pesticide price.
[7]The premium price is the tea price received by tea farmers for their organic tea product (th. VND/kg of a fresh tea) and without premium price is the tea price offered for conventional tea product observed in the sample collected in the Thai Nguyen province.

Graph a in Fig. 1 plots the simulation which shows the probability that profit for current organic tea production being less than the average is 21.7% (recall average profit from tea production in the sample was VND 11,314,000). Also, the probability that organic tea farmers will have negative profits is about 7.5% (Fig. 1). The net effects of the premium price are obtained by subtracting the increases in the probability of tea farmers having negative profits or having profits fall below the observed average profit caused by the change in tea price only by the probability of tea farmers having negative profits or profits falling below the observed average profits caused by the fluctuation of all production factors for the organic tea production. These results infer that the net increases in the probability that organic tea farmers will have negative profit and have profit less than the average are 22.5% (i.e., 30% - 7.5%) and 42.5% (i.e., 64.2% - 21.7%) respectively.

3.6 Risk and Profit for Clean Tea Production

Similar to the organic tea production results, Equation 5 was also used as the objective in the risk analytical model for clean tea production. Fig. 2 shows that given currently observed socio-economic conditions for clean tea farms, if there is no premium[8] for the clean tea product, then, the probability of having profit less than zero is approximately 28.7% (increasing by 28.7% from 0% to 28.7% in Fig. 2a).

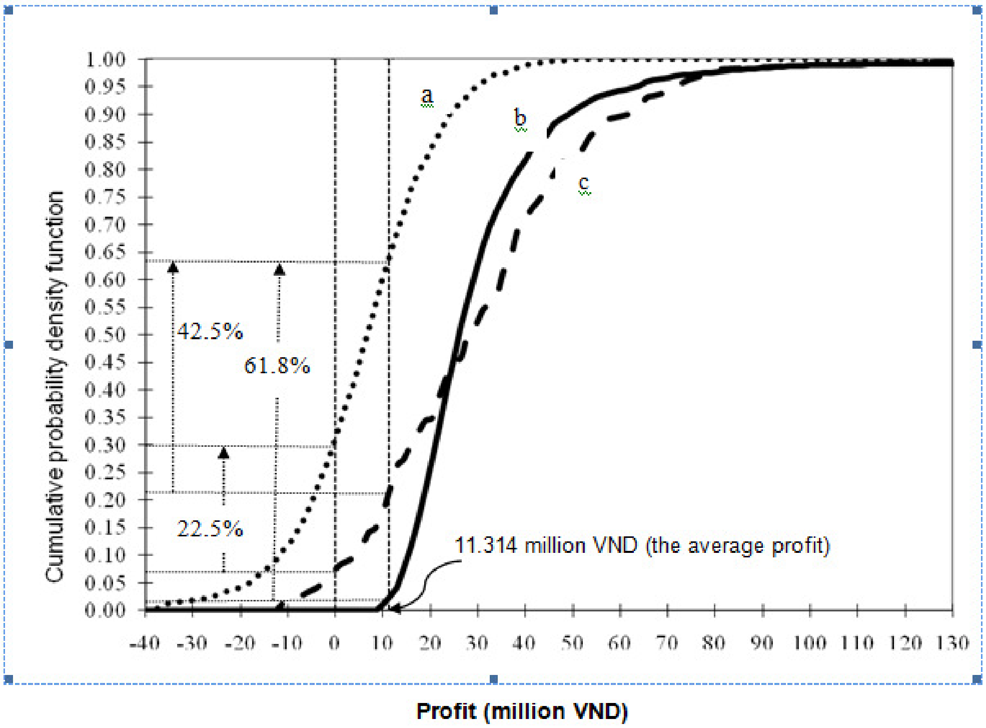

Fig. 1. Profit for organic tea with and without the premium price

a: The cumulative probability distribution function of the profit for organic tea production given the conditions that all variables but tea price are fixed at their means and allowing tea price to vary as the observed price for organic tea (with premium price) in the sample.

b: The cumulative probability distribution function of the profit for organic tea production given the conditions that all variables but tea price are fixed at their means as observed for organic tea producers and tea price varies as the oberserved tea price for conventional tea (without premium price) in the sample.

c: The cumulative probability distribution function of the profit for organic tea production given the conditions that all variables vary as observed in the sample.

