[주제 1]

PROFIT EFFICIENCY ESTIMATION OF COCOA FARM PLOTS USING THE STOCHASTIC FRONTIER MODEL APPROACH

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Financial and accounting measures of profit are commonly used to evaluate the performance of firms, even in agriculture. However, these measures do not estimate the ideal level of profit for firms and firms' actual performance in generating profits. It is more informative to estimate the most efficient profit frontier and compare firms' profit efficiency performance to this calculated frontier. Given the importance of cocoa production to cocoa-producing countries, it is prudent to investigate if cocoa farmers, and cocoa farm plots as business units, are generating profits efficiently, considering the observed contemporary trend of diversification of cocoa with other tree crops, food crops and livestock alternatives. This study adopts a translog stochastic frontier model with random coefficients and a truncated normal distribution to estimate the efficiency of cocoa farmers in the Western and Ashanti regions of Ghana. The study also investigates the relationship between farmers' choice of diversification strategy and profit efficiency. The results show that farmers' mean profit efficiency was 41.8%, with the maximum frontier having a profit efficiency of 99.6%. Also, it is observed that farmers who diversify into all three options have the highest average profit efficiency of 56.3%. Farm size and diversification of cocoa with food crops were found to be significantly related to profit inefficiency with negative and positive relationships respectively. The results confirm the literature that profit inefficiency increases as farm size reduces. The results also indicate that diversifying cocoa with food crops may be the most profit-inefficient diversification strategy for cocoa farmers.

Key Words: Profit Efficiency, Stochastic Frontier Model, Cocoa
JEL Codes: P34, Q12, Q14,

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Introduction

Background

Financial and accounting measures of profitability have long been adopted in studies, especially in management and economic sciences, to compute the profitability of resource-based firms, including agricultural sector companies (Nkang et al., 2007; Norton & Nalley, 2013; Nunoo & Owusu, 2017; Tsiboe, 2015). However, accounting and financial measures have serious drawbacks when applied to the estimation of aggregate firm performance, especially in resource-based industries such as agriculture. Coff, (1999) for example argues that there exists the possibility that marginal returns generated as a result of competitive advantage within a group of firms will not be captured by traditional financial measures of performance. In agribusiness performance evaluation, this can be an important factor for economic and development planning purposes. In sub-Saharan Africa, 33 million farms are still smallholder and contribute 70-80% of the food supply (IFAD, 2022). Thus, the efficiency with which farmers as business units utilize scarce land, capital and labour resources is crucial to key developmental outcomes such as poverty reduction and food security. At the household and firm levels, the prudent use of resources is of paramount importance to profitability, household incomes, access to healthcare and other outcomes. At the macro level, the importance of cash crops such as cocoa, coffee and oil palm to national development cannot be overstated. These crops contribute significantly to employment, GDP, Balance of Payments, and Exchange Rate stability, especially for developing countries such as Ghana and Cote d'Ivoire. In Ghana, cocoa production accounts for 17% of employment and contributes about 3 billion dollars in foreign exchange and accounts for approximately 1% of GDP (Abbadi et al., 2019; Ghana Commercial Bank, 2022; Hudson, 2022). Hence it is in the interest of the government to ensure that farmers continue to make the decision to produce cocoa and do so efficiently. As business units, the main motivation for this decision is comparatively higher profits, with respect to alternatives. For policymakers, it is critical to evaluate the profitability of such groups of farmers to improve the design and targeting of policies that improve the profitability of such groups of farmers or value chains. In this regard, the most popularly used assessment metrics are Gross Margin/Profit, Net Margin/Profit, Return on Assets (ROA) and Return on Equity (ROE) (Bierly & Chakrabarti, 1996; de Carolis, 2003; Deephouse, 2000; Fernández et al., 2019; Hull & