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RESEARCH ARTICLE

Technical Efficiency of Artisanal Fishing Households in Malawi

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Abstract: This study assesses the technical efficiency of artisanal fishing households in Malawi using the stochastic production frontier model, particularly, the Cobb-Douglas model. The specific objectives of the study were two-fold: to measure the productivity of the artisanal fishers in Malawi and to find the determinants of their technical efficiency. The study used data obtained from the Malawi's Fifth Integrated Household Survey (IHS-5), and results indicate that artisanal fishers are highly productive as the Cobb-Douglas stochastic frontier production function exhibited increasing returns to scale. The study also found that the artisanal fishers are technically efficient as their mean technical efficiency score is about 99 percent, implying that on average, a typical artisanal fisher operates only 1 percent below the maximum potential output, hence, highly efficient. Furthermore, the study findings indicate that amount of money a household pays as rent for a fishing gear, number of fishers hired, and number of fishing gears operated by a household are positive determinants of technical efficiency among artisanal fishers whereas the payment to hired fishers on credit is a negative determinant of technical efficiency among the artisanal fishing households in Malawi. Hence, two-fold policy implications emanate from the study as follows: Firstly, in order to promote technical efficiency of the artisanal fishing households in Malawi, policymakers need to intensify efforts aimed at encouraging spawning of fish by, strictly, prohibiting fishing in the fish spawning months. Secondly, policymakers need to encourage the artisanal fishers to subsidize the productive inputs in the artisanal fisheries sub-sector such as fishing gears and boats, and improve fishers access to credit.

Keywords: Artisanal fishers; Cobb-Douglas production function; Fishery; Technical efficiency; Stochastic frontier production function

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1. Introduction

For Malawi, a landlocked country with 20 percent of its area covered by water bodies, fishing and the fisheries sector are crucial for the development of the country [1]. This is so because fishing is important for the country's poverty alleviation efforts as it provides employment, income and, significantly, contributes to the food security and livelihoods of millions of the people in Malawi [1]. For example, fisheries and aquaculture provided direct employment to 153 084 inland fishers and 12 800 fish farmers, 30 percent of which being women, in the year 2018 [1]. Fishing is also a source of foreign exchange as in 2018 fish exports were estimated at US$ 348 000 [1]. In terms of contribution to income for the people of Malawi, fish generates revenue of about US$24 million annually, and contributes about 4 percent to Malawi's GDP[2]. Again, with respect to food security, approximately 40 percent of the overall protein supply to Malawians comes from fish[3]. Since fish is mostly consumed in Malawi's rural areas, it thus plays a vital role in meeting the daily nutritional needs of the country's impoverished rural masses. And moreover, being a good source of animal protein, essential fatty acids and micronutrients such as vitamin A, iron, and zinc, fish immensely helps meet the daily nutritional demands of those who have greater nutrient requirements, such as elderly persons, children, and people living with HIV (PLWH) [1].

The major fish species caught in Malawi include Oreochromis karongae (chambo), Oreochromis Mossambicus (makakana) Diplotaxodon spp. (ndunduma) Offshore Haplochromine Cichlids (chisawasawa), Ramphochromis spp. (mcheni), Bagrus spp. (kampango), Engraulicypris sardella (usipa), Copadichromis (utaka), Clarias glariepinus (mlamba) and Barbus paludinosus (Matemba), hereafter referred to as chambo, makakana, ndunduma, chisawasawa, mcheni, kampango, usipa, utaka, mlamba, and matemba, respectively. It is worth noting that of these species, chambo is regarded as the most valuable fish species in Malawi.

Malawi's fisheries sector is categorized into two, namely; the large-scale commercial (formal) sector and the traditional or artisanal sector. The artisanal sector consists of traditional fishers who use relatively limited amounts of capital as well as relatively small fishing boats, and they make shot, near-shore fishing trips mostly for local use. Moreover, since they account for about 90 percent of all fish captures in Malawi, artisanal fishers are the majority of the country's fisheries producers. They primarily produce fish for their own consumption as well as for local markets [3, 4]. As such, their production plays a vital role in Malawi's food security as the formal fisheries sector as well as the formal markets only provide for a portion of the population [3]. With regards to fishing gears, the artisanal fishers use a variety of fishing gear, including handlines, longlines, gillnets, fish traps, beach seines, and open sea seine nets. Their primary fishing vessels include plank boats and dugout canoes. Between 2000 and 2015, the average annual catches of fish from artisanal fishers were 90,000, primarily consisting of mlamba and usipa [4].

However, despite being key in the supply of essential nutrients to Malawians, production of fish from capture fishery sub-sector has, lately, been declining in Malawi. In particular, the catches of chambo, have remained low compared to the period between mid-1970s and early 1980s. For example, the average annual production of chambo declined from more than 10,000 tons between 1980 and 1990 to around 4,000 tons between 2000 and 2015 [1], a decline of about 60 percent in 10 years. Some of the causes of this reduction in the fish catches include overfishing due to increased human population leading to high local demand for fish, climate variability which affects the production and productivity of fish, poor fisheries management which leads to fish habitat degradation [2], and the availability of limited alternative income generating activities among the fishing households surrounding the water bodies [1]. Consequently, the decline in capture fishery is putting fishing pressure on the fish stocks in the in-shore waters, a thing that leads to further over-fishing. For example, in an effort to increase the quantity of fish catches, artisanal fishers tend to use longer nets with smaller mesh sizes, often made from mosquito nets. These mosquito nets further destroy fish stock as they catch fish at a very small size before they are fully grown and able to breed [2]. It is for this reason that many fish species, mainly the chambo, are now classified as endangered or vulnerable.

In an effort to address the problem of declining fish stocks, the Malawi government has, over the years, come up with different initiatives. For instance, it switched the artisanal fisheries sub-sector's traditional fisheries management system from the previous top-down management method to a participatory one. It emphasized that prior to management measures being approved and incorporated into fishing rules, fishing communities must be consulted. Additionally, in line with the Fisheries Conservation and Management Regulations of 2000, the Malawi government adopted several fisheries regulations that target fish species and are usually implemented by employing various fish gear types [1]. Among these regulations were the following: (1) establishing minimum mesh sizes for different kinds of fishing gear according to information on the size at maturity of the target fish species, (2) restricted fishing seasons and areas to safeguard specific species during their breeding season; this is accomplished by outlawing the use of specific fishing gear, primarily beach seines, (3) limiting the minimum size that can be harvested for various fish species in order to save juvenile fish, (4) regulating the maximum size of fishing nets in order to manage fishing effort, and (5) licensing fishing gear in order to manage fishing activity. What is clear from the foregoing fisheries conservation and management initiatives is the fact that they focus on making artisanal fishing households more technically efficient.

For a fishery, technical efficiency is a measure of the ability to produce the maximum output possible from a given set of inputs subject to the production technology, weather conditions, resource levels, as well other technological constraints [4]. Thus, one can expect that the fisheries regulations imposed by Malawi government can have an effect on the efficiency of the artisanal fishers. However, despite there being a lot of studies in technical efficiency in developing countries, very few have focused on the technical efficiency of artisanal fishers[5]. For instance, in Malawi, most studies on technical efficiency on the fishery have concentrated on the aquaculture sub-sector because it is perceived to be crucial for turning around the country's dwindling fishing industry [6, 7]. This has led to the neglect of the artisanal fishers despite their ability to significantly contribute to fisheries output in Malawi. This study, therefore, bridges this knowledge gap by empirically determining the technical efficiency of artisanal fishers in Malawi.

