DOES COOPERATIVE MEMBERSHIP IMPROVE TECHNOLOGY ADOPTION? THE CASE OF DAIRY BUFFALO FARMERS IN THE PHILIPPINES

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ABSTRACT

Cooperative has long been regarded as a vital tool to promote technology adoption and boost smallholder farmers' income. Cooperatives are being tapped to extend hands-on training and seminars on production and management practices in dairy buffalo milk production. Several studies investigated the causal relationship between technology adoption and cooperative membership. However, no empirical studies tried to explore the effect of cooperative membership on the technology adoption extensity. This study analyzes the factors affecting the decision of farmers to become members of cooperatives and the impact of cooperative membership on the adoption of technologies. The study utilized farm-level data from 351 randomly selected dairy buffalo raisers from the Philippines' major dairy buffalo milk-producing regions. The Poisson regression with endogenous treatment model was used to analyze causality that links cooperative membership to technology adoption. Variables representing cooperative membership, farmgate price of milk, dairy farming as the primary source of income, training attendance, number of milking cows, and cold storage (refrigerator/freezer) ownership positively influence the technology adoption. The results of the endogenous treatment regression show that cooperative membership positively and significantly influenced technology adoption. Findings imply that cooperative membership is an effective tool to enhance technology uptake among dairy buffalo farmers for improved productivity and income.

Keywords: *Cooperatives, technology adoption, poisson regression, endogenous treatment, dairy buffalo*

INTRODUCTION

There is a wide recognition that enhancing agricultural productivity is vital because of its effective contribution to poverty alleviation through higher farm incomes and better food security. In fact, productivity improvements have been included in three out of the 17 priority action areas of the United Nation's 2030 Sustainable Development Goals (UN SDGs). Agricultural productivity refers to the farmers' ability to efficiently use the available resources (e.g., land, labor, capital, and management) to produce farm outputs (Competition Policy Review Panel, 2014). Increased agricultural productivity can be achieved by improving efficiency and/or introducing yield-increasing technologies, such as high-yielding varieties and genetically improved breeds (Aragon et al., 2013; Pabuayon et al., 2013; World Bank, 2020, UN 2021).

However, low and slow agricultural productivity growth remains an enormous challenge, particularly in those land-scarce developing countries like the Philippines. From 2005 to 2015, the country's total factor productivity (TFP) score only grew by 0.64%, well behind Vietnam, Thailand, Indonesia, and Malaysia's growth rates of 2.21%, 2.16%, 2.12%, and 1.8%, respectively (USDA-ERS 2021). One of the primary constraints to increased agricultural productivity stems from the limited adoption of farming technologies, equipment, and inputs (Pabuayon et al., 2013). These farmers, particularly those smallholders, often do not adopt the available technologies. Some are even unaware of new technologies or their optimal usage (World Bank 2020). The limited technology adoption at the farm level resulted from several factors, such as inadequate R&D budget support, weak extension system, high cost of inputs, limited access to formal credit, inadequate irrigation system, and high transaction costs associated with accessing new technologies (Valentinov 2007; Feleke and Zegeye 2006; Aragon et al., 2013; Ma, Abdulai, and Goetz 2018;). This underscores the need for an effective reform to increase new knowledge and ensure the adoption of technologies that improve farmers' productivity (World Bank, 2020).

In recent years, cooperatives have been regarded as a key to promoting the adoption of improved agricultural technologies. These self-help groups help promote new technologies by offering capacity-building activities such as trainings, and seminars. (Wollni and Zeller, 2007; Gachango et al., 2014; Ma et al., 2018). These cooperatives also serve as intermediaries by facilitating the exchange of information between farmers and technology suppliers such as the government, research institutes, technology companies, and agricultural extension agents.

Despite the abundant studies that looked into the causal relationship between technology adoption and cooperative membership, what has been less explored empirically, is how participation in a cooperative affects the adoption extensity. Adoption extensity refers to the "level or number of technologies adopted by a farmer from a bundle of technology or a wide range of multiple technologies." Farmers may be interested in utilizing cooperative services for a set of technologies that complement each other or that match their farms' specialization, particularly in diversified smallholder farming systems (Wainaina et al., 2018; Ma et al., 2018).

The impact evaluation of agricultural cooperatives on household welfare and poverty has been done in the Philippines (Jimenez et al., 2018; Jimenez et al., 2020). However, no empirical studies tried to explore the effect of cooperative membership on technology adoption, particularly on the adoption of an array of agricultural technologies in the country.

The dairy buffalo industry provides an interesting topic for this analysis as it is one of the major livestock animals and a source of livelihood and income for small and marginal farmers in the

Philippines (DA-PRDP, 2014). Dairy buffalo raisers are also faced with a number of constraints. This includes low milk yield, limited knowledge of milk production and processing technologies, poor access to extension services, lack of capital, inadequate processing capability, facilities, and equipment that affects quantity and quality of milk produced, and institutional failure in linking farmers to markets (Lantican et al., 2017). To address these issues, the government and local government units (LGUs) encourage these farmers to join cooperatives for greater access to extension services (e.g., material inputs, capital, training, and seminars) and appropriate information on technologies for improved productivity and income.

This study intends to analyze the impact of cooperative membership on the technology adoption of dairy buffalo farmers in the Philippines. Specifically, it aims to provide answers to the following research questions: Does membership to a cooperative positively and significantly affect the number of adopted technologies by dairy buffalo farmers? How does membership/participation to cooperatives affect the adoption of technologies in dairying? and, lastly, what are the determinants of farmers' technology adoption extensity?

METHODOLOGY

Sampling and Sample Size Determination

A multistage sampling technique was used to draw appropriate samples for this study. This is due to the fact that the population from which the sample will be drawn constitutes a heterogeneous group (cooperative members and non-members). In the first stage, six provinces across four regions, namely Isabela (II), Nueva Ecija (III), Cavite (IV-A), Batangas (IV-A), and Bohol (VII) were identified as study sites. In the second stage, three municipalities were selected in each province. In the third stage, a simple random sampling procedure was employed to determine three barangays from each selected municipality. The same sampling technique was also used in selecting the dairy buffalo farmers from the lists of dairy buffalo farmers in each barangay. The selected respondents included cooperative and non-cooperative members.

Given the above sampling technique, the sample size was computed given the the assumption that the observation from the dairy farmers is normally distributed. The confidence level was set to 95% (α=0.05).

A total of 351 farmers were interviewed. This is comprised of 249 cooperative members and 102 cooperative non-members. The distribution of farmer respondents per province is as follows: Isabela- 32, Nueva Ecija-133, Cavite-47, Laguna-40, Batangas-15, and Bohol-84.

Empirical Model

Cooperative members and non-members may not be directly comparable. This is because members may self-select to join cooperatives due to unobserved factors, (e.g., incentives and ability). These unobserved characteristics may also affect the level of technology adoption so cooperative membership is endogenous in technology adoption. The selection bias and endogeneity problems cannot be ignored because without accounting for these will result in inconsistent estimates and lead to biased conclusions (Heckman, 1979; Gerber, 1998).

To deal with these problems, Poisson regression with endogenous treatment model was employed in this study. The treatment variable used in the model is cooperative membership, while the outcome variable is the level of technology adoption. This method simultaneously estimates the treatment and outcome equations by analyzing the factors influencing cooperative membership and the level of technology adoption among dairy buffalo farmers. With this, endogeneity is controlled as the residuals (errors) from the treatment equation are included as an explanatory variable in the outcome equation; hence, justifying the robustness of this method.

More formally, the outcome and treatment equations are given by:

$$E(TA_i|x_i, C_i, \varepsilon_i) = exp\ (x_i\beta + \delta C_i, + \varepsilon_i) \quad (1)$$

$$C_i = \begin{cases} 1, & w_i\gamma + \mu_i > 0 \\ 0, & otherwise \end{cases} \quad (2)$$

The are the regressors used for the outcome equation, are the regressors used for the treatment equation and error terms and are bivariate normal with mean 0 and covariance matrix

$$\begin{bmatrix} \sigma^2 & \sigma\rho \\ \sigma\rho & 1 \end{bmatrix} \quad (3)$$

The covariates and are unrelated to the error terms. Note that in this case, is a count variable and nonnegative in this specification.

In this model, the dependent variable is a Poisson distributed count (i.e., farmer's technology adoption with values ranging from 0-22). The parameters estimated by the model are then employed to estimate the average treatment effect (ATE) and average treatment effect on the treated (ATET).

Table 1 presents a description of the dairy buffalo technologies, while table 2 shows the variable definition in the Poisson regression with endogenous treatment model.

Table 1: Description of dairy buffalo technologies

Technologies/Practices		Description
1. Stocks and selection of dairy animals	a. Heifer selection	Select a heifer that is docile and easy to handle, 2.5-3 years old with a weight of 300 kg
	b. Bull selection	Select purebred Murrah, 2.5-3 years old, with a weight of 300 kg
2. Herd and size management	a. Calving interval	Follow 18 months calving interval
	b. Weaning	Wean calf (separate calves from the mother) 5-7 days after calving
	c. Use of milk replacer	Provide whole milk or skim milk depending on calves' body weight
	d. Growing calves	Separate male and female after 14 months to avoid unwanted breeding

