Technical Efficiency of Cacao (*Theobroma cacao*) Farms in Davao City, Philippines

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ABSTRACT

This paper determined the technical efficiency (TE) and productivity of managed cacao farms in Davao City using the data envelopment analysis. Results of the analysis revealed that the efficiency level's mean score under noncost model is 0.339 under CRS and 0.472 under VRS. For cost model, mean scores are 0.235 and 0.39 under CRS and VRS assumptions, respectively. Moreover, this paper identified and evaluated the influence of socioeconomic factors on TE using ordinary least square regression. The method identified that the age of farm managers, distance to market, access to credit, and household size were the variables that significantly influenced the inefficiencies under noncost model, while only age of the farm managers, distance to market, and access to credit were the factors that impacted inefficiencies under the noncost model. The means of the computed TE scores for both VRS and CRS, and under non-cost and cost models are all below 50% which highlights that cacao productivity in the city is low. Similarly, the distribution of farms' TE scores showed that more than half of the sampled farms have scores that are less than 25%.

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1. INTRODUCTION

Roasted beans of cacao trees are the primary source of chocolates. In early civilizations (1500-400 BC), cacao beans were regarded as a wealth symbol. It was used as a monetary unit, and its consumption was only reserved for the elites. As claimed by Meier et al. (2017) and Henriques (2017), it has an exceptional association with heaven and appears to be a remedy for any human circumstance. True enough, recent studies emphasized cacao's numerous importance to health (Shahanas et al., 2019; Wickramasuriya & Dunwell, 2018), the environment (Schroth et al., 2016; Braga et al., 2019; Moelyaningrum, 2018), and global wealth (Nair, 2021; United Nations Conference Trade and Development [UNCTAD], n.d.).

Economically, cacao (*Theobroma cacao*) is a significant agricultural and commercial produce for millions of farmers worldwide. It supplies the major ingredient for the multibillion-dollar chocolate industry, which generates an estimated $100 billion in yearly revenue (Hoare et al., 2017). Five million farming households depend on it as a cash crop. It provides livelihood to around 40 to 50 million people worldwide from its production, particularly those in humid tropical regions (Beg et al., 2017; Wickramasuriya & Dunwell, 2018; Voora et al., 2019).

Notably, the Philippines is one of the conducive locations for cacao production; ergo, it has intensified the desire of local farm managers and exporters to strive for a competitive cacao farming business that keeps pace with other cacao-growing countries (Department of Agriculture [DA], 2018). The thriving cacao industry in Davao City, the Cacao Capital of the country, is acknowledged as one of the world's finest (Perez, 2021; Colina, 2020). However, despite the combined efforts of government and agricultural managers to meet the continuous surge in demand in the chocolate industry, DA reported a shortage in cacao production and the country still falls short of its potential yield (Casamayor, 2019). The Department stated that the demand for the crop is "estimated to reach between 4.7 million to 5 million metric tons (MT) by 2020, but a cocoa shortage is also predicted at 1 million MT." Correspondingly, the country's domestic consumption is at 50,000 MT yet the supply can only range from 10,000 to 15,000 MT (Colby-Sy, 2020; Department of Trade and Industry [DTI], 2021). Furthermore, regardless of the numerous interests and intentions to address the growing need to increase cacao productivity and profitability worldwide, there are no, if not limited, recent studies related to raising productivity efficiencies of cacao farms in the Philippines.

To alleviate the aggravated shortfall in production, it is viable to escalate agricultural yields by enhancing the level of cacao farms' technical efficiency without extra capital outlay (Binam et al., 2008; Dzene, 2010). Technical efficiency was defined by Coelli et al., (2002) as "the degree to which a farm manager produces the maximum feasible output from a given bundle of inputs or uses the minimum feasible amount of inputs to produce a given level of output". It is a significant element in profitability as it measures a decision-making unit's (DMU) capability to produce the utmost yield from a given set of inputs. The calculation of technical efficiency allows the identification of factors influencing the level of efficiency index. Hence, analysis based on technical efficiency helps agribusiness growers and managers through its effect on their average operational costs and direct impact on the managed farm's market competitive position and ability to stay in business (Ben-Belhassen & Womack, 2000).

