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Economic impact of linkage in rice production and consumption in the Mekong River Delta, Vietnam: A farm level study

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ABSTRACT
This study examines the economic impact of linkage in rice production and consumption in the Mekong River Delta, Vietnam. Since 2018, the Vietnamese government has implemented an incentive policy aimed at fostering linkages in the production and consumption of agricultural products. Despite this initiative, there is a scarcity of research examining the effects of contract farming on the economic performance of farms in Vietnam. Consequently, this study aims to investigate the causal relationships between farmers' involvement in the linkages of rice production and consumption, facilitated by both private and public enterprises, and various farm performance metrics, including productivity, selling prices, and farm income. Empirical data for this analysis were gathered from 390 rice farmers located in the Vietnamese Mekong Delta. The data were divided into two categories based on the type of linking contract systems, specifically those led by public and private firms. The propensity score matching method was primarily utilized to assess the impact of these linking contract systems on rice farm performance. The results indicate that participation in linkage schemes, whether led by public or private entities, positively influences farm incomes and selling prices, although it does not affect rice yield. This study suggests that the Vietnamese government should expand the linkage models for rice production and consumption to benefit farmers and various business types, including both public and private enterprises.

Contribution/Originality: This study significantly contributes to the literature on the linkages in rice production and consumption in Vietnam because it first provides empirical evidence on estimating the impact of linking contract systems operated by both public and private-owned enterprises.

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1. INTRODUCTION
Presently, Vietnam is one of the world's top rice exporters, accounting for about 18% of the world market (Nhan, Gillette, Yutaka, & Can, 2020). However, when compared to other countries that export rice, the nation's rice export price is not very high (FAO - Food and Agriculture Organization of the United Nations, 2016). Known as Vietnam's rice basket, the Mekong Delta River region has significantly contributed to the country's transition from a rice deficit to a rice surplus (Demont & Rutsaert, 2017). In fact, the Mekong Delta River occupies around 13% of Vietnam's total

land area; it generates about 55% of the country's paddy volume and 95% of its entire exported rice production each year (GSO, 2021). Rice cultivation plays a vital part in the country's economy, but it also makes a substantial contribution to the household economy of farmers in this region, accounting for between 50 and 60 percent of rural households' earnings (GSO, 2022). Nonetheless, a great deal of the Delta rice-farming households have been finding it difficult to make ends meet with the meager money they receive from their crop (Coxhead, Linh, & Tam, 2012). According to a study by Nhan, Ly, and Tan (2020) rice-farming households in the Delta had monthly average incomes per person that were 48% less than the national average. In 2018, the Vietnamese government released Decree No. 98/2018/ND-CP on incentive policy aimed at developing production and consumption linkages of agricultural products. This policy was designed to assist farmers and other actors involved in the rice value chain in improving economic performance. The implementation of this policy has been expected to improve farmers' farm income, particularly in the Mekong River Delta. The definition of linkages in production and consumption of agricultural products in the decree is that farmers and firms should sign a contract for agreement to produce and purchase a farm product. Under the contract terms, farmers agree to produce and sell their products at a predetermined price and quantity. Similarly, firms agree to provide input and technical advice and commit to purchasing contract farmers' output at a predetermined price. Thus, the linkage model in production and distribution of agro-products in Vietnam may be referred to as contract farming systems in other countries. Previous studies show that there is no existing evidence on investigating impacts of linkage policy on economic performance of rice farms. Thus, this study attempts to estimate impacts of participation in the linking contract system on rice farmers' outcomes, such as yield, selling price, and farm income. This study focused on two cases of linking contract systems operated by private and public-owned firms and rice farmers in order to provide overall view on the impact of linkages in rice production and consumption in the Mekong Delta. The linking contract scheme is operated by public-owned firms that often receive strong political support for export priority from the Vietnamese government's policies. Findings from this study can help understand further how much effect the Vietnamese government's linkage policy has on economic returns of rice farms.

To illustrate the impact of linkages in rice production and distribution, primary data collected from 390 rice households located in Vietnam's Mekong River Delta were used for empirical analysis, and propensity score matching (PSM) method that can control selection bias was employed to measure the casual effects in this study.

