Technical Efficiency of Milkfish Production in the Province of Iloilo, Philippines

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ABSTRACT

The Philippine aquaculture sector is primarily dominated by milkfish, with the province of Iloilo as one of the key producing areas. However, the production in the province has exhibited a decreasing trend since 2011. In this light, this study is undertaken to determine the technical efficiency of milkfish production in the province of Iloilo and identify the factors that significantly affect such efficiency. Utilizing the maximum likelihood estimation method, a Cobb-Douglas production function was specified to estimate farm-level efficiency using the data from 181 milkfish producers interviewed. The technical efficiency scores ranged between 12.38% to 90.00%, with a mean of 59.16%. Efficiency was negatively affected by the length of culture, while the source of stocking material, pond tenure status, and frequency of stock checking positively contributed to efficiency. The results of this study emphasized potential areas where the production efficiency of milkfish can be further improved.

Keywords: *extensive milkfish culture, technical efficiency, stochastic production frontier, productivity*

Introduction

The Philippine aquaculture sector is primarily dominated by milkfish. It consistently tops the list of aquaculture species reared in the country in terms of value and the most traded in the local markets, making it a significant contributor to local and national earnings (Bureau of Fisheries and Aquatic Resources [BFAR] 2018). Production of milkfish in the Philippines is predominantly based on extensive brackish water pond culture, where the pond's productivity strongly relies on the supply of natural food (Yap *et al.* 2007). Key milkfish-producing regions are Ilocos (27.36%), Western Visayas (19.32%), CALABARZON (17.02%), and Central Luzon (16.07%) (Philippine Statistics Authority [PSA] 2018).

Being the second largest producer of milkfish in the country with a total production value of PHP 7.2 billion, Western Visayas has been long identified as a traditional, likewise advanced, milkfish producing area. Top producing provinces are Capiz, Negros Occidental, and Iloilo. Most milkfish produced in the region were reared from brackish water fishponds, observing either extensive, modular, polyculture, or intensive culture methods (BFAR 2018, PSA 2018).

Among other major producers of milkfish in Western Visayas, production in Iloilo has exhibited a decreasing trend since 2011. This is contrary to the production performance of other key milkfish-producing provinces in the region where production has been steadily increasing. In terms of yield, Irz and Stevenson (2012) reported a combined average yield of 378.78 kilograms of milkfish

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per hectare for Central Luzon and Western Visayas. However, such yield was 58.24% lower than the reported national average yield of 907 kilograms per hectare for brackish ponds by the PSA in the same year.

To lessen this gap, the sector's productivity can be improved by increasing farm-level efficiency and identifying the factors that significantly affect the efficient production system. Currently, there are limited technical efficiency measurement studies involving milkfish production in the Philippines particularly in the province of Iloilo, which is a key player in the industry. The foregoing discussions on efficiency measurement in the aquaculture sector showed that less focus is given to milkfish production as most of the existing literature focused on measuring the technical efficiency of other aquaculture species. Hence, this study will investigate the technical efficiency of extensive monoculture production on milkfish in brackish water ponds in the province of Iloilo and further identify the factors that significantly affect such efficiency. Also, production- and marketing-related problems that confront the milkfish farmers will be presented. The findings of this study hope to benefit major industry stakeholders by emphasizing potential areas where the production efficiency of milkfish can be further improved.

Methodology

Stochastic Production Frontier Model

The stochastic frontier (SF) approach is commonly used among various approaches available in measuring technical efficiency. The SF model highlights the decomposition of the deviation from the frontier into two components: stochastic noise and technical inefficiency. However, a notable disadvantage is its requirement to impose a specific functional form for the core production technology employed (Crentsil and Essilfie 2013).

The SF analysis was pioneered by the early works of Aigner, Lovell, and Schmidt (1977), Battese and Corra (1977), and Meeusen and van den Broeck (1977). The SF production model for the estimation of farm-specific technical is expressed as:

$$Y_i = f(X_i; \beta) + \varepsilon_i \qquad i = 1,2,\ldots,n \tag{1}$$

where Y_i is the output, X_i is a vector of inputs, β is a vector of production function or technology parameters, and ε_i is the error term. Aigner, Lovell, and Schmidt (1977) further decomposed the error term into two components:

$$\varepsilon_i = V_i - U_i \tag{2}$$

where V_i is the symmetric disturbances assumed to be identically, independently, and normally distributed as $N(0, \sigma_V^2)$. The component U_i, on the other hand, is a one-sided error term assumed to be normally distributed as $N(0, \sigma_U^2)$, and independent of V_i. This error component permits actual production to fall below the efficient frontier without attributing all deviations from the frontier to inefficiency.

