RESEARCH ARTICLE

Impact of Cooperative Membership on Technical Efficiency and Marketing Efficiency: The Case of Dairy Buffalo Farmers in the Philippines

Agham C. Cuevas and Ceptryl S. Mina*
University of the Philippines Los Baños, Philippines
csmina@up.edu.ph

Collective action by smallholder farmers through cooperative membership is regarded as one of the approaches to overcome production and marketing inefficiencies. This study investigates the impact of cooperative membership on the technical efficiency (TE) and marketing efficiency (ME) of dairy buffalo farmers in the Philippines. A total of 351 (249 cooperative members and 102 non-cooperative members) randomly selected farmers from Regions II, III, IV-A, and VII were interviewed. Using cross-sectional farm household data of dairy buffalo farmers, technical and marketing efficiencies were estimated. Linear regression with endogenous treatment was performed to determine the impact of cooperative membership on the TE and ME scores of dairy buffalo farmers. Results suggest that compared to those who are non-members, cooperative farmer-members increase their TE and ME scores by 0.105 points and 0.242 points, respectively. Results imply that participation in cooperatives is an effective strategy to improve the productivity and marketing efficiency of dairy buffalo farmers in the country.

Keywords: cooperatives, dairy buffalo, endogenous treatment, technical efficiency, marketing efficiency

***JEL Classifications*:** Q13, J54, P13

There is wide recognition that improving smallholder farmers' productivity and marketing efficiency are among the key strategies for rural and economic development. To enhance productivity, farmers must realize the maximum possible output given the available resources and level of technology (Farrell, 1957; Battese & Coelli, 1995). Meanwhile, to improve marketing efficiency, farmers must receive the highest possible price for their products and services (Abbot & Makeham, 1981).

However, increasing smallholder farmers' efficiency in production and marketing is still an enormous challenge for policymakers and other development practitioners. With farmers who are often subsistent, small-scale, and fragmented, and with a marketing system characterized by a very long and complex supply chain, inefficiencies in moving the goods and services from the point of production up to the point of consumption are expected. These inefficiencies are commonly caused by the lack of market information, unavailability of reasonable credit, non-attractive business prospects, poor management practices, and difficulty accessing updated agricultural production technologies (Cuevas et al., 2018).

The establishment of rural-based organizations (RBOs), like cooperatives, are among the identified interventions to improve smallholder farmers' productivity and marketing efficiency. Cooperatives are institutional arrangements that adhere to the theory of collective action. Seth (2009) noted that collective action is deemed necessary in encouraging the farmers to proactively participate in the daily operations and coordination of the cooperatives' activities to improve their production and marketing efficiencies.

As early as the 1970s, cooperatives have been tapped to improve the production and marketing performance of smallholder farmers; and improve their potential to expand market access (Sumalde & Quilloy, 2015). Cooperatives contribute to the increased productivity of smallholder farmers because they provide members with an enabling environment for sharing information, pooling resources, and distributing costs and risks among their members. This would not be possible if the smallholder farmer worked alone or individually (Hogeland, 1987). In addition, because cooperatives act as single buyers or sellers, these groups of farmers now have greater market power (Siebert, 2001). Hence, when farmers organize themselves and decide to form a farmer group/organization, they can overcome the challenges associated with production and marketing inefficiency.

Cognizant of its vital role in economic development, the cooperative has been regarded as one of the key policy instruments in technology promotion, efficiency enhancement, and welfare improvement of smallholder farmers in the Philippines (Jimenez et al., 2020; Jimenez et al., 2018; Sumalde & Quilloy, 2015). For instance, dairy cooperatives serve as conduits of government initiatives and other programs to improve the economic performance of the Philippine dairy buffalo industry (Palacpac, 2010; Lantican et al., 2017; Cuevas et al., 2018). However, despite the increasing advancement in promoting cooperative as a development tool, its role and contribution to agricultural development are often understated. Furthermore, though there are researches that emphasized the role of cooperatives in production and marketing, these studies provided only anecdotal shreds of evidence and did not use widely accepted statistical methodologies.

To fill this gap, this study assessed the impact of cooperative membership in the production and marketing efficiency of dairy buffalo farmers in the Philippines.

