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Impact of Conversion to Organic Tea Cultivation on Household Income in the Mountainous Areas of Northern Vietnam

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Received: 2 October 2018; Accepted: 14 November 2018; Published: 28 November 2018

Abstract: This study aims at determining if organic tea farming results in higher net income than conventional tea farming in the mountainous areas of Northern Vietnam. Our sample includes 226 traditional and 319 organic tea-producing households in the provinces of Thai Nguyen, Phu Tho, Ha Giang, and Lai Chau. Using a propensity score matching approach, the study finds that the adoption of organic tea production had a positive impact on households' farm income in the study area. Using different matching algorithms, organic tea adopters earned higher income than did non-adopters, from 1038.8 to 1059.0 thousand Vietnamese Dong (VND) per hectare of cultivation plot. To increase conversion to organic tea farming amongst smallholder farmers, the government and other stakeholders should aim to provide better extension services, which incorporate relevant training to farmers and better access to information on organic tea production, as well as encouraging the commercialization of organic fertilizers. Simultaneously, the Vietnamese government should introduce mechanisms to coordinate production activities and deliver tea products to processing and/or marketing facilities.

Keywords: organic tea conversion; propensity score matching; ethnic minorities; Northern Vietnam

1. Introduction

Over the past decades, adverse social and environmental effects have increased the need for a more sustainable production system. One strategy for such long-term production with minimal effects on the environment is conversion from conventional to organic farming practices. The extant literature documents the environmental and social benefits of organic over conventional farming. From the environmental perspective, organic farming can save energy, preserve biodiversity, mitigating climate change, and sustain the environment, especially in the long run [1–3]. In addition, it can enhance soil fertility and feed nutrients to the soil. Furthermore, organic farming helps to reduce non-renewable energy use and contributes to mitigating global warming by locking away carbon in long-term reserves. From asocial perspective, owing to the constrained use of inputs, organic farming inevitably leads to healthier lives of both producers and consumers [4,5]. At the same time, organic farming often results in higher demand for labor than does conventional practice. This should contribute to employment in rural areas and to rural economies through sustainable development.

However, the economic benefit of converting from conventional to organic farming has been debatable. First, organic farming can reduce production costs because of limited opportunities to use chemicals, fertilizers, and pesticides [6,7]. However, the cost of controlling insects naturally is relatively high. In addition, more labor is necessary to implement organic farming and operate the farms, leading to higher production costs and loss of off-farm income [8]. Second, organic products can be sold at high prices owing to consumers' willingness-to-pay for better quality and healthier products [9]. However, organic farming often results in lower yields than conventional farming, especially during the transition period [2,10]. Lower output does not allow farmers to gain the income comparable to conventional farming. In addition, as organic production is often in small amounts, its marketing and distribution is not efficient. To maintain effective distribution channels, farmers have to incur additional costs. Third, despite growing demand for organic products, the market is still narrower compared to that for conventional products, especially for the underdeveloped regions. All these problems have led to ambiguity on whether or not organic farmers can be better off than conventional farmers, at least from an economic perspective.

The mountainous areas of Northern Vietnam are among the poorest regions of Vietnam, and their major inhabitants are ethnic minorities. In these areas, ethnic minority farmers have low levels of education. At the same time, weather conditions are severe while terrains are craggy. In order to earn a living, farmers have had a long tradition of conventional farming using chemicals, pesticides, and inorganic fertilizers. This farming practice brings about economic efficiency in the short run because of cheap inputs and high productivity. However, such exploitation has quickly caused the depletion of soils and degradation of trees, leading to low productivity and reduced economic efficiency in the long run. Since farmers in these areas are generally poor, economic motives are of paramount importance. Converting to organic production would probably help farmers to solve the above challenges to the economic sustainability. Specifically, organic farming provides local producers with great opportunities to sustain the farmers' incomes because of the following reasons. First, yields under organic practice are more stable than those under conventional ones [2,11]. Under conventional practice, due to intensive farming, soil nutrients are quickly exhausted while plants are easily degraded. In contrast, organic farming contributes to better preservation of soil due to lower level of runoff and erosion [12]. Soil under organic farming also has high organic matter content [13] and microbial biomass carbon [14], which releases nutrients from crop residues. In addition, organic farming helps to preserve water quality [15] because it prevents water contamination by chemicals and pesticides, induces less nitrate leaching [16], and results in less phosphorous losses [13]. Furthermore, organic practice reinforces sustainable biodiversity [17–19]. Second, the application of organic production means appropriate management of resources, brings about cost-effectiveness, and therefore leads to higher efficiency [20]. Third, the market for organic products has promising growth due to increased local demand, enhanced export prospect to developed countries, and higher return on investment [21]. The possible explanation is that organic products taste better, contain no pesticide residues and heavy metals [5], and have higher nutrients such as polyphenol content [22], vitamin C [23], and antioxidants [24]. Fourth, organic farming mitigates climate change via reduced greenhouse gas emissions [25], which affects production negatively. Finally, due to labor intensive requirements and non-use of synthetic chemicals, organic farming improves working conditions for farmers and provides healthy foods for the inhabitants in these areas [26]. Agricultural chemicals sprayed on the plants can last for years and are extremely harmful to farmers' health via contaminated air, water, and foods. Therefore, organic farming results in better health via reduced exposure to chemicals and increased quality of food.

The tea sector has played an important role in Vietnam's agricultural development. Tea is grown in 40 out of 63 provinces with a total tea-producing area of approximately 130,000 hectares, with more than 400,000 households involved in tea production. However, the production of tea is mainly concentrated in the mountainous areas of Northern Vietnam, which account for 80 percent of the area. With more than 160 exporting companies, Vietnam has been able to export various kinds of tea. During the period 2012–2016, the average export revenue was 173 million USD per year [27]. Among exported tea, black tea accounts for 78 percent, while green tea and other tea products make up 22 percent. The price of exported tea is relatively low, approximately 1.67 USD/kg in 2016 [27]. This is lower than the world average because of low and unequal quality and safety reasons. Because of this, Vietnam tea is mainly exported to Pakistan, Taiwan–China, Indonesia, and Russia, while exports to the EU are very modest.

The mountainous areas of Northern Vietnam are characterized by the topography of mountains with the temperature, water quantity, and light conditions being suitable for tea production. In these areas, Thai Nguyen, Phu Tho, Ha Giang, and Lai Chau are among the major tea-producing provinces. Previously, tea production in the mountainous areas of Northern Vietnam was mainly carried out on a small scale and based on individual experience. This farming practice resulted in low productivity and uneven quality. However, in recent years, farmers have been increasingly aware of the consequences of conventional practice and the advantages of organic farming. With support from the government, farmers gradually shifted to organic production.

Organic tea is produced based on the topographical and climatic characteristics of each area. In addition, farmers must use seeds originating from the locality in order to make sure tea trees have strong resistance to the climate conditions, diseases, and insects. Therefore, organic tea products in the mountainous areas of Northern Vietnam are diversified. In addition, several specialties are produced in these provinces such as Shan tea in Ha Giang Province, Tam Duong tea in Lai Chau Province, and Tan Cuong tea in Thai Nguyen Province. This diversity helps the organic tea of the areas meet the consumers' demands in both domestic and international markets. In the domestic market, organic tea is mainly sold to the consumers who have high incomes. Organic tea not only contributes to improving farmers' income, solving the problem of unemployment, and reducing poverty in the region, but also helps Vietnam become the fifth largest tea exporter in the world.