The concept of efficiency is imperative in the agricultural business sector because it can evaluate how resources are put to the best possible use in converting them into output (Fawole & Ozkan, 2018). Identifying factors that limit farm managers from reaching their best possible yields could help progress their production levels, increasing their earnings and the sustainability of the cacao industry. Moreover, improved productivity has been essential in poverty reduction and food security, a substantial global concern (Mozumdar, 2012; Conceição et al., 2016). The gained knowledge from computed efficiency scores is relevant to various analyses concerning the best appropriate practices for farm administrators as better farming management can yield decent earnings (Cocoa Cultivation Information Guide, 2018). The result of this study provides data to cacao farm managers of the research locale as support for their farming business approaches that could positively affect their income and living conditions. Likewise, the study could be a significant addition to the limited references in the Philippines impacting the cacao industry.

This study intends to determine the technical efficiency of cacao farms in Davao City in Davao Region, Philippines which aims to address the following objectives: first, it aims to determine the operating profile of cacao farms about inputs and output variables. The inputs include farm size, number of pod-bearing trees, pesticides, fertilizers, and man-hours, while the output is the sales and number of kilograms of cacao produced. Second, the technical efficiency scores in the research locale will be computed using the Data Envelopment Approach (DEA) to analyze how many inputs and outputs are needed by inefficient farms to reach the efficiency frontier. Third, it also intends to identify and evaluate the influence of socioeconomic factors on technical efficiency in terms of age, years in farming, education, access to extension services, access to credit, cooperative membership, gender, marital status, household size, and distance to market of cacao farmers using Ordinary Least Square (OLS) regression. Moreover, the study aims to determine cacao farms so that their fellow farmers can benchmark. Furthermore, based on the existing related studies, the researchers also intends to estimate the relationships of socioeconomic factors – age of cacao farmers, years in farming, education, access to extension services, access to credit, cooperative membership, gender, marital status, household size, as well as the distance to market, to farms' technical inefficiencies.

2. RESEARCH METHOD

2.1 Unit of Analysis

The area of study where the essential input and output data of 60 cacao farms for the 2021 productive year gathered from farm managers were the Davao City's four main cacao-producing districts, namely: Calinan, Tugbok, Marilog, and Baguio Districts. This study utilized primary data from both smallholder cacao farms as well as major producers from these districts.

In addition, the inputs and outputs chosen to determine the technical efficiency scores and the socioeconomic variables were filled in by the farm managers as part of the sample size, which was determined using a purposive sampling technique. The researchers aimed to select participants from the study locale whom she considered eligible based on predetermined criteria to provide the best and most reliable data for the study, notwithstanding nonrandom selection from the total population of cacao producers in the area.

2.2. Materials and Instrument

The instrument for data collection used was a structured questionnaire detailing the socioeconomic status of the research participants. The same questionnaire acquired the latest data for its input-output requirement for technical efficiency computation. Correspondingly, these selected input and output variables were based on existing related studies and literature that established relevant specifications notwithstanding the various applications and methods used in their studies.

Specifically, the first part of the questionnaire comprised the socioeconomic details of the study participants as follows: age of the farm manager, years in farming, education, access to extension services, access to credit, cooperative membership, sex, marital status, household size, and distance to market. Meanwhile, the second part contained both the input and output variables. The output filled in were the kilograms of produced cacao by each of the 60 farm managers in the year 2021, while the input section contained information on the farm size, number of pod-bearing trees, pesticides, and fertilizers, and man-hours in the same year as output to complete the needed data for technical efficiency estimation. The instrument went through a series of expert validations to ensure the appropriateness and validity of the instrument used.

2.3. Design and Procedure

The study was quantitative research using statistical and numerical techniques on the collected data. This study mainly utilized DEA, an econometric method that measures the comparative efficiency of single or multiple input-output variables of decision-making units (DMUs). DEA specifies a nonparametric program that estimates the best practices (Charnes et al., 1978). This approach is more flexible in managing several inputs and outputs, having no parametric condition. Meanwhile, the effects of socioeconomic factors on each farm manager's technical efficiency were analyzed through ordinary least-squares (OLS) regression method. The farm managers' socioeconomic details were analyzed to predict any changes in the inefficiency scores of the DMUs.