Technologies/Practices		Description
3. Feeds and feeding	a. Ad libitum grass and legume	Provide ad libitum amount of grass and legume with 70:30 ratio
	b. Concentrate mix	Supplement 1-2 kg of concentrate mix per day
	c. Mineral lick	Provide dairy buffaloes with continuous access to a mineral lick
4. Milk collection	a. Disinfection	Apply iodine before milking to avoid mastitis and udder infection
	b. Milk storage	Use of cold storage in milk transportation, use of milk cans in milk transportation
5. Breeding	a. Breeding practice	Breed buffalo twice (breed in the afternoon and repeat in the morning or breed in the morning and repeat in the afternoon)
	b. Artificial insemination	Practice artificial insemination
	c. Crossbred and purebred	Use of crossbred or purebred bull in breeding
6. Health practices	a. Detection of diseases	Use of test kit for buffalo diseases
	b. Deworming	Practice deworming: every six months in zero-grazing and four months in grazing
	c. Vaccination	Perform regular vaccination on FMD and Hemosep
7. Housing and milking infrastructure	a. Floor space	
	i. Bull	Use 6 square meters per head
	ii. Yearling	Use 4 square meters per head
	iii. Calf	Use 1-2 square meters per head
	b. Housing	Ensure that the house is well-drained, well-ventilated with a water supply
	c. Miking area	Use concrete floor with wood or pipes to restrain buffalos, constructed within or beside the animal house

Table 2: Description of variables in the poisson regression with an endogenous treatment model

Variable	Type	Description
Dairy buffalo technologies	Count	Number of technologies adopted
Cooperative membership	Binary	1 if farmer respondent is a cooperative member, 0 otherwise
Farmers' age	Continuous	Age of farmer engaged in milk production (years)
Years in schooling	Continuous	Farmer repondent's highest level of education (years)
Household size	Continuous	Number of family members in the household

Dairying as main source of income	Binary	1 if dairying serves as the main source of income of the household, 0 otherwise
No. of milking caracows	Continuous	Number of milking caracows (head)
Ave. travel time	Continuous	Average time from farm to market outlet (minutes)
Transaction cost	Continuous	Transaction costs incurred in production and marketing milk (PhP/year)
Attendance to training	Binary	1 if farmer attended training/seminar, 0 if otherwise
Cellphone ownership	Binary	1 if household owns a cellular phone, 0 if otherwise
Vehicle ownership	Binary	1 if household owns a vehicle, 0 if otherwise
Cold storage ownership	Binary	1 if household owns a cold storage, 0 if otherwise
Access to credit	Binary	1 if household has access to credit sources, 0 if otherwise
Access extension service	Binary	1 if household has access to extension service providers, 0 if otherwise
Output price	Continuous	Price received by farmers for selling milk (PhP/kg)
Batangas	Binary	1 if household is located in Batangas, 0 if otherwise
Cavite	Binary	1 if household is located in Cavite, 0 if otherwise
Laguna	Binary	1 if household is located in Laguna, 0 if otherwise
Isabela	Binary	1 if household is located in Isabela, 0 if otherwise
Bohol	Binary	1 if household is located in Bohol, 0 if otherwise

RESULTS AND DISCUSSION

Characteristics of Dairy Buffalo Farmer-Respondents

Table 3 shows that dairy farmer-respondents owned an average of two lactating caracows. Dairy farmers in Batangas and Nueva Ecija raised three lactating caracows, while those in Bohol, Cavite, and Laguna had an average of two lactating caracows each. It can also be observed in table 3 that the average lactation period of animals raised by the respondents is 252, shorter than the national average of 270 days. The longest animal lactation period was recorded in Batangas (310 days), followed by Nueva Ecija (301 days), while Isabela recorded the shortest lactation period (230 days) among the different provinces. Isabela dairy farmers recorded the lowest milk yield, with an average of 3.7 liters per animal per day. Nueva Ecija recorded the highest productivity with a mean milk yield of 5.97 liters per animal per day, followed by Batangas (4.99 liters) and Cavite (4.83 liters).

Regarding group membership, both coop and non-coop farmers are comparable in terms of the number of milking carabaos raised. However, it can also be observed that the animals raised by coop farmers have a more extended lactation period of 283 days compared to non-coop with only 220 days. This gap in the lactation period is primarily because all cooperative farmers use genetically improved breeds (i.e., crossbred and purebred caracows) for dairying, while most non-members use native ones. Coop farmers are also found to perform well in terms of milk yield. The average milk yield of coop farmers is 5.07 liters, which is within the national average of five liters, while the yield of non-coop farmers is only limited to 4.42 liters per day. High milk production may also be attributed to the improved breeds of caracows and better management practices that have resulted from training and extension services.