Battese and Corra (1977) gave importance to the resulting variances of the error components. Identified as the variance ratio Gamma (γ), each resulting value of the respective variance relay essential information. It can identify whether the deviation of the actual output from the maximum (efficient) output is caused by either random specification errors or inefficient use of farm resources. The variance ratio takes a value between 0 and 1 and can be written as:

$$\sigma^2 = \sigma_U^2 + \sigma_V^2 \tag{3}$$

$$\gamma = \sigma_U^2/\sigma^2 \tag{4}$$

Suppose $\sigma_V^2 = 0$, then the principal error in the stochastic production function model is caused by U, and that the variance ratio is equal to 1. This implies that the difference in the actual output of farmers considered from the maximum output is mainly due to technical efficiency. Contrary to when $\sigma_U^2 = 0$, the variance ratio is equal to 0, and that the predominant error in the stochastic production function model is due to the symmetric error V.

Technical Efficiency Estimation

The stochastic frontier model discussed earlier is estimated using the maximum likelihood estimation method. Farm-specific technical efficiency is obtained through the conditional expectation of the error component U_i, as proposed by Jondrow (1982), expressed as:

$$E(U_i|\varepsilon_i) = \frac{\sigma_U\sigma_V}{\sigma}\left[\frac{f(\varepsilon_i\lambda/\sigma)}{1-f(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \tag{5}$$

where f and F respectively represent the standard normal density and cumulative distribution function, evaluated at ε_i/σ. Moreover, $\lambda = \sigma_U/\sigma_V$ and $\sigma^2 = \sigma_U^2 + \sigma_V^2$.

Given the definition of farm-specific technical efficiency in terms of the actual output (Y_i) to the corresponding frontier output (Y_i^*) for a given technology, it can be expressed as:

$$TE = \frac{Y_i}{Y_i^*} = \frac{E(Y_i|U_i, X_i)}{E(Y_i|U_i = 0, X_i)} = E\left[\exp(-U_i|\varepsilon)\right] \tag{6}$$

$$TE = \exp\,(-U_i) \tag{7}$$

Hypotheses Tests

In this study, several hypotheses were tested using the generalized likelihood-ratio test:

(1) $H_0: \mu = 0.$ This hypothesis specifies that a simpler half-normal distribution is an adequate representation of the given data, given the specifications of the generalized truncated-normal model.

(2) $H_0: \gamma = \delta_0 = \delta_1 =..= \delta_P = 0.$ This specifies that inefficiencies are absent from the model at every level.

(3) $H_0: \gamma = 0.$ This null hypothesis specifies that inefficiencies are not stochastic, implying that the traditional average production adequately represents the structure of sample milkfish farms.

(4) $H_0: \beta_7 = \beta_8 = \beta_9 = 0.$ This indicates that the study site effect or differences in the location do not significantly affect milkfish production. Specifically, the technology employed is assumed to be homogenous across all sample farmers, which may be attributed to knowledge spillover brought about by the proximity of ponds to each other.

In contrast to the usual t-test in testing the significance of a particular variable, Battese and Coelli (1988, 1992) and Coelli (1995) stressed the necessity of utilizing the composite hypotheses when more than one coefficient is being looked at, thus the use of the generalized likelihood-ratio test (Dey *et al.* 2000). The generalized likelihood-ratio test statistic is defined as:

$$LR = -2\left\{\ln\left[L\left(H_0\right)\right] - \ln\left[L\left(H_1\right)\right]\right\} \quad (8)$$

Study Site and Data Collection

Four municipalities were purposively determined as the study's locale: Dumangas, Barotac Nuevo, Anilao, and Ajuy. The provincial agriculture office also identified these municipalities as the top four milkfish producing areas in the province.

