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TECHNICAL EFFICIENCY ESTIMATES OF COFFEE PRODUCTION IN DAVAO CITY, PHILIPPINES: A DATA ENVELOPMENT APPROACH

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Abstract:
The Philippine coffee industry is dominated by small-scaled farm households. This study was conducted to measure the technical efficiency of coffee production in Davao City using Data Envelopment Analysis. The study also determined the factors that contribute to the technical efficiency of coffee farms using Logistic Regression. Among the 166 respondents obtained, the study revealed that only 11 DMUs are technically efficient operating under constant return to scale while 154 and 1 were technically inefficient operating under increasing return to scale and decreasing return to scale, respectively. This means that input such as farm size, labor, number of coffee trees, age of coffee trees, fertilizers and pesticides has to be adjusted in order to reach the frontier to be technically efficient DMUs in which coffee farms are the potential to increase production if provided with appropriate support. Furthermore, to achieve bias-corrected DEA technical efficiency scores, Bootstrapping was done and later used for regression. Meanwhile, the logistic regression results revealed that there were significant relationships between technical efficiency and socioeconomic such as Age of Household Head, Sex, Access to Credit, Cropping System, Technology, and Coffee Variety. However, the logistic regression also revealed the factors that have no statistically significant relationship in the variables such as Education, Farm Experiences, Household Size, Extension Services, and Off-farm Activities.

JEL: L60; L66; O13

Keywords: coffee, efficiency, DEA, production

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1. Introduction

Coffee is one of the priority products of the Philippines. Thousands of farmers rely on coffee for their income and livelihood. Touted as the 5th most imported agricultural product, the coffee industry demonstrates growth potential (Department of Trade and Industry, 2018). In 2018, according to official statistical figures, coffee production in the Philippines was experiencing a decline owing to the factors that affect the performance of the industry, which contributes a margin of 0.32 percent to the GDP (Philippine Statistics Authority, 2016; 2018).

While the whole industry is shrinking, the Davao coffee production shows an increase in production volume since 2016, with small-scale farmers taking the bulk of production share (PSA, 2018; DTI, 2018). Amid this increment in Davao Region's coffee industry performance, it remains an important consideration of the traditional factors that affect coffee farming such as seed variety (Sarmiento, 2015b; PSA, 2017; BPI, 2017), and the crop-shifting of some farmers where they prefer other crops to earn better income (Ang, 2010; DTI 2018).

Consequently, the DA, and DTI and BPI, established a Road Map to improve the coffee industry (Ang, 2010). Other studies related to the coffee industry are more focused on coffee shop industries (Arroyo, 2020), fertilizer application (R.Z. Margate *et al.*, 1994), enterprising (Tan, 2021), production forecast (Tolentino and Hernandez, 2019), except in technical efficiency of the industry. There are no established or related technical efficiency studies in the region, so this research adds to the body of knowledge on how coffee farmers optimize coffee production.

Nonetheless, given the industry's situation, assessing coffee farms' efficiency is necessary to improve the farm's production performance and optimize resources by maximizing opportunities (Diega, 2014; PSA, 2016). Thus, this research aims to determine the coffee farming best practice by identifying the technical efficiencies of the various farms in Davao City.

1.1 Objective

The primary objective of the study is to estimate the technical efficiency and sources of the inefficiency of Coffee Farms in Davao City.

2. Method

The study used a quantitative research method (Creswell, 2013; Perreault, 2011; William, 2006), which tests the objective theories by examining the relationship among variables that can be measured using a survey instrument or opinion of the population by studying a sample of that population. Data Envelopment Approach and Causal Approach were used in measuring the technical efficiency and the factors affecting the technical efficiency, respectively.

Moreover, Data Envelopment Analysis is a non-parametric approach that is an appropriate tool used in this study to measure technical efficiency. This avoids the specification bias in functional form and distributional assumption (Varian, 1984 as cited by Poudel *et al.*, 2012; Dao, 2013). Conversely, the Causal Design approach was also used in the study to measure the coffee production efficiency and the cause-and-effect relationship contributing to efficiency, which assumed that any variation in the behavior of each independent variable would induce a corresponding increment in the dependent variable of the study (Hamidi, 2016; Nyagaka *et al*., 2010).

The study follows the two-step analysis, (1) estimating efficiency and (2) measuring the effects of efficiency, in order to address the objectives of the study. The first step is the non-parametric approach useful in calculating the technical efficiency given the inputs and output of the study (Hamidi, 2016; Nyagaka *et al.,* 2010). And the technical efficiency score can be obtained by estimating a constant return to scale (CRS) or variable return to scale (VRS) models. Scale efficiency measures the optimality of the operation and can be obtained by dividing CRS over VRS (Coelli *et al.,* 2005).

The second step is the Causal Approach, which is an effective technique for measuring the relationship between the variables. Using the efficiency scores obtained is regressed on different combinations of explanatory variables to explore technical efficiency determinants. The research design outlines the use to generate answers to the research problems. The use of these approaches was to assess the efficiency estimates of the coffee production for best practices from an efficient farm and focus on economic optimization (Hamidi, 2016) by determining the factors contributing to the farms' efficiency.

2.1 Sources of Data

The focus of the study is the production of coffee farms in Davao City. Coffee production refers to the factors of production (inputs) used in the farm to generate output which is the coffee beans. Primary cross-sectional data for the year 2019 in different parts of the city were obtained through a survey questionnaire and voluntarily asked the respondents to truthfully answer the aforementioned. The year 2019 coffee production was the ideal year to obtain data from coffee farmers since, after the succeeding years, most coffee farms have already been converted to other high-value crops.

3. Results and Discussions

The findings of the study addressing specific objectives are discussed in this part and the interpretation and analysis of the results. The findings are primarily derived from data obtained from coffee farmers in the city.

3.1 The Socioeconomic of Coffee Farmers

Average statistics were summarized and presented in Table 1 for the sampled coffee farmers. A typical coffee farmer in the city is less than 50 years old on average, and all or most of these farmers have been employed all their lives as farmers. In the Philippines, a sad situation in agriculture is that Filipino farmers are aging in the region and the country. According to the Nazario report (2020, cited from Manila Bulletin), 65 percent of farmers claim that if their children become farmers themselves, they will not have a future. The findings of Bamber, Daly & Gereffi (2017) revealed that the average age of farmers in the Philippines is 57 to 60 years old and that coffee is still produced using outdated agricultural techniques. To add fuel to the fire, parents assume no future in agriculture, but the youth lack interest (Inso, 2018). Most of these young people migrate to urban areas, creating adverse impacts on agriculture's overall production; this scenario is referred to as rural-urban migration (Zhang *et al.,* 2020). On the other hand, as opportunities in urban areas increase, rural-urban migration has a positive effect on the economy, as the ratio of per capita urban income to per capita rural income is positive (Goldsmith *et al.,* 2004). As supported by Nguyen *et al.* (2015), the per capita income from increased agricultural investment and strengthened poverty alleviation has increased.

In addition, most of these coffee farmers are male, with a household size of 5 people and an elementary level, with 17 years of agricultural experience and no extension of contact in a year. Coffee farmers do not have access to credit for use on farms and are dependent solely on farming without any off-farm work. Furthermore, the government's attempts, headed by the department of agriculture to assist these farmers, are noted by the lack of extension services and access to credit provided over the past few decades. The department introduced a program that was somehow successful in providing seedlings to farmers. Nevertheless, it is merely on the distribution surface and does not entirely resolve the problem, including substandard quality planting (Bamber, Daly & Gereffi, 2017; Inso, 2018). Farmers who have less interaction with any extension services are not well educated about innovation and up-to-date practices; hence, farmers are not particular to technology use.

Most coffee farmers introduce an intercropping system with at least two or more crops grown on the land. Many of these farmers practice intercropping rather than monocropping methods, primarily because the soil's nutrition weakens. When planting the same crop repeatedly, the vulnerability to pests and diseases is often very high (Altieri, Nicholls, & Ponti, 2008).

The variety of coffee that is mostly planted by coffee farmers was the Robusta coffee (BPI, 2017). This has been the preferred variety because it is ideal for low land elevation and more excellent resistance to pests and diseases.

Table 1: Average Statistics of Coffee Farmers

Variables	**Mean Value**	**Std. Dev.**	**Minimum**	**Maximum**
Age of Farmer	47.50	13.56	20.00	86.00
Sex	0.75	0.44	0	1
Household Size	4.77	2.38	1	15
Education	2.10	1.35	0	7
Farm Experiences	17.13	11.13	2.00	78.00
Extension Services	0.20	0.41	0	1

Access to Credit	0.12	0.33	0	1
Off-Farm Work	0.43	0.50	0	1
Cropping System	0.70	0.46	0	1
Technology	0.10	0.30	0	1
Variety	1.04	0.28	1	3

3.2 Average Statistics of Inputs and Output

Table 2 summarizes and describes the average statistics of coffee farmers using inputs to generate production. The average farm size for coffee farmers is less than 3 hectares of land, varying from a minimum of 0.25 to a maximum of 19 ha. Coffee farms are labor-intensive and have at least four farm workers and a maximum workforce of up to 13 workers. On average, many of these farmers planted 455 coffee trees and about 30 to 13,000 tops maximum. Most of these coffee trees are 3 to 60 years of age, with a coffee tree averaging 17 years of age and 25 kilos of fertilizer applied. Some farmers use no fertilizer, while others use up to 500 kg per year. And on average 2 liters of pesticides a year to 22.74 liters. Coffee farmers can produce an average of 421 kilograms of coffee beans annually with all the farm inputs. However, some farmers can only have 10kgs per year, while others can have 39,000kgs annually.

Similarly, the estimated number of coffee trees on a hectare of land is 1,111 with a planting distance of 3x3 (Coste, 2018), reflecting that coffee farmers do not maximize the inputs used in production efficiency. Instead of rejuvenation, several of these farmers decided to cut down non-productive coffee trees (Ang, 2010). One reason also is that instead of rejuvenating, farmers in the city prefer to cut down the trees where the land is under the ancestral domain. For several years, most coffee trees have been present and were inherited from their grandparents down to their parents. Another explanation of why coffee farmers do not use their farmland entirely is the fragmentation of the land. Due to steep terrain or the farm's distance from the home, other areas of the farmer's land are difficult to reach. If farmers want to access that fragment of land, they have to employ workers for it, which is an additional expense to them, so farmers tend to use parts of their land that are easy to access rather than the entire land they own (Dao, 2013). Furthermore, the age of coffee trees harms production; as the tree ages, the coffee yield decreases (Huong & Anh, 2019).

The application of fertilizer depends on the plant's condition and what the plant needs. There is no standard application quantity, but fertilizer is necessary during the early stage. The findings of Tampuli Abukari & Alemdar (2019) fertilizer application showed a significant increase in production. There are two types of fertilizer, organic or synthetic, but Complete Fertilizer with a composition of 14 Nitrogen (N), 14 Phosphorus (P), and 14 Potassium (K) (14-14-14) is the typical synthetic fertilizer used by coffee farmers (Byrareddy *et al.*, 2019). At the same time, the typical organic fertilizer used is chicken dung. Although the Robusta tree needed less fertilizer application than Arabica (Winston *et al.*, 2005), it is difficult for most farmers to apply fertilizer to their farmland, not because of the lack of workers but because of the costs involved. While fertilizer is costly, it will provide a hefty number of returns with the correct and timely application

(FAO, 1977); that is why farmers will sacrifice to borrow money or wait for government assistance.

Like most plants, coffee is vulnerable to numerous pests, diseases, fungi, and anything that could kill the plant and its fruits, ultimately affecting production (Boyd, 2015). Pesticide applications often do not have a regular application quantity, like fertilizer. However, depending on the environment and the pests infested, pesticide application plays a critical role in crop protection. While pesticide use has many environmental and health issues (de Queiroz *et al.*, 2018), farmers continue to apply pesticides to avoid production losses (Cerda *et al.*, 2017).

Table 2: Descriptive Statistics of Inputs and Output of Coffee Farmers

Variables	Mean Value	Std. Dev.	Minimum	Maximum
Output (kg)	421.40	3022.91	10	39000
Inputs				
Farm Size (ha)	2.29	1.91	0.25	19
Labor	4.22	2.78	1	13
No. of Trees	454.94	1072.09	30	13000
Age of the Tree (yrs)	17.22	11.30	3	60
Fertilizer (kg)	25.11	73.56	0	500
Pesticide (lit)	2.06	4.01	0	23

3.3 Technical Efficiency Estimates Results

Table 3 shows the results guided by the Data Envelopment Analysis (DEA) model. It is evident from the results that technical efficiency constant return to scale (TE_{CRS}) varies from 0.02 to 1.0, with a mean score of 0.31. The mean of technical efficiency variable return to scale (TE_{VRS}) of the sample farms is 0.69, with a low of 0.16 and a high of 1.0. According to the technical efficiency theory, a farm can reduce its inputs $\left(\frac{1}{TE_{VRS}} - 1\right)$without changing the output level (Vitale *et al.*, 2019). The results imply that if the average sample farm operated at full efficiency level, it could reduce, on average, its input use by 44.43 percent $\left(\frac{1}{0.69} - 1\right)$and still produce the same level of output.

Besides, it is also shown that the mean scale efficiency is 0.44 in the sample farm, varying from 0.04 to 1.0. This implies that estimates of 31 percent VRS inefficiency and 56 percent scale inefficiency were provided by decomposing the overall technical inefficiency measure. Farms can increase their average technical efficiency level from 31 to 69 percent by eliminating scale inefficiency. Following the bootstrap method of Simar and Wilson (1998), with a 95 percent confidence interval, the bias-corrected TE scores were estimated, given the mean of 0.69, which has the same value as the initial TE scores. This means that the amount of input saving is 44.9 percent $\left(\frac{1}{0.69} - 1\right)$ after correcting for bias.

Similarly, recognizing the limitations in the paper. Provided that the referencing is a function of the respondents' knowledge of their peers rather than the randomness effect of a scientific inquiry, the result may have been reasonably gravitating towards the similarity of the farmers given that the respondents of the sample were selected from a snowball, and easy to reach respondents. Hence the result could have been fairly leaning towards the farmers' similarity given that the referencing is a product of their knowledge of their peers rather than the randomness effect of a scientific inquiry.

Table 3: Technical Efficiency Score of Estimates

Variables	Mean	Std. Dev.	Min	Max
TE_{CRS}	0.31	0.26	0.02	1
TE_{VRS}	0.69	0.26	0.16	1
Scale *Eff.*	0.44	0.28	0.04	1
Biased-corrected TE	0.69	0.02	0.66	0.72

3.4 The Return to Scale Efficiency Estimates

The sources of scale inefficiency are examined through their return to scale characteristics with respect to the inputs used, shown in Table 4. The results presented in this table are the percentages of farms operating in different characteristics such as Constant Return to Scale (CRS), Increasing Return to Scale (IRS), and Decreasing Return to Scale (DRS). Results have shown that 6.63 percent of the sample are operating in scale efficiency, while 93.37 are scale inefficient. Furthermore, farms have an average of 4 hectares of land with about 1,640 coffee trees, 58.18kg of fertilizer, and 3 liters used compared to IRS. Farms under CRS is the desirable scale of operation as it operates both technical and scales efficiently.

Moreover, among the scale inefficient farms, 154 farms (represents 92.77 percent) have increasing returns to scale; these farms use less farmland (2Ha), coffee trees (370), fertilizer (21kg), and pesticides (2.02). Furthermore, farms under IRS must expand their farmland up to 4 hectares and have four workers (1ha is to 1 worker), increase the number of coffee trees to 1,270, additional 37.22 kg of fertilizer, and 0.74 increase in pesticides used. While only one farm (represents 0.6 percent) operates under decreasing return to scale, which uses 1 hectare of land and has 11 people working for only 450 coffee trees with extensive use of fertilizer without using pesticides, which can reduce its scale of operation. Thus, farms under IRS can increase their output given appropriate guidance and support, including DMU under DRS, which must decrease the use of inputs to operate and achieve efficiency.

Table 4: Summary of Return to Scale (n=166)

Characteristics	Number of Farms	Percentage	Mean	Std. Dev.	Min	Max
CRS						
Output	11	6.63	4208.18	11545.75	120	39000
Farm Size in Ha			3.94	5.23	0.75	19
Labor in man days			4	2.28	1	8
No. of Trees			1640	3784.65	40	13000
Age of Trees in years			16.55	10.59	5	40
Fertilizer in kg			58.18	101.27	0	250
Pesticides in Lit			2.76	5.57	0	16

IRS						
Output	154	92.77	148.79	188.38	10	1200
Farm Size in Ha			2.19	1.39	0.25	8
Labor in man days			4.19	2.77	1	13
No. of Trees			370.32	441.79	30	3000
Age of Trees in years			17.25	11.42	3	60
Fertilizer in kg			20.96	67.64	0	500
Pesticides in Lit			2.02	3.90	0	22.74
DRS						
Output	1	0.6	750		750	750
Farm Size in Ha			1		1	1
Labor in man days			11		11	11
No. of Trees			450		450	450
Age of Trees in years			20		20	20
Fertilizer in kg			300		300	300
Pesticides in Lit			0		0	0

Note: CRS: Constant return to scale; IRS: increasing return to scale; DRS: Decreasing return to scale

3.5 Logistic Regression Results

The results from the analysis of the Logistic Regression model are presented in Table 5. In general, the strength of the model is stable, with the Likelihood Ratio (LR) Chi-square test of 54.59 is significant at a 1 percent level of significance. It means that at least one of the predictors' regression coefficients is not equal to zero in the model. The log-likelihood of -40.39 with Pseudo R2 of 0.40 shows that the model has a moderately strong relationship between the dependent and independent variables, which suggests that the model is useful in explaining the determinants of efficiency.

The factors that influence technical efficiency are the age of the household head, sex, access to credit, cropping system, technology, and variety. However, the factors that do not influence efficiency are Education, Farm Experiences, Household Size, Extension Services, and off-farm activities.

3.6 Age of Farmers

The result has shown that the age of farmers has a positive relationship with technical efficiency. The coefficient of age 1.69 is positive and significant at the 5 percent level, which indicates that as the farmer ages, the greater technical efficiency scores farmers have. The probable reason is that as farmers grow older, they become more skillful due to accumulated experiences (Dessale, 2019). The result is supported by Essilfie, Asiamah, and Nimoh (2011), who indicated that a farmer's technical efficiency increases as age increases. This conforms to the demographic structure of coffee farmers in the city as many of these farmers ages 45 to 50 years old (BPI, 2017), not only coffee farmers but the average farmers (57 years old) of the country as a whole (Palis, 2020; Bamber, Daly & Gereffi, 2017).

However, farmers' efficiency increases 5 to 10 percent in general but have an age interval of 35 to 44, and beyond that, farmer's age technically inefficient at the same rate

(Tauer, 1995). Concur with the explanation by Pantzios, Rozakis, & Tzouvelekas (2002), young producers will become more productive over time to a point where the relationship between age and efficiency is leveled off, but as farmer reach retirement age, efficiency declines. This coincides with the contradiction of Bozoğlu and Ceyhan (2007) and Kamau, Ateka, Mbeche, & Kavoi (2017), about older farmers tend to be more efficient than the younger ones, as there is a limit to how efficient a person can be as he/she ages, which means to say, increase in age does not always correlate the increase in productivity and efficiency.