2. LITERATURE REVIEW

Investigating the impact of contract-farming operations on farm outcome indicators of adopters is still a hot and debatable topic (Minot, 1986; Minot & Sawyer, 2016). There are a plethora of empirical studies estimating the impact of participation in the contract farming on participants. A number of earlier studies revealed that contract schemes have remarkable impacts on adopters' outcome performances by using econometric models such as propensity score matching, Heckman model, instrumental variable model, and endogenous switching regression. The majority of those studies reported that participation in the contract farming principally has led to improved both farm and household incomes (Birthal, Jha, Tiongco, & Narrod, 2008; Bolwig, Gibbon, & Jones, 2009; Cahyadi & Waibel, 2013; Hu, 2013; Jones & Gibbon, 2011; Maertens & Swinnen, 2009; Maertens & Velde, 2017; Miyata, Minot, & Hu, 2009; Wainaina, Okello, & Nzuma, 2014). Khanal, Mishra, Mayorga, and Hirsch (2020) indicated that participation in contract-farming arrangements helped ginger growers increase remarkably yields, profits, and selling price as well. Hailu and Kidu Mezgebo (2024) indicated adoption of contract farming helped sesame farmers in Ethiopia increase productivity by 150 kg per hectare.

These studies on contract farming adoption primarily focus on high-value products, which suggests that little is known about the effects of contract farming on staple crop growers' incomes. In contrast, several empirical studies found negative impacts of contract farming schemes on participants' outcomes. The report by Minot (2011) indicated that contract farming may lower the incomes of smallholder households. Eaton and Shepherd (2001) reported that the adopters of contract farming may experience a negative impact on their incomes. Little and Watts (1994) indicated that contract farming schemes may cause some social problems, such as conflicts of interest between two contracting parties and an imbalance of power between two sides. Singh (2002) reported that contracting schemes may increase social inequalities in a rural community and cause dissension between contractors and non-contractors in India. In general, contracting scheme has helped enhance participants' revenue, but it also created some social issues (Porter & Phillips-Howard, 1997).

Abdulai and Al-hassan (2016) showed that participation in contracts did not help increase soybean farmers' income in Ghana. Recently, Hoang (2021) reported that contract farming mechanism had no impact on farmers' income in Vietnam using a pooled sample of rice farmers, Daxanh pomelo fruit farmers, coconut farmers, and vegetable farmers. A study by Khan, Nakano, and Kurosaki (2019) finds that contract-farming schemes help increase tremendously income for contract potato farmers, while they almost have no impact on both productivity and income of maize farmers. Mishra, Kumar, Joshi, and D'Souza (2018) revealed that adoption of contract farming has a positive and significant effect on lentil producers' revenues, profits, and yield but has a negative impact on production costs. Numerous studies in Vietnam have examined the connections between the production and distribution of agro-products. Thanh and Nghi (2019) investigated factors affecting the linkage in rice production and consumption between firms and rice growers in the Mekong Delta's Can Tho City. Similarly, Ai, Chieu, and Kim (2020) studied factors influencing the linkage in fisheries supply chain in Vietnam's southeast region.

Tuyen, Sirisupluxana, Bunyasiri, and Hung (2022) studied the obstacles and prospects of linking contract systems in rice farms in Vietnam. Evidence shows that little is known about investigating the impact of linking contract systems on economic performance of farms.

3. MATERIALS AND METHODS

3.1. Method used for Estimating Impact

The purpose of this study was to determine the extent to which policies pertaining to the production and distribution of agricultural products enhance the crop outcomes, yield, output price, and farm income of rice farmers. Estimating the average treatment effect on the treated (ATT) was the goal of the current investigation. In this way, we define that the household's participation in the linking model yields Y(1), and the household's non-participation in the model yields Y(0). Consequently, ATT was typed as follows:

$$ATT = E[Y(1) - Y(0)|P = 1] = E[Y(1)|P = 1] - E[Y(0)|P = 1] \quad (1)$$

ATT is defined as the disparity between the mean expected outcomes for households that participate in the linkage model and the mean expected outcomes for those households had they not participated in the model. The variable P denotes the adoption of the linkage model, where P equals 1 if a household is engaged in the model and P equals 0 if it is not.

The inability to observe the outcomes for the same farmer outside the linkage model while they are in the linkage system makes Equation 1's ATT value estimation is impossible. Specifically, the term E⌈Y(0)|P=1⌉ remains unobserved. Consequently, an appropriate substitute was employed. However, it is generally inadvisable to simply use the average outcome of actual non-participants, represented as E⌈Y(0)|P=0⌉, as a replacement for E⌈Y(0)|P=1⌉, since the factors influencing the decision to participate may concurrently impact the expected outcomes (Caliendo & Kopeinig, 2008).