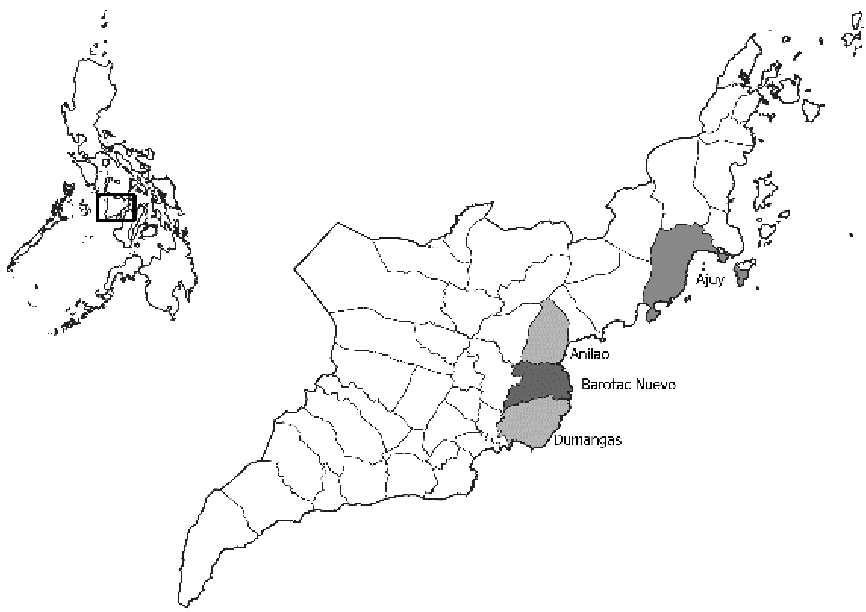

Figure 1. Modified Map[1] of Study Areas (UN OCHA, n.d.)

From a total population of 443 pond owners identified, a sample size of 181 was determined by estimating the population mean. The sample size for each study site was then obtained using proportional sampling and sample respondents were randomly identified using the lists provided by the provincial and local agriculture offices. Data on farm characteristics, operator's profile, farm operation activities (i.e., quantity of inputs used, and output produced in their most recent production cycle during the interview), input and output prices, and marketing information were obtained through a farm survey conducted from November to December 2018.

[1] The authors requested Mediodia, H.J. to modify the map of the study areas.

The Stochastic Production Function Frontier and the Inefficiency Model

For this study, a Cobb-Douglas stochastic production function was employed in estimating the technical efficiency scores of each milkfish pond owner expressed as:

$$ln\,Q_i = \beta_0 + \sum_6 \beta_j\, ln\, X_{ji} + V_i - U_i \quad (9)$$

$$i = 1,..,n;\; j = 1,..,9$$

where			
	Q_i	Total production of the i^{th} farm	Milkfish production in the most current cycle (kilogram)
	X_1	Quantity of stocking materials	Quantity of stocking material used (fry, juvenile, or fingerling) (1,000 pieces)
	X_2	Quantity of nitrogen	Quantity of nitrogen applied (kilogram)
	X_3	Quantity of phosphorus	Quantity of phosphorus applied (kilogram)
	X_4	Quantity of feeds	Quantity of feeds used (kilogram)
	X_5	Quantity of labor	Quantity of labor rendered (operator, family, and hired) (man-day)
	X_6	Pond area	In hectares
	X_7	Dumangas site	D = 1 if the pond is in Dumangas, 0 if otherwise
	X_8	Anilao site	D = 1 if the pond is in Anilao, 0 if otherwise
	X_9	Barotac Nuevo site	D = 1 if the pond is in Barotac Nuevo, 0 if otherwise
	β_0, β_j	Estimated parameters representing the intercept and production elasticities, respectively	
	V_i	Random variable: $V(0,\sigma^2)$; Independent of U_i	
	$-U_i$	Non-negative random variable assumed to capture technical inefficiency in the production	

Other than inputs used in the production process, dummy variables representing the study sites were included in the production function. This is to account for possible variation in technology or culture practice employed across the sample farmers that can further influence the level of production. Conventionally, technology use is assumed to be influenced by demographic, socio-economic, institutional, and geographical factors (Melesse 2018, Sun and Fan 2017).

Moreover, inefficiency is attributed to various farm-specific indicators, farmer's socio-economic characteristics, and farmer's management skills. The inefficiency model is further expressed as:

$$\mu = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \cdots + \delta_9 z_9 \quad (10)$$

Variable	Description	Unit of Measure (Expected Sign)
z_1	Farmer's years of education	Years (-)
z_2	Farmer's years of experience in pond management	Years (-)
z_3	Contact to extension services	Absolute number of public, private, or combination of both, extension services received (-)
z_4	Membership to fishery-related association	D = 1 if yes, 0 if otherwise (-)

z_5	Length of culture	Months (+)
z_6	Source of stocking material	D = 1 if wild-bred, 0 if otherwise (-)
z_7	Pond tenure status	D = 1 if leased, 0 if otherwise (-)
z_8	Frequency of stock checking	Absolute number of times stock checking was performed in the whole production cycle (-)
z_9	Frequency of water replacement	Absolute number of times pond water was replaced per month (-)
$\delta's$	Estimated parameters	

The specified structural model was estimated using the FRONTIER 4.1 program by Coelli (1996). The statistical package specifically uses the maximum likelihood estimate (MLE) method to simultaneously estimate the frontier production function and the inefficiency effect model.

