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Cooperatives as instruments of smallholder development: Evidence from banana, cocoa, coffee, and palm oil producers in Peru

Jasper Grashuis [a,*], Angie Higuchi [b]

[a] *University of Missouri, United States of America*
[b] *Universidad del Pacífico Peru*

Abstract

Collective action in the agricultural sector of Peru started in the form of agrarian production cooperatives around 1969. Following the collapse of the collectivisation program in the 1980s, external stakeholders helped to form marketing cooperatives in select sectors to discourage coca leaf production. Nowadays, cooperatives are only active in four sectors: banana, cocoa, coffee, and palm oil. Case study evidence of the performance of cooperatives in Peru is mixed, which raises the need for applied research to inform if cooperatives have been successful as instruments of smallholder development. We address the situation with empirical analysis of comprehensive survey data collected for the 2016-2019 period. Using multiple empirical techniques, we estimate the farm-level treatment effect of selling output to cooperatives. Generally, we find a positive effect of cooperatives on the price received and the quantity sold of their patrons. Palm oil cooperatives, which appear to have started in the recent past, form an exception. Implications of our findings are discussed.

Keywords: agricultural cooperative, propensity score matching, treatment effect

1 Introduction

Empirical evidence of the farm-level effect of cooperatives in the developing world is mounting. For example, farmers who are members of cooperatives enjoy improvements in price (Bernard *et al*., 2008), profit (Ma & Abdulai, 2017), technical efficiency (Neupane *et al*., 2022), and yield (Grashuis & Skevas, 2023; Lin *et al*., 2022; Ma *et al*., 2022). While most of the empirical evidence is from countries in East Africa and East Asia (Grashuis & Su, 2019), many other countries in the developing world in which cooperatives are active have been overlooked.

In Peru, for example, cooperatives in the agricultural sector have been active on and off since 1969, showcasing a turbulent history with several transformations in structure and orientation (Funes, 2019). However, most of the findings on the performance of Peruvian cooperatives have come in the context of case study work (Higuchi, 2014; Kurjanska, 2015; Donovan *et al*., 2017; Higuchi *et al*., 2020; Sirdey & Lallau, 2020); observations of one or several cooperatives cannot be generalised to facilitate sector-wide or industry-wide insights. A recent exception is from Grashuis & Skevas (2022), who conducted a large-scale study of Peruvian coffee producers and observed a positive effect of cooperative membership on farm-level performance. Of course, given differences in value chains, actors, technologies, and other factors, evidence from the coffee sector may have little bearing on other sectors.

As such, whether cooperatives have been instruments of smallholder development in Peru is still largely an open question. Yet the matter is of substantial current interest as farmers in Peru continue to face several production and marketing constraints such as poor infrastructure and limited service availability, all of which hamper access to end markets. Additionally, there are increasing requirements from buyers in terms of quantity, quality, and timeliness of delivery. Individually, farmers have difficulties in meeting such requirements and hold almost no bargaining power in negotiations with industrial processors or final consumers. Cooperatives, which can facilitate an improvement of volume and quality processes as well as an expansion of other sales channels

* Corresponding author: grashuisj@missouri.edu

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(Higuchi *et al.*, 2023), may present a viable institutional option to such farmers.

Considering the above, further investigation into the effect of cooperatives on farmers in Peru is necessary. With comprehensive survey data collected by the Peruvian government for the 2016-2019 period, we look at four sectors in which cooperatives are active: banana, cocoa, coffee, and palm oil. To the best of our knowledge, ours is the first study of cooperatives in these four main sectors in Peru. We contribute to the scarce literature with several novel findings. First, while controlling for selection bias, Peruvian cooperatives have a positive effect on the price received and the quantity sold by smallholders in the banana sector and the coffee sector. The positive effect is also observed in the context of cocoa producers, but not in the last year of the study period (i.e. 2019). Second, there is no significant effect of cooperatives on the price received or quantity sold by oil palm producers. We discuss the implications of our findings in the conclusion.

1.1 Background

1.1.1 History of cooperatives in Peru

Cooperatives have been active in Peru since 1969 in various constructions. During the early phase of the military junta, agrarian production cooperatives (collectives) were viewed as a primary instrument for restructuring the agricultural sector. The military government in particular targeted the coastal region with its many sugar and cotton estates. At the beginning of the 1970s, land reform occurred across the entire coastal region (Torre Villafane, 1995). As part of the collectivisation program, the government expropriated many commercial farm estates to form cooperatives, and smaller holdings were consolidated into units collectively owned by associations.

Around 1978, the military government reversed the collectivisation program and began dividing the agrarian production cooperatives among its members. However, when the civilian government took over in 1980, most of the reforms of the previous decade were scaled down or even abandoned, resulting in the gradual disappearance of many agrarian production cooperatives because of the lack of a long-term political vision, a poor economy, and the will of the members to have private property (Eresue & Auzemery, 1986). In other cooperatives, the government took an active role in terms of governance and management. The ambiguous stance facilitated a dichotomy with cooperatives as enterprises under centralised administration as well as sole proprietorships owned by members who simultaneously served as workers and bosses. Many cooperatives went bankrupt (Gonzales de Olarte, 1997).