Rosenbaum and Rubin (1983) introduced PSM technique, which allows for the identification of a treated group consisting of farmers who participated in the linkage model. Furthermore, this technique allows for the selection of a control group, which consists of farmers who did not participate in the linkage system but have similar propensity scores to those in the treated group. Consequently, the anticipated outcome for the control group serves as the counterfactual outcome, denoted as E⌈Y(0)|P=1⌉. ATT, which reflects the impact of the treatment on the participants, was calculated as the difference between the average outcomes of the treated and control groups (Smith & Todd, 2005). The following equation can be reformulated accordingly:

$$ATT_{(PSM)} = E[E\{Y(1)|P = 1, P(X)\} - E\{Y(0)|P = 0, P(X)\}|P = 1] \quad (2)$$

The variable P(X) represents the probability of a household participating in the linkage system, which is characterized as the propensity score. This study employed Equation 2 to evaluate the causal impacts of adopting the linkage model on various outcome variables, such as productivity, output price, and farm income. The two-step empirical approach of the Propensity Score Matching (PSM) technique, as outlined by Kassie, Shiferaw, and Muricho (2011) was utilized in this research.

In the initial phase of applying PSM, the probability P(X) was estimated using a probit model. Consequently, P(X) is expressed as follows:

$$P(X) = Prob\,(P = 1|X) = \alpha + \beta X + \varepsilon \quad (3)$$

X represents a vector of household characteristics that may influence both the involvement of farmers in the contract scheme and the anticipated outcomes for these farmers. However, the treatment (participation) had no influence.

The subsequent step involves the creation of a control group by aligning participants in the contract scheme with non-participants based on their propensity score values. ATT is then determined by comparing the mean outcomes of the treated group with those of the control group.

This study employed nearest neighbor matching (NNM) and kernel matching (KM) to pair participants with non-participants based on their propensity scores. (Becerril & Abdulai, 2010) widely utilize these matching techniques due to their significant complementarity.

It is essential to thoroughly evaluate the quality of the matching process both prior to and following the matching procedure. Initially, the mean standardized bias post-matching should be below 25% (Stuart & Rubin, 2007) indicating that the matching has been effectively executed. Also, the pseudo-R2 values should be significantly low after matching, which would demonstrate the successful removal of systematic disparities among covariates between the two groups of contract participants and non-participants (Maertens & Velde, 2017).

3.2. Definition and Selection of Variables

In this paper, PSM method was employed, and three components of variables were used.

Firstly, the treatment variable defined as a dependent variable shows rice households' participation in any linkage model, including private or public ones.

Second, covariates play a crucial role in the generation of propensity scores. It is essential to select observable covariates that influence both participation in the linkage system and the outcomes of interest, while ensuring that these covariates are not affected by participation itself. The probit regression model, which constructs the propensity scores, depends on this selection (Austin, 2011; Caliendo & Kopeinig, 2008; Maertens & Swinnen, 2009; Smith & Todd, 2005). Generating propensity scores isn't so much about figuring out how likely someone is to follow the contracting scheme as it is about finding good matches or making sure that the distribution of covariates is balanced (Girma & Gardebroek, 2015; Kassie et al., 2011). Based on a comprehensive literature review (Awotide, Fashogbon, & Awoyemi, 2015; Maertens & Swinnen, 2009; Maertens & Velde, 2017) and the availability of collected data, nine covariates were incorporated into the probit model for estimating the propensity scores. Table 1 details the definitions of the selected covariates.

Thirdly, outcome variables were used as indicators to measure the impacts of participation in linkage model. In this research, productivity in tons per hectare and output price per kilogram in VND were also measured to further understand which components contribute to the farm income. Farm income derived from rice production was primarily estimated in million Vietnamese Dong (VND) per hectare, which was defined as the difference between the total production output value and production costs.

Table 1. Definition of variables used for empirical model.