Results and Discussion

Milkfish Production in Iloilo

Milkfish is reared using various methods such as (1) traditional or extensive, (2) progression or modular, (3) semi-intensive, and (4) intensive. These methods differ according to the stocking density employed, food source, pond structure and equipment, feed application, number of production cycles in a year, and expected production volume (PCAARRD 2016).

Among these culture methods, the majority (90%) of milkfish producers in the province of Iloilo practice extensive culture method (BFAR R06, 2018). This culture method is characterized by its high dependence on natural food (i.e., *lab-lab* and *lumut*) for feeding. However, supplemental feed (i.e., commercial feed or breadcrumbs) is applied when deemed necessary. Unlike other culture methods, the traditional means of culturing milkfish do not require machines such as aerators and electric feeder in the production process and primarily relies on the natural productivity of the pond.

Milkfish Farm and Farmers' Profile

Socio-economic characteristics of milkfish farmers (i.e., age, sex, years of education received, and years of pond management experience) are presented in Table 1.

Table 1. Summary of socio-economic characteristics of 181 milkfish producers, Iloilo, Philippines, 2018

Item	Unit	Dumangas (*n=105*)	Barotac Nuevo (*n=30*)	Anilao (*n=15*)	Ajuy (*n=31*)	Total (*N=181*)
Age	Years	52.86	54.60	52.80	51.90	52.97
Sex*						
Male		98	27	15	27	167
Female		7	3	0	4	14
Education	Years	8.94	9.60	7.87	9.06	8.98
Pond management experience	Years	15.67	18.60	15.73	20.23	17.00

* Figures on sex are frequency counts, not average

The average age of the milkfish farmer respondents in the study is 53 years old, with the youngest at 23 years old and the oldest at 81 years old. Comparing the mean age of the farmers from each study site, milkfish farmers in Barotac Nuevo are relatively old, while relatively young farmers are from Ajuy. In terms of education, Barotac Nuevo milkfish farmers have relatively more years of education than their counterparts from the other study sites. The average years of education was nine, where mostly reached high school (39.77%). The majority (93%) of the respondents directly involved in the operation were male, with the women comprising only seven% of the sample. Most of the ponds covered in the study were operated by caretakers, with owners having minimal control in the production process except for the provision of capital.

The average total pond management experience among the respondents is 17 years, whereas farmers with the most experience in pond management can be found in Ajuy with 20.23 years. It was observed from the study that most pond operations for both the owners and caretakers were passed down from older generations. On the other hand, farmers from Dumangas and Anilao relatively have the least experience in pond management. Consequently, the same group of farmers was also the youngest and with the least years of education. Of the total sample farmers, the majority (80.66%) primarily rely on milkfish production for income.

Quantity of Output and Input Use

Table 2 summarizes the minimum and maximum output and input mean values used in milkfish production. Yield and input use were expressed on a per hectare basis. Quantities of output and inputs were obtained based on the most recent production cycle of the farmers.

Table 2. Summary of respondent's mean output and input values in milkfish production, 2018

Item	Unit	Total (*n=181*)	Minimum	Maximum
Pond area	ha	10.52	1.00	45.00
Yield	kg/ha	271.16	17.68	1,025.83
Stocking material	1,000 pcs/ha	3.95	1.50	500.00
Lime	kg/ha	44.88	0.00	450.00
Pesticide	kg/ha	1.03	0.00	20.00
Organic fertilizer	kg/ha	699.06	0.00	1,055.56
Inorganic fertilizer	kg/ha	103.67	1.07	190.47
Feed	kg/ha	157.28	0.00	1,500.00
Labor	md/ha	20.47	1.02	57.89

The average yield of the sample farmers was 271.16 kilograms per hectare. This is lower than the national average yield of 1,087 kilograms per hectare for brackish ponds reported by PSA in 2018. Moreover, given that yield falls below 500 kilograms per hectare confirms that the milkfish production in Iloilo was extensive in nature (Irz and Stevenson 2012).

Pond areas range between 1 hectare to 45 hectares, with a total pond area average of 10.52 hectares. Stocking materials have three (3) types, namely: (1) fry, (2) juvenile, and (3) fingerling. Use of these materials primarily depends on the preference of the farmer. However, in this study, only the number of stocking material used in the grow-out phase was considered. The average total usage of the stocking material across the sample farmers was at 3.95 thousand pieces per hectare.

To ensure and hasten the growth of natural food, milkfish farmers observe several pond-preparation practices: (1) pesticide application, (2) lime application, and (3) fertilizer application. All farmers that applied pesticide in the pond made use of tea seed, with a total average usage across of 1.03 kilograms per hectare. Moreover, lime application ranged from zero to 1,272.73 kilograms per hectare, averaging 450 kilograms per hectare. This is a little bit lower than the recommended application for old ponds (PCAARRD 2016). Two types of fertilizers are usually applied to accelerate the growth of natural food: (1) organic and (2) inorganic. The average use of organic fertilizer among sample farmers is 699.06, falling short of the recommended application of 3,000 kilograms per hectare. In terms of applying inorganic fertilizer, the usage among farmers ranged from zero to 1.07 to 190.47 kilograms per hectare.

While some farmers tend to use a combination of at least two inorganic fertilizers, the frequently used was Urea (46-0-0).

When the natural food is depleted or the farmer wants to hasten the growth of the stock, some find it necessary to employ supplement feeding. The total average feed usage was 157.28 kilograms per hectare. Labor-wise, the average man-days per hectare rendered across the sample was 20.63 man-days per hectare.

Result of the Generalized Likelihood-Ratio Statistics

The result of the generalized log likelihood-ratio test for each hypothesis was summarized and illustrated in Table 3.

Table 3. Result of the generalized likelihood-ratio test on several hypotheses, 181 milkfish producers, Iloilo, Philippines, 2018

Null Hypothesis (H_o)	Likelihood Ratio Test	Critical Value $\chi^2_{df,0.10}$	Decision
$H_0: \mu = 0$	0.080	1.642	Failed to reject H_0
$H_0: \gamma = \delta_0 = \delta_1 = .. = \delta_9 = 0$	42.340	16.670	Reject H_0
$H_0: \gamma = 0$	2.900	1.642	Reject H_0
$H_0: \beta_7 = \beta_8 = \beta_9 = 0$	3.980	5.528	Failed to reject H_0

The first hypothesis tested was on the technical assumption on the distribution of the inefficiency factor error term (μ_i) having a half-normal distribution. The resulting LR statistic coefficient of 0.080 was lower than the tabular chi value of 1.642 at α=10%, thus failing to reject the null hypothesis. Therefore, following a half-normal distribution for the inefficiency factor error term is preferred over the truncated normal distribution.

The second hypothesis checked for the existence of the inefficiency factors. The null hypothesis is stated as having the gamma coefficient and all the δ's equal to 0. This implies that there is no inefficiency in the production of milkfish in Iloilo. Based on the result of the LR test, the computed chi estimate was 42.340, greater than the critical value equal to 16.670 with a significance level of 10% and degrees of freedom of 11. This verified the existence of inefficiency in milkfish production in Iloilo, thus rejecting the null hypothesis.

The third hypothesis specifies that inefficiencies are absent from the model at every level; each fish farm in the sample operates on the technically efficient frontier. With this, the model reduces to the average response function (OLS model). Based on the MLE run, the gamma (γ) variable resulted in a value of 0.868, contrary to the null hypothesis identified. In support of this, the resulting LR test estimate of 2.900 is greater than the tabular value equal to 1.642. From this, the null hypothesis was rejected and further implied that the traditional average response is not an adequate representation of the data.

Lastly, the hypothesis on the effect of the study site on milkfish production was tested. It was initially assumed that production practices do not differ or are too minimal to affect production and efficiency. In the case of milkfish farmers in this study, knowledge spillover is expected due to the proximity of the ponds to each other. This creates a positive externality through information sharing (i.e., culture practices), leading to pond operators observing and following the same culture practices as their fellow farmers from nearby ponds. Such result is further validated by the resulting LR test coefficient of 3.980 being less than the critical value equal to 5.528. This led to failing to reject the null hypothesis, implying that production practices are homogenous among sample farmers across the study sites and do not significantly influence milkfish production. With this, the model was reduced to a 6-input production function.

Estimation of the Stochastic Production Function

Table 4 summarizes the resulting maximum likelihood estimates of the stochastic frontier production function. All the resulting coefficients were positive, conforming to the a priori assumption that the estimated production function is increasing (Dey *et al.* 2000).

Table 4. Summary of maximum likelihood estimates of the stochastic Cobb-Douglas production function, 181 milkfish producers, Iloilo, Philippines, 2018

Variable	Parameter	Coefficient
Constant	β_0	4.206***
Stocking material	β_1	0.158*
Nitrogen	β_2	0.179***
Phosphorus	β_3	0.023*
Feed	β_4	0.011**
Labor	β_5	0.086*
Pond area	β_6	0.480***
Gamma	γ	0.855***
Sigma-squared	σ^2	0.779***
	σ_U^2	0.666
	σ_V^2	0.113

Note: ***,**,* Significant at 1%, 5%, and 10% probability levels, respectively

Among the inputs considered, pond area, nitrogen, and stocking material were the topmost important inputs influencing milkfish production. The pond area appeared to have the highest output elasticity with 0.480, implying that production will increase by 48% when pond area is to increase by one hectare, *ceteris paribus*. This result is comparable to the findings of Irz and Stevenson (2012) on brackish water ponds in the Philippines, attributing this to the extensive nature of the technology employed.

On the other hand, nitrogen was found to positively contribute to production, with an output elasticity of 0.179. Increasing nitrogen usage by one kilogram increases production by 17.90 percent, *ceteris paribus*. The study of Dey *et al.* (2000) on tilapia grow-out ponds reported a relatively lower output elasticity for nitrogen application. In terms of stocking material used, the resulting output elasticity of 0.1577 suggests a 15.77% increase in milkfish production for a 1,000-piece increase of its use, *ceteris paribus*. This result is relatively higher than the reported finding on extensive fish culture in Thailand (0.080) by Dey *et al.* (2005). Given the current culture system widely observed among the milkfish farmers, it is possible to increase production substantially by improving the pond's natural productivity and stocking density. Finally, a scale elasticity value of 0.940 was obtained after taking the sum of all the output elasticities. This further indicates that milkfish production in the province on average exhibits decreasing returns to scale.

The resulting gamma coefficient from the MLE run of the production function yielded a value of 0.855, highly significant at α=1%. This suggests that much of the variation in the composite error term is attributed to the inefficiency component. The gamma ratio indicates the relative magnitude of the variance, σ^2, associated with the technical inefficiency effects (Akinbode, Dipeoluand, and Ayinde 2011). The predicted mean technical efficiency of the sample milkfish farmers in Iloilo is 0.592, ranging from 0.124 to 0.900. That is, on average, the milkfish farmers are producing 40.84% below the optimal level.

Following the analysis of Akinbode, Dipeolu and Ayinde (2011), from the resulting individual and mean technical efficiency scores in this study, if the average farmer in the sample was to achieve the technical efficiency of his most efficient counterpart, then the average farmer could realize a 34.27% increase in output (i.e., 1 – (0.5916/0.9000)). A similar calculation for the most technically inefficient farmer in the study reveals an increase in output of 87.26% (i.e., 1 – (0.1238/0.9000)). The wide variation shows an opportunity for improvement by some farmers and that an enhancement of productivity can be initially done by improving farm-level efficiency. The resulting gap verifies the argument raised by Yap (1999) and Irz and Stevenson (2012) that brackish water fishponds are underproductive and underdeveloped.

Distribution of Efficiency Scores

The distribution of the technical efficiency scores of the 181 sample milkfish farmers in Iloilo is illustrated in Table 5.

Table 5. Distribution of technical efficiency score, 181 milkfish producer respondents, province of Iloilo, 2018

Score Range	Frequency	Percentage
0 to 0.30	24	13.26
0.31 to 0.40	14	7.73
0.41 to 0.50	18	9.94
0.51 to 0.60	22	12.15
0.61 to 0.70	35	19.33
0.71 to 0.80	41	22.65
0.81 to 0.90	27	14.92
Mean	0.592	
Maximum	0.900	
Minimum	0.124	

According to Grabowski (1990), a firm is considered technically efficient if it obtains a technical efficiency estimate of at least 82%. Following this, the milkfish producers in the province of Iloilo are considered relatively less efficient, with 85.08% having a technical efficiency score of 0.80 or lower. Moreover, only 27 farmers, comprising 14.92%, had a resulting efficiency score of 0.80 or better. This result is significantly higher than Irz and Stevenson's work on extensive polyculture ponds in Central Luzon and Western Visayas combined in 2012, where most of the sample farmers have technical efficiency scores ranging from 0.20 to 0.40.

Determinants of Technical Inefficiency

Table 6 reviews the result of the technical inefficiency model of the Cobb-Douglas production function. Various farm-specific indicators and farmers' socio-economic characteristics and managerial skills were investigated to see how these affect the resulting technical efficiency scores and its potential to improve milkfish farmers' technical knowledge in Iloilo.

Table 6. Summary of respondent's technical inefficiency estimates of the stochastic Cobb-Douglas production function, Iloilo, Philippines, 2018

Variable	Parameter	Coefficient
Years of education	δ_1	0.031
Years of experience in pond management	δ_2	-0.0004
Contact to extension services	δ_3	-0.271
Membership in fishery-related association	δ_4	-0.629
Length of culture	δ_5	0.222*
Source of stocking material	δ_6	-1.002*
Pond tenure status	δ_7	-0.537*
Frequency of stock checking	δ_8	-0.166*
Frequency of water replacement	δ_9	-0.008

Note: * statistically significant at 10%

Most of the variables in the inefficiency model had a resulting sign conforming to a priori assumptions, where four appeared to be significantly affecting efficiency. These variables were the length of culture, pond tenure status, source of stocking material, and frequency of stock checking. Meanwhile, variables such as farmer's years of education, years of experience in pond management, contact to extension services, membership in fishery-related association, and frequency of water replacement appeared to be statistically non-significant.

Stock checking and pond water management are essential in realizing a successful production cycle (Sharma and Leung 1998, 2000). In this study, fish stock management was represented by the frequency of stock checking in the duration of the production cycle. This step primarily ensures the quality of the seed purchased (i.e., swimming in circles and against the current) to gain an approximate count of the total stock, lessens the mortality rate, and checks the health condition of the stock while it is growing. From this, more frequent stock checking is expected to decrease inefficiency. Efficient water management through frequent pond water replacement, on the other hand, involved the absolute count of water replacement done. In the absence of pond aerators, this step is likewise necessary for attaining a balanced oxygen level in the water that significantly aids the healthy growth of the fish and natural food. Hence, it is expected to contribute to efficiency positively. For the milkfish farmers in Iloilo, both fish stock and water management variables yielded the expected sign as that with the finding of Sharma and Leung (2000). However, the frequency of water replacement appeared to be statistically non-significant in this study.

Furthermore, pond tenure appeared to be negatively affecting the inefficiency of milkfish producers as well. It can be noted that rented ponds were assigned a code of 1 in the data, implying that a rented pond tends to be more efficient relative to an owned pond. This can be attributed to the annual fixed rent the tenant is required to pay. Such liability places pressure on the tenant to ensure a level of production that will yield a positive profit, enabling him to fulfill this obligation.

The source of stocking material appeared to be an equally important indicator contributing to efficiency. In the case of the sample milkfish farmers in the study, those who utilize stocking material that is wild bred seemed to be more efficient than farmers who sourced theirs from a nearby hatchery. Though claimed to be more accessible to most and available all year round, less preference among farmers was observed towards stocking material from hatcheries.

Lastly, the length of the culture, on the other hand, appeared to be positively contributing to inefficiency. This suggests that the longer the production cycle, the more inefficient the producer becomes. One contributing factor is that longer production cycles entailed more resources. Instances were noted during the interview that some producers would extend the cycle for at least a month (i.e., deciding to supplement feed), expecting the stock to grow more in weight. However, the majority experienced losses because slow feeding was observed among the fish stock. The producers attribute such in having to utilize a poor-quality stock in the production cycle covered.

Production and Marketing Problems Encountered

The producers involved in the study were also asked to identify the production- and marketing-related problems they encountered. Results are summarized in Table 7.