Farmers and cooperatives experienced a different situation in the jungle. The traditional system of the jungle is based on the following conditions: a low level of urbanisation, a low occupational diversification, a high concentration of land ownership, a very low level of technological development, an undeveloped communication system, and a high rate of illiteracy. Here, agrarian production cooperatives first focused on tea production. However, when these cooperatives failed during the 1980s, many local farmers transitioned toward the production of coca, which became a boom crop because of the high return from drug trafficking (Bedoya, 1986). While profitable, the crime associated with coca production in many parts of rural Latin America reduced government and donor willingness to help farmers. Consequently, many farmers in the jungle lacked access to adequate technical and financial assistance to develop their agriculture-based livelihoods and faced hardship in the free market without financial or technical support.

Since 1991, the United Nations and several other organisations again supported the development of cooperatives in the jungle in order to promote alternatives to coca production (Ruiz, 2007; Chauvin, 2010). The effort focused primarily on cocoa and palm oil production. While the alternative crops did not yield the same amount of profit as coca (Dammert, 2007), the shift helped farmers in the jungle to diversify income in a legal and sustainable manner. However, in spite of external donor support, cooperatives still face many obstacles today. For example, among old farmers, "cooperative" is somewhat of a dirty word. Cooperatives are often perceived to be less successful than other types of local organisations. Farmers do not have extensive access to on-farm training; political, technical, and organisational skills are generally in short supply and can reinforce low self-esteem and confidence. Such deficiencies at the farm-level inhibit organisation, even when encouraged by the government. Unfortunately, the government itself may also contribute to ineffectiveness (Ortiz, 2006); failures of cooperatives are often linked to corruption and incompetence.

Even so, the government continues to support cooperatives in the jungle in the ongoing battle against coca leaf production. Cooperatives in the jungle are subject to the Amazon Investment Promotion Law (Law No. 27037), which aims to promote the sustainable development of the Amazon by establishing the conditions for public and private investment to promote the conservation of biological diversity and the protection of nature. Likewise, processors of agricultural commodities such as palm oil, coffee and cocoa in the jungle receive an income tax discount depending on the area within the Amazonian territory.

1.1.2 Cooperatives versus intermediaries

Because of wide variability in socio-economic characteristics and land and capital endowments, quantity and quality in the agricultural sector of Peru are not standardized (De Weck *et al*., 2009). Furthermore, small farmers with little land ownership and low production do not have much bargaining power in a complex and fractured market inhabited by cooperatives, intermediaries, retailers, and exporters. For example, post-harvest and trade processes are very disorganised because of the lack of sufficient road infrastructure and the absence of wholesale market channels, which burdens small farmers who are unable to achieve scale efficiency by decreasing the average cost of production (Peruvian Ministry of Agriculture, 2011).

Because of the widespread lack of organisation among small farmers, intermediaries are able to capture a large share of the market (Pokhrel & Thapa, 2007). In the past, the geography of the jungle favoured the intermediaries, who had boats and trucks for transporting the farm supplies. Farmers in the jungle, many of whom have cash flow problems, sold output to whoever passed through the gate and offered a price (Garcia, 2002; Pabon Pedraza, 2017). The intermediaries had few competitors and essentially formed a monopoly. Farmers had little knowledge of market prices, in part because of insufficient communication with the intermediaries. Also, farmers depended on intermediaries to fund production at the beginning of the season. Then, intermediaries often paid farmers a low price for their harvest (Bedoya, 1986). Even so, intermediaries always face shortages and cannot meet market demand (Lozano & Garfias, 2007).

In comparison to intermediaries, cooperatives have several potential advantages. For example, cooperatives absorb the volatility of global market capitalism; farmers who are organised have a greater capacity to withstand price fluctuations (De Weck *et al*., 2009). Cooperatives seek to reduce the layers of middlemen between producers in the developing world and consumers in the developed world by taking responsibility for transportation, product certification, and other functions (Arnould et. al., 2007). Cooperatives in the jungle standardise quantity and quality to better negotiate with buyers in export markets (De Weck *et al*., 2009). In the process, cooperatives provide technical assistance, information, credit, and other services in order to improve member welfare (Higuchi *et al*., 2012). Cooperatives facilitate an increase in cultivation, productivity, and output (Aspiazu, 2010). In terms of pricing, cooperatives use the price from intermediaries as a reference. When cooperatives manage to negotiate a good price with buyers because of high quality or supply scarcity, the price from cooperatives may exceed the local price, which is especially appealing during periods of crisis (Tulet, 2010). In fact, prior analyses showed how farmers who sell output to cooperatives both produce more and receive more (Arnould *et al*., 2007; Grashuis & Skevas, 2022).

2 Materials and methods

2.1 Empirical model

The empirical point of departure is defined as:

$$Y_{ic} = \alpha + \beta x_{ic} + \gamma T_{ic} + \varepsilon_{ic} \tag{1}$$

where Y is a vector of outcome variables for farm operator i who produces commodity c (i.e. banana, cocoa, coffee, palm oil), α is an intercept, x is a vector of observed farm and farm operator characteristics, T is a binary variable indicating the treatment (i.e. selling output to cooperatives), ε is a random stochastic term, and β and γ are the unknown parameters to be estimated.