[8]*The premium price is the tea price received by tea farmers for their clean tea product (th. VND/kg of a fresh tea) and without premium price is the tea price offered for conventional tea product observed in the sample collected in the Thai Nguyen province.*

The effect of removing the premium price on the probability of facing losses is less severe for clean tea production as compared to the organic tea production. The probability of profits falling below average profit (i.e., VND 11, 314,000) increases by 33.6% (from 22% to 55.6%, see Fig. 2). Also, the graphs in Fig. 2 show that at current socio-economic conditions, the probability that profit for clean tea farmers is less than the average is 36.7% and the probability that clean tea farmers will experience negative profits is 13.3% (graph c in Fig. 2). These translate into net increases in the probability that clean tea farmers will have negative profit and have profit less than the average are 15.4% (i.e., 28.7% - 13.3% = 15.4%) and 18.9% (i.e., 55.6% - 36.7% = 18.9%) respectively. This effect is also less severe in comparison to the effect of removing the premium price on organic tea production (i.e., the net increase in the probability of profit being less than the sample average increased by 42.5% for organic tea). These results suggest that removing the premium price will have higher risk effects for organic tea producers than for clean tea producers.

Table 3. Cross comparison of the means for profit efficiency

Pair-comparison	Statistics		
	Mean	**Standard deviation**	**Prob. |t| > t***
Organic tea vs.	0.836	0.092	0.011**
Clean tea	0.747	0.232	
Organic tea vs.	0.836	0.092	0.000***
Conventional tea	0.454	0.285	
Clean tea vs.	0.747	0.232	0.000***
Conventional tea	0.454	0.285	

*Ho: No difference in means, *** = significant at the 1% level. ** = significant at the 5% level*
Source: data computed from field survey data in 2007

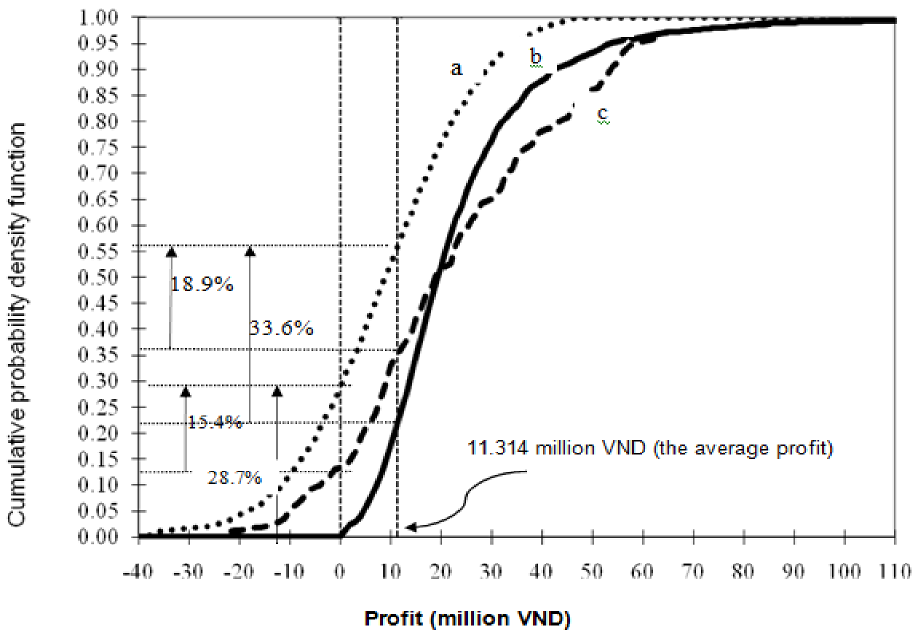

Fig. 2. Profit for Clean Tea with and without the Premium Price

a: The cumulative probability distribution function of the profit for clean tea production given the conditions that all variables but tea price are fixed at their means and allowing tea price to vary as the observed price for clean tea (with premium price) in the sample.

b: The cumulative probability distribution function of the profit for clean tea production given the conditions that all variables but tea price are fixed at their means as observed of clean tea producers and tea price varies as the oberserved tea price for conventional tea (without premium price) in the sample.