Variable	Description
Treatment	
Linkage	1 if the farmer participates in the linkage system, and 0 otherwise
Independent variables	
Experience	Farming experience of households in years
Education	Schooling of household head in years
Household size	Number of family member in household
Rice area	Area planed with rice (ha)
Boat	1 if household owns a boat, 0 otherwise
Storage	1 if household owns a storage, 0 otherwise
Tractor	1 if household owns a tractor, 0 otherwise
Membership	1 if household is a member of farmer organization, 0 otherwise
Distance	Distance from home to the nearest miller (km), measure ability to access to market
Outcome variables	
Productivity	Rice yield in ton per hectare (ha)
Output price	Farm-gate price for rice in VND per kg
Farm income	Return derived from rice cultivation in million Vietnam Dong (VND) per ha

3.3. Data Collection

The core purpose of this study was to examine how much the linkage policy affects the outcomes of involved farmers, such as productivity, output price, and farm income. Data collection was conducted through household surveys from May to July 2022 in An Giang province. An Giang has been recognized as the second largest rice producer in the Mekong River Delta, and the linking system in the rice sub-sector is largely operated in this province as compared to other parts of the Mekong Delta where more than 10% of rice farmers have engaged in the linkage model operated by both public and private owned enterprises.

Regarding data collection process, it employed a multi-stage sampling method for collecting data. Firstly, we chose An Giang province as the study site. Secondly, Thoai Son district of An Giang province was selected as the first sampling site since the public-led contract farming has been adopted by a large number of farmers there, while An Giang province's Chau Thanh district, where linking systems led by private-owned firms have been widely operated, was selected as the second sampling area. Three communes of each district where linking schemes adopted by a majority of rice growers were selected at the third stage. Finally, 390 rice farmers were face-to-face interviewed. Accordingly, 210 rice farmers were investigated in the Thoai Son district, comprising of 100 linked farmers and 110 non-linked ones, while 180 rice farmers located in Chau Thanh district, including 85 linked farmers and 95 non-linked farmers, were interviewed. Both groups of farmers (linked farmers who engaged in linkage models and non-linked ones who have never participated in any linkage systems) were selected randomly. The linked farmers were selected from lists of the linking firms, while non-linked farmers were selected from lists provided by the hamlets' leaders. Remarkably, the two groups resided in a geographic location, which may assure homogeneity of agro-ecological status, transportation, and culture.

A structured questionnaire was used for gathering data from rice growers. The contents of questions basically focus on characteristics of households and farms, assets, and rice performance, including farm-gate price, productivity, and returns.

4. RESULTS AND DISCUSSION

4.1. Summary of Descriptive Statistics Results

Results shown in Table 2 report the distribution of sampled households according to the ownership types of firms and differences in the features of linked farmers and non-linked ones. The results show that there were some differences in socio-economic attributes between linked farmers and non-linked ones. More specifically, for rice households that participated in the linkage system led by public-owned firms in Thoai Son district, there appeared to be significant differences in farming experience among households, boat ownership, tractor ownership, members of farmers' organizations and distance from the farm to a miller.

Meanwhile, major differences in characteristics between participants and nonparticipants of the linking system led by private-owned firms in Chau Thanh district were mostly rice-farming experience of households, the number of family members, and membership in farmers' organizations.

The findings suggest that the presence of differences in farm and household characteristics across the samples should be taken into account when investigating the true effect of the linkages in rice production and consumption.

Table 2. Differences in characteristics of participants and nonparticipants using a t-test.

Covariate	Linkage led by public firms			Linkage led by private firms		
	Participants (n = 100)	Nonparticipants (n = 110)	*p*-values	Participants (n = 85)	Nonparticipants (= 95)	*p*-values
Experience (Years)	21.48	25.77	0.023	27.51	23.31	0.015
Education (Years of schooling)	6.10	6.94	0.172	6.73	6.00	0.123
Household size (Member)	4.65	4.43	0.711	4.83	4.45	0.051
Rice area (ha)	3.27	2.75	0.293	1.96	2.22	0.369
Boat (Dummy)	0.50	0.29	0.037	0.56	0.55	0.926
Storage (Dummy)	0.04	0.08	0.404	0.02	0.02	0.717
Tractor (Dummy)	0.19	0.06	0.065	0.03	0.06	0.412
Membership (Dummy)	0.29	0.06	0.003	0.28	0.15	0.027
Distance (km)	1.82	3.30	0.025	1.79	2.17	0.193

Findings presented in Table 3 show that the farm income and output prices of linked farmers were significantly higher than those of non-linked ones, while productivity between the two groups of farmers was relatively similar. However, those comparisons did not make into account the differences in the characteristics between the two groups of households, which could potentially influence their participation in the linkages in the rice production and consumption, as well as the resulting outcomes.