According to expected utility theory, farm operator i chooses to sell output to cooperatives if the expected utility associated with selling output to cooperatives U^1 is greater than the expected utility of not selling output to cooperatives U^0, as in:

$$T_i^* = U_i^1 - U_i^2 > 0 \tag{2}$$

where the difference in the utility T^* is unobserved. Instead, T^* is modelled as a latent binary variable as in:

$$T_i^* = \pi z_i + \mu_i, T_i = \begin{cases} 1 & \text{if } T_i^* > 0 \\ 0 & \text{if } T_i^* \leqq 0 \end{cases} \tag{3}$$

where T is a binary variable which is coded as one if farm operator i sells output to cooperatives and coded as zero if not, z is a vector of farm operator and farm characteristics, μ is a random stochastic term, and π is an unknown parameter to be estimated.

Because the vectors of farm operator and farm characteristics in Equation (1) and Equation (3) are identical, the correlation between the stochastic term ε_i in Equation (1) and the stochastic term μ_i in Equation (3) may be non-zero. If so, ordinary least square estimates of the effect of selling output to cooperatives are not free from selection bias. As evidenced by the recent empirical literature on farmer cooperatives (Grashuis & Su, 2019), the most common method to address selection bias in order to yield robust estimates of the effect of cooperative membership is propensity score matching (PSM). A propensity score is the probability of assignment to treatment conditional on a vector of observed covariates (Rosenbaum & Rubin, 1983). The premise of PSM

is to mimic a randomized control trial with observational data by constructing a balanced sample of the treated (i.e. members) and the untreated (i.e. non-members). The matching of the treated and the untreated is not based on the full range of observed characteristics, but instead on one single dimension (i.e. the propensity score). Common matching algorithms are kernel, nearest neighbour, and local linear regression. Most studies use multiple algorithms for the sake of robustness (e.g. Abate *et al*., 2014; Ahmed & Mesfin, 2017; Grashuis & Skevas, 2022).

Following the estimation of the propensity score by means of Equation (3), the primary objective of PSM is to estimate the average treatment effect on the treated (ATT), as in:

$$ATT = E(Y_i - Y_0 \mid T = 1) = E(Y_1 \mid T = 1) - E(Y_0 \mid T = 1) \quad (4)$$

which yields the difference in the observed outcome for the treated in case of treatment and the unobserved outcome for the treated in case of no treatment. Put differently, the ATT indicates how much patrons of cooperatives would gain or lose if selling output to non-cooperatives.

Although PSM is useful to estimate the farm-level effect of selling output to cooperatives, there are inherent weaknesses. Most notably, PSM is unable to address bias stemming from unobservable characteristics. An endogeneity problem may occur if such characteristics affect both the selection and the outcome equations, which in the prior literature has been addressed by means of techniques such as endogenous switching regression (ESR) (e.g. Ma *et al*., 2022) and inverse probability weighted regression adjustment (IPWRA) (e.g. Grashuis & Skevas, 2022). For the sake of robustness, we use the IPWRA method for the robustness check. We refer the interested reader to Manda *et al*. (2020) for further information about the IPWRA method in the context of the treatment effect of farmer cooperatives.

2.2 *Data and variables*

Our secondary data come from the National Survey of Crop and Livestock Agriculture (Encuesta Nacional Agropecuaria), which is an annual survey administered by the National Institute of Statistics and Informatics (*Instituto Nacional de Estadística e Informática*) in Peru. The most recent version of the survey is 2019. Like Blazquez-Soriano & Ramos-Sandoval (2022), we use information from 2016-2019 to determine if the estimated effect is consistent across time[1]. Although the survey is conducted on an annual basis, there is no apparent panel structure to the data as few respondents appear consecutively in the survey. We thus effectively have four separate but representative cross-sections. For more information about the survey methodology, we refer the interested reader to the web site of the National Institute of Statistics and Informatics in Peru[2].

For the treatment variable, it is customary in the empirical literature on the effect of farmer cooperatives to sample respondents on the basis of membership, which is ideal if membership is in fact synonymous with patronage. However, the secondary data reveal the presence of many members who do not actually sell output to cooperatives, as well as many non-members who do sell output to cooperatives[3]. Since membership in our case is a flawed indicator and may therefore yield biased or incorrect inferences, our treatment variable is instead indicated by patronage via the question "To whom did you sell the production of . . . ?" [4,5], for which one of the given options is association (*asociación*) or cooperative (*cooperativa*). While the two types of organisations are legally distinct, in practice both are owned and controlled by farm producers who are both investors and suppliers. The main difference between associations and cooperatives in Peru relates to the objectives; the former only has a social objective while the latter has both social and economic objectives. Per law, cooperatives must reinvest 20 % of their profit into the business and return the other 80 % to the members on the basis of proportionality (i.e. farmers who sell more output, receive more profit). In practice, the 80 % is often returned to members in non-financial form (e.g. t-shirts, caps, backpacks, provisions). By comparison, associations do not return any profit to their members. Instead, the profit is converted into equity on the balance sheet. Most of the equity is then used to make investments in property or equipment for such purposes as dry storage (e.g. fermentation boxes, concrete floors).

Each year, the survey respondents grew approximately 400 different commodities, but only frequently sold four to cooperatives: banana, cocoa, coffee, and palm oil. Therefore, our sample is comprised of the respondents who reportedly sold a non-zero amount of banana, cocoa, coffee,

[1] While the survey was also conducted in 2014 and 2015, the data structure is not consistent with more recent versions.

[2] National Institute of Statistics and Informatics. https://www.gob.pe/inei/

[3] Member loyalty or commitment to cooperatives is hindered by competition from intermediaries. Side-selling to intermediaries is an attractive option to members who seek payment in the present rather than in the future. Intermediaries offer payment upon receipt of the product. Cooperatives, and the members by extension, are only paid once the output arrives to its end destination. Also, because of the primary focus on the national market as opposed to the international market, intermediaries use lower quality standards than cooperatives.

[4] *¿A quien le vendio la produccion de ...?* (English: To whom did you sell the production of . . . ?)

[5] To remain consistent with the empirical literature, we continue to speak of cooperative membership throughout the manuscript.

Table 1: *Mean group comparisons of the price received and the quantity sold.*

		Price received (PEN/kg)*			*Quantity sold† (kg)*		
		Patronage			*Patronage*		
Crop	*Year*	*No*	*Yes*	*p*	*No*	*Yes*	*p*
Banana	2016	0.88	1.11	0.000	5842.70	16653.81	0.000
	2017	0.87	1.09	0.000	5540.37	13217.42	0.000
	2018	0.91	1.04	0.104	5969.16	15191.94	0.000
	2019	0.95	1.11	0.005	6598.11	14743.51	0.000
Cocoa	2016	7.13	7.57	0.000	647.96	1023.85	0.000
	2017	5.12	5.50	0.000	736.90	1247.35	0.000
	2018	5.45	5.73	0.009	794.96	1235.18	0.001
	2019	5.66	5.79	0.177	786.19	1469.43	0.000
Coffee	2016	5.69	6.35	0.000	599.86	800.74	0.000
	2017	6.01	7.05	0.000	589.32	802.65	0.004
	2018	5.41	6.19	0.000	579.41	842.38	0.000
	2019	5.36	6.23	0.000	632.23	1068.48	0.000
Palm Oil	2016						
	2017						
	2018	0.31	0.29	0.119	72820.97	57214.29	0.371
	2019	0.31	0.29	0.158	90600.00	78354.84	0.431

*PEN: Peruvian sol. 1 PEN = 0.25 EUR; †per producer

Table 2: *Overview of sample characteristics by sector and year.*

	Banana				*Cocoa*			
Variable	*2016*	*2017*	*2018*	*2019*	*2016*	*2017*	*2018*	*2019*
Coop patron (yes/no)	0.03	0.03	0.02	0.02	0.08	0.08	0.08	0.08
Farm size (hectares)	8.51	8.01	9.81	8.81	10.02	10.27	12.52	12.30
Parcels (number)	5.42	5.52	5.14	4.65	5.76	5.98	5.43	4.81
Age (years)	50.54	51.07	52.16	54.50	49.39	50.12	51.05	53.39
Male (yes/no)	0.83	0.83	0.83	0.76	0.84	0.81	0.82	0.76
Education level								
None	0.06	0.06	0.06	0.09	0.06	0.07	0.06	0.08
Primary	0.56	0.54	0.55	0.57	0.57	0.57	0.58	0.58
Secondary or more	0.38	0.40	0.39	0.34	0.37	0.36	0.35	0.33
Off-farm income (yes/no)	0.57	0.46	0.53	0.54	0.52	0.43	0.52	0.57
Distance to district capital (hours)	2.27	1.87	1.94	2.06	2.08	1.77	2.06	1.74
	Coffee				*Palm Oil*			
Variable	*2016*	*2017*	*2018*	*2019*	*2016*	*2017*	*2018*	*2019*
Coop patron (yes/no)	0.10	0.10	0.14	0.12			0.10	0.19
Farm size (hectares)	4.15	4.14	5.22	5.08			21.11	19.13
Parcels (number)	7.30	6.58	7.03	7.12			3.31	3.19
Age (years)	47.10	49.36	49.33	52.57			50.21	53.59
Male (yes/no)	0.84	0.84	0.83	0.75			0.75	0.72
Education level								
None	0.06	0.08	0.08	0.09			0.00	0.02
Primary	0.64	0.62	0.61	0.64			0.42	0.49
Secondary or more	0.29	0.30	0.31	0.27			0.58	0.48
Off-farm income (yes/no)	0.60	0.52	0.53	0.57			0.55	0.32
Distance to district capital (hours)	2.85	2.23	2.32	2.36			1.24	1.45

or palm oil[6]. The proportion of respondents who are patrons of cooperatives varies across the four years and the four sectors. The proportion is the lowest (0.02) in the banana sector and the highest (0.19) in the palm oil sector in 2019. In 2016 and 2017, only a single survey respondent sold palm oil to cooperatives, which is why we do not analyse the palm oil sector for the years 2016 and 2017.

Following Bernard *et al.* (2008), our two outcome variables are the price received and the quantity sold. Together, these variables are the two components of the revenue equation. To facilitate a preliminary perspective of the difference between farm producers who patronise and do not patronise cooperatives in terms of the two outcome variables, we first conduct mean group comparisons on the basis of the treatment (see Table 1). In the banana sector, the mean price received is significantly different in three of the four years and the mean quantity sold is significantly different in all four years. The same applies to the cocoa sector, where 2019 is the only year in which the difference in the mean price received is not significant. The mean price received and the mean quantity sold are significantly different in the coffee sector across the full study period. The palm oil sector is the exception as in both 2018 and 2019 the differences in the mean price received and the mean quantity sold are not significant.