The identification and assessment of the factors influencing fishing households' technical efficiency can offer a great chance to increase the technical efficiency of Malawi's artisanal fishers because it can give insight into the types of artisanal fishing households' operations and how they react to government rules in accordance with their preferences [8]. The importance of understanding how the artisanal fishing households respond to the government's regulations is two-fold. Firstly, it can help policymakers develop efficient policies targeting fisheries resources conservation. Secondly, it can help in the identification of factors affecting the productivity of artisanal fishing households in Malawi which, consequently, can be helpful in the formulation of policies aimed at enhancing the efficiency of the fishers. For instance, based on the knowledge obtained, the fishery managers may reduce technical inefficiency by constraining the use of certain inputs[9] or, alternatively, they may improve technical efficiency by expanding the use of certain inputs deemed highly productive [5]. Therefore, this study contributes to the literature of technical efficiency in two ways. Firstly, it estimates the level of technical efficiency for artisanal fishing households in Malawi. Secondly, it shows how the artisanal fishing households' technical efficiency scores are influenced by the socio-economic characteristics of the fishing household. It, thus, sheds more light on which fishing household's socio-economic characteristics determine the technical efficiency scores of the artisanal fishers. The study seeks to address the following questions: (1) Do Malawi government's fisheries regulations targeting fish species help enhance technical efficiency of artisanal fishing households? (2) what socio-economic characteristics of the artisanal fishing households influence their technical efficiency? Answering these questions provides useful insights to policymakers in the fisheries sector regarding the level of productivity among artisanal fishers in Malawi so that proper action can be taken to either improve or limit it.

2. Theory of Technical Efficiency

Efficiency analysis, according to Jacobs et al[10], is centered on the decision-making unit (DMU) of an organizational locus of production, which is typically a household. Allocative efficiency and technical efficiency are the two categories under which efficiency is classified. Selecting the optimal input mix based on relative input prices or selecting the optimal output mix based on relative output prices is known as allocative efficiency. Put differently, allocative efficiency pertains to the process of modifying inputs and outputs in order to align with relative pricing, given that the production technology has already been selected. On the other hand, technical efficiency is mainly concerned with measuring the competence with which the DMUs are converting the inputs into valued output[10]. There are two orientations to the definition of technical efficiency, namely; output orientation and input orientation[11]. For example, using output orientation, technical efficiency is defined as the ability of a DMU to obtain the maximum output from a set of inputs whereas using input orientation, technical efficiency is defined as the ability of a DMU to produce a given output using the lowest possible quantity of inputs[11]. However, the present study adopted the output-oriented approach to measuring technical efficiency on the assumption that the artisanal fishers aim to maximize the quantity of fish on each fishing trip they make.

The measurement for technical efficiency is based on Debreu[12], who developed a conceptual model involving the use of inputs to an efficient frontier and laid the foundations for the stochastic frontier production function (SFPF) and Data Envelopment Analysis (DEA). Thus, measurement of technical efficiency is done using two approaches namely; parametric (econometric approach) and non-parametric (mathematical programming) approach. An example of a parametric approach is the stochastic production frontier model (SPFM) developed by Aigner and Chu[13]. The SPFM approach acknowledges the influence of random errors and data noise on production as it assumes that the deviations from the production frontier may not entirely be under the control of the producers. In doing so, it helps distinguish the effects of stochastic noise from the effects of other inefficiency factors. Additionally, the SPFM allows for hypothesis testing on both production structure and efficiency. However, the SPFM is restrictive as it imposes some restrictions on the deviations from the production frontier something which DEA does not do as it is considered to be deterministic.

Of the two approaches to measuring technical efficiency, this study adopted the SPFM technique over the DEA technique for the following reasons: (1) the DEA technique is unable to capture the underlying stochasticity that is typical in fishing due to weather disruptions; whereas, the SPFM does so adequately, (2) the study will be able to test hypotheses about the existence of technological inefficiency using the SPFM, which is not possible using the DEA framework, and (3) the study will be able to evaluate hypotheses about the existence of technological inefficiencies using the SPFM, which is not possible using the DEA framework.

