2528-9705

Örgütsel Davranış Araştırmaları Dergisi

Journal Of Organizational Behavior Research

Cilt / Vol.: 9, Sayı / Is.: 1, Yıl/Year: 2024, Sayfa/Pages: 98-112

https://doi.org/10.51847/zZnZml9tth

ECONOMIC AND ENVIRONMENTAL PERFORMANCE OF FARMS IN VIETNAM: DOES CONTRACT FARMING MATTER?

Mai Thi Xuan NGUYEN[1]*, Anh Thi Mai PHAM[1], Nguyet Hoang Minh LE[1], Khoa Dang NGUYEN[1]

[1]Faculty of Statistics, National Economics University, Vietnam.

*Corresponding Author
E-mail: mainx@neu.edu.vn

ABSTRACT

Implementing contract farming is considered to bring benefits to participating parties, especially farms/farming households. Many studies have shown the impact of participating in contractual arrangements on the welfare of farms/farming households, often in a region or small area and some typical agricultural production activities. The paper uses data from the Vietnam 2020 mid-term Rural and Agricultural Survey and the propensity score matching method to explore the impact of participating in contract farming on the economic and environmental performance of farms engaged in the cultivation of rice, annual crops, and perennial crops. The results reveal that the farm head's education level, the rate of outsourced labor on the farm, and the proportion of farm-owned land area affect the farm's decision to participate in contract farming. This impact varies between farms growing different types of crops and depending on the type of contract. In addition, farms in the South have a higher likelihood of participating in contractual arrangements than those in the North. The study also reveals that farms with contracts were found to have higher revenues and use less chemical fertilizer compared to farms without contracts.

Keywords: *Contract farming, Economic performance, Environmental performance, Propensity score matching.*

INTRODUCTION

Agricultural activities are crucial as the main livelihood for many people in the developing world. In Vietnam, half the population depends on agriculture for income (GSO, 2017), and 66% of rural households and 77% of poor households are actively involved in agricultural production (Ha *et al.*, 2015). However, the recent boost in agricultural productivity has led to intensified use of natural resources and agrochemicals (World Bank, 2016), causing environmental degradation and adversely affecting Vietnam's agricultural product quality reputation in global and local markets.

In response to these challenges, the Vietnamese government has implemented various policies to promote contractual relationships, known as contract farming (CF), between farmers and enterprises. Enterprises are driven to offer contracts by consumer quality demands and production scale economies; meanwhile, households are motivated to enter into these contracts due to factors like prices, access to key technology, and support services (Ton *et al.*, 2017). As per its design, CF is expected to enhance farm productivity and simultaneously reduce environmentally harmful practices.

Geliş tarihi/Recieved: 27.10.2023 – Kabul tarihi/Accepted: 20.02.2024 – Yayın tarihi/Published: 30.03.2024

Despite abundant empirical evidence showing the positive effects of CF on farm productivity and income (Bidzakin *et al.*, 2019; Dubbert, 2019; Liang *et al.*, 2023), there is limited understanding of its impact on farms environmental performance, and findings are often inconclusive. For example, Mishra *et al.* (2018), Ren *et al.* (2021), Gao *et al.* (2022), and Zhang *et al.* (2023) find that CF promotes environmental sustainability, while Dubbert *et al.* (2023) suggest that participation in contract farming impedes the adoption of sustainable farming practices.

This study aims to contribute empirical evidence on the effects of CF on the economic and environmental performance of farms producing rice, annual crops, and perennial crops in Vietnam, utilizing data from the 2020 mid-term Rural and Agricultural Survey and the propensity score matching method. The results of this study are not only pertinent to Vietnam but also hold relevance for other Asian countries with a significant portion of their population engaged in agricultural activities, such as China, Indonesia, and Myanmar.

Literature Review

Economic and Environmental Performance of the Farm

Farms, central to agricultural production, are significant contributors to environmental impacts (Repar *et al.*, 2017). Despite these environmental concerns, existing literature has primarily concentrated on assessing farms' economic performance.

DeBoe (2020) identifies various measures, including productivity, competitiveness, economic efficiency (technical and allocative), and financial profitability, for evaluating economic performance. Studies utilize different approaches such as single-factor productivity (Dubbert, 2019) or multi-factor productivity like TFP (Bureau & Antón, 2022). Benchmarking methods for assessing technical and allocative efficiency include parametric approaches like stochastic frontier analysis and non-parametric approaches like data envelopment analysis (Ait Sidhoum *et al.*, 2022). Coeli *et al.* (2005) assert that higher productivity or efficiency indicates better economic performance. Competitiveness, as Mechri *et al.* (2017) note, compares a farm's economic performance to others, considering it competitive even if not economically efficient. Sapolaite *et al.* (2023) conducted a profitability change decomposition, evaluating farm economic performance based on structural, activity, and intensity (efficiency) effects.

Interest in farms' environmental performance has risen since the early 2000s (Reinhard *et al.*, 2000; Repar *et al.*, 2017; DeBoe, 2020). Various methods exist for assessing a farm's environmental performance. Reinhard *et al.* (2000) define environmental efficiency as the ratio of minimum feasible to observed use of environmentally harmful inputs, contingent on observed levels of desired outputs and conventional inputs. DeBoe (2020) suggests evaluating environmental performance through farm-level environmental management strategies, specific production methods like conservation tillage, reduced input use, or measurable environmental benefits such as decreased nutrient runoff. For example, minimizing input use in farms, such as fertilizers, contributes to improved environmental performance.

Farms aiming to enhance productivity often resort to mechanization and increased use of fertilizers and chemicals, which can lead to environmental degradation and challenging working conditions (Bureau & Antón, 2022). Numerous studies have investigated the trade-off between the economic and environmental performance of farms.

De Boe (2020) contends that empirical studies at the farm level haven't established a simple relationship between economic and environmental performance in agriculture. However, certain factors, such as farm size, demand for environmentally differentiated goods, and the ability to respond proactively to external pressures, have been identified as positively impacting this link.

Jan *et al.* (2012) found no trade-off between economic and environmental performance in Swiss dairy farms, indicating that improvements in one aspect often lead to enhancements in the other. Ho *et al.*'s (2021) study on coffee farming in Vietnam showed that sustainability-certified farms outperformed non-certified ones in both economic and environmental aspects. Vogel's (2022) study in Brazil revealed that in dairy farming, improving environmental performance was possible by increasing outputs while reducing methane emissions without raising farm inputs; however, in lowland paddy field-based crop-livestock systems, a trade-off emerged as increasing inputs without appropriate crop rotation boosted production and profits but offered limited advantages in environmental performance.

Graham (2004) suggests that improving farmers' use of environmentally harmful inputs can lead to the simultaneous achievement of economic and environmental goals. However, DeBoe (2020) argues that participation in agri-environmental schemes is voluntary, and rational profit-maximizing farmers may refrain from participating if they perceive a compromise in their economic performance.

Contract Farming

Small-scale farmers often struggle to fully participate in the market economy (Eaton & Shepherd, 2001) due to limited information about production methods, market opportunities, and insufficient financial reserves from restricted access to credit (Bijman, 2008). The adoption of CF emerges as an effective solution to address these challenges, simultaneously reducing uncertainty for all involved parties (Bijman, 2008). Essentially, CF establishes a framework that promotes reliability and mutual benefit for both farmers and businesses in the agricultural supply chain.

While it is anticipated to have positive impacts on farm performance, empirical studies across various countries reveal differences in the effects of CF participation on the economic performance of farms. Numerous studies demonstrate favorable outcomes, such as increased productivity, technical efficiency, and income for farms engaging in CF (Ton *et al.*, 2018; Bidzakin *et al.*, 2019; Dubbert, 2019; Liang *et al.*, 2023). However, Minot and Ronchi (2014), drawing from research in developing countries, highlight higher income associated with CF only for high-value crops. Otsuka *et al.* (2016) conclude that CF positively impacts income from contracted products but has a smaller effect on total household income. Contrarily, Li *et al.* (2016) find that CF does not significantly increase farmers' income. Soullier and Moustier (2018) argue that marketing contracts have no impact on farm income, but production contracts positively influence the income of farms without access to state credit, as participating in a contract provides funding for production activities.

The existing research overview indicates a limited number of studies on the influence of CF participation on the farm's environmental performance. Dubbert *et al.* (2023) highlight the importance of considering the potential environmental impacts of CF, as it can contribute to increased cultivation of contract crops in terms of area and intensity of input applied. Research on small samples of baby corn farms in India, rice farmers, vegetable farmers, and tea farmers in China, conducted by Mishra *et al.* (2018), Ren *et al.* (2021), Gao *et al.* (2022), and Zhang *et al.* (2023), suggests that adopting CF results in a reduction in the use of chemical fertilizers and an increased likelihood of applying organic fertilizers. However, empirical results from Dubbert *et al.* (2023) show that participating in CF hinders the use of sustainable farming practices, whereas these practices contribute to soil preservation, environmental protection, and enhanced productivity.

Vietnam has implemented CF for over 20 years. However, the World Bank (2016) notes that cooperative forms and CF are less developed in Vietnam compared to other countries. The quality of CF links in Vietnam is low, with frequent disputes and contract breaches (Ho, 2013). Additionally, CF is not universally suitable for all product types (Ho, 2013) and may not be feasible for all farmers and businesses (Nhan & Yutaka, 2019). Despite existing challenges, Ho (2013) believes that one factor positively impacting business-farmer linkages is the economic efficiency of farmers, ensuring higher benefits for farmers than market mechanisms.

Research on CF in Vietnam often concentrates on evaluating the economic performance of rice production, particularly in the Mekong River Delta (Ba *et al.*, 2019; Nhan & Yutaka, 2019; Tuyen *et al.*, 2022). Overall, these studies suggest that CF participation positively influences a farm's economic performance, leading to increased income, profits, and technical efficiency. Hoang (2021), however, notes that in the short term, CF may not significantly impact farm income due to potentially equal or lower prices than the spot market, coupled with increased production costs; yet, in the medium to long term, CF participation positively influences income, sustainability, and welfare by enhancing farmers' competitiveness. Additionally, non-contract farmers often employ traditional methods with excessive inputs, while contract farmers, guided by businesses, adopt more efficient and sustainable practices, contributing to environmentally friendly agricultural products and environmental protection (Nguyen *et al.*, 2019).

MATERIALS AND METHODS

Data and Variables

This paper utilizes data from the 2020 mid-term Rural and Agricultural Survey conducted by Vietnam's General Statistics Office. Between the 10-year censuses, a mid-term survey synthesizes key indicators on rural areas and agriculture, collecting information from all countrywide farms.

As of July 1, 2020, the entire country had 20,611 farms, representing just 0.23% of the total number of agricultural, forestry, and fishery production households. Of these, 12,242 were engaged in cultivation. Within cultivation-focused farms, approximately 10% were owned by females, 5% by ethnic minorities. Regarding the owners' qualifications, 6.4% held college degrees, 12.3% had intermediate and elementary degrees, 32.7% underwent training (certified and non-certified), and 48.6% were untrained. Additionally, 61.4% of farms were located in the Southern region.

In Vietnam, CF involves signing agreements to sell main crop products before or after harvesting. The analysis focuses on two CF variables: participation both before and after crops, and participation before crops. Farms were categorized into three crop groups: rice, annual crops,

Örgütsel Davranış Araştırmaları Dergisi
Journal of Organizational Behavior Research
Cilt / Vol.: 9, Sayı / Is.: 1, Yıl/Year: 2024, Sayfa/Pages: 98-114

and perennial crops. The study aims to explore the impact of each scenario on the economic and environmental performance of farms involved in various cultivation activities.

We gauge economic performance by calculating the average revenue per hectare of harvested area. Environmental performance is evaluated by the average amount of chemical fertilizer used per hectare of harvested area. To enhance the analysis, control variables are included, such as the sex and age of the farm head, farm region, education level of the farm head, rate of outsourced farm labor, and the proportion of farm-owned land area. **Table 1** outlines these variables and their measurements.

Table 1. Variable description

Variable	Description
CF	Participating in CF. CF = 1: Having CF; CF = 0: Having no CF
CF1	Participating in CF before crops. CF1 = 1: Having CF before crops; CF1 = 0: Having no CF before crops
Revenue	Average revenue per hectare of harvested area (thousand VND/m2) = Revenue earned from selling the farm's crop products / harvested area
Fertilizer	Average amount of chemical fertilizer used per hectare of harvested area (kg/m2) = Amount of chemical fertilizer used/harvested area
Sex	Sex of farm head. Sex = 1: Male; Sex = 0: Female
Age	Age of farm head
Region	Region of farm. Region = 1: North; Region = 0: South
Edu1	Edu1 = 1: Farm head with a college degree or higher; Edu1= 0: Other
Edu2	Edu2 = 1: Farm head with elementary and intermediate education; Edu2= 0: Other
Edu3	Edu3 = 1: Farm head with training (certified and non-certified); Edu3= 0: Other
Empl	Rate of farm’s outsourced labor = Total number of farm’s outsourced workers / Total number of farm’s regular workers
Land_rice	Proportion of farm-owned rice land area = (Total farm's rice land area - Outsourced rice land area) / Total farm's rice land area
Land_annual	Proportion of farm-owned annual cropland area = (Total farm's annual cropland area - Outsourced annual cropland area) / Total farm's annual cropland area
Land_perennial	Proportion of farm-owned perennial cropland area = (Total farm's perennial cropland area - Outsourced perennial cropland area) / Total farm's perennial cropland area

Source: Authors’ suggestion.

Table 2 displays the percentages of farms with signed contracts (including both pre-and post-harvest) and those with contracts signed before harvesting, computed individually for each crop type and certain characteristics of farm owners.

Table 2. The percentage of farms engaged in contract farming

	Total		Rice		Annual plants		Perennial plants	
	Having CF	Having CF before crops	Having CF	Having CF before crops	Having CF	Having CF before crops	Having CF	Having CF before crops
Total	**18.5**	**15.0**	**30.1**	**24.9**	**24.5**	**20.2**	**15.8**	**12.4**
Sex of farm head								
Male	18.7	15.3	29.8	24.8	24.6	20.4	15.7	12.4
Female	16.0	12.6	35.3	26.9	23.8	18.2	16.1	12.8
Education level of farm head								
Colleges and above	22.1	18.1	26.7	19.8	23.0	17.7	23.9	19.1
Elementary and Intermediate	15.0	12.4	21.5	16.9	20.5	16.8	14.4	11.7
Trained	19.9	15.8	31.9	27.5	24.7	21.0	17.7	13.1
No education	17.9	14.7	30.4	24.8	25.4	20.7	13.5	11.1
Region								
North	4.9	3.6	4.4	3.6	5.2	4.2	5.5	3.9
South	27.0	22.2	41.9	34.7	39.2	32.4	22.7	18.2

Source: Authors' calculations.

Survey results reveal that, despite constituting only around 10% of farms involved in cultivation, female-owned farms exhibit CF participation rates comparable to those of male-owned farms. Notably, in rice production, the proportion of female-owned farms engaged in CF is slightly higher than that of male-owned farms. Examining educational backgrounds, although representing only 6.4% of the total, farms with heads holding a college degree or higher demonstrate a relatively high CF participation rate (22.1%). Similarly, farms with trained owners show a 19.9% participation rate, while farms with untrained heads, constituting nearly half of the total, participate at a rate of only 17.9%.

Significant regional disparities in CF participation exist between the North and South of Vietnam. While the South accounts for 61.4% of all farms with cultivation activities, a substantial majority of contracted farms are located in the South. Specifically, 95.4% of rice-growing farms under contract are in the South, along with 90.8% for annual crop farms and 86% for perennial crop farms. **Table 2** indicates that in the North, only around 4.4% of rice-growing farms, 5.2% of annual crop farms, and 5.5% of perennial crop farms have signed contracts. In the South, these rates are significantly higher at 41.9%, 39.2%, and 22.7%, respectively.

Table 3 presents descriptive statistics for two outcome variables: average revenue and average amount of chemical fertilizer used per hectare of the harvested area for farms with different CF statuses and across various types of crops.

Table 3. Descriptive statistics

Variable	Having no CF		Having CF		Having CF before crops	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Rice						
Fertilizer	0.097	0.728	0.064	0.099	0.062	0.089

Revenue	3.149	3.656	4.530	2.889	4.640	2.560
Annual plants						
Fertilizer	0.120	1.215	0.070	0.136	0.068	0.127
Revenue	7.081	35.503	8.112	32.038	8.147	28.507
Perennial plants						
Fertilizer	0.213	2.713	0.262	1.500	0.269	1.671
Revenue	25.203	52.623	40.100	38.125	41.969	39.976

Source: Authors' calculations.

Table 3 highlights differences in fertilizer usage between contracted and non-contracted farms, as well as between farms with contracts before crops and those without. As discussed in Part 2, the emphasis on sustainable agriculture and increasing consumer demands for product quality often leads to restrictions on potentially harmful inputs, such as chemical fertilizers. Consequently, farms involved in contracts, especially before harvest, must comply with their partners' regulations, including terms on input usage, resulting in reduced fertilizer use.

Conversely, the average revenue per hectare of the harvested area is higher for farms with contracts than those without. Farms with contracts before crops experience slightly higher average revenue than those with contracts. This difference is attributed to contracted farms often securing better output prices, avoiding situations of poor harvest prices. Moreover, adhering to safety and hygiene standards in agricultural production enhances the quality and selling price of products, contributing to higher revenues compared to conventional cultivation.

Method

To test whether CF matters to farms' economic and environmental performance, we use the propensity score matching (PSM) method. The reason for using this method is that participating in contractual arrangements is a self-selection, resulting from both observable and unobservable reasons. It would be the case that a more capable farmer may participate in contractual activities while others do not. Thus, simply comparing the outcome of farms with and without contracts may be misleading due to the selection bias. The PSM method aims to create farms, which are comparable in terms of propensity scores, conditional on farms' observable characteristics. It should be noted that PSM can reduce, but not eliminate, biases generated by unobservable confounding factors, i.e., the variables that affect both farms' outcomes and the possibility of signing contracts.

To apply the PSM method, we divide farms in the sample into two categories: farms with CF (treatment group) and farms without contractual arrangement (control group). Let Y_i denote the outcome of interest of farm i. The outcome would be Y_{1i}^C if the farm has a contract and Y_{0i}^C if it would not participate in contractual arrangements. The difference in the outcome for farm i from having contracts and in the case of not signing contracts is:

$$\Delta_i = Y_{1i}^C - Y_{0i}^C \quad (1)$$

With the cross-sectional data, Y_{0i}^C can not be observed. Estimating the individual farm treatment effects, thus, is impossible and one has to estimate the average treatment effects (Caliendo & Kopeinig 2008). The average treatment effect on treated (ATT) is identifiable as in equation (2):

$$ATT = E(Y_1^C) - E(Y_0^C) \quad (2)$$

The problem of estimating (2) is that the outcome of a farm if it would not have contracts cannot be observed. A solution for this is to replace it with a farm without contracts. Thus ATT can be identified by:

$$ATT = E(Y_1^C) - E(Y_0^{NC}) \quad (3)$$

where Y_0^{NC} is the outcome of farms without contracts.

If farms are randomly drawn from the population, then $E(Y_1^C) = E(Y_0^{NC})$. However, participating in contractual arrangements is a decision process that depends on farm characteristics, leading to $E(Y_1^C) \neq E(Y_0^{NC})$.

This problem is known as the selection bias and can be solved by the PSM. The method applies a matching procedure to match control farms, which have similar propensity scores ('i.e.', the probability for a farm to participate in a contractual arrangement given its observed characteristics) as that of the treated. To estimate the propensity scores for each farm, a probability model (either logit or probit) is applied. Independent variables of the logit/probit models are a set of farms' characteristics (X) that are correlated with the farm's decision to sign contracts but not influenced by this activity. In this study, X is a set of variables that reflect the characteristics of farms and farms' heads.

To match the treated and control farms, the matching procedure divides the sample into several blocks based on the estimated propensity score such that the mean propensity score is not different within each block. Different PSM methods use different ways to match treated units (farms with contracts) to control units (farms without contracts). In our study, we use Nearest-Neighbor Matching to estimate the average treatment effect of CF on farms' economic and environmental performance. Then, the group of farms without contracts is selected to include farms with a propensity score close to the propensity score of farm i in the group with contracts. The estimated ATT depends on the quality of the matching procedure which, in turn, depends on the balancing condition. As stated in Caliendo and Kopeinig (2008), the balancing condition requires the distribution of observed covariates of treated and control units to be the same, given their balancing scores. To test this condition, this paper uses a t-test to compare the mean of the treatment and control groups.

RESULTS AND DISCUSSION

Using the PSM method, we can consider two groups of farms with and without contracts to have the same characteristics. CF participation is subdivided into two scenarios: having contracts (both before and after crops) and having contracts before crops. This analysis will be conducted separately for farms engaged in rice cultivation, annual crops, and perennial crop activities.

Factors Influencing the Possibility of Having Contracts

First of all, the propensity score is estimated using the probit model. The results are documented in **Table 4**.

Table 4. Participation in contract farming or contract farming before crops

	Rice		Annual plants		Perennial plants	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Participation in contract farming						
Age	-0.0001	0.0026	0.0021	0.0031	0.0050	0.0030
Sex	-0.0927	0.1046	-0.0887	0.1201	-0.0084	0.0917
Region	-1.2872	0.0933***	-1.1409	0.0882***	-1.0284	0.0812***
Edu1	0.2374	0.1666	0.5434	0.1520***	0.5680	0.1055***
Edu2	0.1350	0.1110	0.2445	0.1095**	0.1462	0.0899
Edu3	0.0125	0.0538	0.1465	0.0634**	0.2844	0.0676***
Empl	-0.5836	0.0797***	-0.4351	0.0891***	0.0591	0.0849
Land	-0.1758	0.0918*	-0.1749	0.0910*	-0.6403	0.0871***
Constant	0.1962	0.1821	-0.0434	0.2032	-0.6006	0.1966***
	N = 2,839		N = 2,197		N = 3,145	
	LR chi2 = 280.65		LR chi2 = 222.68		LR chi2 = 239.51	
	Prob > chi2= 0		Prob > chi2= 0		Prob > chi2= 0	
	Log likelihood = -1733.393		Log likelihood = -1302.2709		Log likelihood = -1293.7699	
Participation in contract farming before crops						
Age	-0.0015	0.0027	0.0007	0.0032	0.0048	0.0033
Sex	0.0209	0.1084	0.1999	0.1301	0.0132	0.0992
Region	-1.2324	0.0999***	-1.1253	0.0941***	-1.1486	0.0930***
Edu1	0.2094	0.1727	0.5327	0.1570***	0.4638	0.1127***
Edu2	0.1068	0.1151	0.3289	0.1124***	0.0952	0.0968
Edu3	0.0576	0.0550	0.1852	0.0654***	0.1009	0.0738
Empl	-0.6443	0.0831***	-0.5708	0.0936***	-0.0459	0.0913
Land	-0.1805	0.0948*	-0.2217	0.0947**	-0.8726	0.0966***
Constant	-0.0303	0.1875	-0.3832	0.2133*	-0.4876	0.2124**
	N = 2,839		N = 2,197		N = 3,145	
	LR chi2 = 244.23		LR chi2 = 203.85		LR chi2 = 220.45	
	Prob > chi2= 0		Prob > chi2= 0		Prob > chi2= 0	
	Log likelihood = -1630.6101		Log likelihood = -1205.34		Log likelihood = -1089.9497	

Significant at the 10% level (*), 5% level (**), 1% level (***).
Source: Authors' calculations.

The estimation results, as presented in **Table 4**, highlight several noteworthy relationships. Notably, the education level of the farm head, labor utilization on the farm, and the farm's land size exert a discernible influence on the decision to engage in CF. This aligns consistently with findings from various studies (Swain, 2012; Rondhi *et al.*, 2020; Taslim *et al.*, 2021).

The education level of the farm head exhibits a positive impact on the decision to sign a contract, except in the case of farms with rice-growing activities. Specifically, farm heads with a college degree or higher influence the decision to participate in CF and CF before crops for annual crops and perennial crops farms. However, farm heads with intermediate and elementary degrees only influence participation in CF in annual crop farms. For perennial crop farms, the education level of farm heads being trained did not affect their participation in contracts before crops. Generally, a higher education level of the farm head correlates with a greater likelihood of signing a contract.

This can be attributed to the fact that well-educated farm heads are more likely to understand the benefits of CF, enabling them to make informed decisions (Taslim *et al.*, 2021). Their educational background equips them to comprehend contracts, and contract terms, and engage in more effective negotiations (Bidzakin *et al.*, 2019). Moreover, businesses prefer collaborating with farmers with higher education levels, assuming they are more innovative and productive (Swain, 2012).

The use of labor on the farm, represented by the variable "rate of farm's outsourced labor," exhibits a significant negative impact on participation in CF or CF before crops for farms engaged in rice and annual crop growing activities. In simpler terms, as these farms increase their reliance on outsourced labor, the probability of signing a contract decreases. This finding aligns with Taslim *et al.* (2021) assertion that farmers predominantly involved in CF often rely on family labor.

The farm's land size, indicated by the proportion of farm-owned land area planted to each crop group, also shows a significant negative impact on the farm's participation in CF or CF before crops across all three crop groups. This implies that as the proportion of farm-owned land area increases, the likelihood of farms participating in CF decreases.

Regional factors in Vietnam significantly influence contract signing in all farm types. Farms in the South show a higher probability of participating in CF compared to those in the North. This result aligns well with the findings discussed in the previous section, indicating a higher prevalence of contract signing in the South.