Given secondary data availability, we consulted the prior literature to select relevant farm operator and farm characteristics to help explain variability in the probability of the treatment variable as well as variability in the two outcome variables. According to Bernard & Spielman (2009), male and older farmers are more likely to be members of cooperatives. Farm size is expected to positively affect the probability of cooperative membership (Chagwiza *et al.*, 2016; Ahmed & Mesfin, 2017). Cooperative membership is also more likely for farmers who are more educated (Manda *et al.*, 2020), as well as farmers who have off-farm employment (Twumasi *et al.*, 2021). Finally, we use the distance to the local market as an instrumental variable to help explain variability in cooperative membership (Mojo *et al.*, 2017). Table 2 reports the summary statistics of the above variables. There are some notable differences across the four samples. Especially the characteristics of the sample of palm oil producers differ substantially in comparison to the other three samples. Relatively, the average palm oil producer is more likely to be educated, to be a member of cooperatives, to live closer to the district capital, to have a larger farm size, and less likely to have off-farm income.

[6]We exclude respondents who produced a given commodity purely for household consumption. As such, we place emphasis on commercialisation rather than production.

Table 3: *Results of the probit model of cooperative patronage for the sample of banana farmers for the year 2017.*

Variable	*β*	*S.E.*	*p*
Intercept	-2.768	0.920	0.003
Farm size	-0.053	0.016	0.001
Number of parcels	-0.215	0.030	0.000
Male	0.336	0.175	0.055
ln age	0.353	0.209	0.091
Primary school	0.321	0.283	0.257
Secondary school	0.373	0.297	0.209
More than secondary school	0.365	0.322	0.257
Off-farm income	0.046	0.110	0.680
Distance to regional capital	-0.232	0.051	0.000
N	3,818		
Log likelihood	-347.25		
Pseudo R^2	0.23		

3 Results and discussion

3.1 Determinants of selling output to cooperatives

Regardless of the method or algorithm, the first stage of the regression model is the estimation of the probability of selling output to cooperatives as defined in Equation (3) to address selection bias. Instead, Table 3 only reports the results of one probit model for the sample of banana farmers for the year 2017[7]. According to the estimates, selling output to cooperatives is related negatively to farm size; similar to Verhofstadt & Maertens (2015) yet contrary to Blekking *et al.* (2021), relatively small banana farmers are more likely to sell output to cooperatives. The model suggests male banana farmers are also more likely to sell output to cooperatives, although the estimate is not statistically significant at the 95 % confidence level. Unlike Manda *et al.* (2020), we do not find a significant relationship of education to the probability of selling output to cooperatives. Again like Verhofstadt & Maertens (2015), we also observe how the distance to the regional capital has a negative relationship to the probability of selling output to cooperatives. As such, cooperatives are less inclusive of relatively remote banana farmers who may face a substantial cost of transaction in the marketplace. In other studies (e.g. Ma *et al.*, 2022), market distance played no significant role in predicting the probability of selling output to cooperatives.

[7]There are 14 models to be estimated (four each for the sub-samples of banana, cocoa, and coffee farmers, and two for the sub-sample of palm oil farmers). The results of each probit model are available upon request.

Table 4: *Treatment effect of cooperatives on banana farmers*

		Price received (PEN kg^{-1})				*Quantity sold (kg)*			
Year	*Method*	*Treatm.*	*Control*	*Diff.*	*T-stat*	*Treated*	*Control*	*Diff.*	*T-stat*
2016	PSM 1NN	1.11	0.85	0.25	3.71	16653.81	8949.00	7704.81	2.91
	PSM 3NN	1.11	0.96	0.14	2.88	16653.81	7864.12	8789.69	4.26
	PSM 5NN	1.11	0.93	0.17	4.38	16653.81	8530.57	8123.23	3.87
	PSM Kernel	1.11	0.88	0.23	8.75	16693.10	9534.59	7158.51	3.89
	IPWRA	1.11	0.87	0.24	10.99	16653.81	9249.93	7403.88	3.78
2017	PSM 1NN	1.09	0.94	0.15	2.53	13217.42	12602.43	614.986	0.20
	PSM 3NN	1.09	0.86	0.23	6.18	13217.42	9058.85	4158.57	1.87
	PSM 5NN	1.09	0.86	0.22	7.03	13217.42	8372.24	4845.17	2.35
	PSM Kernel	1.09	0.87	0.21	7.97	13217.42	6808.26	6409.16	3.36
	IPWRA	1.09	0.87	0.21	8.54	13217.42	6239.35	6978.07	4.28
2018	PSM 1NN	1.04	0.82	0.22	3.32	15191.94	11988.58	3203.36	1.03
	PSM 3NN	1.04	0.86	0.18	3.82	15191.94	10473.04	4718.90	2.67
	PSM 5NN	1.04	0.83	0.21	5.63	15191.94	9221.48	5970.46	4.17
	PSM Kernel	1.04	0.89	0.15	5.19	15191.94	7052.38	8139.56	7.29
	IPWRA	1.04	0.86	0.18	6.34	15191.94	7921.26	7270.68	6.62
2019	PSM 1NN	1.11	0.81	0.30	5.02	14743.51	5080.85	9662.66	5.15
	PSM 3NN	1.11	0.81	0.30	6.21	14743.51	5889.60	8853.91	5.01
	PSM 5NN	1.11	0.84	0.27	6.05	14743.51	5850.70	8892.81	5.10
	PSM Kernel	1.11	0.86	0.25	7.14	14743.51	6606.29	8137.21	4.68
	IPWRA	1.11	0.84	0.26	7.15	14743.51	6287.40	8456.11	5.39

Note: PSM = propensity score matching, NN = nearest neighbour, IPWRA = inverse probability weighted regression adjustment.

3.2 Treatment effect (ATT) of selling output to cooperatives

We report the estimates of the average treatment effect on the treated (ATT) by sector in Tables 4-7. The ATT indicates the estimated effect of selling output to cooperatives for the sub-sample of farmers who in fact received treatment (i.e. sold output to cooperatives). As such, the relevant unit of observation is the patron, and all estimates should be interpreted as the price received and the quantity sold per patron.

3.2.1 Banana

In terms of price received, the ATT in the banana sector ranged from 0.14 PEN kg^{-1} in 2016 to 0.30 PEN kg^{-1} in 2019. At the maximum, a difference of 0.30 PEN kg^{-1} constituted a 37 % increase relative to the price received by the control group. The ATT estimates in terms of the quantity sold by patrons of cooperatives in the banana sector are relatively less significant, though still well in excess of the 99 % confidence level in most cases. Exceptions are the estimates in 2017 with the 1-nearest and 3-nearest neighbour algorithms as well as 2018 with the 1-nearest neighbour algorithm. When excluding the nonsignificant estimates, the magnitude of the effect ranged from as low as 4,800 kg in 2017 to as high as 9,600 kg in 2019. As such, the estimated effect of banana cooperatives varied across the years but also across the algorithms, which highlights the advantage of a longitudinal study.

Our results inform the mixed findings of other studies on the performance of banana cooperatives. Arguably the most relevant comparison is to Loconto *et al.* (2021), who conducted a case study to examine how banana cooperatives in Peru and Ecuador help to facilitate a price premium through the Fair Trade label. The banana cooperatives mediate the relationship between the producers and the consumers by ensuring compliance with Fair Trade standards. As such, our positive estimate of the treatment effect of cooperatives on the price received by banana farmers is perhaps mediated by the Fair Trade label. Indeed, as noted by Barreto *et al.* (2022), the Fair Trade label has facilitated the sustainable development of the banana sector, particularly in the northwest coastal area of Peru (i.e., Tumbes, Piura, Lambayeque, and La Libertad). Methodologically, our study is most comparable to Ma *et al.* (2022), who observed a positive effect of cooperative membership on the ability of banana farmers in China to increase yield and decrease risk exposure. However, the comparability is limited by differences in outcome variables and study settings; in the agri-food industry

Table 5: *Treatment effect of cooperatives on cocoa farmers*

		Price received (PEN kg^{-1})				*Quantity sold (kg)*			
Year	*Method*	*Treatm.*	*Control*	*Diff.*	*T-stat*	*Treated*	*Control*	*Diff.*	*T-stat*
2016	PSM 1NN	7.57	7.17	0.40	2.27	1023.85	646.27	377.58	3.23
	PSM 3NN	7.57	7.01	0.55	3.97	1023.85	742.93	280.91	2.70
	PSM 5NN	7.57	7.00	0.57	4.51	1023.85	670.39	353.46	3.81
	PSM Kernel	7.57	7.12	0.44	4.26	1023.85	660.63	363.22	4.41
	IPWRA	7.57	7.12	0.45	4.40	1023.85	675.60	348.25	4.50
2017	PSM 1NN	5.50	5.23	0.27	1.87	1247.35	777.19	470.16	3.14
	PSM 3NN	5.50	5.17	0.33	2.77	1247.35	749.11	498.24	3.74
	PSM 5NN	5.50	5.19	0.30	2.79	1247.35	789.63	457.72	3.57
	PSM Kernel	5.50	5.12	0.37	3.88	1247.35	758.71	488.65	4.17
	IPWRA	5.50	5.13	0.36	3.73	1247.35	778.36	468.99	4.13
2018	PSM 1NN	5.73	5.30	0.43	2.57	1235.18	747.27	487.92	2.64
	PSM 3NN	5.73	5.44	0.29	2.21	1235.18	883.18	352.00	2.08
	PSM 5NN	5.73	5.45	0.28	2.27	1235.18	983.45	251.74	1.51
	PSM Kernel	5.72	5.45	0.27	2.48	1170.64	816.88	353.76	2.48
	IPWRA	5.73	5.50	0.22	2.05	1235.19	890.48	344.71	2.38
2019	PSM 1NN	5.79	5.50	0.30	1.69	1469.43	775.51	693.92	2.82
	PSM 3NN	5.79	5.71	0.09	0.61	1469.43	919.65	549.78	2.44
	PSM 5NN	5.79	5.67	0.13	0.93	1469.43	897.70	571.73	2.57
	PSM Kernel	5.79	5.66	0.14	1.08	1469.43	830.34	639.09	2.95
	IPWRA	5.79	5.64	0.15	1.26	1469.43	822.04	647.39	3.00

Note: PSM = propensity score matching, NN = nearest neighbour, IPWRA = inverse probability weighted regression adjustment.

in general and the banana sector in particular, cooperatives appear to be much more prominent in China as compared to Peru and may therefore have greater capacity to positively affect farmers. Another noteworthy study is from Gebre *et al*. (2020), who concluded that Ethiopian banana cooperatives are not strong enough to compete successfully with intermediaries, in part because of insufficient capacity to accept and process all the member output. Cooperatives in the Ethiopian banana sector thus act as price takers and not price setters, and therefore do not have a significantly positive effect at the farm-level.