Table 3: Performance of dairy buffalo farms by type of farmer-respondents and by province, 351 dairy buffalo raisers, Philippines

ITEM	ALL FARMERS	COOPERATIVE MEMBERSHIP		PROVINCE					
		MEMBER	NON-MEMBER	ISABELA	NUEVA ECIJA	CAVITE	LAGUNA	BATANGAS	BOHOL
Average no. of milking animals	2	2	2	2	3	2	2	3	2
Lactation Period	252	283	220	230	301	284	284	310	270
Yield	4.75	5.07	4.42	3.7	5.97	4.83	3.86	4.99	4.1

Adoption of Dairy Buffalo Technologies

As shown in table 1, there are 22 technologies/practices for improved productivity and efficiency of dairy buffaloes. Adoption of these practices would also have implications on the performances of dairy buffalo farms. Based on the results of interviews, ad libitum grass-feeding, concentrate mix feeding, use of milk replace, artificial insemination, use of genetically improved breeds, 18 months calving interval, appropriate housing for the herd and milking chute for the caracows, deworming, vaccination for FMD, application of iodine when milking and use of milk cans are the commonly used/adopted technologies by dairy buffalo farmers. Table 4 shows that ad libitum feeding had the highest adoption rate of 86%. This is followed by deworming (73%), use of milking chute (70%), artificial insemination (65%), and use of genetically improved breeds of dairy buffaloes (62%). Meanwhile, the use of milk replacer (5%) had the lowest adoption rate. This is expected because milk replacer is relatively expensive, and farmers also would like to raise and feed the newborn calf. In terms of group characteristics of farmers, it can be observed that cooperative members have higher adoption rates in all the technologies listed in table 4.

Table 4: Summary of selected technologies adopted by dairy buffalos raisers

Specific Technology	Adoption Rate		
	All Farmer	Coop-Members	Non-Coop Members
Feeding			
1. Ad Libitum Grass Feeding	86%	85%	88%
2. Concentrate Mix Feeding	44%	49%	31%
3. Milk Replacer[1]	5%	6%	3%
Breeding			
1. Artificial Insemination	65%	69%	56%

2. Use of Crossbred and Purebred	62%	66%	50%
3. Calving Interval	15%	17%	9%
Housing			
1. Housing	54%	57%	46%
2. Milking Chute	70%	78%	52%
Animal Health			
1. Deworming	73%	79%	59%
2. Vaccination for FMD[2]	26%	27%	22%
Milk Collection and Milk Handling			
1. Use of Iodine	40%	49%	20%
2. Use of milk cans	34%	37%	27%

Notes:

[1] *Milk replacer has been introduced to the farmers in the study areas in 2018, which was not covered in the period of analysis (2016-2017 production). However, there are already adopters of this technology during the data gathering.*

[2] *The Philippines has been recognized as FMD-free without vaccination and Petits Ruminants (PPR), hence, this might have influenced farmers' decision not to adopt vaccination against FMD in the study areas.*

The differences in the adoption rates of farmers and performances of dairy buffalo farms could be attributed to genetic factors, including breeds of animals (e.g., crossbred and/or purebred bulls and caracows), and non-genetic ones such as production and management practices (e.g., amount and quality of feed, housing, calving intervals), and access to extension support (e.g., capital and material input support, training/seminars on herd management and milk production). For instance, results revealed that dairy farmers from Nueva Ecija, the province with the highest technology adoption rate and performance, have the full support of PCC national headquarters and are located within the national and regional impact zones for dairy buffalo farming. It is also in Nueva Ecija, where many crossbred and purebred animals are being distributed to farmer-cooperators.

Similarly, the higher adoption rates and performance were observed among cooperative-members because existing cooperatives are being tapped by PCC, PCAARRD, LGUs, and other developmental agencies to serve as conduits for the distribution of farm inputs (e.g., crossbred and purebred Murrah, feeds, milking machines, milk cans), promotion of recommended practices for dairy buffalo milk production, and conduct of various training/seminar on herd management (e.g., detection of heat and illnesses, deworming) and milk production and processing (e.g., proper milking collection and milk pasteurization and storage). In addition, cooperatives serve as regular markets of fresh milk and link between farmers and end-consumers. Through their product consolidation strategy, centralized milk collection, farmer-members received higher income due to reduced marketing and transaction costs and higher output prices. Cooperatives also provide other benefits such as patronage refund, knowledge sharing, and systematic and effective credit schemes for cooperative members.

Endogenous Treatment Regression (ETR)

Robustness of The Poisson Regression Model

The Wald chi2(16) = 376.50 is significant at 1% probability model, implying a good model fit (Table 5). The correlation between the treatment-assignment errors and the outcome errors is estimated at -1, suggesting that unobservables (e.g. motivations, ability) that influence technology adoption tend to occur with unobservables that influence cooperative membership. This is supported by the estimate of the Wald test of independent equations (<0.00) that is highly significant, inidicating a significant relationship between the residual of the treatment (cooperative membership) and the outcome (technology adoption) equations. This also suggests a potential problem of selectivity bias; hence, justifying the appropriateness of the model used in this study.