2.1 Empirical Estimation of Technical Efficiency in Fisheries

In fisheries, production frontiers are generally given as a function of two inputs, namely; fishing efforts and stocks abundance[14]. Fishing effort encompasses all physical inputs employed in the harvesting of fish whereas fish stock refers to the population or total mass of a fishery resource. This study focuses on the exploited fish stock and investigates the artisanal fishing household's socio-economic determinants of technical efficiency. Thus, following Meussen and van den Broeck[15] and Aigner et al.[16], the stochastic production frontier function used by the study was specified using the following equation:

$$\mathrm{Quantity_i} = \mathrm{f}(\mathrm{X_i}; \beta)\exp(\mathrm{V_i} - \mathrm{U_i}) \tag{1}$$

Where: $Quantity_i$ is the output of the i^{th} fishing household,

X_i is the vector of inputs it uses in the production process,

β is a vector of unknown parameters to be estimated,

V_i is a two-sided random variable assumed to be independently and identically distributed, $\mathrm{N}(0, \sigma_\mathrm{v}^2)$ and is independent of U_i. It shows arbitrary fluctuations in the economic conditions that the production units face because of things like chance, errors of measurement, weather, and missing variables. Thus, it takes into consideration differences in yield that are attributed to causes other than the artisanal fishers.

U_i is a one-sided random variable utilized to account for production's technical efficiency. It is called the technical inefficiency effect because it shows the technical inefficiency in relation to the stochastic frontier. Moreover, there are two-fold assumptions associated with U_i, namely; it only assumes positive values, and it is normally distributed with mean equal to μ_i, and variance σ_{u}^2

where:

$$\mu_{\mathrm{i}} = \mathrm{Z_i}\delta_{\mathrm{i}} \tag{2}$$

Z_i is a vector of fishing household's specific factors that may influence the technical efficiency. Thus, equation (2) gives the technical inefficiency model.

Therefore, the fishing household's specific stochastic production function frontier that represents the maximum possible output can be given by:

$$\mathrm{Quantity}^* = \mathrm{f}(\mathrm{X_i};\beta)\mathrm{exp}\ (\mathrm{V_i}) \tag{3}$$

Expressing equation (1) in terms of equation (3), yields:

$$\mathrm{Quantity} = \mathrm{Quantity}^*\mathrm{exp}\ (-\mathrm{U_i}) \tag{4}$$

It, therefore, follows that technical efficiency of the i^{th} fishing household, denoted by $\mathrm{TE_i}$, can be expressed as:

$$\mathrm{TE_i} = \frac{Quantity_i}{\mathrm{Quantity}^*} = \mathrm{exp}\ (-\mathrm{U_i}) \tag{5}$$

3. Data and Methods

This study uses quantitative data from the fifth integrated household survey (IHS-5), the most recent nationally representative data produced by Malawi's National Statistical Office (NSO). To determine the sample size for the study following formula was used:

$$n = \frac{z^2p(1-p)}{e^2} \tag{6}$$

Where: n is the number of fishing households,

p is the proportion of the fishing households which as suggested by Zikmund et al.[17] was 50 percent,

z is the statistical confidence level, which was 95 percent for this study giving a z statistic of 1.96,

e is the maximum allowable error and it was equal to 7 percent for the study.

Utilizing the foregoing information, the representative sample size for the study was calculated as follows:

$$n = \frac{(1.96^2)(0.5)(0.5)}{0.07^2} = 196 \tag{7}$$

The choice of variables used in the study was based on the understanding that the standard approach of fisheries economics relates the catch of fish to fishing effort[1] and the abundance of the exploited fish stock[14]. The estimations were done employing Stata version 17.0. Table 1 presents a description of the variables that have been used in the study.