3.7 Sex

The result for sex shown has a negative relationship between technical efficiency. The negative coefficient of sex (-47.52) is significant at the 5 percent level, which means that sex can relatively influence technical efficiency. Some studies have found similar results (Abdulai, Nkegbe, & Donkoh, 2013; Itam *et al.,* 2015). Moreover, male coffee farmers are aggressive in farm activities, and most males in agriculture are always being favored in farming (PSA, 2018) compared to their female counterparts. This conforms to the earlier findings in the literature as most males are involved in heavy tasks, such as plowing, harvesting, transport, etc. (Quisumbing, 1996), dominating farm activities (Nginyangi, 2011). The result also indicates that male farmers obtained a higher level of technical efficiency compared to females. Male tends to produce more output and more efficient than the female counterpart (Addison, Ohene-Yankyera, & Fredua-Antoh, 2016; Danso-Abbeam & Baiyegunhi, 2020). Although not directly involved in the production, most females influence technical efficiency differently, such as domestic, economic, and non-economic life (Abdallah, 2016; Abdulai *et al.,* 2013). However, the result was refuted by Furi & Bashargo (2018) claimed that female is more efficient than male as females is better in the management of resources that their male counterpart.

Nevertheless, other studies have reported no statistically significant results of the influence of sex on efficiency (Li & Sicular, 2013). Hence, this study contributes to the long ongoing debate on the role of sex/gender in farm efficiency.

3.8 Access to Credit

Access to credit can be from cooperatives, banks, or other financial entities where a farmer can borrow money. It plays a crucial role in agriculture, especially in rural communities, affecting farm decisions (Tenaye, 2020). Access to credit shown a negative relationship between technical efficiency with a coefficient of -57.34 and significant at 5 percent level. The results revealed that access to credit could significantly influence technical efficiency negatively, which has the same finding of Nginyangi (2011) and Huong & Anh (2019), stating that farmers who intend to borrow money for timely farm activities such as purchasing coffee inputs to secure an increase in output can improve technical efficiency. However, these farmers have diverted the credit acquired from the original intentions of buying farm inputs to something else other than for coffee production. One of the factors coffee farmers are having trouble purchasing input materials, like fertilizer and pesticides, is the access to credit, as these inputs are badly needed in production farmers. On the other hand, they do not have the qualifications to borrow money from financial institutions, or if they do, they prefer not to because of the fear of not being able to pay them (Awotide *et al.*, 2015).

The report of Abdallah (2016) stating that farmers have a high probability of accessing credit if they are a member of an economic group or association, which indicates that if a farmer can purchase the right and timely inputs, there is a high chance of an increase in production. Also, access to credit plays a significant role in undertake new investments and acquire new technology. Notably, the sad part in the Philippine farmers (and fishermen) have historically been considered unreliable borrowers by financial institutions even when the government has Law requiring local banks to allocate 25% of their loan portfolio (Asian Development Bank (ADB), 2019) that is why most farmers not only coffee farmers have a negative relationship with technical efficiency. Thus, access to credit influence the farmers' technical efficiency (Nchare, 2007; Poudel *et al.*, 2015).

3.9 Cropping System

The result has shown that the cropping system has a positive relationship with technical efficiency. The positive coefficient of 57.87 and significance at a 5 percent level means that cropping systems have positively influenced technical efficiency. The result has a similar finding with Itam *et al.* (2015) that the cropping system is an essential factor in determining technical efficiency. Moreover, those coffee farmers implemented an intercropping system in farms reveals a positive relationship in technical efficiency rather than a monocropping system (Huong & Anh, 2019). However, the result is contrary to Ngango & Kim (2019); Ngango (2018), where the monocropping system tends to have higher technical efficiency than the intercropping system, as this allows coffee farmers to specialized in coffee production alone. Furthermore, it was found that coffee has a lower low technical efficiency because of the intercropping system than the monocropping system (Cardenas, Vedenov, & Houston, 2005). Nevertheless, other studies have reported no statistically significant results of the influence of cropping system on efficiency (Binam *et al.*, 2003); this means that whatever cropping system a farmer used, it does not matter, nor will it affect efficiency.