Determinants of Technology Adoption

The Poisson regression with the endogenous treatment model adopted in the study used the maximum likelihood approach to simultaneously estimate both the treatment and outcome equations. The treatment equation represents determinants of cooperative participation, while the outcome equation represents the determinants of technology adoption. Table 5 shows the the results of the endogenous-treatment regression model on the determinants of cooperative membership and technology adoption by dairy buffalo farmers.

A key variable of interest, cooperative membership, positively influence the adoption of dairy farming technologies. Compared to non-members, cooperative members are likely to adopt more technologies/practices related to dairy farming. In addition, based on the interview with farmers and other stakeholders, there are different ways through which cooperative membership had influenced the level of technology adoption. For instance, identified cooperatives and farmers' associations facilitate technology transfer and adoption by providing the venue for participative capability building and knowledge-sharing. Cooperatives and farmers' associations served as a tool for the government and other non-government organizations to extend hands-on trainings/seminars that cover topics on dairy buffalo and farm management and good practices in milk production. These organizations also provide services that improve farmers' access to inputs and technical assistance, which increase the degree of technology adoption (Mina et al., 2021). Moreover, cooperatives and farmers' associations also facilitate the adoption of technology through access to credit, enabling the purchase of major dairy production inputs. Lastly, cooperatives and farmers associations served as regular buyers of dairy buffalo milk, which requires the farmers to adopt the recommended practices, especially on milk handling.

Table 5: Determinants of cooperative membership and technology adoption, 351 dairy buffalo raisers, Philippines, 2017

VARIABLE	Cooperative Membership		Technology Adoption	
	Coefficient	Robust S.E.	Coefficient	Robust S.E.
Constant	0.847***	0.000	0.815***	0.245
Price	-0.015***	0.000	0.009***	0.003
Batangas	1.370***	0.000	-0.272***	0.076
Cavite	0.788***	0.000	-0.544***	0.083
Laguna	-0.722***	0.000	-0.226***	0.069
Isabela	0.881***	0.000	-0.420***	0.093
Bohol	1.664***	0.000	-0.335***	0.053
Years in schooling	0.073***	0.000	-0.008	0.007
Age	-0.004***	0.000	0.003	0.002

VARIABLE	Cooperative Membership		Technology Adoption	
	Coefficient	Robust S.E.	Coefficient	Robust S.E.
Family Size	-0.095***	0.000	0.013	0.009
Dairying as main source of income	0.646***	0.000	0.104***	0.038
No. of milking cows	0.018***	0.000	0.014**	0.007
Ave. travel time	-0.030***	0.000		
Ave. travel time^2	0.000***	0.000		
Transaction cost	0.002***	0.000		
Attendance to training			0.337***	0.054
Cellphone ownership			0.028	0.068
Vehicle ownership			-0.042	0.068
Cold storage ownership			0.080**	0.038
Cooperative membership			0.240***	0.053
/athrho			-9.229***	0.013
/lnsigma			-4.337***	0.811
rho(ρ)			-1***	0.000
sigma			0.013	0.011
Wald chi2(16)		376.50***		
Log pseudolikelihood		-878.627		
Wald test of indep. eqns.		**0.00*** **		
Observations	351			

Note:

****, **, and * refer to significant at 1%, 5% and 10% probability levels, respectively.*

Source: Derived from survey data (2018).

The second column of table 5 indicates that technology adoption is affected by cooperative membership, farmgate price of milk, farm location (province), dairying as the main source of income, training attendance, number of milking cows, and cold storage (refrigerator/freezer) ownership.

Attendance in trainings increases the number of adopted dairying technologies, with a coefficient of 0.337 that is highly significant (p-value < 1%). This result confirms the critical role of human capital formation in technology adoption.

The price per liter of milk, cold storage ownership, number of milking cows, and dairying as a major source of income also positively and significantly influence farmers' level of technology adoption. The variable for the farmgate price of dairy buffalo milk positively influenced technology adoption, implying that increasing the output price received for dairy buffalo milk will encourage more farmers to adopt improved production and marketing technologies. Meanwhile, the coefficient for number of milking cows is positive and significant, suggesting that the number of technologies adopted by dairy farmers increases with herd size. Based on interviews with farmer respondents, farmers adopt more technologies (e.g., milking machines, milk cans) because they want to take advantage of the economies of scale (reduce the average/ per unit cost) in the production and marketing of milk. Cold storage such as freezers and refrigerators are important assets in production since dairy buffalo milk is highly perishable.

Based on the results, this variable positively and significantly influences the adoption of technologies for dairy buffalo. This suggests that farmers who lack cold storage facilities such as milk coolers and freezers find no benefits in adopting technologies. Without these assets, farmers cannot produce larger amounts of milk since milk can easily get spoiled without cold storage. The coefficient for dairying as the main source of income is positive and significant, implying that a farmer will likely adopt technology for improved production and marketing if dairying is their primary source of income. Lastly, the location dummies representing the major dairy buffalo provinces such as Batangas, Cavite, Laguna, Isabela, and Bohol were all negative and statistically significant. This implies that compared to Nueva Ecija (the base variable), the number of technology bundles adopted in these provinces is significantly lower. This highlights the importance of proximity to the primary source of technology which the sample farmers in Nueva Ecija enjoy. This also accentuates the positive impacts that more extension activities can bring about on technology adoption.