The study used the Cobb-Douglas specification of the stochastic production frontier model of the form:

$$\begin{aligned} &lnQUANTITY_i = \beta_0 + \beta_1 lnGEAR_i + \\ &\beta_1 lnLAB_i + \beta_1 lnBCOST_i + \\ &\beta_1 lnCFUEL_i + V_i - U_i \end{aligned} \tag{8}$$

On the other hand, the Tobit regression model was used to estimate the determinants of technical efficiency among the fishing households. The Tobit regression model was employed because technical efficiency, the dependent variable, is censored from above at 1 and from below at 0. The Tobit regression equation was specified as follows:

$$\begin{aligned} TE_i = \delta_0 + \delta_1 PFISH_i + \delta_2 FHIRED_i + \\ \delta_3 CREDIT_i + \delta_4 NBOATS_i + \\ \delta_5 NGEAR_i + \delta_6 lnRENT_i + \\ \delta_7 BRENT_i + W_i \end{aligned} \tag{9}$$

Where:

TE_i: is technical efficiency;

$\delta_0 - \delta_7$: are parameters estimated;

W_i: is the disturbance term.

4. Results and Discussions

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[1] Fishing effort is a measure of fishing intensity examples of which include number of boats hired, number of fishermen, number of fishing gears employed, and crew size.

[2] This represents Malawi Kwacha, Malawi's currency.

Table 1. A description of the variables that have been used in the study.

Variable	Description
Output and input variables	
QUANTITY	Total quantity of fish caught in kilograms
GEAR	Total cost of fishing gears operated by a fishing household
LAB	Number of weeks devoted to fishing by a household
BCOST	Cost of fishing boat (MK[2])
CFUEL	Cost of fuel and maintenance (MK)
Household specific variables	
PFISH	Payment for hired fishers (=1 if paid using part of the fish caught, 0 otherwise)
FHIRED	Number of fishers hired by a fishing household
CREDIT	Payment for hired fishers (1= if paid on credit, 0 otherwise)
NGEAR	Number of fishing gears operated by a fishing household
RENT	Amount of money a household pays as rent for a fishing gear (MK)

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
FHIRED	196	0.606	2.255	0	19
LAB	196	7.389	5.773	0	32
QUANTITY	196	19539.316	153761.08	0	1500000
NGEAR	196	232.783	1607.26	0	20000
GEAR	196	82789.006	200151.14	0	1490000
RENT	196	108925	233597.39	100	700000
COST	196	16582.721	26726.196	0	200000
NBOATS	196	1.212	0.737	0	6
BCOST	196	289265.5	639141.59	0	3100000
BRENT	196	9100.938	25864.244	0	200000
CFUEL	196	15501.77	68976.538	0	680000
Source: Own computations					

Source: Own computations.

4.1 Descriptive Statistics

Table 2 presents descriptive statistics of the variables used in the Cobb-Douglas stochastic frontier production and the technical inefficiency regression equation.

Table 2 indicates that the maximum number of hired fishers was 19 with zero as the minimum. Again, the table shows that cost of boat had the highest mean and the largest standard deviation of MK289,265.50 MK639141.59, respectively. This suggests that there was greater variability in the cost of boats among the fishing households. Again, Table 2 indicates that the maximum number of boats owned by a household was 6 with 0 as the minimum.

4.2 Econometric Results

Before presenting econometric results, the study used the log-likelihood test to determine the presence of inefficiency effects in the stochastic frontier model. The log likelihood test gave a test statistic of 340.08 and a critical value of 5.412. Hence, the null hypothesis that there were no inefficiency effects in the model was rejected at 1 percent level of significance as the test statistic is greater than the 1 percent critical value. Table 3 presents results of the Cobb-Douglas stochastic production frontier.