3.10 Technology

Technology is a catalyst that helps in production, especially in agriculture. The results speak for this as technology has a positive and statistically significant relationship with technical efficiency, which indicates that if farmers use technology, it will greatly increase production, leading to efficiency. The result is in line with the findings of Abdallah (2016), Poudel *et al.* (2012), and Coelli *et al.* (2005), stating that technology is a crucial tool in production that significantly affects technical efficiency. Farmers who adopt technology can greatly benefit from it, increasing farm productivity, efficiency, and income (Nginyangi, 2011). On the other hand, farmers who have no access to agricultural technology were more technically inefficient than those who utilize technology in production (Abdulai *et al.*, 2013). Moreover, another study suggests that for technology to influence efficiency, farmers must be aware, have enough knowledge and most significantly money (Ntshangase, *et al.*, 2018). Thus, the application and utilization of technology in agriculture can help achieve a greater height of production and efficiency.

3.11 Coffee Variety

The country has four different varieties, namely Arabica, Robusta, Excelsa, and Liberica; among these varieties, Robusta has been the cream of the crop for coffee farmers in the city. The result has shown that coffee variety has a positive coefficient and statistically significant relationship with efficiency; this means that the variety used in the production can significantly influence the technical efficiency. The findings are supported by Ngango and Kim (2019); Wollni & Brümmer (2012), stating that superior and pest-resistant variety can increase production efficiency and achieve higher output levels, respectively. In addition, the Robusta variety has a high resistance to pests and diseases, which significantly influence yield and quality (Anh *et al.*, 2019). The study's findings conform to the country's geographic and demographic characteristics as 70 percent of coffee farmers planted Robusta (DTI, 2018;2017; BPI, 2017).

3.12 Other Factors

Other factors such as education (4.16, p>0.54), farm experience (0.58, p>0.33), and extension services (24.90, p>0.16) showed a positive coefficient but found statistically insignificant contributors to efficiency. In addition, household size (-5.72, p>0.16) and off-farm activities (-22.27, p>0.08) have a negative coefficient and are not statistically significant to efficiency. Although many studies have claimed that these factors can influence technical efficiency, the result, however, has shown otherwise (Abdallah, 2016; Owusu, 2017). One of the notable explanations for this is that the sample's demographic characteristics are different from the other countries (Pantzios, Rozakis, & Tzouvelekas, 2002; Rahji, Akintola, & Tiamiyu, 2009 and Dao, 2013).

Table 5: Determinants of Technical Efficiency Estimates from Logit Model

Variables	Coefficient	Standard error	p-value	Decision on Ho
Intercept	-226.81	83.98	0.01	Reject Ho
Age of Farmers	1.69	0.70	0.02	Reject Ho
Sex	-47.52	12.86	0.00	Reject Ho
Education	4.16	6.83	0.54	Accept Ho
Farm Experiences	0.58	0.59	0.33	Accept Ho
Household Size	-5.72	4.02	0.16	Accept Ho
Extension Services	24.90	17.63	0.16	Accept Ho
Access to Credit	-57.34	26.66	0.03	Reject Ho
Off-farm Activities	-22.27	12.67	0.08	Accept Ho
Cropping System	57.87	24.02	0.02	Reject Ho
Technology	65.50	28.88	0.02	Reject Ho
Variety	149.60	41.38	0.00	Reject Ho

Diagnostic Statistics				
Log likelihood	-40.39			
Prob > chi2	0.00			
Pseudo R2	0.40			
LR chi2(11)	54.59			

4. Conclusions

This study aimed to determine the technical efficiency of coffee farmers in annual cropping in Davao City. The importance of this is that Davao City has a growing population with limited available land cultivation (mostly has been converted), and the demand for coffee has been substantially increasing but declining supply over the years, which requires agricultural strategies. The enormous challenge is to increase production to meet the needs of the people. This paper emphasizes the importance of technical efficiency to improve coffee production and its best practices. Therefore, the present study addresses the primary objectives in estimating the technical efficiency and sources of the inefficiency of Coffee Farms in Davao City.