Conversely, the variables of age and gender of the farm head are not significant in any case. This is in line with the existing experimental study conducted by Rondhi *et al.* (2020).

Impacts of Contract Farming on Farms' Economic and Environmental Performance

Next, we utilize the estimates for the effects of the average treatment on the treated (ATT) to assess the impact of participating in CF on outcome variables presented in logarithmic form. The results are detailed in **Table 5**.

Table 5. Impact of participating in contract farming on revenue and chemical fertilizer usage in farms

	CF				CF1			
	Treated	**Controls**	**S.E.**	**Tstat**	**Treated**	**Controls**	**S.E.**	**Tstat**
Rice								
lnRevenue	1.431	1.379	0.024	2.22**	1.458	1.366	0.025	3.63***
lnFertilizer	-2.964	-2.929	0.030	1.16	-2.962	-2.943	0.031	0.63
Annual plants								
lnRevenue	1.533	1.456	0.042	1.84*	1.566	1.490	0.039	1.96**
lnFertilizer	-2.938	-2.945	0.039	0.19	-2.947	-2.953	0.037	0.17
Perennial plants								

lnRevenue	3.220	2.915	0.066	4.66***	3.270	3.107	0.076	2.13**
lnFertilizer	-2.022	-2.224	0.071	2.83***	-2.063	-2.115	0.081	0.64

Significant at the 10% level (*), 5% level (**), 1% level (***).
Source: Authors' calculations.

The results in **Table 5** indicate that participating in CF or engaging in CF before crops has led to an increase in the average revenue per hectare harvested across all three farm groups although the significance levels vary. This outcome aligns with expectations and is consistent with numerous prior studies suggesting that farms participating in CF tend to enhance their productivity and income, thereby improving economic performance.

However, participating in CF only shows a significant reduction in the amount of chemical fertilizer used per hectare of harvested land for perennial crop farms. In the remaining cases, this effect is not observed. These findings align with Zhang *et al.*'s (2023) study on tea farms (a perennial plant), but they differ from Mishra *et al.*'s (2018) study on baby corn farms (an annual plant). The latter two studies concluded that participation in CF resulted in a reduction in the use of chemical fertilizers.

To ensure the reliability of the results, balance tests were conducted to examine whether the characteristics of farms with contracts and those without contracts were significantly different. The t-test was employed to compare the means of all covariates, conditioned on the propensity score.

The results presented in **Table 6** demonstrate that the means of variables in the treated group and control group are statistically equivalent. In simpler terms, there is balance in the matching samples, reinforcing confidence in the calculated ATT results mentioned earlier.

Table 6. Balance test

Variable	Rice				Annual plants				Perennial plants			
	Mean				Mean				Mean			
	Treated	Control	%bias	p>t	Treated	Control	%bias	p>t	Treated	Control	%bias	p>t
Between farms with and without contract farming												
Age	51.774	51.845	-0.7	0.864	51.701	51.780	-0.8	0.872	53.106	53.282	-1.9	0.769
Sex	0.935	0.943	-3.3	0.454	0.935	0.936	-0.6	0.916	0.888	0.892	-1.1	0.858
Region	0.036	0.036	0.0	1.000	0.086	0.087	-0.2	0.956	0.177	0.194	-3.9	0.473
Edu1	0.021	0.020	0.8	0.829	0.040	0.031	4.3	0.374	0.117	0.132	-5.1	0.476
Edu2	0.054	0.052	0.9	0.831	0.080	0.091	-3.9	0.449	0.121	0.106	4.6	0.435
Edu3	0.346	0.333	2.8	0.525	0.352	0.331	4.5	0.385	0.308	0.293	3.3	0.608
Empl	0.209	0.205	1.2	0.777	0.256	0.243	3.9	0.426	0.399	0.411	-3.6	0.572
Land	0.846	0.849	-1.2	0.754	0.739	0.738	0.4	0.938	0.737	0.714	5.7	0.359
	Ps R2 = 0.000				Ps R2 = 0.001				Ps R2 = 0.002			
Between farms with and without contract farming before crops												

Age	51.625	51.206	4.4	0.364	51.563	51.203	3.8	0.500	52.922	52.245	7.4	0.308
Sex	0.942	0.941	0.2	0.968	0.951	0.939	5.7	0.319	0.893	0.909	-5.3	0.450
Region	0.037	0.037	0.0	1.000	0.084	0.084	0.0	1.000	0.165	0.177	-2.7	0.653
Edu1	0.020	0.019	0.3	0.944	0.037	0.048	-5.4	0.353	0.120	0.146	-8.8	0.288
Edu2	0.052	0.052	-0.2	0.966	0.084	0.084	0.2	0.967	0.120	0.085	10.4	0.103
Edu3	0.361	0.401	-8.4	0.085	0.364	0.349	3.2	0.577	0.268	0.232	8.1	0.240
Empl	0.197	0.198	-0.1	0.975	0.235	0.235	0.0	0.999	0.378	0.356	6.4	0.374
Land	0.845	0.859	-5.0	0.255	0.733	0.732	0.3	0.961	0.699	0.686	3.2	0.646
	Ps R2 = 0.002				Ps R2 = 0.001				Ps R2 = 0.007			

Source: Authors' calculations.