Determinants of Cooperative Membership

As shown in the first column of table 5, all the regressors of cooperative membership have high statistical significance. Variables representing years of schooling, number of milking cows, dairying as the main source of income, and transaction cost positively influence the probability of being a cooperative member. The variable representing the years of schooling has a positive and significant coefficient (0.073), indicating that farmers with higher levels of education are more likely choose to join cooperatives.

The number of milking cows significantly and positively influenced the participation decision on cooperative membership. This is because a larger milking herd translates to a higher marketable surplus, which means that farmers would need market outlets (buyers) that regularly and easily accept large quantities of milk, benefit that cooperative membership provides.

Farmers who have dairying as the main source of income have higher probability of becoming cooperative members since they are the ones who are more in need of the benefits like technology, knowledge and practices, lower marketing costs, etc. Based on farmer interviews, these benefits and services are currently being offered by the existing cooperatives in the area.

Transaction costs have a positive and significant influence on the decision of farmers to join cooperative organizations. The higher the transaction cost incurred by the farmer, the more likely a farmer will join in a cooperative as it lowers the total transaction cost incurred by dairy farmers as membership facilitates access to information, technology, inputs, and markets. This results is consistent with the findings of Alemu and Adesina (2015), showing that transaction costs positively affect cooperative membership.

Accessibility of the milk market as represented by the average travel time affects the probability of cooperative membership nonlinearly. The coefficient of the base term is negative, while the coefficient of the squared term is positive, indicating a U-shaped curve. This implies that for farmers located farther from the wholesale market, the probability of joining cooperatives increases with distance. Verhofstadt and Maertens (2015) and Ahmed and Mesfin also found that distance to market postively and significantly influence cooperative membership. This is because, as the distance from the farm to the nearest market increases, the farmer incurs higher transaction costs in transportation of produce and input acquisition; hence, the farmer tends to be more dependent on a group and opts to sell to cooperatives.

Meanwhile, factors such as output price, age, and household size reduce the probability of joining a cooperative. The negative and significant coefficient of price implies that farmers receiving a higher farmgate price of milk are less likely to join in the cooperative. This is possible since cooperatives usually offer lower farmgate prices compared to private processors.

Age negatively and significantly influences the decision towards cooperative membership. This is expected since age is highly correlated with farming experience. Having a relatively lesser farming experience, younger farmers would choose to be cooperative members to obtain more information and gain more networks (Chagwiza et al., 2016; and Wossen et al., 2017).

Family (household) size positively affects the decision of farmer to join a cooperative, and this could be attributed to increased household labor endowment (Zheng et al., 2012; Ma et al., 2018).

All location dummies are positive and significant except for Laguna. With Nueva Ecija as the base variable, this implies that Cavite, Bohol, Isabela, and Batangas have higher proportions of sample farmers who are cooperative members compared to Nueva Ecija. This may be because farmers in Nueva Ecija have easier access to technology and markets due to their proximity to PCC. Spillover effects of technology diffusion might be strong in Nueva Ecija, which reduces the benefits of being a cooperative member. On the other hand, Laguna may have an even smaller proportion of cooperative members in the sample because the province, specifically the municipality of Sta. Cruz, is known for "kesong puti" and there are many private independent dairy milk processors that offer higher buying (farmgate) prices for dairy buffalo milk.

Impact of Cooperative Membership on Technology Adoption

Table 6 shows the estimated ATE of membership to a dairy cooperative. The results show that cooperative membership positively and significantly affects the level of adoption of dairy buffalo management technologies. Specifically, this number means that an average farmer will adopt 1.306 more milk production and marketing technologies if he/she is a cooperative member. Meanwhile, the estimated ATET of cooperative membership on the number of adopted technologies is 1.320. Thus, a cooperative member will adopt 1.320 more milk production and marketing technologies than he/she would if he/she is a non-coop member.

Table 6: Impact of cooperative membership on technology adoption of dairy buffalo raisers, 351 farmers in the Philippines, 2017

VARIABLE	Cooperative Membership	
	Coefficient	**Std. Error**
ATE	1.306***	0.271
ATET	1.320***	0.267

Note:

ATE- average treatment effect

ATET- average treatment effect on the treated;

*** refers to significant at 1% probability level

CONCLUSION AND RECOMMENDATIONS

The study was undertaken to determine the impact of cooperative membership on technology adoption for improved productivity of dairy buffalo raisers in the Philippines. Information from 351 randomly sampled farmers was used in the analysis.