3.2.2 Cocoa

For the first three years of the study period (2016-2018), patrons of cocoa cooperatives enjoyed a positive effect in terms of the price received. The ATT ranged from 0.40-0.57 PEN kg^{-1} in 2016, from 0.30-0.37 PEN kg^{-1} (excluding the nonsignificant estimate from the 1-nearest neighbour algorithm) in 2017, and from 0.22-0.43 PEN kg^{-1} in 2018. In 2019, none of the algorithms yielded a significant estimate of the ATT. In terms of the quantity sold, the ATT ranged from 250-700 kg per patron throughout the study period. The quantity sold appeared to have increased for the treatment group as well as the control group from 2016 to 2019, but more so for the treatment group.

Quality is one possible explanation for the positive effect of cocoa cooperatives on the price received and the output sold of its patrons. As opposed to intermediaries, who focus solely on the national market price, cooperatives pay premiums on the basis of product quality in order to pursue differentiation in the marketplace (IICA, 2009). Farmers who produce cocoa for intermediaries do not pay attention to the humidity percentage or the fermentation degree of the beans. Moreover, large and small impurities such as dust, shells, and fibres are included in the final cocoa weight. Cocoa supplied to intermediaries is more likely to be used in the production of low-quality cocoa butter or cocoa powder for the domestic market (IICA, 2009). As intermediaries receive a uniform price for the entire supply, there is no incentive to improve product quality or even limit cocoa forgery (Inter-American Institute for Cooperation in Agriculture, 2009), which decreases the price received by farmers (Aspiazu, 2010).

We relate our result to Higuchi *et al*. (2020), who studied the concept of member satisfaction as well as related constructs in the context of cocoa cooperatives in Tocache,

Table 6: *Treatment effect of cooperatives on coffee farmers*

		Price received (PEN kg^{-1})				*Quantity sold (kg)*			
Year	*Method*	*Treatm.*	*Control*	*Diff.*	*T-stat*	*Treated*	*Control*	*Diff.*	*T-stat*
	PSM 1NN	6.35	5.95	0.40	2.99	800.74	653.48	147.26	1.01
	PSM 3NN	6.35	5.90	0.45	4.86	800.74	645.10	155.64	1.58
2016	PSM 5NN	6.35	5.86	0.49	6.05	800.74	646.40	154.34	1.80
	PSM Kernel	6.35	5.73	0.61	10.31	800.74	603.89	196.85	3.23
	IPWRA	6.35	5.76	0.59	10.16	800.74	611.28	189.46	3.18
	PSM 1NN	7.05	6.05	1.01	7.96	802.65	503.69	298.96	4.50
	PSM 3NN	7.05	6.05	1.00	11.76	802.65	530.46	272.19	4.97
2017	PSM 5NN	7.05	6.01	1.04	14.20	802.65	541.71	260.94	5.15
	PSM Kernel	7.05	6.02	1.03	19.77	802.65	613.52	189.13	3.92
	IPWRA	7.05	6.03	1.02	19.56	802.64	626.55	176.09	3.56
	PSM 1NN	6.19	5.19	1.01	7.96	842.38	527.88	314.50	3.31
	PSM 3NN	6.19	5.38	0.81	8.56	842.38	643.67	198.71	3.04
2018	PSM 5NN	6.19	5.44	0.75	9.21	842.38	642.85	199.53	3.47
	PSM Kernel	6.19	5.39	0.80	12.84	842.38	592.69	249.69	5.29
	IPWRA	6.19	5.38	0.82	12.36	842.38	582.84	259.54	5.66
	PSM 1NN	6.23	5.51	0.73	5.57	1068.48	837.95	230.53	1.72
	PSM 3NN	6.23	5.57	0.66	7.67	1068.48	875.99	192.49	1.93
2019	PSM 5NN	6.23	5.56	0.68	9.04	1068.48	754.31	314.17	3.72
	PSM Kernel	6.23	5.42	0.81	14.37	1068.48	619.21	449.27	6.54
	IPWRA	6.23	5.43	0.81	14.23	1068.48	606.74	461.74	6.89

Note: PSM = propensity score matching, NN = nearest neighbour, IPWRA = inverse probability weighted regression adjustment.

Table 7: *Treatment effect of cooperatives on palm oil farmers*

		Price received (PEN kg^{-1})				*Quantity sold (kg)*			
Year	*Method*	*Treatm.*	*Control*	*Diff.*	*T-stat*	*Treated*	*Control*	*Diff.*	*T-stat*
	PSM 1NN	0.29	0.32	0.03	-1.46	57214.29	67785.71	-10571.43	-0.35
	PSM 3NN	0.29	0.32	0.03	-1.39	57214.29	65559.52	-8345.24	-0.44
2018	PSM 5NN	0.29	0.32	0.03	-1.45	57214.29	61325.71	-4111.43	-0.23
	PSM Kernel	0.29	0.31	0.02	-1.20	57214.29	68152.71	-10938.43	-0.66
	IPWRA	0.29	0.31	0.02	-1.42	57214.28	69913.54	-12699.26	-0.93
	PSM 1NN	0.29	0.34	0.05	-2.23	78354.84	74645.16	3709.68	0.10
	PSM 3NN	0.29	0.32	0.03	-1.85	78354.84	96698.92	-18344.09	-0.74
2019	PSM 5NN	0.29	0.31	0.02	-1.15	78354.84	93975.48	-15620.65	-0.73
	PSM Kernel	0.28	0.35	0.07	-2.92	79800.00	68165.03	11634.97	0.45
	IPWRA	0.29	0.30	0.01	-0.86	78354.84	81344.41	-2989.57	0.30

Note: PSM = propensity score matching, NN = nearest neighbour, IPWRA = inverse probability weighted regression adjustment.