CONCLUSION

The study significantly contributes to the existing knowledge by illuminating the diverse implications of CF in the Vietnamese agricultural context. Findings pertaining to farms engaged in crop cultivation highlight key determinants, including the farm head's education level, rate of outsourced labor, the proportion of farm-owned land area for each crop group, and regional location, impacting the decision to participate in CF. This impact varies across different crop types and contract scenarios, emphasizing the nuanced nature of these relationships.

PSM analysis results further demonstrate that farms involved in CF generally experience higher average revenue per hectare of harvested land across all three farm groups, indicating positive economic effects. Additionally, a reduction in chemical fertilizer use is observed exclusively for perennial crop farms with contracts, reflecting a positive environmental impact.

Given the undeniable benefits for parties involved in CF, the Vietnamese Government should implement policies to further promote association contracts in agricultural production. Enhanced support mechanisms for businesses, policies facilitating production-consumption linkages, and widespread propagation campaigns for farmers to understand and comply with contract terms are essential. Furthermore, increasing training opportunities for farmers to enhance their knowledge and practical skills in agricultural production, ensuring adherence to quality, safety, and environmentally friendly standards, is crucial for the sustainable growth of agriculture in Vietnam.

ACKNOWLEDGMENTS: I would like to thank The National Economics University, Vietnam for financial and spiritual support.

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: This research was funded by The National Economics University, Vietnam under contract No 24/HD-CBQT2.2020.24.

ETHICS STATEMENT: None

References

Ait Sidhoum, A., Dakpo, K. H., & Latruffe, L. (2022). Trade-offs between economic, environmental and social sustainability on farms using a latent class frontier efficiency model: Evidence for Spanish crop farms. *PLoS One*, *17*(1), e0261190. doi:10.1371/journal.pone.0261190

Ba, H. A., de Mey, Y., Thoron, S., & Demont, M. (2019). Inclusiveness of contract farming along the vertical coordination continuum: Evidence from the Vietnamese rice sector. *Land Use Policy*, *87*, 104050. doi:10.1016/j.landusepol.2019.104050

Bidzakin, J. K., Fialor, S. C., Awunyo-Vitor, D., & Yahaya, I. (2019). Impact of contract farming on rice farm performance: Endogenous switching regression. *Cogent Economics & Finance*, *7*(1), 1618229. doi:10.1080/23322039.2019.1618229

Bijman, J. (2008). *Contract farming in developing countries: an overview*. Working paper. The Netherlands' Ministry of Foreign Affairs Government and Wageningen UR.

Bureau, J. C., & Antón, J. (2022). *Agricultural Total Factor Productivity and the environment: A guide to emerging best practices in measurement*. OECD Food, Agriculture and Fisheries Papers, No. 177, OECD Publishing, Paris.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys*, *22*(1), 31-72.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*. springer science & business media.

DeBoe, G. (2020). Economic and environmental sustainability performance of environmental policies in agriculture. OECD Food, Agriculture and Fisheries Papers, No. 140, OECD Publishing, Paris.

Dubbert, C. (2019). Participation in contract farming and farm performance: Insights from cashew farmers in Ghana. *Agricultural Economics*, *50*(6), 749-763.

Dubbert, C., Abdulai, A., & Mohammed, S. (2023). Contract farming and the adoption of sustainable farm practices: Empirical evidence from cashew farmers in Ghana. *Applied Economic Perspectives and Policy*, *45*(1), 487-509.

Eaton, C., & Shepherd, A. (2001). *Contract farming: partnerships for growth* (No. 145). Food & Agriculture Org.

Gao, Y., Yao, X., Chen, C., & Niu, Z. (2022). Can farmers' participation in contract farming promote the application of organic fertilizer? Empirical evidence from a sample of vegetable farmers in Shandong province of China. *Renewable Agriculture and Food Systems*, *37*(5), 479-489.

Graham, M. (2004). *Environmental efficiency: meaning and measurement and application to Australian dairy farms* (No. 415-2016-26217). Presented at the 48th Annual AARES Conference, Melbourne, Victoria, February 2004.

GSO. (2017). *Summary report of 2016 rural, agricultural and fishery census*. Statistical Publishing House, Hanoi.

Ha, P. V., Nguyen, H. T. M., Kompas, T., Che, T. N., & Trinh, B. (2015). Rice production, trade and the poor: regional effects of rice export policy on households in Vietnam. *Journal of Agricultural Economics*, *66*(2), 280-307.

Ho, Q. H. (2013). Factors affecting the economic linkage between processing enterprises and farmers in Vietnam. *Journal of Economics & Development*, (193), 46-53.

Ho, T. Q., Hoang, V. N., & Wilson, C. (2021). Trade-off analysis of cost and nutrient efficiency of coffee farms in vietnam: A more generalised approach. *Journal of Environmental Management*, *279*, 111601. doi:10.1016/j.jenvman.2020.111601

Hoang, V. (2021). Impact of contract farming on farmers' income in the food value chain: A theoretical analysis and empirical study in Vietnam. *Agriculture*, *11*(8), 797. doi:10.3390/agriculture11080797

Jan, P., Dux, D., Lips, M., Alig, M., & Dumondel, M. (2012). On the link between economic and environmental performance of Swiss dairy farms of the alpine area. *The International Journal of Life Cycle Assessment*, *17*, 706-719.