Although the mountainous areas of Northern Vietnam have considerable potential for organic tea production owing to favorable natural conditions, increasing awareness among producers of environmental impact, and growing demand for healthier food, a large number of ethnic minority farmers are still reluctant to convert to organic tea farming methods. Some even returned to conventional farming after a few years of organic farming. The most important reason for such behavior is the perception that the benefits of organic farming do not exceed the costs of conversion. In other words, ethnic minority farmers are unsure if organic tea conversion really makes them economically better off when considering the benefits and costs of organic conversion.

Recognizing the potential benefits of conversion from traditional to organic tea farming, there has been a growing interest in organic tea farming from both supply and demand sides in Vietnam. Thus far, several studies have analyzed various aspects of organic conversion. Most such studies found that farmers in developed countries are more concerned about health and environmental issues, whereas farmers in developing countries focus on economic benefits. However, there is little consensus on whether organic tea farming results in higher income than conventional tea production when the opportunity costs of organic conversion are taken into consideration. Given the knowledge gap in the existing literature, this study is unique, in that no empirical study has been conducted in the mountainous areas of Northern Vietnam for the purpose of such comparison.

The objective of this study is to determine if organic tea farming brings about higher income than conventional tea farming in the underdeveloped mountainous areas of Northern Vietnam. To do so, this study adopts the following research objectives:

- It aims to systematize the theoretical foundation and empirical evidence on income difference between conventional and organic tea production.
- It aims to empirically compare the incomes of tea producing farmers under conventional and organic farming methods.

2. Literature Review

According to the adoption models of a new technology, farmers make decisions attempting to maximize their utility. In principle, farming households would only adopt a new technology if the expected value of benefits from the adoption exceeds the value of the benefits generated from current practices, at least in the long run. Although non-economic benefits play an important role in the conversion decision in developed countries, economic benefits have dominated the decision-making process in developing countries. To this date, the literature has discussed whether or not organic farmers can be economically better off than their conventional counterparts [28–30]. Despite the evident relationship between organic conversion and economic benefit in the existing literature, the nature and direction of such relationships have been potentially debatable.

From a theoretical perspective, converting from conventional to organic farming would probably lead to two opposite effects. On the one hand, organic farming increases profitability [31] and income for farmers [28,32]. First, organic production results in significant cost reduction due to lower input costs of pesticides, fertilizers, and fuels to maintain farms [33–35]. Second, organic products can be sold at higher prices than traditional farm produce due to consumers' willingness-to-pay for better quality products [5,29,36–88]. Third, subsidies also play an important role in the profitability of organic farms [39]. Finally, in the context of climate change, organic farmers are less vulnerable to natural risks [40] and can better adapt to the changing climate [41]. On the other hand, organic conversion is likely to result in the reduction of farmers' net incomes [42]. First, organic farming is subject to potential production risk, which includes lower yields [43] and productivity [34] in certain crops. This is due to the application of new production methods, lack of chemical stimulation, adoption of new management practices, and weed and pest outbreaks. Second, organic farmers are more likely exposed to price risks [44] due to underdeveloped markets for organic products. Although premium price is the most attractive factor for farmers, access to premium markets is limited in many developing regions. Third, the increase in producer price for organic products might be insufficient to compensate the increase in cost of production [8]. As organic farming is more labor-intensive [33], additional labor is needed to maintain a competitive yield [29]. In addition, the cost of certification and annual inspection would be significant, especially for small-farming households [45,46].

In the context of the mountainous areas, conventional production is widely applied. Under this farming system, farmers often use crossbreeds, which brings about high productivity, which is further boosted by inorganic fertilizers. Since crossbreeds are less resistant, farmers use chemicals to protect plants from insects and antibiotics to prevent diseases for plants. All these inputs are very cheap, and thus, affordable in the mountainous areas. The advantage of this farming practice is apparently low input cost and high productivity in the short run. However, this farming practice can lead to serious long-term economic (yield instability, decreased fertility, and volatile profitability), environmental (compressed soil, increased erosion, and decreased biodiversity), and social (negative health consequences) side effects [47,48].

Under an organic system, farmers must make efficient use of locally available resources. In the mountainous areas, local seeds are often used in order to ensure a certain level of resistance to environmental conditions. Unlike conventional farming, organic production uses such methods as soil cleaning, crop rotation, and biological pest control to prevent pest infestation. The use of bio-pesticides is not harmful to human health and crops, such as drugs derived from micro-organisms and herbs. In the context of the mountainous areas, there are several visible advantages of organic production. First, organic farming provides enhanced access to attractive markets [49] because the products can be easily sold to the consumers in the cities and exporting companies with high price (In the domestic market, the average price of conventional tea is 105,000 VND, while that of organic tea is 200,000 VND). Second, organic products are rich in nutrient contents and improve the quality of health [49,50]. This advantage is becoming increasingly important because of the increased number of farmers suffering from lung and liver cancers recently. Third, crop yields under organic systems are more stable, especially in risk-prone ecosystems [2]. Finally, organic farming contributes to the sustainable development via preservation of the environment [30]. However, several drawbacks and challenges of organic farming must be addressed [51]. First, the crop productivity is often lower than that in conventional farming in the short run due to the use of local seeds and absence of synthetic fertilizers and pesticides. Second, the mountainous areas have a humid season. In this case, crops face diseases, bacteria, and germs. Third, the cost of natural methods of pest control are often higher than that of conventional farming. Fourth, since organic products are only suitable for people with high income, the market for organic products is not developed in the mountainous areas. Finally, there is a lack of consumers' belief in whether or not the products are really produced in an organic way. In many cases, consumers are often confused by labels and indications which seem to be organic but are actually not.

In terms of marketing, the distribution channel under conventional production is more diverse than that under organic production. First, a large portion of conventional products is sold to the region—mainly sold directly to the consumers. The majority of consumers are people who live in the mountainous areas. Second, another portion is sold to the consumers in the cities, mainly through merchants. Third, the rest of the conventional products are exported through exporting companies. However, major importing destinations are those developing countries whose quality requirements are easy and not strict. In contrast, organic products are usually not sold in the mountainous areas because of high price. First, a portion of organic products are sold to the cities, mainly through retail channels. The majority of consumers in the cities are those who have high incomes. Second, another portion is often sold to the manufacturing companies in the form of raw materials. Third, the rest of organic products are exported through the exporting companies. However, the organic products do not meet strict standards regarding fertilizer and chemical use set by importers in the developed countries.

Owing to the offsetting nature of these two effects, no determinate prediction can be made regarding the income effect of organic conversion. Such theoretical ambiguity has led to several empirical attempts at resolution [52–54]. These empirical studies can be classified into three groups. The first group of studies states that organic farming households are economically better off than their conventional counterparts [32,33,55]. For example, Galnaitytė et al. [55] found that organic farming practices achieve higher profitability and greater energy efficiency. In addition, higher values of benefit to cost ratio and lower value of total cost of production in organic rice production imply that organic farm management showed more economic improvements than the conventional rice production system [56]. Conversely, the second group of studies found opposite results. For example, Lien et al. [54] found that the organic farming was less economically sustainable than the conventional practice, especially when the organic price premiums and organic area payments were to be phased out. In addition, Zhang et al. [42] found that the net income per ha was 25% lower in organic farming than the conventional soybean production system. Interestingly, the last group of studies indicated that whether organic farming households are economically better off than conventional farming households depends on specific circumstances. For example, Delate and Cambardella [57] demonstrated that organic and conventional soybean yields were similar in the first three years of transition. According to Binta and Barbier [30], organic farming is economically more attractive to farmers in the Niayes than the conventional counterpart, only when a premium price is applied to organic crops. Forster et al. [53] found different outcomes; while soybean gross margin was significantly higher in the organic system than the conventional systems in India, it depends on the cycle of other crops. Therefore, our extensive review of the literature suggests that the income effect of organic conversion is an empirical issue.

Based on extensive review of the literature, we designed our study in a way that differentiates it from previous ones in two important aspects. First, when comparing the incomes of conventional and organic tea farmers, we take into account the opportunity costs of organic tea production. As the opportunity costs of organic tea farming are relatively high, ignoring them would lead to biased and inaccurate estimates. Second, instead of using total income from tea as a unit of measurement, we opt for average income per 1000 m^2, as there are great variations in land areas used for tea growing in this region.

3. Methodology

This study aims at estimating the average treatment effect (ATE) of conversion to organic tea production on household income. However, the most challenging task in estimating such a treatment effect in observational studies is that the assignment to treatment is not random. In experimental studies, participants can be randomly allocated to control or treatment groups. However, in most social science-related research with observational data, individuals often "self-select" into the treatment [8]. In this study, farmers are not randomly assigned to produce tea conventionally or organically. Instead, certain number of farmers are more likely to voluntarily choose organic tea production than are others. In the case where assignment to the treatment is not random, simply comparing the outcome variable between the two groups can lead to potential bias estimate because it ignores some underlying factors that affect both assignment to the treatment and the outcome variable. For instance, if the level of education of farmers is correlated with both conversion to organic production and farm household income, the difference in farm household income between the two groups of farm households may be attributable to both the treatment status, that is, organic or conventional, and educational attainment.

An alternative method to estimate the ATE, which has been widely recognized in social science research, is to match observations in both the treatment and control groups based on some observable characteristics. Several "matching estimators" have been put forward based on the method used to match observations from the two groups. Rosenbaum and Rubin [58] proposed the propensity score, according to which we can employ predicted probability of being in the treatment estimated in either the logit or probit models. An important feature of the propensity score model is that it summarizes the information contained in the multi-dimensional vector into a single-index variable [59].

To overcome the problem of self-selection bias, we employ a framework with two potential outcomes Y^1—an outcome for converting (treated) households, and Y^0—an economic for non-converting (control) households. The observed outcome for any individual household i can be written as $Y_i = T_i \cdot Y_i^1 + (1 - T_i) \cdot Y_i^0$, where $T \in \{0, 1\}$ indicates treatment status, with $T = 1$ if a household converted to organic tea production. The gain/loss of individual household i from converting to organic tea production is $\Delta_i = Y_i^1 - Y_i^0$. Since we cannot observe both outcomes for individual household i, estimating the individual household treatment effect i is impossible. Therefore, we need to concentrate on (population) average treatment effects (ATEs), as displayed in Equation (1) [60]:

$$ATE = E\left(Y_i^1 - Y_i^0\right) \tag{1}$$

The most popular evaluation parameter is the "average treatment effect on the treated" (ATT), which in our context represents the difference between the expected economic performance and viability outcomes of converting households and non-converting households had they converted. Algebraically, this can be presented in Equation (2):

$$ATT = E\left(Y_i^1 \middle| T_i = 1\right) - E\left(Y_i^0 \middle| T_i = 1\right) \tag{2}$$

In practice, observing $E\left(Y_i^0 \middle| T_i = 1\right)$ in Equation (2) is not possible. A household has either converted or not converted; treatment assignments are mutually exclusive. Estimating the ATT associated with adoption of organic tea production for households that converted by comparing the mean difference between $E\left(Y_i^1 \middle| T_i = 1\right)$ and $E\left(Y_i^0 \middle| T_i = 1\right)$ will result in serious errors due to selection bias. To overcome this problem, we opt for propensity score matching (PSM) as the best procedure. In impact evaluation, if the covariates have many dimensions, individual matching on the basis of observed covariates may not be feasible. Thus, matching along the propensity scores can provide better results than matching along the covariates. The effectiveness of PSM depends on two assumptions: conditional independence and common support.

First, according to the conditional independence assumption (CIA), selection into the adoption group is solely based on observable characteristics. Given the values of some observable covariates, this assumption implies that the value of the outcome variable is independent of the treatment state. This means that the household's income should be independent of the adoption of conversion assignment. Therefore, the outcomes for adopters and non-adopters of organic tea production are independent of the treatment status: $Y^0,\ Y^1 \perp T \middle| P(X)$ where $\perp$ denotes independence [61–65].

Second, according to the common support assumption (CSA), ATT is only defined within the region of common support. It also assumes that no explanatory variable predicts the treatment perfectly. Common support also assumes that the probability of being treated (given covariates X) falls between

0 and 1, $0 < P(T = 1|X) < 1$. Under the CIA and CSA, the PSM estimator for the ATT can be written as shown in Equation (3):

$$\begin{aligned} \tau_{ATT}^{PSM} &= E\left[Y_i^1 - Y_i^0 \middle| T_i = 1\right] \\ &= E\left\{E\left[Y_i^1 \middle| T_i = 1, P(X)\right] - \left[Y_i^0 \middle| T_i = 0, P(X)\right] T_i = 1\right\} \end{aligned} \tag{3}$$

A post-matching balancing test was carried out to ensure that the covariates balancing property was satisfied. This test involved comparisons of the characteristics of participating and non-participating households (adopters and non-adopters) before matching, and an evaluation of whether any significant differences in the characteristics of the two farming groups were revealed after matching. Once the post-matching balancing test was completed, the participating and non-participating households were matched on the basis of estimated propensity scores, which were used to derive the impact of conversion to organic tea production on the households' income.

4. Data

4.1. Study Areas

In this study, we selected the four provinces of Thai Nguyen, Phu Tho, Ha Giang, and Lai Chau. These provinces were chosen because they are among the largest provinces in Vietnam in terms of tea production. A brief introduction of each of the provinces is presented below:

Ha Giang is the third largest province in Vietnam in terms of tea production, just after Lam Dong (Lam Dong province is located in the Central Highlands of Vietnam. Therefore, it was not included in our sample) and Thai Nguyen provinces. According to the Ha Giang Statistics Office, by 2017, the total tea-producing area was approximately 18,231 hectares with the total fresh tea output of more than 67 thousand tons [66]. The average yield is 3.72 tons per hectare. In Ha Giang, tea is mainly grown in five rural districts of Bac Quang, Quang Binh, Vi Xuyen, Hoang Xu Phi, and Xin Man. These places have a cool climate, abundant fresh water, and mountainous foggy terrains, which are suitable for tea production. At present, Ha Giang province has 1720 hectares of certified organic tea. Organic tea products are processed for consumption in the domestic markets and such international markets as Taiwan–China, Russia, and Germany, while raw materials are mainly exported to China and India.

Lai Chau is the fifth largest province in Vietnam in terms of tea production. According to the Lai Chau Statistics Office, the total tea-producing area is approximately 4976 hectares with a total output of approximately 27,486 tons. The average yield is 9.58 tons per hectare [67]. By 2017, the province has 200 hectares of certified organic tea. The weather in Lai Chau is cold and frosty, which is suitable for developing concentrated areas of tea production with high quality such as Shan tea. Taking advantage of land and climate, this province has expanded its tea-producing areas to numerous districts such as Tan Uyen, Than Uyen, Tam Duong, Phong Tho, Sin Ho, and Nam Nhun. Lai Chau tea is sold in domestic markets such as Hanoi and Hai Phong. It is also exported to the Middle East, China, and Pakistan.

Phu Tho is the fourth largest province in Vietnam in terms of tea production. According to the Phu Tho Statistics Office, by 2017, the total tea-producing area was approximately 15,534 hectares with a total tea output of 172,742 tons [68]. The average yield is 11.1 tons per hectare. The province is characterized by sub-tropical and humid climate, which is suitable for producing various varieties of tea. In this province, tea is widely grown in such districts as Thanh Ba, Ha Hoa, Doan Hung, Thanh Son, Tan Son, and Yen Lap with high-quality varieties such as LDP1, LDP2, and PH11. In the areas which are suitable for growing organic tea, the province has built models of organic tea production in such districts as Thanh Son, Ha Hoa, Doan Hung, Thanh Ba, Tan Son, and Phu Ninh. So far, the province has 153.3 hectares of certified organic tea. Phu Tho tea is famous in domestic markets and exported to many countries in the world, including India, China, Pakistan, Germany, USA, and the Netherlands.

Thai Nguyen is ranked second in terms of tea area and total output in Vietnam. According to the Thai Nguyen Statistics Office, by 2017, the total tea-producing area is approximately 21,649 hectares with the total output of approximately 224,780 tons [69]. The average yield is 11.4 tons per hectare. Thai Nguyen has various varieties of tea such as Tan Cuong tea, La Bang tea, and Trai Cai tea due to the mixture of climate in the mountains and the midlands. There are 15 models of organic tea in Thai Nguyen including the districts of Dai Tu, Dong Hy, Dinh Hoa, Vo Nhai, Pho Yen, and Phu Luong. The province has 735 hectares of certified organic tea. Thai Nguyen tea is sold in both domestic and international markets, with 70 percent of the local market consuming green tea and specialty green tea. Only 30 percent of the processed tea is exported. The main importers of Thai Nguyen tea include countries in the Middle East, Asia, and Eastern Europe.

4.2. Sampling

In this study, quantitative data were collected from a sample survey, which includes 545 tea-producing households in the provinces of Thai Nguyen, Phu Tho, Ha Giang, and Lai Chau. Specifically, our sample consists of 72 households in Lai Chau, 234 households in Thai Nguyen, 71 households in Phu Tho, and 168 households in Ha Giang. Originally, all of these households followed conventional tea production. Among them, 319 households converted from conventional to organic tea production and 226 households remained conventional. This study chose the above provinces because they were among the most important in terms of tea production in Vietnam. For each province, we selected the commune with the largest number of tea growing households. For the purpose of unbiased comparison between conventional households' and organic households' incomes, the sample was then selected randomly from a list provided by the commune authority. The effects of farm size, tea cultivating experience, etc. on household incomes were eliminated via the Probit model, which was used to estimate the propensity scores. This procedure allowed us to purely compare the net incomes of conventional households and that of organic households without worrying about other factors that might affect the net income. In addition, the average income per 1000 m^2 wasused because there were considerable variations in tea-producing areas in this region. The survey was conducted between May and August 2015. To obtain the most accurate information, interviews were conducted with the household heads or the second most important household member. A standardized and structured questionnaire was used for 545 households to capture the characteristics of households and householders (e.g., age, educational level, farm labor supply, agricultural experience, and knowledge), assets (e.g., land area and livestock holdings), tea production statistics (e.g., inputs and outputs), and government supports. In addition, qualitative data about the motives behind and problems faced when converting to organic production were collected through large, heterogeneous group discussions.

Table 1 summarizes the variables used in the estimates and their definitions.

Table 1. Definition and measurement of independent variables.

Variable	Definition and Measurement
Income	The household's net income per ha per month, 000 VND
Farm size	Upland area used for tea cultivation, measured in hectares
Farm labor supply	The total number of working adults in each household
Gender of household head	Dummy variable that takes the value of 1 if the household head is male, and zero otherwise.
Age of household head	Age of only household head, measured in years
Education level of household head	Number of years in schooling
Education level of household head square	Number of years in schooling square
Culture	Dummy variable that takes the value of 1 if the household head belongs to the ethnic Kinh group, and zero if the household heads belongs to other ethnic minority groups (Vietnamese majority Kinh and ethnic minority groups represent two distinct cultural systems).

Table 1. *Cont.*

Variable	Definition and Measurement
Participation in training programs	Dummy variable that takes the value of 1 if the household head has participated in organic farming training programs, and zero otherwise.
Tea cultivation experience	Number of years spent cultivating tea
Access to credit	Dummy variable that takes the value of 1 if the household has access to credit, and zero otherwise
Technological support	Dummy variable that takes the value of 1 if the household has access to technological support, and zero otherwise
Extension service support	Dummy variable that takes the value of 1 if the household has access to extension service support, and zero otherwise
Production contract	Dummy variable that takes the value of 1 if the household has a contract to sell organic tea products to the enterprise, and zero otherwise.

5. Results and Discussions

5.1. Descriptive Analysis

Table 2 displays the descriptive statistics of the variables for adopters and non-adopters of organic tea production. The adoption of organic tea production in mountainous areas of Northern Vietnam was quite high. The study shows that about 59% of the farmers interviewed applied organic tea production methods in their tea fields. Farmers used natural wastes such as compost to create soil pigments and use natural methods to control pests and weeds. The results indicated that the mean of farm size, age of household head, education, culture, participation in training programs, access to credit, technological support, extensive service support, and market access were significantly different between the adopters and non-adopters of organic tea production. Besides, while the mean of farm size, participation in training programs, access to credit, and market access were higher among the adopters of organic tea production than the non-adopters, the mean of age of household head, education, and extensive service support of non-adopters tended to be higher than that of adopters. Further, as the results revealed, some variables did not exhibit significant mean difference between adopters and non-adopters of organic tea production. However, there was a variation in the averages of these variables among the groups (Table 2).

Table 2. Summary of statistics for adopters and non-adopters of organic tea production.

	Adopters *N* = 319 (59%)		**Non-Adopters** *N* = 226 (41%)		**Mean Difference**	**Test Statistics (*t*-Value)**
	Mean	**SD**	**Mean**	**SD**		
Income	4778.555	1789.897	3772.15	1215.416	1006.405	−7.338 ***
Farm size	0.9213	1.006	0.326	0.557	0.595	−8.060 ***
Farm labor supply	2.893	1.105	2.858	1.074	0.035	−0.369
Gender of household head	0.909	0.288	0.867	0.340	0.042	−1.549
Age of household head	43.382	11.803	45.960	10.505	−2.578	2.628 ***
Education level of household head	6.251	3.941	8.296	2.118	−2.046	7.1083 ***
Education level of household head square	54.558	50.694	73.296	36.417	−18.738	4.755 ***
Culture	0.223	0.417	0.965	0.185	−0.742	25.073 ***
Participation in training programs	0.934	0.248	0.628	0.484	0.306	−9.634 ***
Tea cultivation experience	20.803	12.694	21.504	10.515	−0.702	0.682
Access to credit	0.611	0.488	0.473	0.500	0.138	−3.214 ***
Technological support	0.680	0.467	0.597	0.492	0.083	−1.997 **
Extension service support	0.765	0.425	0.606	0.489	0.159	−4.031 ***
Production contract	0.859	0.349	0.447	0.498	0.412	−11.359 ***

Source: The authors' calculations based on the survey data in 2016. Note: * significant at 0.1 level; ** significant at 0.05 level; *** significant at 0.01 level; SD denotes standard deviation.

The results show that the mean difference in farm size for adopters and non-adopters was 0.59 and was statistically significant at the 1% level. Among the adopters, 64.6% of the households cultivated below 1ha of tea (Table 3). Households with smaller farm sizes can easily mobilize labor force and organic inputs and meet other required organic regulations [70–72]. In addition, small farms are unlikely to take advantage of scale economies, and thus, tend to convert to organic farming to improve farm returns [73]. However, households that cultivate larger farms tend to adopt organic production methods, as compared to those with small tea fields. This could be because they have better opportunities to implement extensive farming technology [74]. In addition, the adoption of organic farming as a new production method requires significant capital investment and only larger-scale farmers can afford to pay for such production costs and relevant organic certifications [75–77]. There is also significant mean difference between adopters and non-adopters in terms of culture. The survey data revealed that there was higher adoption of tea organic production among ethnic minority groups than the Kinh group. Interestingly, about 77.74% of adopters were from ethnic minority groups, compared with 3.54% of non-adopters of organic tea production (Table 3). In the mountainous areas of Vietnam, households belonging to a culture with high power distance were more likely to adopt organic conversion because they accept a hierarchy where everybody has a place. Owing to little resistance from household members, the decision to convert from conventional to organic production was usually fast. Participation in training programs was higher among adopters of organic tea production. The mean difference (0.31) was statistically significant at the 1% level. Ninety-three percent (93.42%) of the adopters took part in training programs, while 62.83% of the non-adopters participated in these programs (Table 3).

Table 3. Results on farm size, culture, participation in training programs, access to credit, technological support, extensive service support, and production contract.

Characteristics		Adopters		Non-Adopters	
		Freq.	%	Freq.	%
Farm size	Above one hectare	113	35.42	5	2.21
	Below one hectare	206	64.58	221	97.79
Culture	Yes	71	22.26	218	96.46
	No	248	77.74	8	3.54
Participation in training programs	Yes	298	93.42	142	62.83
	No	21	6.58	84	37.17
Access to credit	Yes	195	61.13	107	47.35
	No	124	38.87	119	52.65
Technological support	Yes	217	68.03	135	59.73
	No	102	31.97	91	40.27
Extensive service support	Yes	244	76.49	89	39.38
	No	75	23.51	137	60.62
Production contract	Yes	274	85.89	101	44.69
	No	45	14.11	125	55.31

Source: The authors' calculations based on the survey data.

Access to credit was higher for adopters of organic tea production. About 61.13% of the households had access to credit among the adopters, whereas the figure for non-adopters was 47.35%. The mean difference for access to credit between adopters and non-adopters was0.14 and statistically significant at the 1% level. Moreover, access to extension service was also higher for adopters of organic tea production. Among the adopters, 76.49% of the households had access to extension service, while the figure for non-adopters was 39.38%. The mean difference (0.16) was statistically significant at the 1% level. Similarly, access to production contact was higher among adopters of organic production. The results showed that the mean difference in access to production contact for adopters and non-adopters was0.41 and was statistically significant at the 1% level. Lastly, adopters of organic tea production earned an average tea income of 4779 thousand VND/ha, while that of non-adopters was

3772 thousand VND/ha. It is evident that adopters generated 1,006 thousand VND/ha more than the non-adopters did. The mean difference in tea income for adopters and non-adopters was statistically significant at the 1% level.

As explained before, the important point is to control for the sample self-selection bias. In order to do so, we applied the PSM method, developed by Rosenbaum and Rubin [58]. We analyzed the effect of adoption of organic tea production according to the procedure used by Wang et al. [78]. First, the propensity score (p-score) was obtained using a probit model. Second, we applied three matching approaches to search for objects from the control group matching those in the treatment group. Third, the average effect of treatment on the treated group (ATT) was computed by comparing the different matching groups.

5.2. Estimation of Propensity Scores

It is not feasible to rely on the traditional method for conducting multi-dimensional matching [78]. To eliminate the potential sample selection effect, we carefully choose the observable characteristics that will compose the matching index [8]. As explained earlier, for many matching estimators, it is necessary to estimate a binary logit or probit model with the treatment status being the dependent variable. In this study, we use a binary probit model to assess the factors which affect the conversion to organic tea farming to test for the balancing property as discussed in Becker and Ichino [59]. The model specification was extremely important for ensuring that the matching procedure was valid. Table 4 presents the results of four different probit formulations. However, there are no such simple criteria for diagnosing the accuracy of the model specifications. Therefore, we applied one indirect diagnostic that was widely reported in the literature, namely, the area under the receiver operating characteristic (ROC) curve (AUC). The AUC indicator, which is widely used in the ROC, can provide accurate causal inferences. As a convention, an AUC with a value greater than 0.7 can be considered a good indicator that the model's specifications are appropriate [79]. In our study, the AUC exceeded 0.92 for all four models (Figure 1). Thus, the model specifications were appropriate for the study.

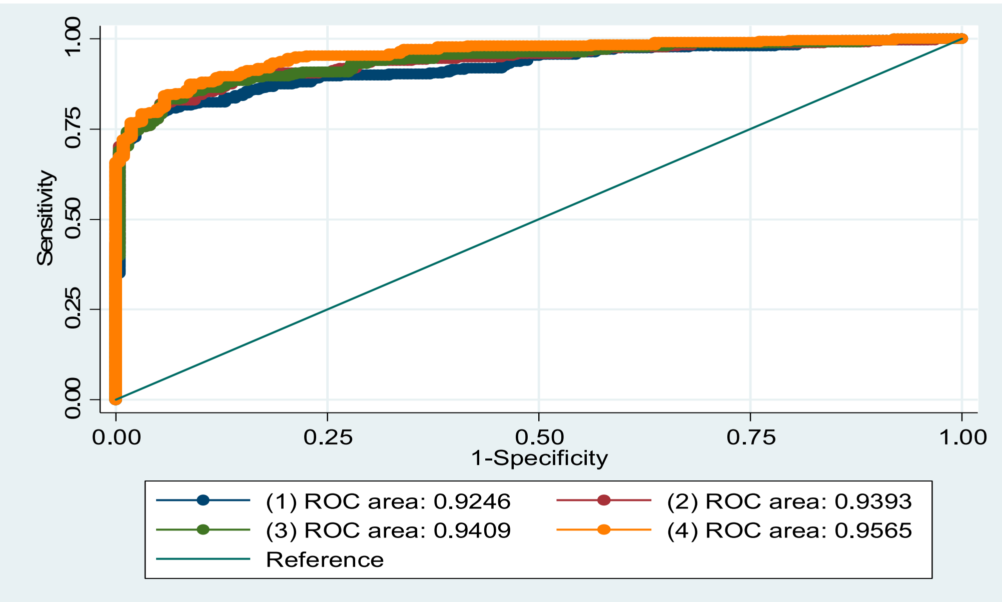

Figure 1. Area under receiver operating characteristic(ROC) curve in different model specifications.

There are parts of the characteristics variables for Models (1)–(3). Model (4), based on whole variables, had the highest AUC indicator. Therefore, this model could have greater influence on household behavior in the conversion to organic tea farming than other specifications, and was used to calculate the p-score in this study. The pseudo R^2 indicated that the model was able to explain 61.6% of the variability of the dependent variable. The Chi2 result of 445.76 and the corresponding test statistic ($p < 0.000$) implies that the included explanatory variables of the model were capable of explaining the farmers' propensity of adoption of organic tea production. Although not all coefficients were statistically significant, the covariates were retained in the model to calculate the most appropriate propensity score [80].

Table 4. Estimation of the propensity scores for conversion to organic tea farming.

Probit Specification	(1)	(2)	(3)	(4)
Farm size	0.209 *	0.305 **	0.320 ***	0.348 **
	(1.79)	(2.52)	(2.63)	(2.58)
Farm labor supply	−0.0226	−0.000115	0.0108	0.0604
	(−0.28)	(-0.00)	(0.13)	(0.68)
Gender of household head	0.419	0.300	0.278	0.234
	(1.51)	(1.05)	(0.98)	(0.78)
Age of household head	−0.0310 **	−0.0349 ***	−0.0356 ***	−0.0385 ***
	(−2.47)	(−2.74)	(−2.79)	(−2.79)
Education level of household head	−0.597 ***	−0.551 ***	−0.543 ***	−0.599 ***
	(−3.47)	(−3.22)	(−3.16)	(−3.18)
Education level of household head square	0.0298 ***	0.0267 ***	0.0262 ***	0.0282 **
	(2.95)	(2.64)	(2.58)	(2.57)
Culture	−2.104 ***	−2.248 ***	−2.301 ***	−2.451 ***
	(−10.34)	(−10.63)	(−10.71)	(−10.11)
Participation in training programs	0.734 ***	0.799 ***	0.805 ***	0.650 ***
	(3.76)	(3.97)	(3.97)	(3.06)
Tea cultivating experience	0.0181	0.0182	0.0174	0.0221 *
	(1.58)	(1.59)	(1.51)	(1.76)
Access to credit	−0.0122	0.329 *	0.449 **	0.615 ***
	(-0.08)	(1.81)	(2.27)	(2.78)
Technological support		−0.811 ***	−0.651 ***	−0.973 ***
		(−4.21)	(−3.03)	(−4.08)
Extensive service support			−0.375	−0.371
			(−1.63)	(−1.49)
Production contract				1.164 ***
				(6.11)
Constant	4.232 ***	4.590 ***	4.698 ***	4.536 ***
	(4.73)	(5.07)	(5.17)	(4.55)
Pseudo R^2	0.530	0.555	0.559	0.616
AUC	0.925	0.939	0.941	0.957
LR Chi2	391.98	410.68	413.37	445.76
N	545	545	545	545

Notes: The *t*-statistics are in parenthesis. The dependent variable was binary, with 1 denoting adoption of conversion to organic tea production and 0 denoting non-adoption of conversion to organic tea production. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Farm size, age of household head, education level of household head, education level of household head square, culture, participation in training programs, tea cultivation experience, access to credit, technological support, and production contract, significantly affected the probability of conversion to organic tea production. Farm size is positive and statistically significant at the 1% level. Our result is in line with Bolwig et al. [76] and Karki et al. [77]. The implication is that households cultivating larger farms tend to adopt organic production methods, unlike those with small tea fields. This could be because they have better opportunities to implement extensive farming technologies [74]. In addition, the adoption of organic farming as a new production method requires significant capital investment and only larger-scale farmers can afford to pay for such production costs and relevant organic certifications [75–77]. Moreover, the variable "Age of household head" has a significantly negative effect on conversion to organic tea production. This result indicates that older farmers have accumulated substantial experience in conventional practices; therefore, they find it difficult to give up such practices to switch to organic production methods. In addition, older farmers are generally more conservative than young farmers. Hence, younger farmers are more likely to convert to organic production. The results agree with the studies by Burton et al. [70], Shams and Fard [81], and Okon and Idiong [82] that younger farmers were dominant among organic farmers. Regarding the impact of the educational level of the head of household on the probability of adopting organic tea production, our quantitative analysis found that the coefficient of educational level of household head is negative and that of the squared educational level of household head is positive. The negative coefficient of educational level of household head was consistent with Sodjinou et al. [72]. As both coefficients are statistically significant, the impact of education on organic conversion exhibits a U-shape. To explain this, we use in-depth qualitative analysis, which reveals that the impact of education on farmers' conversion from conventional to organic tea farming was not straightforward. Better-educated farmers have higher abilities to convert to organic tea production (expertise effect), but simultaneously, these farmers are more cautious about conversion than are less-educated farmers (caution effect). In reality, farmers are often skeptical about the economic viability and sustainability of organic tea. As these two effects are offsetting, the net impact of education on conversion depends on the magnitude of each effect. At the low side of educational level, better-educated farmers are less likely to convert from conventional to organic tea production because the increase in "expertise effect" as a result of higher level of education is not high enough to outweigh the increase in the "caution effect". On the medium side of educational level, the impact of educational level on decision to convert is not clear because the increase in the "expertise effect" due to a higher level of education is cancelled out by the increase in the "caution effect." Conversely, on the high side of educational level, better-educated farmers are more likely to convert from conventional to organic tea production because the increase in the "expertise effect" outweighs the increase in the "caution effect."