Table 3 indicates that among the productive inputs used, cost of fishing gear and labour are positive and statistically significant at 1 percent level of significance (p-value<0.01) whereas cost of fuel and maintenance are positive and statistically significant at 10 percent level

Table 3. Parameter estimates of stochastic production frontier.

lnQUANTITY	**Coef.**	**St.Err.**	**z-Value**	**p-Value**	**[95% Conf.**	**Interval]**	**Sig**
lnGEAR	0.126	0.037	3.40	0.001	0.053	0.198	***
lnLAB	1.753	0.149	11.75	0.000	1.461	2.045	***
lnBCOST	-0.042	0.033	-1.29	0.198	-0.106	0.022	
lnCFUEL	0.125	0.064	1.95	0.051	0.000	0.249	*
Mean dependent var		3.907		SD dependent var		2.533	
Number of obs		196		Chi-square		727.461	
Prob > chi2		0.000		Akaike crit. (AIC)		873.634	

**** p<0.01, ** p<0.05, * p<0.1*

Source: Own computations.

of significance (p-value<0.1). This, therefore, shows that the elasticity of fish output with respect to cost of fishing gear was 0.126, the elasticity of fish output with respect to labour was 1.75, and the elasticity of fish output with respect to cost of fuel and maintenance was 0.125. This suggests that a 1 percent increase in cost of fishing gear leads to a 12.6 percent increase in fish output, a 1 percent increase in cost of labour leads to a 175 percent increase in fish output, while a 1 percent increase in cost of fuel and maintenance leads to a 12.5 percent increase in the fish output. The sum of the coefficients of the Cobb-Doulas production function, since it is in double-log form, yields returns to scale of the production function. Thus, the returns to scale will be found by: $0.126 + 1.75 - 0.042 + 0.125 = 1.959$. This suggests that the Cobb-Douglas production function employed in the study exhibited increasing returns to scale suggesting that a proportional increase in fish output is larger than the underlying proportional increase in the productive inputs, hence highly productive. Having determined the productivity of the artisanal fishers, Table 4 presents parameter estimates of the technical inefficiency equation.

Before interpreting results in Table 4, it has to be emphasized that with regards to technical efficiency studies, the dependent variable is technical inefficiency suggesting that an independent variable whose coefficient has a negative sign will have a negative effect on technical inefficiency but a positive effect on technical efficiency. Similarly, an independent variable that has a positive sign is said to have a positive effect on technical inefficiency but a negative effect on technical efficiency[18]. As shown by Table 4, negative and statistically significant determinants of technical inefficiency among the artisanal fishers include rental cost of fishing gear, number of hired fishers, and number of fishing gears operated by a household. In particular, rental cost of a fishing gear is statistically significant at 10 percent level of significance (p-value <0.1), whereas number of hired fishers and number of fishing gears operated by a household are statistically significant at 5 percent level of significance (p-value<0.05). On the other hand, payment to hired fishers on credit is positive and statistically significant at 1 percent level of significance (p-value<0.01). Hence, following the foregoing explanation, this finding suggests that rental cost of a fishing gear, number of fishers hired, and number of fishing gears operated by a household are positive determinants of technical efficiency among artisanal fishers while the payment to hired fishers on credit has a negative effect on technical efficiency among the artisanal fishers in Malawi. The payment to hired fishers on credit has a negative effect on technical efficiency because it demotivates the hired fishers in the course of fishing as most fishers prefer to be paid in cash in order to purchase their daily needs. This conforms with Setsoafia et al.[19], and Aminu et al.[20], who found that income serves as a catalyst in fisher catch-efficiency.

Having discussed the determinants of technical efficiency, the study now focuses on the summary statistics of the technical efficiency scores estimated following Jondro et al.[21] who posits that technical efficiency is the ratio of actual output to maximum potential output. Table 5 presents summary statistics of technical efficiency.

As indicated in Table 5, the mean technical efficiency score of the artisanal fishers in Malawi is about 98.7 percent with the minimum and maximum technical inefficiency scores of about 98.69 percent and 98.72

Table 4. Parameter estimates of technical inefficiency model.