Liang, Y., Bi, W., & Zhang, Y. (2023). Can contract farming improve farmers' technical efficiency and income? Evidence from beef cattle farmers in China. *Frontiers in Sustainable Food Systems*, *7*, 1179423. doi:10.3389/fsufs.2023.1179423

Mechri, A., Lys, P., & Cachia, F. (2017). *Productivity and efficiency measurement in agriculture: Literature review and gaps analysis*. technical report series GO-19-2017.

Minot, N. (2015). *Contract farming: Risks and benefits of partnership between farmers and firms*. The World Bank Group.

Mishra, A. K., Kumar, A., Joshi, P. K., D'Souza, A., & Tripathi, G. (2018). *Contract farming, productivity and fertilizer usage: Empirical evidence from specialty crop production* (Vol. 1768). Intl Food Policy Res Inst.

Nguyen, H. K., Chiong, R., Chica Serrano, M., Middleton, R. H., & Pham, D. T. K. (2019). Contract farming in the Mekong Delta's rice supply chain: insights from an agent-based modeling study. *Journal of Artificial Societies and Social Simulation*, *22*(3). doi:10.18564/jasss.4008. Url: http://jasss.soc.surrey.ac.uk/22/3/1.html

Nhan, T. Q., & Yutaka, T. (2019). Contract farming and profitability: Evidence from rice crop in the Central Mekong Delta, Vietnam. *AGRIS on-line Papers in Economics and Informatics*, *11*(665-2019-3998), 83-91. doi:10.7160/aol.2019.110109

Otsuka, K., Nakano, Y., & Takahashi, K. (2016). Contract farming in developed and developing countries. *Annual Review of Resource Economics*, *8*, 353-376.

Reinhard, S., Lovell, C. K., & Thijssen, G. J. (2000). Environmental efficiency with multiple environmentally detrimental variables; estimated with SFA and DEA. *European Journal of Operational Research*, *121*(2), 287-303.

Ren, Y., Peng, Y., Campos, B. C., & Li, H. (2021). The effect of contract farming on the environmentally sustainable production of rice in China. *Sustainable Production and Consumption*, *28*, 1381-1395.

Repar, N., Jan, P., Dux, D., Nemecek, T., & Doluschitz, R. (2017). Implementing farm-level environmental sustainability in environmental performance indicators: A combined global-local approach. *Journal of Cleaner Production*, *140*, 692-704.

Rondhi, M., Aji, J. M. M., Hasan, A. F., & Yanuarti, R. (2020). Factors affecting farmers' participation in contract farming: The case of broiler sector in Indonesia. *Tropical Animal Science Journal*, *43*(2), 183-190.

Sapolaite, V., Reziti, I., & Balezentis, T. (2023). Dynamics in the economic performance of farms: a quintipartite decomposition of the profitability change at the aggregate level. *Economic Research-Ekonomska Istraživanja*, *36*(1), 2120039. doi:10.1080/1331677X.2022.2120039

Soullier, G., & Moustier, P. (2018). Impacts of contract farming in domestic grain chains on farmer income and food insecurity. Contrasted evidence from Senegal. *Food Policy*, *79*, 179-198.

Swain, B. B. (2012). Determinants of farmers' participation in contract farming: the cases of gherkin and paddy seed in Andhra Pradesh, India. *Millennial Asia*, *3*(2), 169-185.

Taslim, A., Karim, M. R., & Rahman, M. S. (2021). Factors Influencing Participation of Farmer in Contract Farming in Narsingdi District of Bangladesh. *Asian Journal of Agricultural Extension, Economics & Sociology*, *39*(11), 569-576.

Ton, G., Desiere, S., Vellema, W., Weituschat, S., & D'haese, M. (2017). The effectiveness of contract farming in improving smallholder income and food security in low-and middle-income countries: a mixed-method systematic review. *International Initiative for Impact Evaluation (3ie), London*.

Ton, G., Vellema, W., Desiere, S., Weituschat, S., & D'Haese, M. (2018). Contract farming for improving smallholder incomes: What can we learn from effectiveness studies?. *World Development*, *104*, 46-64.

Tuyen, M. C., Sirisupluxana, P., Bunyasiri, I., & Hung, P. X. (2022). Perceptions, Problems and Prospects of Contract Farming: Insights from Rice Production in Vietnam. *Sustainability*, *14*(19), 12472. doi:10.3390/su141912472

Vogel, E. (2022). *Assessing the Economic and Environmental Performance of Dairy and Paddy Field Agricultural Systems in Brazil*. Dissertation to attain the degree Doctor of Philosophy (Ph. D.) of the Graduate School Forest and Agricultural Sciences (GFA) at the Department of Agricultural Economics and Rural Development, Faculty of Agricultural Sciences, Georg-August-University Göttingen, Germany.

World Bank. (2016). *Transforming Vietnamese Agriculture: Gaining More from Less*. Vietnam Development Report. Washington, D.C. World Bank.

Zhang, Y., Yang, R., Zhao, K., & Kong, X. (2023). Fertilizer Application in Contract Farming: A Risk Analysis. *Land*, *12*(8), 1495. doi:10.3390/land12081495