Methodology

Selection of Study Areas

Six provinces across four regions were identified as survey sites for the field survey. The selected provinces are the major provinces engaged in buffalo production. These were: Isabela in Region 2; Nueva Ecija in Region 3; Batangas and Cavite in Region 4A; and Bohol in Region 7. The criteria used in the selection of the municipalities are the following: (a) municipalities where dairy buffalo interventions were placed and (b) municipalities with the highest dairy buffalo milk production. Information on the specific municipalities covered in the study were obtained from the available documents from the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCARRD), and Philippine Carabao Center (PCC). On the other hand, data on milk production of each province and municipality were obtained from the PCC.

Sample Size and Method of Data Collection

A total of 351 randomly selected farmers were interviewed, of which 249 were cooperative members, and 102 were non-cooperative members. Out of the 351 farmers, 15 are from Batangas, 47 from Cavite, 40 from Laguna, 32 from Isabela, 84 from Bohol, and 133 from Nueva Ecija.

Both primary and secondary data were used in the study. Descriptive statistics were used to describe the general characteristics of households, as well as their production and marketing systems to show differences in performance between cooperative and non-coop farmers. Econometric analyses were used to determine whether cooperative membership has a positive influence on the production and marketing efficiency of farmers.

Primary data were gathered through household surveys, focus group discussions (FGDs), and key informant interviews (KIIs). A farm household survey was performed from June to August 2018 using a structured survey questionnaire covering among others: (a) buffalo inventory and productivity (type of breed, milk yield, lactation period, etc.); (b) method of reproduction; (c) feeds and feeding system; (d) breeding practice; (e) housing and health provisions; (f) milk collection and milk handling; (g) milk production, volume of sales, and types of buyer; and, (h) costs and returns.

Analytical Tool

Production Efficiency Model

The stochastic frontier model (SFA) with inefficiency components was utilized in assessing the impact of cooperative membership on production efficiency. SFA estimates an efficient frontier by imposing the same level of technology across observations. Any deviations from the frontier are attributed to the inefficiency and error components of the model.

Following the model of Battese and Coelli (1993, 1995), it has the general form:

$$M_i = f(X_i, \beta)\exp(\varepsilon_i) \quad (1)$$

where M_i represents the quantity of milk per head in liters of farm$_i$ ($i = 1, 2, \ldots, N$); X_i is the vector of inputs of farm$_i$; β is the vector of coefficients; and ε_i is the disturbance term that ε_i is composed of two independent error components, v_i and u_i, such that $\varepsilon_i \equiv v_i - u_i$. The $v_i \sim N(0, \sigma_v^2)$ represents any random variations beyond the farmers' control (e.g., luck, weather, etc.), where a symmetric component is normally distributed.

On the other hand, the $\mu_i \sim |N(0, \sigma_v^2)|, \mu_i \geq 0$ component represents the pure technical efficiency (i.e., managerial ability). It is assumed that u_i is defined by truncation of the normal distribution with mean,

$$\mu_i = \delta_0 + \sum_{j=1}^{J} \delta_j Z_{ji} \quad (2)$$

and variance, σ^2 where Z_{ji} represents variables that explain the variable in technical efficiency; and δ_0 and δ_1 are unknown parameters.

The MLE can be used to estimate the parameters of both the stochastic frontier model and the inefficiency effects model. The variance parameters of the likelihood function are estimated in terms of $\sigma_S^2 \,..\, \sigma_V^2 + \sigma_U^2$ and $\gamma \,..\, \sigma_U^2 / \sigma_S^2$.

Following equations (1) and (2), the technical efficiency for each farm can be defined by

$$TE_i = \exp(-u_i) \quad (3)$$

The predicted technical efficiencies of each farm are based on its conditional expectation, given the observable value of (v_i-u_i; Battese & Coelli, 1988; Jondrow et al., 1982). The TE score is 1 if the farm is efficient (has zero inefficiency effect) and it is less than 1 otherwise.

The production efficiency effects (TE_i)—assumed to be independently but not identically distributed—generated in equation (1) are estimated as:

$$TE_i = \delta_0 + \delta_1 X_1 + \delta_2 X_2 \ldots + e_i \quad (4)$$

Where X_i is the characteristic of the i^{th} farm that determines relative efficiency. The disturbance term e_i is defined by the truncation of the normal distribution with a mean 0 and variance σ^2. The truncation of e_i occurs at $+e_i \geq X_{ik}\delta_k$ (Battese & Coelli,1995).