As a supplement, a summary of inputs and outputs was made after gathering all the necessary data for both DEA and OLS. The datasets of inputs and outputs were transferred to a data file in DEAP 2.1 software to determine technical efficiency scores. Specific commands were done to process the data and obtain the estimations in the output file. In this study, to be considered efficient, a DMU must obtain a score of one (1), and any other less than the indicated implies inefficiency at some point. The possible reasons or factors for any inefficiencies were also analyzed using the socioeconomic profiles of cacao farmers employing OLS regression analysis. The analysis results using these statistical tools were interpreted to answer the objectives set for the study.

2.4 Ethical Considerations

To ensure the ethical soundness of this paper, the researchers observed full ethical standards in conducting the study, following the study protocol assessments and standardized criteria, particularly in managing the population and data contingent to UM Ethics Review Committee approval no. UMERC-2022-282.

3. RESULTS AND DISCUSSIONS

3.1 Production Variables of Cacao Farms Efficiency

Cacao farms' efficiencies were analyzed based on their operating profiles regarding production variables – the output, which was the peso sales and number of kilograms of cacao produced, and the input variables, which included farm size, number of pod-bearing trees, pesticides, fertilizers, and the number of man-hours employed in a given timeframe. The selected inputs considered are consistent with previous studies, such as those of Danso-Abbeam and Baiyegunhi (2020) that included farm size, labor, fertilizer, and pesticides as variables in its TE computation and Fadzim et al. (2016) who also included the abovementioned factors added by the number of cocoa trees.

Table 1, shown below, is an analysis focusing on the mean scores of each variable adopted, and the standard deviation of the data gathered from 60 cacao farms located in the top four cacao-producing districts of Davao City. The average size of the cacao farms was 1.48 hectares, of which 1,152 were planted with pod-bearing cacao trees that were the harvest source for 2021. Cacao farms used an average of 3.13 liters, costing Php2,952 and 267.5 kilograms, respectively, spending Php9,457 for pesticides and fertilizers. Also, 2,181.20 man-hours were spent on cacao farming, or an average of 272.65 days during the same year. Meanwhile, as to outputs, 693.82 kilograms of dried cacao beans earning Php72,442.23 were produced on average.

Table 1. *Production variables of cacao farms in Davao City (N=60)*

Variables	Mean	SD
Outputs		
Dried cacao beans produced (in kg)	693.82	1,426.17
Income earned from dried cacao beans (in Php)	72,442.23	165,229.46
Inputs		
Farm size (in hectare)	1.48	1.49
Number of pod-bearing trees	1,152.42	1,267.72
Pesticides (in L)	3.13	9.73
Pesticides (in Php)	2,951.92	8,009.44
Fertilizers (in kg)	267.50	368.76
Fertilizers (in Php)	9,457.33	14,375.64
Labor (in hours)	2,181.20	1,908.22

3.2. CRS and VRS Technical Efficiency Scale Using DEA

DEA benefits entities wishing to enhance their performances by reducing input consumption or increasing output production. However, it can only be useful if its performance, in terms of its efficiency, is determined in comparison to its competitors or other DMUs (Shanmugam, 2014). The efficiency of which Charnes et al. (1978) obtained from calculating a maximal performance metric for every DMU’s decision variables relative to other units in the sample and is measured relative to the behavior of a reference unit located in the frontier where any deviances identified are assumed to be inefficiency. In evaluating business performance, DEA is serviceable in assessing comparative efficiencies of businesses based on multiple factors (Škrinjarić & Šego, 2021).

Another significant aspect of efficiency formulation is to utilize the model that best fits the data under consideration. This study used the output-oriented approach, which focuses on how much a farm in a given set of inputs can maximize its output level. Although the efficiency frontier would be dissimilar in a Variable Returns-to-Scale (VRS) or Constant Returns-to-Scale (CRS) model, the frontier would be unaffected by being either input or output-oriented. DMUs on the frontier in an input-oriented model would also be on the same frontier surface as in output orientation (Huguenin, 2012). Further, TE scores in a CRS model would be the same in both orientations. The values only change based on the model's orientation when VRS is assumed. It is to note, however, that Coelli and Perelman (1996) emphasized that there is only a minor impact on the TE score results computed by the VRS model.

Moreover, this paper presents two models for analyzing TE following the output orientation approach. The first model (Model 1) focused on non-cost variables such as farm size, pod-bearing trees, and pesticides and fertilizers' weight in kilograms as its inputs, while total kilograms of cacao beans were produced as its output. On the other hand, the second model (Model 2) concentrated on variables with costs. Thus, Philippine pesos spent on pesticides and fertilizers as well as man-hours for inputs and total income in Philippine pesos earned for the year as output was used for analysis.

Table 2 presents the allocation of technical efficiency scores of cacao farms in both CRS and VRS assumptions in Model 1. Under Model 1, only three farms out of 60 cacao farms (or 5%) were technically efficient under the CRS assumption, while 11 farms (or 18.33%) were marked as fully technically efficient under VRS. On average, the constant returns-to-scale (CRTS) of cacao farms' efficiency scores was 33.9%, which denoted that these farms could still improve their outputs by 66.10% with the same level of inputs. Meanwhile, cacao farms' average efficiency score in variable returns-to-scale (VRTS) for the non-cost model was 47.2%, which indicated that to be fully technically efficient, these farms could grow their yields by 52.8%.

Table 2. *Distribution of technical efficiency scores cacao farms under output-oriented CRS and VRS DEA*

TE Score	CRS Assumption		VRS Assumption	
	f	%	*f*	%
Model 1 (noncost)				
less than 25%	31	51.67	23	38.33
25 to 50%	18	30.00	13	21.67
51 to 75%	5	8.33	9	15.00
76 to 99%	3	5.00	4	6.67
100%	3	5.00	11	18.33
Mean TE	33.99%		47.20%	
Model 2 (cost)				
less than 25%	38	63.33	31	51.67
25 to 50%	15	25.00	9	15.00
51 to 75%	6	10.00	9	15.00
76 to 99%	0	0	3	5.00
100%	1	1.67	8	13.33
Mean TE	23.50%		39.00%	

Conversely, under Model 2, only one (or 1.67%) and eight (13.33%) farms were technically efficient under CRS and VRS assumptions, respectively. The CRTS of efficiency score is 23.5%, and they could still increase their income by 76.5% while spending the same amount on pesticides, fertilizers, and labor. VRTS, however, was at 39%, meaning these cacao farms still had a 61% potential to be more profitable.

In addition, the list of three technically efficient farms that have attained the perfect TE scores of 1.00 in both CRS and VRS assumptions with non-cost variables is shown in Tables 3 and 4. Notably, being efficient can be attained through input and operations management. Notwithstanding the farm size to cultivate and quantity of other input combinations, some cacao farms were still considered efficient in optimizing their output size from farming even with lesser farm area and usage of pesticides or fertilizers. None of the bigger farms included in the study was technically efficient under this model or the second model, as shown in Table 5. The latter shows only one profile of a cacao farm operating efficiently for both CRS and VRS assumptions when considering the peso spent and income earned (cost model).

Table 3. *Profile of technically efficient cacao farms in Davao City under both CRS and VRS assumptions (Model 1 – non-cost model)*

DMU	Farm size (in hectares)	No. of pod-bearing trees	Pesticides used (in liters)	Fertilizers used (in kg)	Labor (in man-hours)	Dried cacao beans produced (in kg)
Farm 14	1.33	1,200	24	600	3,792	2,160
Farm 19	1	150	1.25	250	282	350
Farm 55	1.75	1,500	0.25	300	832	2,660

Table 4. *Profile of technically efficient cacao farms in Davao City under both CRS and VRS assumptions (Model 2 – cost model)*

DMU	Pesticides used (in peso)	Fertilizers used (in peso)	Labor (in man-hours)	Income earned from dried cacao beans sold (in peso)
Farm 55	250	10,200	832	265,000

Furthermore, DEA's statistical output can identify cacao farms on the frontier that inefficiently managed farms can benchmark so as to maximize their production. Additional analysis can be made from the peer count summary that serves as a reference for improving productivity. Efficiently managed cacao farms such as Farm 55 have 42 peers that could likely benchmark it for their non-cost input combinations. Likewise, Farm 2 has 26 cacao farm peers that could mark it as a reference, and Farm 46 could serve as a benchmark for 25 of its peers. Benchmarking for peso spending on inputs (with cost variables), on the other hand, showed that Farm 55 has 42 other farms that could likely compare and Farm 18 has 30 peers that could follow. If inefficient farms wish to increase their output, they must consider benchmarking the best practices established by their efficient peers (Huguenin, 2012).

3.3. Slack Analysis

When compared to their peer efficient benchmark targets, slack summary, as appended, represented the possible improvements in output maximization and input minimization for the identified inefficient units in the dataset. A slack analysis is necessary to drive the inefficient DMUs to the frontier. In examining total efficiency, observance of the ratio efficiency and the slacks is imperative as the latter uncovers any input surpluses and output shortages of the DMUs involved (Tone, 2001).

The statistical output of DEA could produce a slack analysis summary for inputs and outputs. As to inputs, inefficient cacao farms needed to increase their farm size by 0.265 hectares and plant and reap an additional 260 cacao trees. The mean scores also showed that farms had to utilize an additional 0.47 liters and spend an additional Php1,845.61 for pesticides and 58.11 kilograms with Php1,718.78 on average for fertilizers. Further, spending an extra 816.94 to 834.59 hours or 102 to 104 eight-hour working days in a year, depending on how many people the farm owner will hire, can also push these inefficient farms to the frontier.

Concerning the above, most managed farms had issues with increasing the farm size to cultivate a bigger farm. Out of 60 cacao farms involved in the study, 56 farms (or 93%) needed to expand, and 34 farms (or 56.67%) had concerns about additional pod-bearing cacao trees to harvest. Regarding the number of pesticides and fertilizers, 50 (or 83%) and 39 (65%) farms needed extra liters and kilograms, respectively. The cost model, however, indicated that 20 (or 33.33%) and 51 (85%) farms needed help with increasing expenditures for each to achieve technically efficient production. Lastly, 23 (38.33%) and 19 (31.67%) cacao farms must increase labor hours for non-cost and cost models accordingly to cover the leftover part of inefficiencies.

As to output slacks, statistical output resulted in 0 kilograms and Php0.00 mean scores, indicating that inefficient cacao farms did not need to increase their harvests of cacao beans in kilograms and revenue earned. None of the 60 cacao farms as DMUs had issues changing the quantity and income of cacao beans sold to attain the optimal output.

3.4. Determinants of Technical Inefficiency of Cacao Farms Using OLS

Determining the causes of differences in technical efficiency estimations is equally important as determining their significance in identified efficiency levels (Onumah et al., 2013). Socioeconomic variables can cause these differences; thus, details of each farm householder were gathered and summarized in Table 5.

The distribution of the sampled farm householders or managers indicated that most were married (83.3%) and males (63.3%). The average age was 54 in 56.7% of farm managers in the 51 to 70 age bracket. Moreover, 33 managers (55%) had three to six people in their households, 21 (35%) of which had one to three persons, while 10% or six farm managers had more than six people. The calculated mean of the years spent in school was 9.37, which belongs to the secondary level of education. 18 or 30% of the sampled farm managers spent one to six years in school or elementary level, while 14 or 23.3% had above 12 years on their educational attainment level or reached the tertiary level. In addition, 30.5 years of farm management experience on average was calculated in the dataset, 18 farmers, or 30%, had 31 to 45 years of experience, followed by 15, or 25%, with one to 15 years. Meanwhile, the majority, or 41.7%, had attended seminars and training once or thrice since they had started farming. Presented on the table, 12.49 kilometers on average was the farms' distance to the market; 50% of them were located 11 to 20 kilometers from the market. Finally, 40 (66.7%) farmers were members of cooperatives, while 20 (33.3%) were non-members. Out of the 60 sampled farm managers, 48 or 80% had access to credit institutions, compared to 12 or 20% that had none.

Table 6 shows the results of the ordinary least squares regression following a non-cost approach for the variables. The age of the managing farmer was a significant predictor of the technical inefficiency of cacao farms ($\beta=-0.0087$, $t=-1.828$, $p<0.10$). The beta coefficient's sign was negative, which means that an increase in age by a year decreased the technical inefficiency of cacao farms by about 0.0087, ceteris paribus. This implied that older farmers were more productive than their younger counterparts. The accumulated farming knowledge and skills that heighten with age likely cause this result. Like other professions, farming requires acquired knowledge, skillset, and physical fitness, which are crucial in preventing inefficiencies (Dessale, 2019, as cited in Alemu et al., 2018). This is consistent with the study of Damian et al. (2012), in which the result stated that efficiency rates develop as years pass by. It is noticeable, however, that the analysis could not establish the years of farming experience as a factor in minimizing technical inefficiency.