Table 3. Differences in crop outcomes of participants and nonparticipants using a t-test.

Outcome variable	Linkage led by public firms			Linkage led by private firms		
	Participant	Nonparticipant	*p*-values	Participant	Nonparticipant	*p*-values
Productivity (Ton/Ha)	7.46	7.57	0.549	7.57	7.53	0.766
Selling price (VND/kg)[$]	5,700	5,074	0.000	5,253	5,067	0.000
Farm income (Million VND/ha)[$]	24.065	19.692	0.000	21.724	19.732	0.017

Note: [$]1 USD exchanges 25,000 VND.

4.2. Results of Probit Model

Table 4 reports the results of probit model used as the first step of PSM technique. The estimates were used to predict propensity score for matching in the next step. However, results of probit model should be discussed.

For an investigation in Thoai Son district, it was shown that five factors significantly influenced farmers' participation in the linkage model operated by public-owned enterprises. The household head's year of schooling and farming experience negatively affected the joining of linkage system. The distance from farmers' houses to a miller was also negatively associated with the households' adoption ability for the linking scheme. By contrast, participation in farmers' organizations and boat ownership positively influenced the participation in the linking system. Yet, other covariates, including family size, land area planted with rice, storage facility, and tractor ownership, were not highly associated with linkage system adoption.

Table 4. Results of probit model for generating propensity scores.

Covariate	Linkage led by public firms		Linkage led by private firms	
	Coef.	z-stat	Coef.	z-stat
Experience (Years)	-0.053***	-2.76	0.018*	1.70
Education (Years of schooling)	-0.119**	-2.25	0.047	1.22
Household size (member)	0.018	0.17	0.206**	2.01
Rice area (Ha)	0.065	0.93	-0.062	-0.85
Boat (Dummy)	0.614**	2.00	-0.059	-0.27
Storage (Dummy)	-0.154	-0.24	-0.884	-0.90
Tractor (Dummy)	0.645	1.31	-0.467	-0.80
Membership (Dummy)	1.360***	3.10	0.554**	2.09
Distance (km)	-0.101*	-1.79	-0.074	-1.20
Constant	1.406*	0.075	-1.636***	-2.80
Log likelihood	-49.610		-93.999	
LR $chi^2(9)$	33.86		18.94	
Prob > chi^2	0.0001		0.0258	
Pseudo-R^2	0.2545		0.0915	

Note: *, ** and *** display significant levels at 0.1, 0.05 and 0.01, respectively.

For the sample in Chau Thanh district (farmers joining the linking system operated by private-owned firms), there were three factors that remarkably influenced the adoption of the linkage model. Specifically, farmers' experience in

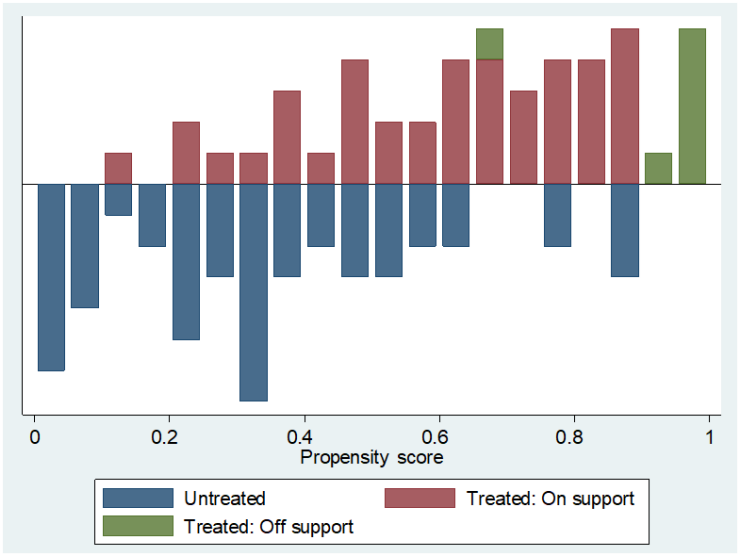
rice farming was positively associated with becoming a linked farmer. A number of family members and being a member of farmers' organization positively influenced the adoption of linking system. Other characteristics of the households, such as education of household head, rice land size, boat ownership, storage facility, tractor ownership, and distance from farm to a miller, were not significantly associated with the probability of linkage-system adoption.