Technical Inefficiency	Coef.	St.Err.	z-Value	p-Value	[95% Conf.	Interval]	Sig
FISHP	0.00012	0.00012	−0.12	0.908	−0.00078	0.00025	
BRENT	9.31e-10	9.31e-10	0.43	0.680	−1.71e-09	2.50e-09	
RENT	−7.05e-11	3.48e-11	−2.03	0.073	−1.49e-10	8.15e-12	*
FHIRED	−5.63e-06	2.17e-06	−2.59	0.029	−0.00001	−7.12e-07	**
NGEAR	−1.00e-07	3.32e-08	−3.02	0.015	−1.76e-07	−2.52e-08	**
CREDIT	0.987	0.00003	286844	0.000	0.9867	0.9870	***
Mean dependent var		0.987		SD dependent var		0.000	
Pseudo R-squared		7.605		Number of obs		196	
F-test		16547.406		Prob > F		0.000	
Akaike crit. (AIC)		−198.273		Bayesian crit. (BIC)		−197.080	

**** p<0.01, ** p<0.05, * p<0.1*

Source: Own computations.

Table 5. Summary statistics for the technical efficiency.

Variable	Obs	Mean	Std. Dev.	Minimum	Maximum
Technical efficiency	196	0.9869	0.00004	0.986875	0.987165

percent, respectively. This low variation in the maximum and minimum technical efficiency scores can be attributed to the fact that data for the study were collected soon after the opening of the high fishing season in Malawi. The foregoing finding implies that on average, the artisanal fishers produce about 98.7 percent of the maximum output. Or, put differently, this means that on average, a typical artisanal fisher operates 1.3 percent below the maximum potential output due to technical inefficiency suggesting that they are technically efficient. This conforms with Setsoafia et al.[19], who found that artisanal fishers in Ghana were technically efficient.

5. Conclusions and Policy Implications

This study has examined technical efficiency of artisanal fishing households in Malawi employing Cobb-Douglas stochastic frontier model. The study findings have shown that artisanal fishing households in Malawi are highly productive, relative to each other but not in absolute terms, as the Cobb-Douglas production function employed exhibited increasing returns to scale. The study findings also show that artisanal fishing households have an average technical efficiency level of about 98.7 percent, implying that, on average, they are technically efficient. This finding implies that the fishing productivity level of the artisanal fishers is very close to what they could have obtained had they used productive factors more efficiently. Thus, since data for the study were collected soon after opening the high fishing season in Malawi, this finding further suggests that Malawi government's fisheries regulations, in general, do help enhance technical efficiency of the artisanal fishing households in Malawi. Furthermore, with respect to the determinants of technical efficiency, the study has found that rental cost of fishing gear, number of fishers hired, and number of fishing gears operated by a household are positive determinants of technical efficiency among artisanal fishers while the payment to hired fishers on credit is a negative determinant of technical efficiency among the artisanal fishing households in Malawi.

Key policy implications arising from this study are two-fold. Firstly, firstly, policymakers need to encourage the artisanal fishers to hire a large to number of fishers as Malawi has an abundant supply of cheap labour, to subsidize the cost of fishing gears, and to enable fishers have access to credit in the high-fishing season. However, there is danger that if most fishermen increase investment in an effort to increase their production capacity it could lead to overfishing. And if left unchecked, the overfishing can result in the depletion of the fisheries resource and ultimately reduce fishermen's income. Hence, the second policy is that Malawi government needs to intensify efforts aimed at encouraging spawning of fish by, strictly, prohibiting fishing in the fish spawning months, maintaining the closed fishing period, and specifying minimum catch sizes.

6. Study Limitation and Areas for Further Study

The study's main limitation is the fact that it used data collected from the high fishing season in Malawi which led to low variation in the maximum and minimum technical efficiency scores among the artisanal fishers. It is imperative that further studies should consider comparing technical efficiency of artisanal fishers using data from the high fishing season and the low fishing season as this would paint a clear picture about the technical efficiency of the artisanal fishers in Malawi.

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Data Availability

The data used for the study are available upon request from the author.

Conflict of Interest

The author declares no conflict of interest.

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