Moreover, the farm manager's household size was also identified as a significant influencer of inefficiency at a 10% significant level ($\beta=-0.0496$, $t=-1.809$, $p<0.10$). Having a negative coefficient sign signified that every increase in household members decreased the technical inefficiency level by 0.0496, ceteris paribus. The result is supported by several studies such as those by Tiku et al. (2016) and Tenaye (2020) which emphasized the optimistic effect of having additional in-house labor in farm management and cultivation. In addition, Bymolt et al. (2018) also mentioned the benefit of engaging the family workforce to higher efficiency due to higher trust and confidence than hiring outside workers.

Table 5. *Socioeconomic profiles of the respondents*

Variables	Frequency	%	Mean
Civil status			
Single	10	16.7	
Married	50	83.3	
Age (years)			54
21 to 50	21	35	
51 to 70	34	56.7	
Above 70	5	8.3	
Sex			
Male	38	63.3	
Female	22	36.7	
Household size (No. of persons)			4
1 to 3	21	35	
3 to 6	33	55	
Above 6	6	10	
Years in school			9.37
1 to 6	18	30	
7 to 12	28	46.7	
Above 12	14	23.3	
Years in farming			30.5
1 to 15	15	25	
16 to 30	14	23.3	
31 to 45	18	30	
Above 45	13	21.7	
No. of seminars and trainings attended			4.48
None	15	25	
1 to 3	25	41.7	
4 to 6	12	20	
Above 6	8	13.3	
Distance to market (in kilometers)			12.49
1 to 10	19	31.7	
11 to 20	30	50	
Above 20	11	18.3	
Cooperative membership			
Members	40	66.7	
Non-members	20	33.3	
Access to credit			
With access	48	80	
No access	12	20	

Another significant variable at a 5% significance level was the distance from farm to market ($\beta=-0.0321$, $t=-2.255$, $p<0.05$). The beta coefficient sign was also negative, conveying that with every kilometer increase from the market, technical inefficiency decreased by 0.0321, ceteris paribus. Although market access is highly connected to the market's distance, as transportation costs increase input costs and lower the potential revenue they can be paid for their outputs, the results suggested that the farther the farm from the market, the less inefficient the farm is. This is due to the probable relevance of topography where cacao thrives. Vanzile (2021) affirms that the location is critical for cacao cultivation. Cacao trees must be planted with proper drainage and be well protected from the sun, wind, and extreme temperatures. Markets where crops are sold are typically found in strategic urban areas. Cacao, however, requires a humid environment with regular rainfall and grows best covered by fractional shade in rainforests that are located away from the city or town center (Rainforest Alliance, 2014).

Table 6. *Estimates of OLS Regression Model - Noncost*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
(Constant)	1.47622	0.493974	2.988	0.0044 **
age	−0.00869262	0.00475483	−1.828	0.0736 *
civil status	0.139840	0.224643	0.6225	0.5365
sex	0.0231292	0.0920755	0.2512	0.8027
household size	−0.0495916	0.0274196	−1.809	0.0766 *
years in school	0.0104641	0.0166377	0.6289	0.5323
years of experience	0.00360924	0.00415599	0.8684	0.3894
seminars and trainings	−0.00183498	0.00628042	−0.2922	0.7714
distance to market	−0.0321445	0.0142558	−2.255	0.0286 **
membership in coop	0.208839	0.130258	1.603	0.1153
access to credit	−0.511704	0.229942	−2.225	0.0307 **

***, ** and * represents 0.01, 0.05 and .10 significance levels, respectively

Further, farm householder access to credit was also a predictor of cacao farms' inefficiency at a 5% significance level ($\beta=-0.5117$, $t=-2.225$, $p<0.05$). A negative beta coefficient signified that an increase in farmers' credit access decreased technical inefficiency by 0.5117, ceteris paribus. In agro productivity, credit is a significant factor in satisfying financial requirements brought by the production cycle (Dessale, 2019). The result implies that accessibility of credit reduces the cash constraints that could hinder the timely acquisition of resources if mainly relying on the farmer's available funds. Extra source of cash through credit enhances the farm inputs' utilization, which leads to reduced inefficiency, which is consistent with Martey et al. (2019), who confirmed the opportunity for enhanced productivity through access to credit, which enables better farming technology and machinery investments, excellent seed quality and better fertilizer adoption. Conversely, being relatively connected, membership in a cooperative could not be determined as a significant predictor of technical inefficiency. This is probably due to the added cash inflows from formal or informal sources of credit compared to exclusively getting funds from cooperatives.