These results provide firm evidence that there is some self-selection among participants in the linking system. Indeed, the adoption of a linkage scheme is more likely biased towards education and experience of household head, family size, households with a boat, households with membership in farmers' organizations, and distance from farm to a miller.

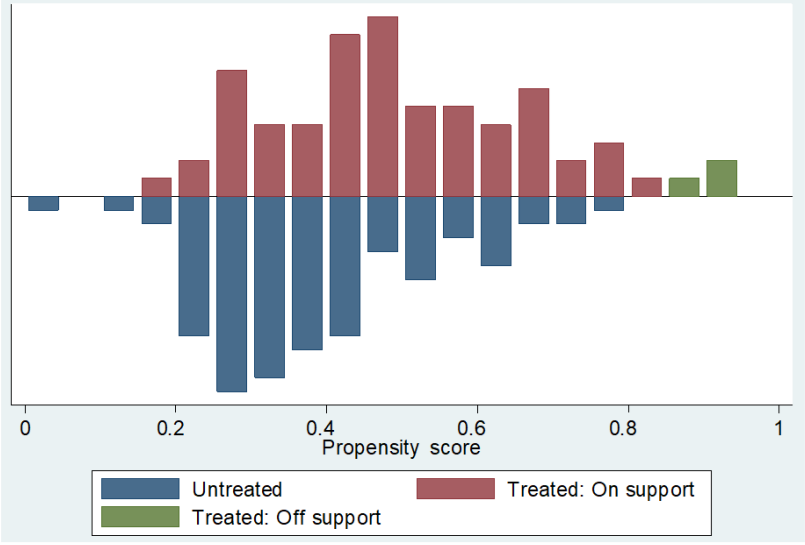
In general, there are some differences in factors affecting the participation in the linking systems between the two study sites, possibly because geographical conditions and socioeconomic environments are heterogeneous between the two districts and firms may have some different requirements for participating in the linkage model.

4.3. Results of Testing Matching Quality

Before discussing the casual effect of linking system participation, one should carefully check the quality of the matching process using PSM, as the linkage model used propensity scores to match participants to nonparticipants. Initially, the common support area was examined, focusing solely on households for the purpose of matching. Figure 1 illustrates the distribution of propensity scores and the common support region pertinent to the empirical analysis. The evidence presented in Figure 1 indicates a significant overlap in the propensity scores between the treated and untreated groups, suggesting that the common support assumption is likely satisfied, which can be interpreted as indicative of good matches.



1a Linkage led by public firms



1b Linkage led by private firms

Figure 1. Distribution of propensity score and common support region.

Second, the reduction in the mean standardized bias between the matched and unmatched households was also checked. The results in Table 5 show that the standardized mean difference for all covariates used in the propensity

score went down by between 10.1% and 12.9% after matching for the case of Thoai Son district case. This meant that the total bias went down by a large amount, between 87% to 84%. Similarly, the total reduction bias for the sample in the study site of Chau Thanh district was approximately 54% to 59%. Table 5 also shows the major decrease of pseudo-R^2 values after matching. The probability tests of the joint regressors for both study sites were insignificant after matching, while they were significant before matching.

The findings suggest a potential bias in the covariates; however, the application of matching techniques has significantly mitigated this bias. In conclusion, the methods used for matching have been successful in balancing the covariate distributions between the participants and nonparticipant groups in the linkage models. As a result, these methods provide reliable estimates of ATTs (Rosenbaum & Rubin, 1985).

Table 5. Quality indicators of PSM before and after matching.

Kind of contract	Matching method	Pseudo R^2 before matching	Pseudo R^2 after matched	$p >$ Chi2 before matched	$p >$ Chi2 after matched	Mean standardized bias before matched	Mean standardized bias after matched	Total % bias reduction
Public scheme	KM	0.254	0.028	0.000	0.955	34.6	12.9	86.7
	NNM	0.254	0.032	0.000	0.891	34.6	10.1	84.2
Private scheme	KM	0.092	0.003	0.026	0.100	21.1	3.8	59.0
	NNM	0.092	0.006	0.026	0.998	21.1	6.7	53.8

4.4. Effects of Linkage in Rice Production and Consumption

Results shown in Table 6 reveal that the farmers participating in the linkage models had statistically significant impacts on output prices and rice farm income but no effect on rice yields. The results estimated using the NNM and KN matching techniques showed significant similarities.