The results show that the variable culture-dummy is significant and negative. This implies that households belonging to minority ethnic groups have a higher probability of converting to organic tea farming. Tea cultivating experience has had positive effect on conversion to organic tea production. Our finding corroborates that of Okon and Idiong [82], Paul et al. [83], and Larry [84] who found positive impacts of farming experience on organic conversion. Farmers who participate in training programs tend to have higher probability of converting to organic tea farming. This finding is similar to Zulfiqar and Thapa [85] and is supported by Karki et al. [77]. Credit access has a positive impact on conversion to organic tea farming. This is compatible with the findings of Sarker et al. [86]. Credit is necessary for the farmers to purchase productive inputs. Sometimes, given the necessary credit support, farmers are able to purchase productive farm inputs. Furthermore, high costs are a constraint to the adoption of agricultural technology. Thus, financial support helps to overcome any financial constraints faced by tea farmers in the first few years after conversion. Access to technical support is significant and negative. This suggests that farmers receiving technical support have a lower probability of conversion to tea organic farming than their counterparts do. This could be because the average school years of a household head is about seven years. Having production contracts has a significantly positive effect on conversion to organic tea farming. This is consistent with a study by Uematsu and Mishra [8], which indicates that the use of marketing strategies has a positive influence on the decision to convert to certified organic production.

5.3. Sample Matching Results

Before assessing the impact of conversion to organic tea production on households' income, the balancing properties of propensity scores must be checked to test whether or not a given characteristic has the same distribution for the treated and comparison groups at each value of the propensity score. The results of balancing hypothesis test are presented in Table 5.

Table 5. Balancing hypothesis test showing the variable characteristics before and after matching.

Variable	Unmatched / Matched	Mean Treated Group	Mean Control Group	Bias (%)	*t*-Value	*p*-Value
Farm size	U	0.921	0.326	73.2 *	8.06	0.000
	M	0.467	0.363	12.8	1.16	0.246
Farm labor supply	U	2.893	2.858	3.2 *	0.37	0.713
	M	2.809	3.065	−23.5	−1.87	0.063
Gender of household head	U	0.909	0.867	13.3	1.55	0.122
	M	0.918	0.942	−7.6	−0.70	0.487
Age of household head	U	43.382	45.96	−23.1 *	−2.63	0.009
	M	45.464	46.115	−5.8	−0.44	0.661
Education level of household head	U	6.251	8.297	−64.7 *	−7.11	0.000
	M	7.927	7.583	10.9	1.10	0.273
Education level of household head square	U	54.558	73.296	−42.5 *	−4.75	0.000
	M	68.727	62.297	14.6	1.26	0.208
Culture	U	0.223	0.965	−230.2 *	−25.07	0.000
	M	0.645	0.671	−7.8	−0.36	0.696
Participation in training programs	U	0.934	0.628	79.5 *	9.63	0.000
	M	0.845	0.851	−1.5	−0.12	0.906
Tea cultivating experience	U	20.803	21.504	−6.0	−0.68	0.496
	M	22.873	23.053	−1.5	−0.12	0.904
Access to credit	U	0.611	0.473	27.9 *	3.21	0.001
	M	0.427	0.592	−33.4	−2.47	0.014
Technological support	U	0.680	0.597	17.3 *	2.00	0.046
	M	0.5	0.523	−4.8	−0.34	0.732
Extensive service support	U	0.765	0.606	34.6 *	4.03	0.000
	M	0.536	0.568	−7.0	−0.47	0.636
Production contract	U	0.859	0.447	95.8 *	11.36	0.000
	M	0.664	0.665	−0.3	−0.02	0.984

Note: Radius matching was used for the balancing test. It performed relatively well across samples in terms of matching quality. * indicates that the difference between unmatched and matched variables was statistically significant at the 90% level. U and M are abbreviations of unmatched and matched samples, respectively.

Table 5 suggests that this finding is in accordance with the balancing hypothesis that significant differences generally do not exist between variables after matching. Thus, the balancing hypothesis was satisfied in this study. Table 6 displays statistical tests to evaluate the matching process. The propensity test reveals substantial reduction in bias resulting from the matching.

Table 6. Test of selection bias after matching.

Matching Algorithm	Mean Bias		% Bias Reduction	Pseudo R^2	
	Before Matching	After Matching		Unmatched	Matched
NN1	54.7	14.6	73.31	0.616	0.098
NN5	54.7	9.3	82.10	0.616	0.050
Kernel	54.7	24.1	55.94	0.616	0.324
Radius 0.02	54.7	12.3	77.51	0.616	0.069
Radius 0.05	54.7	10.1	81.54	0.616	0.044

Notes: NN1 and NN5 stand for the nearest-neighbor matching and five matching partners respectively.

According to the estimates, mean bias before matching was 54.7%. After matching, the mean bias reduced to a range of 9.3% to 14.6%. The percentage reductions are 82.10% and 81.54% for nearest neighbor 5 (NN5) and radius 0.05 matching methods, respectively. We noted that the percentage reduction in bias by all five matching methods was greater than 50%. As recommended by Rosenbaum and Rubin [58], this percentage reduction was considered a substantial reduction in bias. This implies that the matching substantially reduced the selection bias. Similarly, the pseudo R^2 of the estimated probit model was high before matching; however, it reduced significantly after matching. The results of common support assumption test are given in Figure 2.

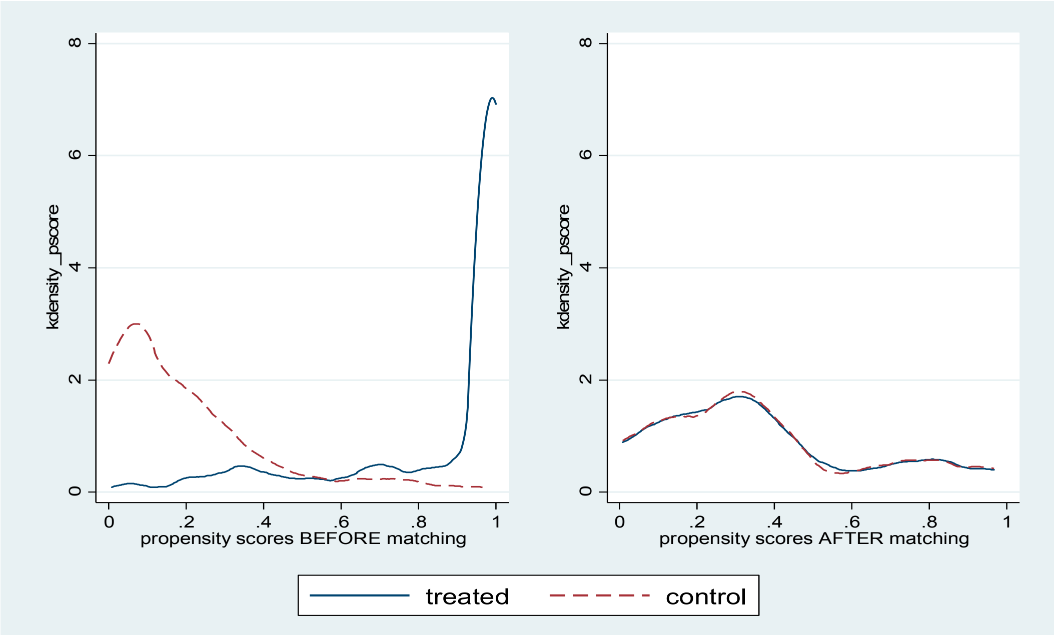

Figure 2. Common support assumption test for evaluating the densities of *p*-scores before and after matching.