In this manner, the researcher found out that among all the 166 DMUs included in the study, only 11 coffee farmers are technically efficient, operating under constant return to scale, implying that these coffee farmers have used their inputs optimally to produce a greater level of output. Furthermore, the 11 DMUs apply the "best practices" of technical efficiency with an efficiency score of 1.000. Some of these DMUs under CRS make use of technology in production, which prominently facilitated the increase in output. On the other hand, 155 DMUs that were technically inefficient farms were evaluated, reflected by their technical efficiency scores of less than 1.000. Likewise, 154 of these DMUs dominate under increasing return to scale, which suggests that they must increase their inputs to be a technically efficient farms, following the examples of the farms under CRS. Also, almost all of the farms operating under IRS means that coffee farms have an impending increase in production if stipulated with appropriate support. Among the technically inefficient farms, only 1 DMU operating under decreasing return to scale implies that this coffee farmer must reduce the use of inputs to achieve technical efficiency such as labor (Reference: Table 3 & 4).

The study also concluded that the relationship of socioeconomic characteristics of coffee farmers concerning technical efficiency has shown positive and statistically significant at 5 percent level were age, cropping system, technology, and coffee variety, which indicates that as the farmer's age increases, the more coffee farmers employ intercropping system and technology. If the coffee variety is Robusta, the greater it contributes to the technical efficiency of the farm. While negative but statistically significant were sex and access to credit, coffee farming is dominated by male farmers who increase production and efficiency more than their female counterparts. Also, as these coffee farmers have access to credit, they may allocate the money differently. It may be allocated to other crops than coffee or food for a living. Thus, these variables were the factors that determine the technical efficiency of coffee farmers in the study. Nevertheless, variables such as education, experience, household size, extension services, and off-farm activities are the factors that do not influence the technical efficiency of coffee farmers in the study. Unlike other related studies, some of these variables were efficient and can significantly affect the TE, especially education and extension services. However, due to the limitation of the study, these variables affect otherwise.

The average coffee beans in a year coffee farmer produced were 421.40 kgs. The produced coffee beans were from an average farm size of 2.29 hectares, with four workers working in the 455 coffee trees that ages 17 years old, applied with 25.11 kgs and 2.06 liters of fertilizer and pesticides, respectively. The age of a coffee farmer was 48 years old, and the older these farmers get, the more they can produce more. Coffee farming is dominated mainly by males, who were at an elementary level, of 5 people household size on average. Furthermore, these coffee farmers have been in the industry for 17 years and have little to no contact with extension services and access to credit, as well as no off-farm jobs. Most of the farmers practice intercropping system and is not implementing technology in the production of Robusta variety.

4.1 Recommendations

From the conclusions rendered above by the researcher, I would like to recommend the following:

To the government, to impose policies on the implementation as well as on the structure of each of the Department of Agriculture' bureaus and attached agencies in Davao City, specifically on the technology allocation and information associates with the proper extension services and most especially on the credit access and financial support to coffee farmers. The frequent visitation and distribution of highly resistant coffee seedlings are greatly beneficial to coffee farmers, including the production inputs such as fertilizer and pesticides that can produce more output.

To the Department of Agriculture's Bureaus and attached agencies in the city, to conduct intensive and relevant information on financial literacy and crop management, to avoid diversion of credit access to other expenses instead of on the production inputs, and to avoid conversion of farmland and total change of crops, respectively. Moreover, the need for proper training and seminars on crop protection, rejuvenation, and intervention. They also empower women in agriculture and encourage youth, as women have less importance in agriculture and the youth to fully engage in agriculture. Also, maintain the balance of technological improvement and utilization of adequate resources for the improvement of their productivity and adequately implore marketing strategies that would strengthen the farmers' participation in the market and in the industry.

To the policymakers, strengthen the law on farmers' financial access in a formal institution and give them confidence in financial matters. Furthermore, establish connections and access to farms such as farm-to-market roads and "bagsakan center," which lessen the middlemen and more earnings for farmers in return. Therefore, financial and government support is a must for sustainable resources.

Conflict of Interest Statement

The authors declare no conflict of interest.

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