Participation in the linkage models operated by both public and private-owned enterprises had a negative but not significant impact on rice yield. On the contrary, previous empirical study results by Miyata et al. (2009); Maertens and Velde (2017); Mishra et al. (2018); Khanal et al. (2020) and Hailu and Kidu Mezgebo (2024) revealed that the linking system significantly brought out an increase in crop productivity of farmers. However, results showed that participation in the linkage models operated by public and private-owned firms significantly contributed to an increase in the output prices around 11% and 4%, respectively. Most linked farmers receive higher selling prices for rice, as linking enterprises often offer a premium over regular market prices for their outputs that meet their standards. This implies that rice quality produced by linked farmers with supervision of the linking firms' staff could be higher as compared to non-linked farmers. This result is consistent with the previous research results indicated by Michelson, Reardon, and Perez (2012); Girma and Gardebroek (2015); Maertens and Velde (2017) and Khanal et al. (2020).

Results also revealed that participation in the linkage systems operated by both the public and private-owned firms dramatically increased rice returns. The linkage's model high income derived from rice production could potentially stem from significantly higher selling prices. In general, linking schemes operated by public and private-owned firms have remarkably positive impacts on farm incomes, which majorly contribute to rice households' incomes. The current results are similar to the previous researches (Birthal et al., 2008; Bolwig et al., 2009; Hu, 2013; Jones & Gibbon, 2011; Khanal et al., 2020; Mulatu, Haji, Legesse, & Ketema, 2017; Wainaina et al., 2014). In particular, Simmons, Winters, and Patrick (2005) revealed that maize seed farmers and poultry farmers in Indonesia participating in contract schemes can help dramatically increase their profits by 71% and 160%, respectively.

To sum up, policy on linkage in production and distribution of agricultural products adopted by both public and private firms may help rice growers enhance their income.

Table 6. Estimated effects of participation in linking schemes on rice outcomes.

Study site	Outcome variable	Matching methods	Mean values		ATT	*t*-value
			Treated	Control		
Linking scheme operated by public firms	Productivity (Ton/ha)	KM	7.56	7.95	-0.390	-1.36
		NNM	7.56	7.90	-0.338	-1.19
	Selling price (VND/ kg)[$]	KM	5,744	5,144	600***	5.32
		NNM	5,700	5,165	535***	5.31
	Farm income (Million VND/ha)[$]	KM	24.343	21.023	3.320**	2.31
		NNM	24.065	21.300	2.766**	2.14
Linking scheme operated by private firms	Productivity (Ton/ha)	KM	7.62	7.76	-0.145	-0.93
		NNM	7.57	7.72	-0.146	-0.90
	Selling price (VND/kg)[$]	KM	5,250	5,052	198***	4.28
		NNM	5,253	5,038	215***	5.16
	Farm income (Million VND/ha)[$]	KM	21.971	20.486	1.485*	1.68
		NNM	21.724	20.218	1.596*	1.73

Note: *, ** and *** display significance levels at 0.1, 0.05 and 0.01, respectively. [$]1 USD exchanges 25,000 VND.

5. CONCLUSIONS

This study first assessed the impacts of policy on linkages in production and consumption of rice products in the Mekong River Delta of Vietnam with two types of operators, including public and private-owned enterprises. The evidence of the results illustrated that the considerable presence of bias in the distribution of covariates between groups of linked farmers and non-linked ones in the linkage schemes was mostly eliminated by using PSM method.

Farmers participating in the linkage models operated by both private and public firms had positive impacts on selling prices and farm incomes of rice growers in the study areas. Yet it had no impact on productivity of the linked farmers. In summary, adopting linking systems led by both private and public-owned firms potentially increases Vietnamese rice farmers' income.

The study may suggest that linkages in rice production and distribution enable rice growers to produce better quality of output, potentially benefiting farmers by gaining higher selling prices and significantly contributing to a remarkable increase in farm incomes. It may be firmly concluded that the policy on contract farming promulgated by the Vietnamese government has a remarkable impact on rice farm incomes. Thereby, expanding a number of farmers and enterprises to engage in the linking scheme seems to be a wise strategy to help enhance rice quality and rice growers' income in Vietnam in general and in the Mekong River Delta in particular.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
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