In Table 7, under the cost model, the age of managing farmers was also a significant influencer of technical inefficiency ($\beta=-0.0135$, $t=-3.145$, $p<0.01$). Similar to the non-cost model, the negative coefficient implied that any increase in the age of the farm manager decreased the technical inefficiency of cacao farms by about 0.0135, ceteris paribus. As Dessale (2019) pointed out, aging results in better farm management experience and causes a greater understanding of substantial and complex decision-making in managing farms involving utilizing inputs efficiently.

The distance to the market was another factor significantly influencing inefficiency at a 1% level under the cost model ($\beta=-0.0414$, $t=-3.225$, $p<0.01$). Following the non-cost model, the negative sign of the coefficient suggests that with every increase of kilometers from the market, technical inefficiency decreased by 0.0414, ceteris paribus. Similar to the non-cost model, the result confirms the critical importance of cacao farms' location and the relevance of typography for best cacao farming. Furthermore, access to credit under the cost model, at a 5% significance level ($\beta=-0.5331$, $t=-2.570$, $p<0.05$), also corroborated with the results of the non-cost model above. Being a negative predictor of inefficiency, this confirms that access to extra cash through credit institutions augments technically efficient farm management and input consumption.

Table 7. *Estimates of OLS Regression Model – Cost*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
(Constant)	1.71023	0.445519	3.839	0.0004 ***
age	−0.0134864	0.00428842	−3.145	0.0028 ***
civil status	0.0590051	0.202607	0.2912	0.7721
sex	0.0383179	0.0830437	0.4614	0.6465
household size	−0.0243269	0.0247299	−0.9837	0.3301
years in school	0.0145521	0.0150056	0.9698	0.3369
years of experience	0.00576188	0.00374832	1.537	0.1307
seminars and trainings	−0.00221451	0.00566436	−0.3910	0.6975
distance to market	−0.0414707	0.0128574	−3.225	0.0022 ***
membership in coop	0.109695	0.117481	0.9337	0.3550
access to credit	−0.533078	0.207387	−2.570	0.0132 **

***, ** and * represents 0.01, 0.05 and .10 significance levels, respectively

4. CONCLUSION

This study unveils that managed cacao farms in Davao City could be more technically efficient in maximizing their potential output and minimizing input usage. The averages or means of the computed TE scores for both VRS and CRS and under non-cost and cost models are all below 50%, which highlights that cacao productivity in the city is low. Similarly, the distribution of farms' TE scores showed that more than half of the sampled farms have less than 25% scores. The scope of the study being limited to the top four cacao-producing districts in Davao City encourages further similar studies expanding the covered locale in the city or the country as viable, which regrettably, has no published data or relevant information as of date that will facilitate better and excellent benchmarking towards improved cacao productivity.

Moreover, the inefficiency analysis model reveals that the age of managing farmers, distance to market, and credit access are the factors that negatively impact the farm managers' technical inefficiency. Implications of these results are due to accumulated knowledge as managers grow older, a topography where cacao trees flourish, and additional cash inflows availability, respectively. As younger farm administrators were noted to be less efficient than the older ones, policies that entice younger managers to improve input utilization through incentives must be considered. To strengthen youth agriculture management, the government can subsidize basic agricultural tools and inaugurate programs promoting employment benefits and poverty alleviation through business agriculture. This, however, should also consider the necessity of older farm managers to maintain the zeal for production efficiency.

The government should likewise intensify agricultural policies and programs on credit access and availability to managers in need of assistance in cultivating their crops and maximize the production potential of cacao, not only in Davao City but also in the entire country. It is also recommended that government interventions on fertilizers and pesticide price hikes should be heightened to mitigate the impact of increasing input costs on farms' productivity.

Finally, despite being technically inefficient, this study confirms that cacao farms can benchmark other farms to increase efficiency and improve productivity. This follows the production function with the inclusion of Farrell's (1957) technical efficiency that an entity's competence reflects on how production inputs are minimized, and yields are maximized, which is the fundamental goal of every production, whether for cost or non-cost business activities. Knowledge of the actual TE levels and the slacks creates opportunities for cacao farm managers to generate better revenue and increased profit for the agribusinessmen and the city and nation's profit indices.

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