Linear regression with endogenous treatment was performed using the predicted production efficiency effects (TE) to identify the significant factors influencing TE and the impact of cooperative membership on TE.

The endogenous treatment-regression model for technical efficiency is comprised of two equations—the outcome equation TE_j and the treatment equation t_j:

Table 1. *Variables Used in the Analysis of Production and Market Efficiency, 351 Dairy Buffalo Farmer-Respondents, Philippines, 2017*

Variable	Description
a. Stochastic Frontier Production Function	
Dependent Variable	
Milk	milk output of farm i (liters per animal)
Explanatory Variables	
Family Labor	amount of family labor used of farm i (man-hours per animal)
Hired Labor	amount of hired labor used of farm i (man-hours per animal)
Feeds	amount of commercial feeds used per year (kilograms per animal)
Health Expenditure	cost of animal health care per year (PhP per animal)
Lactation period	milking period (days per animal)
No. of Milk Buffaloes	total number of dairy buffalo in farm i (heads)
Breed	1 if purebred or crossbred, 0 if otherwise
b. Determinant of Technical Efficiency	
Dependent Variable	
Technical Efficiency index	Technical efficiency score of farmer i (percent)
Explanatory Variables	
Years in Schooling	education level of the farmer (schooling years)
Years of farm experience	dairy experience of the farmer (years)
Nueva Ecija	1 if farm household is located in Nueva Ecija, 0 if otherwise
Dairying as Main Source of Income	1 if dairying serves as the main source of income of the household, 0 if otherwise
Attendance to Training	1 if the farmer attended trainings related to dairying in the last three years, 0 if otherwise
Cooperative Membership	1 if the farmer is a member of a dairy cooperative, 0 if otherwise
c. Marketing Efficiency	
Dependent Variable	
Marketing Efficiency	Marketing efficiency score of farmer_i (percent)
Explanatory Variables	
Nueva Ecija	1 if farm household is located in Nueva Ecija, 0 if otherwise
Marketing Cost	annual cost incurred in marketing fresh milk (PhP per liter)
Price	farmgate price of fresh milk (PhP per liter)
Transaction Cost	cost of finding buyers of fresh milk (PhP per liter)
Cooperative Membership	1 if the farmer is a member of dairy cooperative, 0 if otherwise

$$TE_j = x_j\beta + \delta t_j + \varepsilon_j \tag{5}$$

$$t_j = \begin{cases} 1, & w_j\gamma + \mu_j > 0 \\ 0, & \text{otherwise} \end{cases} \tag{6}$$

where x_j are the explanatory variables of the outcome, w_j are the explanatory variables of treatment assignment, and error terms ε_j and μ_j are bivariate normal with mean equal to 0 and covariance matrix

$$\begin{bmatrix} \sigma^2 & \sigma\rho \\ \sigma\rho & 1 \end{bmatrix} \tag{7}$$

The covariates x_j and w_j are unrelated to the error terms.

Marketing Efficiency

In this study, marketing efficiency is measured using the price received by farmers as a portion of the consumer's price. In analyzing the impact of cooperative membership in farmers' marketing efficiency, linear regression with endogenous treatment was also used. Following Gebre et al. (2021) and Mdoe and Wiggins (1996). The farmers' share was estimated using the formula:

$$\%\ of\ farmers'\ share = \frac{Price\ recieved\ by\ the\ farmer}{Price\ paid\ by\ the\ consumer} X100 \tag{8}$$

whereas marketing efficiency was calculated by:

$$Marketing\ efficiency = \frac{Marketing\ Margin + Farmers\ share}{Marketing\ Margin} \tag{9}$$

The endogenous treatment-regression model for marketing efficiency is composed of an outcome equation ME_j and a treatment equation t_j:

$$ME_j = x_j\beta + \delta t_j + \varepsilon_j \tag{10}$$

$$t_j = \begin{cases} 1, & w_j\gamma + \mu_j > 0 \\ 0, & \text{otherwise} \end{cases} \tag{11}$$

where x_j are the independent variables used to model the outcome, w_j are the explanatory variables used to model treatment assignment, and error terms ε_j and μ_j are bivariate normal with mean 0 and covariance matrix

$$\begin{bmatrix} \sigma^2 & \sigma\rho \\ \sigma\rho & 1 \end{bmatrix} \tag{12}$$

The covariates x_j and w_j are unrelated to the error terms. Table 1 summarizes the variables used to analyze dairy buffalo farmers' production and marketing efficiency.