Peru, a province dominated by coca leaf production for decades. Among other findings, Higuchi *et al.* (2020) observed much heterogeneity in the degrees of member satisfaction and member commitment, which is reflected by our own observation of members of cooperatives who sell output to other individuals and organisations. The matter of heterogeneity also applies to our estimate of a positive effect at the mean; some heterogeneity across the population of cocoa cooperatives is to be expected. Donovan *et al.* (2017) presented a case study of four Peruvian cocoa cooperatives which struggled to achieve success in spite of ten or more years of activity. Blare *et al.* (2020) noted how cocoa cooperatives needed investment from buyers to improve the capacity for post-harvest processing (e.g. fermenting, drying). Outside

of Peru, cooperatives also have a positive effect on cocoa farmers in Ghana and Ivory Coast (Calkins & Ngo, 2010).

3.2.3 Coffee

The estimates of the ATT on the price received and the quantity sold by patrons of cooperatives in the coffee sector more or less conform to the findings of Grashuis & Skevas (2022). With the exception of three and two estimates of the ATT on the quantity sold in 2016 and 2019, respectively, the evidence indicates a positive effect of cooperatives on coffee producers across the study period. However, the magnitude of the ATT decreased from 2017 to 2019 in terms of the price received. Patrons of coffee cooperatives received a maximum of 1.04 PEN kg^{-1} more in 2017, 1.01 PEN kg^{-1} more in 2018, and 0.81 PEN kg^{-1} more in 2019. As such, the positive effect of coffee cooperatives may be on the decline.

3.2.4 Palm oil

Relatively, the results are not as good in the palm oil sector. The sign of the ATT in terms of the price received as well as the quantity sold is negative, but statistical significance is lacking. As such, there appeared to be no benefit to patronizing palm oil cooperatives during the study period.

A possible explanation is the age of the cooperatives. According to the data, palm oil farmers only began patronizing cooperatives from 2018 onward; in 2016 and 2017, all the palm oil farmers in the sample sold output to other individuals or organisations. Therefore, it may simply be too early for the palm oil cooperatives to have a positive effect at the farm-level. Inspiration is drawn from Indonesia, where Jelsma *et al*. (2017) studied a federalised system of palm oil cooperatives which outperformed the national yield average for over 25 years. While the evidence is limited, there is no good reason for the palm oil sector to be exempt from the positive effect of cooperatives which is in general observed across the agri-food industry (Grashuis & Su, 2019).

4 Conclusion

Our findings have several possible implications. (1) In the interest of alternative crop development in the jungle, policymakers may further promote the associativity of farmers. In cooperatives or similar business organisations, cocoa farmers and coffee farmers have demonstrated a greater capacity to negotiate with buyers in terms of price, quantity, and quality, thus facilitating a viable alternative to coca production. The effort may extend to other exotic products (e.g. arracacha, maca, mashua, quinoa, kiwicha, kañiwa, tarwi) in order to benefit more smallholders in Peru. (2) Following the observation of many members of marketing cooperatives who sell to other individuals or organisations, it is in the interest of practitioners to increase member commitment via the establishment and enforcement of member agreements. Cooperatives may use councils or committees to handle internal conflicts, though the external judicial system must also be sound to ensure the enforceability of legal contracts. (3) Similarly, considering the low market share of cooperatives across the four sectors, practitioners and policymakers may use evidence of our findings to promote membership. Effort should be made to formalise relationships with current patrons as well as farmers who sell output to intermediaries. In the process, practitioners and policymakers must address the farm-level opposition toward collective action. Memories from the era of agrarian production cooperatives may form obstacles. (4) Another consideration is the difference in the speed of payment between cooperatives and intermediaries. Since cash flow is of strong importance to relatively poor farmers, intermediaries have an advantage on the spot market with instant payments. Cooperatives, on the other hand, often do not pay suppliers until payment is received from the end consumer. Practitioners, as well as stakeholders in the financial sector, may consider the extension of credit to cooperatives to improve the speed of payment to suppliers.

We note several limitations of our study. First, because of our dependence on secondary data, we lacked the ability to extend the study period further toward the past or the present. For example, we are therefore unable to inform whether palm oil cooperatives have been able to improve performance in 2020 and 2021 given increases in experience. Second, we also lacked additional firm-level data in terms of pricing mechanisms or end buyer relationships. Beyond differences in the organisational form of cooperatives and intermediaries, there may exist other firm-level explanations for farm-gate price variability (e.g. association with Fair Trade label, premiums/discounts for superior/inferior quality). We look forward to future research endeavours to help address the above limitations, thus improving our knowledge of the ability of cooperatives to benefit smallholders in Peru.

Conflict of interest

The authors declare that they have no conflict of interest.

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