Results revealed that cooperatives play a vital role in facilitating the adoption of technology by linking dairy farmers to markets, providing access to inputs, reducing the marketing and other transaction costs faced by the farmers, overcoming information asymmetries and barriers to access in assets (e.g., facilities and equipment) and extending support in the development of farmers' skills. Cooperative membership empowers smallholder farmers by enhancing their collective bargaining power and so reduces the risks that they face in the market. Cooperatives also serve as conduits for the dissemination of agricultural inputs needed for technology adoption. These farmer organizations also provide credit services to their members, hence easing constraints in milk production.

The Poisson regression with endogenous treatment model revealed that cooperative membership significantly and positively affects the level of technology adoption among dairy buffalo farmers. The model also showed that variables representing years of schooling, number of milking cows, dairying as the main source of income, and transaction cost positively influenced decision of farmers towards cooperative membership. In terms of the impact of cooperative membership on technology adoption, it was found out that membership to cooperatives positively and significantly affects the level of adoption of dairy buffalo management technologies. The estimated average treatment effect (ATE) of cooperative membership on the number of technologies is 1.306, suggesting that an average farmer will adopt 1.306 more milk production and marketing technologies if he/she is a cooperative member. The estimated average treatment effect on the treated (ATET) is 1.320, implying that a cooperative member will adopt 1.320 more milk production and marketing technologies than he/she would if he/she is a non-coop member.

These results highlight that cooperative membership is an effective strategy to improve uptake of dairy buffalo production and management technologies. Cooperatives served as an important platform for technology adoption by linking farmers to markets, provide necessary inputs, assist in the development of farmers' skills, and incentivizing farmers' adoption of technologies through patronage refunds and dividends. Cooperatives also serve as regular markets of fresh milk and link between farmers and end-consumers. Through their product consolidation strategy, centralized milk collection, farmer-members received higher income due to reduced marketing and transaction costs and higher output prices.

As this study confirmed that cooperatives help increase the adoption of yield-increasing technologies and practices, policy initiatives that would promote cooperative membership are imperative.

REFERENCES

Ahmed MH, Mesfin HM. (2017). "The impact of agricultural cooperatives membership on the wellbeing of small- holder farmers: empirical evidence from eastern Ethiopia." *Agricultural and Food Economics, 5* (1):6

Ainembabazi, J.H., van Asten, P., Vanlauwe, B., Ouma, E., Blomme, G., Birachi, E.A., Nguezet, P.M.D., Mignouna, D.B., Manyong, V.M. (2017). "Improving the speed of adoption of agricultural technologies and farm performance through farmer groups: evidence from the Great Lakes region of Africa." *Agric. Econ.* 48, 241–259.

Alemu, A.E.; Adesina, J.O. (2017). "In Search of Rural Entrepreneurship: Non-farm Household Enterprises (NFEs) as Instruments of Rural Transformation in Ethiopia." *Afr. Dev. Rev,* 29, 259–271.

Aragon, C.T., A.M. Salazar, AJ.A. Quilloy, and G. Carnaje. (2013). "Increasing Agricultural Productivity in the Philippines." *Food and Fertilizer Technology Center for the Asian and Pacific Region* 35-81.

Bernard, T., Spielman, D.J. (2009). "Reaching the rural poor through rural producer organizations? A study of agricultural marketing cooperatives in Ethiopia." *Food Policy, 34*, 60–69.

Chagwiza, C., Muradian, R., Ruben, R., (2016). "Cooperative membership and dairy per- formance among smallholders in Ethiopia." *Food Policy, 59*, 165–173.

Cuevas, A. and C. Mina. 2022. Impact of Cooperative Membership on Technical Efficiency and Marketing Efficiency: The Case of Dairy Buffalo Farmers in the Philippines. *DLSU Business & Economics Review, Vol. 31*, No. 2, pp. 137-145

Department of Agriculture-Philippine Rural Development Program (DA-PRDP). (2014). Value Chain Anlysis on Dairy Milk Industry: CALABARZON/Region IV-A

Feleke, S., Zegeye, T. (2006). "Adoption of improved maize varieties in southern Ethiopia: Factors and strategies." *Food Policy, 31*, 442–457.

Fischer, E., Qaim, M. (2012). "Linking smallholders to markets: determinants and impacts of farmer collective action in Kenya." *World Dev. 40*, 1255–1268.

Gachango, F.G., Andersen, L.M. and Pedersen, S.M. (2014). "Adoption of milk cooling technology among smallholder dairy farmers in Kenya." *Trop Anim Health Prod, 46***,** 179–184.

Gerber, A. (1998). "Estimating the effect of campaign spending on senate election outcomes using instrumental variables." *American Political Science Review, 92*, 401-411.

Heckman, J.J. (1979). "Sample selection bias as a specification error." *Econometrica, 47*, 153-161.