Table 7. Major production- and marketing-related problems encountered, 181 milkfish producers, Iloilo, Philippines, 2018

Problems Encountered	Frequency (n = 181)
Production-related*	
a. Pests	163
b. Bad weather/natural calamities	121
c. Poor seed quality	28
d. Lack of capital	30
e. Unavailability of desired stocking material	43
Marketing-related*	
a. Varying price of produce	34
b. Unstable price of inputs	61
c. Lack of price information	28

* Multiple responses

Pests, specifically the birds, were identified as the biggest concern among the production-related problems they confront, with 163 milkfish farmers (90.06%) reported to be affected. It was reported during the survey that production losses went as high as 80% in instances when these were not attended. Unexpected heavy rains and winds are also equally detrimental, especially during pond preparation, as it can wash off the natural food being grown. Strong water currents and flooding caused by typhoons destroy the pond walls and dikes. Other problems identified were purchasing poor quality stocking materials, poachers, and negligence among pond caretakers.

Regarding marketing-related problems, the most prevalent issue confronting the milkfish producers was the unstable price of the input, with 33.70% of the sample farmers raising this as a primary concern. This is especially true with fertilizers and feeds. As per the producers themselves, such problems together with the unstable input prices and the lack of marketing information (i.e., on the prevailing farmgate price) pose an alarming threat to their expected returns from production.

Thirty-four (18.78%) sample milkfish farmers likewise reported instances having low prices of produce. *Komisyunista* or brokers were generally the key players in the local marketing of milkfish. A pre-arranged buyer would buy the produce outright in the pond. Plastic crates and vehicles were then sent to the pond and transported produce in the nearest fish market (*pala-pala*). In turn, this broker distributed the fish to different market outlets such as retailers, wholesalers, cooperatives, and consumers (BFAR 2018). The price paid for the produce would depend on the prevailing price for milkfish in the *pala-pala,* leaving the milkfish farmers to have less to no control in determining the price of the produce.

Lastly, 15.47% of the pond operators raised the problem of having limited access to price information. All operators solely relied on price information from the price dictated by the *komisyunista.*

Conclusion and Recommendation

The study specified a Cobb-Douglas production function to estimate the technical efficiency of 181 randomly selected extensive milkfish producers from the four key production areas in the province of Iloilo and determined the factors that affect farm-level efficiency scores. The resulting maximum likelihood estimates show that a potential increase in yield can be achieved by increasing usage of inputs, particularly nitrogen and stocking material. It is, therefore, plausible to increase yield substantially by improving the pond's natural productivity and increasing the stocking density.

The estimated mean technical efficiency of milkfish producers in the province of Iloilo is 59.16%. Such is lower when compared to the resulting TE value to that of the works of Chiang (2004) on milkfish farmers in Taiwan and Suharno (2017) in Indonesia, but relatively higher than that of polyculture producers in brackish water ponds in Central Luzon and Western Visayas combined (Irz and Stevenson 2012). This follows that the average producer could realize a 34.27% increase in output if the average milkfish producer in the sample was to achieve the technical efficiency of his most efficient counterpart. A similar calculation for the most technically inefficient farmer in the study reveals an increase in output of 87.26%.

In addition, the study highlighted the importance of the pond management practice (i.e., frequency of stock checking), length of culture, pond tenure status, and source of stocking material in alleviating inefficiency. An increase in the effort to improve the above-mentioned conditions might be a promising course to improve farm-level efficiency and, eventually, productivity.

Problems confronting the milkfish producers were also presented and discussed. In terms of production problems, the biggest concern was pest infestation, followed by natural calamities or bad weather. In terms of marketing problems, the low price of produce and unstable price of inputs were considered major problems. It can be noted that while the study findings only apply to the identified production areas in this study, its applicability to other production areas outside Iloilo requires further validation.

The resulting mean efficiency estimate implied a significant gap to fill for efficiency improvement among the milkfish producers in Iloilo. With pond area positively and significantly affecting output, it may be recommended that such key input be increased in terms of use. However, since following such entails a significant addition to production cost, one way to improve land's utilization is to design it to accommodate larger stocking density (i.e., making use of deeper ponds). Given that the sample farmers are understocking relatively to the maximum recommended stocking density, increasing the current stocking density observed is recommended. Similarly, another potential input to increase is the usage of nitrogen-rich fertilizers to boost natural food growth further. This can also lessen the production cost (i.e., per unit price of either organic or inorganic fertilizer is less than the per unit price of commercial feed), as an abundant supply of natural food can make the application of supplemental feeding unnecessary anymore. Therefore, it is suggested that focus be directed to more intensive means of culture practices if productivity is to be improved.

The result of the inefficiency model estimation yielded promising results, as all factors considered yielded results conforming to a priori assumptions. However, significant attention may be given to improving the length of culture, access to wild-bred stocking material, and frequency of stock checking.

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