Results and Discussion

Production Efficiency

TE measures a farm's capability to attain the highest possible output given a set of resources or employ the lowest feasible quantity of inputs to produce the same output level. TE provides a way to quantify and compare each farmer's performance and identify the factors that could explain any inefficiencies and differences in production performance (Greene, 1993).

Table 2 presents the estimates of the stochastic production function model. The coefficients of concentrate feeds, breed, number of milking carabaos, and lactation period per animal positively and significantly influenced milk yield at a 1% level of significance. Concentrate feed has a coefficient of 0.028, suggesting that a 1% increase in concentrate feeds rationed would increase milk collection per animal by 0.028%. This is reasonable as concentrate feeds and feeding rate are important for increasing and sustaining milk yield. The use of purebred or crossbreed animals in dairy production has also been found to significantly affect farmers' production efficiency. The coefficient is 0.20, indicating that if a farmer uses improved breeds of animals (i.e., purebred or crossbred), milk production will increase by 0.20%. The coefficient for the lactation period is 0.257, implying that a 1% increase in the lactation/milking period will result in a 0.257% increase in milk yield.

Health expenditure, a proxy variable for the level of animal health care, and hired labor were also significant at a 10% probability level. The coefficient for health expenditure indicates that a 1% increase in expenditure for animal health care would increase milk yield by 0.016%. Hired labor has a coefficient of 0.035, meaning a 1% increase in the man-hours put in for labor would increase milk yield by 0.035%.

The estimated lambda shows that 50.5% of the variation in milk yield is due to technical inefficiency. The coefficient also implies that given the same level of technology, dairy buffalo raisers can still improve their yield by 49.5% if they adopt the management practices of the best-performing buffalo farmer.

Table 3 shows the estimates from the outcome equation of the linear regression with endogenous

Table 2. Maximum-Likelihood Estimates of Stochastic Frontier Production Function Parameters, 351 Dairy Buffalo Farmer-Respondents, Philippines, 2017

VARIABLES	COEFFICIENT	ROBUST SE
ln Family Labor (per animal)	-0.028	0.030
ln Hired Labor (per animal)	0.035*	0.018
ln Feeds (per animal)	0.028***	0.009
ln Health Expenditure (per animal)	0.016*	0.009
ln Lactation period	0.257***	0.032
ln No. of Milk Buffaloes	0.087***	0.032
Breed	0.200***	0.050
/lnsig2_v	-2.069***	0.160
/lnsig2_u	-3.435***	0.568
sigma_v	0.355	0.029
sigma_u	0.179	0.051
Sigma2	0.158	0.014
Lambda	0.505	0.075
Wald chi2 (7)	1317.56***	
Log pseudolikelihood	-174.47	
Number of Observations	351	

*Note: ***, **, and * refer to significant at 1%, 5% and 10% probability levels, respectively.*
Source: Derived from survey data (2018).

Table 3. Factors Influencing Dairy Farmers' Technical Efficiency, 351 Dairy Buffalo Farmer-Respondents, Philippines, 2017

VARIABLES	Technical Efficiency	
	Coefficient	Robust S.E.
Constant	0.776***	0.015
Years in Schooling	-0.001	0.001
Years of farm experience	0.001***	0.000
Nueva Ecija	0.022**	0.010
Dairying as Main Source of Income	-0.015	0.010
Attendance to Training	-0.006	0.008
Cooperative Membership	0.105***	0.016
/athrho	-1.087***	0.233
/lnsigma	-2.570***	0.109
rho(ρ)	-0.796	0.085
Sigma	0.077	0.008
Lambda	-0.061	0.012
Wald chi2(6)	57.400***	
Log pseudolikelihood	285.104	
Wald test of indep. eqns.	21.810***	
Number of Observations	351	

*Note: ***, **, and * refer to significant at 1%, 5% and 10% probability levels, respectively.*
Source: Derived from survey data (2018).

treatment on dairy buffalo farmers' predicted technical efficiency scores. Cooperative membership was found to positively and significantly influence dairy buffalo farmers' technical efficiency scores. The Average Treatment Effect (ATE) estimate of being a cooperative member is 0.105, implying that farmers who belong to the cooperative would increase the technical efficiency index by 0.105 than those who do not belong to any group. This result emphasizes the importance of cooperative membership on the efficiency of dairy buffalo milk production.