Figure 2 shows the pre-matching and post-matching kernel density functions of the two groups. As the figures revealed, differences in the density functions of the two groups were highly significant prior to the matching procedure. After matching, the distribution density functions of the two samples became very similar, with an evident decrease in their deviations. This observation implies that the assumption of common support was satisfied in this study.

5.4. Impact of Conversion to Organic Tea Production on Households' Income

To check for robustness, we employed several matching algorithms. We first utilized the nearest-neighbor matching (NN1) with its replacement. However, the NN1 matching farm likely faces the risk of being a poor match if the closest neighbor is located faraway. To improve the matching quality, we also used radius matching with a caliper recommended by Dehejia and Wahba [61]. However, as discussed in Smith and Todd [62], it is difficult to know a priori reasonable tolerance level. We used the 0.02 and 0.05 caliper in this study. Because there were a large number of comparable untreated (nonparticipating household) observations in the sample, we also employed an oversampling with five matching partners (NN5) and kernel matching algorithms. We used the Gaussian kernel for kernel matching. The optimal bandwidth for the kernel function was selected, following the rule of thumb suggested by Silverman [87]. For each algorithm, the quality of matching outcomes was assessed based on a percent reduction of pseudo R^2 and mean standardized bias [65]. The quality of matching outcomes was evaluated for each matching estimator on the basis of a percent reduction of pseudo R^2, Chi-square, and mean standardized bias. The estimated treatment effects (ATTs) of organic tea conversion on households' income are presented in Table 7.

The results indicate that conversion to organic tea production tends to have a positive impact on household income. As the results revealed the estimated ATTs are positive and statistically significant at the 1% level across all matching techniques. We estimated that the households that adopted organic tea production had earned 1,038.838 to 1,059.016 thousand VND more average per hectare income than the non-adopters. This implies that conversion to organic tea production is crucial for increasing household income. This finding is consistent with the argument by McBride and Greene [88] who found that organic milk producers received an average price premium of $6.69 per hundredweight cwt. Similarly, McBride and Greene [89] posited that organic soybean producers received an average price premium of $9 per bushel despite lower yields and higher production costs. These findings are supported by Vasile et al. [90] and Kamali et al. [32].

Table 7. Estimated treatment effects of organic tea conversion on households' income.

Sample	Treated Group	Control Group	ATT	Std. Err.	*t*-Value
		NN1			
pre-matching	4778.555	3772.150	1006.405 ***	137.152	7.34
post-matching	4562.555	3518.472	1044.083 ***	276.038	3.78
		NN5			
pre-matching	4778.555	3772.150	1006.405 ***	137.152	7.34
post-matching	4562.555	3523.717	1038.838 ***	1038.838	4.17
		Kernel			
pre-matching	4778.555	3772.150	1006.405 ***	137.152	7.34
post-matching	4662.952	3603.936	1059.016 ***	277.480	3.82
		Radius 0.02			
pre-matching	4778.555	3772.150	1006.405 ***	137.152	7.34
post-matching	4562.555	3517.820	1044.736 ***	259.587	4.02
		Radius 0.05			
pre-matching	4778.555	3772.555	1006.405 ***	137.152	7.34
post-matching	4557.675	3513.489	1044.186 ***	257.206	4.06

Notes: * Significant at 10%; ** significant at 5%; *** significant at 1%.

6. Conclusions

Although organic farming is one of the most thriving segments in Vietnam today, consumers recently witnessed periodic shortages of organic products. This study aimed at assessing whether organic households were better off than conventional farmers in terms of farm household income in the mountainous areas of Northern Vietnam. This issue is of paramount importance both in terms of theoretical and practical contributions. From the theoretical perspective, this study is the first study on the impact of conversion to organic tea cultivation on household income in the mountainous areas of Northern Vietnam. The unique feature of our study is that when comparing the incomes of conventional and organic tea farmers, the opportunity cost is taken into account. From the practical perspective, the findings of the study would strongly encourage farmers to convert from conventional to organic tea production. In such an underdeveloped region with high poverty levels as the mountainous areas of Northern Vietnam, economic motives play a dominant role in the conversion from conventional to organic tea production. In contrast, non-economic factors such as health and environment problems are of lesser importance.

Primary data was collected from 319 adopters and 226 non-adopters of organic tea production in this area. Instead of the conventional parametric regression method, we employed a non-parametric approach and used different matching algorithms to estimate the average treatment effect of conversion to organic tea production on farm household income. This matching method allowed us to evaluate the marginal effect of conversion to organic production on the household income without either specifying functional forms or making distributional assumptions about the conditional distribution of the dependent variables.

The results indicated a significant difference in average per hectare income between adopters and non-adopters of organic tea production. Using different matching algorithms, households that adopted organic farming had earned a better average per hectare income than their non-adopting counterparts did. They earned 1038.838 to 1059.016 thousand VND more from a unit hectare of cultivation plot. This implies that the adoption of organic tea production had a positive impact on household farm income in the study area.

Therefore, to increase conversion to organic tea farming amongst smallholder farmers, the government and other stakeholders should provide better extension services, which incorporate relevant training to farmers and greater access to information on organic tea production, while making organic fertilizers easily available for farmers by encouraging commercialization of such fertilizers. Easier access to affordable credit is a policy option for enhancing technology adoption and conversion to organic tea farming, while aiming to increase tea production. Adequate financial support enables farmers to lease more farmlands and adopt improved farm technologies, which have consequential effects on both conversion to organic tea farming and increase in income. Lastly, the Vietnamese government should introduce mechanisms to coordinate production activities and the delivery of tea products by farmers to processing and/or marketing facilities. When efficiently organized and managed, contract farming reduces risk and uncertainty for both parties, in comparison to buying and selling tea on the open market.

The limitation of our study is that we have not explained the reasons why, on average, organic tea producing households are economically better off than conventional counterparts in the mountainous areas of Northern Vietnam. More specifically, our study has not indicated, on which circumstances, organic tea production leads to higher income in comparison with conventional farming. This knowledge gap provides rich opportunity for future research such as factors affecting income difference between conventional and organic tea production in the mountainous areas of Northern Vietnam.

Author Contributions: N.K.D. and N.T.T.T. developed the research idea. N.K.D. and H.Y. reviewed literature. N.T.T.T. formulated the research methodology. H.Y. provided suggestions for the whole study. All three authors have made equal contributions to constructing conceptual framework, collecting and analyzing data, and writing the manuscript. All authors were involved in revising and improving the manuscript according to the reviewers' comments. The revised manuscript was approved by all authors. We would like to express our sincere thanks to the reviewers for their precious comments on the manuscript.

Funding: This research was funded by NAFOSTED (National Foundation for Science and Technology Development, Vietnam).

Acknowledgments: This study was carried out under the project title "Factors Affecting the Transition towards Organic Tea Production in the Mountainous Areas of Northern Vietnam", which is financially supported by the NAFOSTED (National Foundation for Science and Technology Development, Vietnam) [Grant number II4.2-2013.42].

Conflicts of Interest: The authors declare no conflict of interest.

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