Ito, J., Bao, Z.S., and Su, Q. (2012). "Distributional effects of agricultural cooperatives in China: Exclusion of smallholders and potential gains on participation." *Food Policy, 37*, 700-709.

Jimenez, C.D., Catelo, S.P., M.M. Elauria, A.J.U. Sajise. (2018). "Impact of Cooperative Membership on Household Welfare, Evidence from Calamansi Farmers in Oriental Mindoro, Philippines." Accessed May 25, 2021, https://www.researchgate.net/publication/335883093_Impact_of_Cooperative_Membership_on_Household_Welfare_Evidence_from_Calamansi_Farmers_in_Oriental_Mindoro_Philippines

Jimenez, C.D., C.S. Mina, and S.P. Catelo. (2020). "Multidimensional Poverty Among Calamansi Farmers in Oriental Mindoro, Philippines: Does Cooperative Membership Matter?" Accessed

May 25, 2021, https://jemad.cem.uplb.edu.ph/articles/multidimensional-poverty-among-calamansi-farmersin-oriental-mindoro-philippines-does-cooperative-membership-matter/

Kolade O, Harpham T. "Impact of cooperative membership on farmers' uptake of technological innova- tions in Southwest Nigeria." *Development Studies Research An Open Access Journal. 2014; 1(1):340– 53.*

Lantican, F.A., Molina, M.C.M., Lapitan, J.E., Padrid, J.C., Suñaz, E.C., Cañizares, M.A.R., Lantican, J.A.G., and Carandang, L.A.M. (2017). "Dairy Buffalo Value Chain Analysis in Luzon, Philippines" (Monograph). SEARCA College Los Baños, Laguna.

Ma, W., Abdulai, A., (2016). "Does cooperative membership improve household welfare? Evidence from apple farmers in China." *Food Policy 58, 94–102.*

Ma, W., Abdulai, A., Goetz, R., (2018). "Agricultural cooperatives and investment in or- ganic soil amendments and chemical fertilizer in China." Am. J. *Agric. Econ. 100, 502–520.*

Mina, C. and L. Cruz. 2021. Economic Implications of Disasters on Cooperative Sector in CALABARZON, Philippines. *Journal of Economics, Management and Agricultural Development, Vol. 7*, No. 1, pp. 71-88

Mina, C.S., S.P. Catelo, and C.D. Jimenez. (2021). Productivity and competitiveness of garlic production in Pasuquin, Ilocos Norte, Philippines. *Asian Journal of Agriculture and Development 18*(1): 49-63.

Mmbando, F. E., E. Wale, and L. J. S. Baiyegunhi. (2015). "Determinants of Smallholder Farmers'Participation in Maize andPigeonpea Markets in Tanzania."*Agrekon 54 (1): 96–119.*

Pabuayon, I.M., S.P. Catelo, A.C. Rola and T.B. Paris. (2013). "Agricultural Policy: Perspective from the Philippines and other Developing Countries." Quezon, Philippines: University of the Philippines Press.1-26; 135-142.

Spielman, D.J., Byerlee, D., Alemu, D., Kelemework, D., (2010). "Policies to promote cereal intensification in Ethiopia: the search for appropriate public and private roles." *Food Policy 35, 185–194.*

United Nations (UN). (2021). The 17 Goals, Accessed May 25, 2021, https://sdgs.un.org/goals

U.S. Department Of Agriculture- Economic Research Service (USDA-ERS). (2021). Accessed May 25, 2021, https://www.ers.usda.gov/data-products/international-agricultural-productivity/

Valentinov, V. (2007). "Why are cooperatives important in agriculture? An organizational economics perspective." *Journal of Institutional Economics, 3(1):55-69*

Verhofstadt, E., Maertens, M., (2015). "Can agricultural cooperatives reduce poverty? Heterogeneous impact of cooperative membership on farmers' welfare in Rwanda." *Appl. Econ. Perspect. Policy 37, 86–106.*

Wollini, M., Zeller, M., (2007). "Do farmers benefit from participating in specialty markets and cooperatives? The case of coffee marketing in Costa Rica." *Agricultural Economics, 37, 243–248.*

World Bank. (2020). Global Productivity: Trends, Drivers, and Policies, Accessed May 25, 2021, https://openknowledge.worldbank.org/bitstream/handle/10986/34015/9781464816086.pdf

Wossen, T., Abdoulaye, T., Alene, A., Haile, M.G., Feleke, S., Olanrewaju, A., Manyong, V., (2017). "Impacts of extension access and cooperative membership on technology adoption and household welfare." *J. Rural Stud. 54, 223–233.*

Zheng, S., Wang, Z., Awokuse, T.O., (2012). "Determinants of producers' participation in agricultural cooperatives: evidence from Northern China. Appl. Econ. Perspect." *Policy 34, 167–186.*