The better performance of cooperative members can be attributed to the fact that members received regular training and other extension services through the organization. These trainings provide farmers with vital information necessary for the production and marketing of milk. These interventions may have contributed to the improvement in farm management skills and animal husbandry practices because they are designed according to farmers' specific needs.

The coefficients for years of farming experience and a dummy variable for farm location were also significant factors in increasing the technical efficiency scores. The coefficient for years of farming experience is positive, implying that an increase in the years of farming experience increases the technical efficiency index level by 0.001. The dummy variable for farm location (Nueva Ecija) is also statistically significant at a 5% probability level. The results indicate that if dairy farms are located in Nueva Ecija, the technical efficiency index is higher by 0.022 than farms located in other provinces. This is expected because dairy farmers from Nueva Ecija have full support from the PCC national headquarters and are within the national and regional impact zones for buffalo dairying.

Marketing Efficiency

Marketing efficiency is one of the frequently used measures of market performance. Table 4 shows the estimates from the outcome equation of the endogenous-treatment model on marketing efficiency. The ATE estimate of being a cooperative member is 0.242, implying that cooperative members increase marketing efficiency by 0.242 than those who do not belong to any group.

Market efficiency among cooperative members is expected because cooperatives have positively contributed to dairy buffalo farmers' marketing activities. These organizations introduced the use of aluminum milk cans and buckets for proper milk

Table 4. Factors Influencing Dairy Farmers' Marketing Efficiency, 351 Dairy Buffalo Farmer-Respondents, Philippines, 2017

VARIABLES	Marketing Efficiency	
	Coefficient	Robust S.E.
Constant	0.374***	0.087
Nueva Ecija	-0.024	0.015
Marketing Cost	-0.000***	0.000
Price	0.021***	0.001
Transaction Cost	-0.000	0.000
Cooperative Membership	0.242***	0.041
/athrho	-1.435***	0.326
/lnsigma	-1.957***	0.088
rho(ρ)	-0.893	0.066
Sigma	0.141	0.012
Lamda	-0.126	0.020
Wald chi2(5)	296.73***	
Log pseudolikelihood	95.561	
Wald test of indep. eqns.	19.350***	
Number of Observations	351	

*Note: ***, **, and * refer to significant at 1%, 5% and 10% probability levels, respectively.*
Source: Derived from survey data (2018).

handling and transportation. Cooperatives also hired milk collectors so farmers could conveniently sell better quality milk even if the processing facilities are distant from the farm. Cooperative members were also encouraged to sell more milk because the cooperative serves as their regular and reliable market/buyer. By serving as regular markets of fresh milk, cooperatives also made it possible to shorten the long market chain, thereby reducing the marketing cost for dairy buffalo milk. The services provided by cooperatives resulted in reduced marketing margin and increased the price received by farmers.

Other variables, such as marketing cost and farmgate price, also affected dairy buffalo farmers' marketing efficiency. The coefficients for marketing cost and farmgate price are both significant at a 1% level of significance.

Summary and Conclusion

This study analyzed the impact of cooperative membership on the production and marketing efficiency of dairy buffalo farms in the Philippines. A cross-sectional farm household-level data was collected from 351 randomly selected dairy buffalo farming households.

Results of the stochastic frontier analysis revealed that concentrate feeds, breed, number of milking carabaos, lactation period per animal, health expenditure, and hired labor positively and significantly influenced milk yield. Results showed that 50.5% of the variation in milk yield among dairy buffalo farmer-respondents is due to technical inefficiency. Given the same level of technology, farmers can still increase their milk yield by 49.5% if they adopt the management practices of the best-performing buffalo farmer.

The endogenous-treatment model on production efficiency also revealed that compared to those who do not belong to any group, cooperative members increase their technical efficiency scores by 0.105 points. This implies that cooperatives help boost smallholder dairy buffalo farms' production efficiency. Meanwhile, the endogenous-treatment model on marketing efficiency showed that cooperative membership enhanced farmers' marketing efficiency. Compared to non-members, cooperatives improve their marketing efficiency scores by 0.242 points.

The findings highlight the importance of cooperative membership in dairy buffalo milk production and marketing. The results also underscore the need to promote cooperatives and encourage cooperative membership among dairy buffalo farmers in the country.

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