c: The cumulative probability distribution function of the profit for clean tea production given the conditions that all variables vary as observed of clean tea producers in the sample

4. CONCLUSION AND POLICY IMPLICATION

4.1 Profit Efficiency

Organic tea farmers in the Thai Nguyen province of Vietnam were relatively more profit efficient as compared to clean tea and conventional tea producers. Significant factors affecting profit efficiency for organic tea farms include pest control costs and tea growing experience. Pest control costs (non-chemical alternatives for organic tea production) had a significant and negative effect on profit efficiency indicating that current pest control methods are not effective and have a dampening effect on profit efficiency. This is a major concern in organic tea production. Also, tea growing experience had a significant and positive effect on profit efficiency for organic tea production suggesting more experienced farmers have higher profit efficiency.

Fertilizer price and health care related costs were statistically significant and negatively related to profit efficiency for clean tea production while other input costs (labor, pesticide, and other costs) did not have significant effects on profit efficiency for clean tea production. Among inefficient factors, only family size had a significant and positive effect while the age of the household head had a negative and significant effect on profit efficiency for clean tea production only. The highest mean profit efficiency was obtained from organic tea production while conventional tea production had the lowest mean profit efficiency. Also, mean profit efficiency for clean tea production was statistically higher than for conventional tea production.

4.2 Risks and profit

Given current and observed socio-economic conditions for organic tea farms in the Thai Nguyen province, if the premium price is removed for the organic tea product, the probability of profit being less than observed average profit (i.e., VND11,314,000) increases by 61.8% and the probability that organic tea farmers incur a negative profit or economic loss is about 30%. Whereas, current risk involved in organic tea production in Thai Nguyen represented by the probability that organic tea farmers incur an economic loss is about 7.5 % implying the net effect of removing the premium price alone is an increase in the probability of incurring a negative profit to tea farmers of 22.5% (i.e., 30% - 7.5%).

Given current and observed socio-economic conditions for clean tea farms, if there is no premium price for the clean tea product, then, the probability of having negative profits or losses is about 15.4% (i.e., 28.7% - 13.3%). However, the probability of profit falling below the observed average profit (i.e., VND 11,314,000) increases by only 18.9% (from 36.7% to 55.6% see Fig. 2). The effect of removing the premium price on profit reduction is less severe for clean tea production than for organic tea production because clean tea receives a lower premium price than organic tea production (currently the premium prices are about 10% and 30% higher than the regular market price for clean tea and organic tea products respectively).

4.3 Policy implications

The findings discussed in the previous sections suggest that the creation of a market mechanism that guarantees a premium price for the organic tea product would be a policy intervention by the government assisting the development of organic tea production. By removing the premium price, organic tea farmers in the Thai Nguyen province will be at risk of earning negative profits (22.5%) and having a high probability (42.5%) of receiving profits that are lower than the observed average profit received by all tea farmers.

Note that there are market niches for organic tea products in the domestic market. Raising awareness of health and environmental benefits from organic tea production or requiring product labeling with product quality control certification would competitively create a higher price for organic tea products domestically in the long run without the use of governmental administrative intervention.

The finding of the negative and significant effect from pest and disease control costs for organic tea production implies that these costs contribute significantly to reduced profit while substituting for synthetic pesticides. Pimentel et al. [32] reported that “in organic production systems, pest control can be of heightened importance and impact dealing with pest insects and plant pathogens that adversely affect yields is a major problem in organic crop production” Pimentel et al. [32] . Applying crop management measures that can enhance healthy crops and help reduce pests in organic tea farms, such as intercropping with leguminous crops [33], would be promoted. Selection of tea varieties that are resistant to pests and diseases is also advised to promote expansion of organic tea production in Vietnam.

The positive and significant effects of the tea growing experience on profitability for organic tea production, on the other hand, imply that more experience in tea growing will reduce tea profit inefficiency. This result is similar to the result reported by Ali and Byerlee [30] and Sharma et al., [35] that experienced tea farmers are better performers than those without experiences. The government can also hire successful organic tea farmers to demonstrate their production practices as a means of promoting organic tea production in Vietnam.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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