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Research Article

TECHNICAL EFFICIENCY OF SMALL-SCALE FISHERS IN LEYTE, PHILIPPINES: A COBB-DOUGLAS STOCHASTIC FRONTIER ANALYSIS

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The growing demand for fishery products in the Philippines, coupled with declining fish production, highlights the need to improve efficiency in the fisheries sector to meet rising consumer demand. This study examines the technical efficiency of small-scale fishers in Leyte, Philippines, and identifies the factors influencing their productivity to provide recommendations for improving the sector. The study employed the Cobb Douglas Stochastic Frontier Production Approach to estimate the technical efficiency. The results of the stochastic frontier model indicate that fishing hours, fishing costs and travel time are positively associated with fish catch. Furthermore, the inefficiency model shows that socio-economic variables such as education, marital status, and household size significantly reduce technical inefficiency. The findings suggest that strengthening fishers' access to education, training programs and extension services, as well as the provision of subsidies and financial assistance to support fishing operations, can enhance the productivity and technical efficiency of small-scale fishers.

***Keywords*:** Cobb-Douglas production function, small-scale fishers, technical efficiency

***JEL Classification codes*:** Q22, D24, C21

1. INTRODUCTION

The Food and Agriculture Organization (2020) recognized the Philippines as the 13th largest contributor to world fish production. In 2021, the Southeast Asian Fisheries

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Development Center reported that the Philippine fisheries' contribution to the country's gross domestic product was 1.52% at current and constant prices. In terms of exports, the fisheries sector earned about US $1.6 billion in 2018 (Tahiluddin & Terzi, 2021). Meanwhile, according to the Bureau of Fisheries and Aquatic Resources or BFAR (2019), the fisheries sector also provides a livelihood to almost two million coastal residents. Thus, the sector makes a significant contribution to the Philippine economy.

According to the World Bank, the population of the Philippines was approximately 113.9 million in 2021, 115.6 million in 2022, and around 117.3 million in 2023. It was projected by the Philippine Statistics Authority (2024) that the country's population will reach 138.67 million by 2055. This growing population will increase the demand for food among Filipino families. Since fish is the primary source of protein for many Filipinos, the demand for fish and fishery products is also expected to increase. A typical Filipino diet consists of rice, vegetables, and fish (Oceana Philippines, 2022).

BFAR (2019) reported that the average Filipino consumes 37 kg annually accounting for approximately 12% of the total protein intake. Similarly, the Southeast Asian Fisheries Development Center (2021) reported that each Filipino consumed an average of 34.28 kg of fish and fishery products per year. However, the fishery production in Eastern Visayas has been declining, with production decreasing vy 17.66% from 29,488 MT in the fourth quarter of 2021 to 24,279 MT in the fourth quarter of 2022 (PSA, 2023).

This situation calls for improved efficiency in the fisheries sector to meet the rising demand for fishery products. To achieve this, it is necessary to examine the sector's production efficiency through efficiency and productivity studies. The primary motivation for such studies is to identify the factors that influence productivity and e to recommend appropriate measures for sectoral development. This paper is directly linked to Sustainable Development Goal 2 which addresses zero hunger as this expands food security and sustainable incomes. By improving technical efficiency, fish production becomes more productive and sustainable.

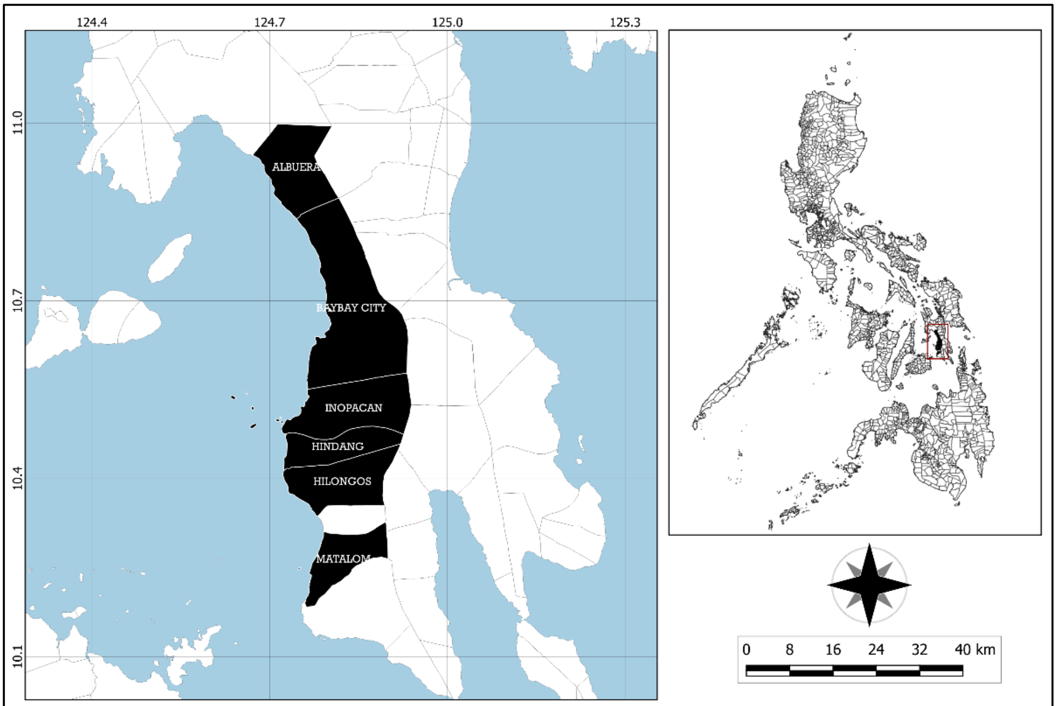
This study estimates the level of efficiency among small-scale fishers in Leyte, Philippines, using Cobb Douglas Stochastic Frontier Production Approach. It also identifies the factors influencing technical efficiency. Leyte Gulf is among the major fishing grounds in the Philippines with an area of 13, 147 km^2 covering the islands of Samar and Leyte (BFAR, 2018). In addition, the study identifies the existence of inefficiency and identifies the factors contributing to it.

2. METHODOLOGY

This section provides details on the study sites, sampling procedures, data collection techniques and data analysis of the study.

Description of the study area

This study was conducted in the province of Leyte which is situated in the eastern section of the Visayas region in the Philippines. Leyte has the land area of 6,335.44 square kilometers. Its population as determined by the 2020 Census reached 1,776,847 (PhilAtlas, n.d). There were only six fishing sites purposively identified in the study namely Matalom, Hilongos, Hindang, Inopacan, Baybay and Albuera.



The map on the left uses shapefiles from NAMRIA. It is projected using the WGS 84 geographic coordinate system (EPG:4326). Highlighted municipalities are classified as research sites in Eastern Visayas, Philippines.

Figure 1. Study sites

Sampling technique and sample size

Stratified random sampling was employed in the selection of respondents, with a total sample size of 266 fishers. The sample size was computed using Cochran's (1963) formula, applying aa 95% confidence interval, a population variance of 0.5 and a 6% margin of error. Using equation 1, the estimated sample size for the study areas was determined:

$$n_o = \frac{Z^2_{\alpha/2}(p)*(1-p)}{e^2} \quad \text{Equation 1}$$

$$n_o = \frac{1.96^2(0.5)*(1-0.5)}{0.06^2} = 266 \text{ fishers}$$

Data collection

Prior to the survey, fisher respondents were asked about their willingness to take part in the study. They were assured that whatever information gathered will be treated with confidentiality which will be utilized solely for the study. Enumerators were hired to assist in the data gathering and they were trained prior to the scheduled data collection so that data will be captured well. Personal interview was done by the enumerators using a pre-tested survey questionnaire.

Data Analysis

After data encoding and curation, data analysis was done. Descriptive statistics such as means, standard deviation, frequency counts and percentages were used to summarize the data collected on socio-economic and fishing characteristics. Stochastic Frontier Approach was applied to measure the technical efficiency of fish production. The Cobb-Douglas form of stochastic frontier production was used.
The production function is specified as:

$$\ln(Y_i) = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + e_i \quad \text{Equation 2}$$

Where:
ln = denotes natural logarithm
Y_i = fish catch in a week of the i^{th} fisher
X_1= number of hours fishing in a week of the i^{th} fisher
X_2 = weekly total expenditure related to fishing of the i^{th} fisher

X_3 = distance travelled from shore to the fishing ground of the i^{th} fisher
e_i = disturbance term made up of two elements (V_1 - μ_i)
V_1 = random error (white noise), it accounts for the stochastic effects beyond the fisher's control such as weather disturbances
μ_i = non-negative random variable called the inefficiency effects

Technical inefficiency was estimated by subtracting technical efficiency from 1. Technical Inefficiency model is a linear function of the socio-economic and fishing related characteristics. It is specified as:

$$\mu_i = \delta_0 + \sum_{i=1}^{3}(\delta_i Z_i + V_i) \quad \text{Equation 3}$$

u_i = the technical inefficiency of the i^{th} fisher
δ_0 the intercept of the technical inefficiency model
$\delta_0 \ldots . \delta_9$ are the coefficient of parameter estimates of the technical inefficiency variables
Z_i stand for vectors of the farm specific variables that affect the technical inefficiency of the i^{th} fisher such as age, education, marital status, household size, org membership, fishing as primary income, usage of motorized boats.

3. RESULTS AND DISCUSSION

Description of research variables

The average age of the fisher respondents was 45 years, with an average of seven years of schooling, indicating that most had attained elementary level education. There are 80% of fisher respondents who are married with five members in the household. In terms of membership in fishing organizations, approximately 37% were members, while the other 63% were not affiliated in any fishing organization. The average weekly catch was 16.02 kg, or approximately 2.67 kg daily, given that most respondents engaged in fishing six days per week. Fishers spent an average of 36.11 hours in a week fishing or about six hours per day. Since there are incurred costs in fishing activity such as fuel, and other paraphernalia, they spent around 1538.35 in Philippine peso (26.49 USD) in a week or about 260 in Philippine peso (4.48 USD) daily. As they travel from shoreline to their fishing grounds, fishers spent 1.68 hours on the average. The majority of respondents (94%) depended primarily on fishing as their primary source of income. Finally, only about 36% used motorized boats while approximately 67% went fishing with a companion.

Table 1. Summary of research variables

Research Variables	Mean	Standard Deviation
Age	45.38	13.55
Education	6.95	3.08
Status (married)	0.80	0.40
Household size	5.03	2.15
Catch in kg (weekly)	16.02	0.72
Hours spent in fishing (weekly)	36.11	0.81
Fishing costs in PHP (weekly)	1538.35	1.11
Travel time (in hours)	8.11	1.00
Membership in fishers' organization	0.37	0.48
Fishing as primary income	0.94	0.24
Usage of motorized boats	0.36	0.48
Having companion in fishing activity	0.67	0.48

Source: Author's own calculation and analysis
1 USD = 58.06 PHP (As of 19 February 2025)

Technical Efficiency

Table 2 presents the results of Cobb-Douglas Stochastic Frontier Production Function, which estimates the technical efficiency of small-scale fishers in Leyte, Philippines. The dependent variable is fishing output, while the explanatory variables are fishing hours, costs and travel time to the fishing ground. Findings show that fishing hours, costs and travel time from shoreline to fishing grounds are statistically significant at the 1% level.

Hours spent fishing is positively correlated to fish catch production, indicating that more hours spent in fishing increases catch. Specifically, a 1% increase in fishing time increases fishing output by approximately 0.26%, holding other factors constant. This result also shows that fishing effort is the most important driver of output among the variables. This finding is consistent with Macusi et al., (2021), who stated that the number of hours in fishing activity determines the catch success in their fishing grounds.

Furthermore, catch rates are dependent on the operational expenses of fishing activity. A 1% increase in fishing cost increases catch by 0.15%. Similar findings are reported by Grilli et al. (2018), showing that fishing effort in the form of expenditures affects catch rates. Higher costs likely reflect greater input use (fuel, gear, maintenance), which improves productivity.

Lastly, travel time is found to positively influence fish catch production. A 1% increase in travel time increases the fishing output by 0.14%. This outcome is parallel the findings of Keppeler et al. (2020), who reported that time traveled to fishing spots influences effort and catch. Fishers who travel farther may access abundant fishing grounds thus improving catch.

Table 2. Technical efficiency analysis

Technical efficiency variables	Coefficient	Standard error
Fishing hours (lnx_1)	0.2578637***	0.0496698
Fishing cost (lnx_2)	0.146141***	0.0354918
Travel time (lnx_3)	0.1410457***	0.0397395
constant	0.8258499	0.3988882
Sigma2 ln	-1.334012	0.3919936
lambda ln	-1.589083	1.396284

*** significant at 1% probability level

Source: Author's own calculation and analysis

Determinants of Technical Inefficiency

Table 3 present the estimates of technical inefficiency model for the small-scale fishers. Among the variables included in the model, education, marital status and household size showed to statistically influence the technical inefficiency.

Education has negative association with technical inefficiency (-0.0066, $p < 0.05$) which indicates that as the number of years of formal years of schooling, technical inefficiency decreases while technical efficiency improves. A similar conclusion was made by Tefaye and Beshir (2014). This result suggests that more educated fishers are better able to understand and adopt fishing technologies resulting to more efficient utilization of resources.

Similarly, marital status was found to negatively influence technical inefficiency (-0.0372482, p-value <0.10). The negative coefficient implies that married fishers tend to more efficient than unmarried fishers. This outcome may be attributed to greater household responsibilities which encourage then to maximize their productivity.

Lastly, household size also has a negative and significant effect on technical inefficiency (-0.0031457, p-value <0.05), indicating that an additional member in the household reduces the technical inefficiency. This may be because larger households can provide additional labor and facilitate knowledge sharing about fishing practices, thereby improving operational efficiency and reducing production inefficiencies.

In contrast, membership in fisher's organization, fishing as primary income, usage of motorized boats, and having companion during fishing activity appeared to have no sufficient evidence showing its statistical significance. This signifies that these variables do not have measurable effect on technical inefficiency among the sampled fishers.

Table 3. Technical Inefficiency analysis of results

Inefficiency variables	Coefficient	Standard error
Age (Z_1)	0.0003132	0.0006284
Education (Z_2)	-0.0065989**	0.0026321
Married (Z_3)	-0.0372482*	0.0211141
Household size (Z_4)	-0.0031457**	0.0037904
Membership in a fishers' organization (Z_5)	-0.0225956	0.0166825
Fishing as primary income (Z_6)	0.0041525	0.0345404
Usage of motorized boats (Z_7)	-0.0124924	0.0169161
Having companion in fishing activity (Z_8)	-0.0011315	0.0170065
constant	0.4470431	0.0532522

*p<0.10, **p<0.05

Source: Author's own calculation and analysis

4. CONCLUSIONS

This study examined the technical efficiency of small-scale fishers in Leyte, Philippines and identified the factors influencing the technical inefficiency using Stochastic Frontier Approach (SFA). The results showed that fishing hours, fishing costs and travel time from shoreline to fishing grounds increases the efficiency of the fishers. In contrast, it was found out that inefficiency is present in the fish production with education, civil status and household size that significantly reduce technical inefficiency while membership in fisher's organization, fishing as primary income, usage of motorized boats, and having companion during fishing showed to have no measurable effect on technical inefficiency. Overall, socio-economic characteristics, particularly education and household composition, play an important role in improving technical efficiency.

5. POLICY RECOMMENDATIONS

The findings suggest that enhancing fishers' knowledge and capacity may contribute to higher productivity. There should be more efforts from the government agencies in strengthening their access to education, training program and extension services that may encourage fishers to adopt fishing practices or technologies that may improve their productivity. Furthermore, local government should consider providing subsidies and financial assistance to support fishing operations. Such effort can aid fishers in acquiring fishing equipment and inputs which can contribute to improve productivity.

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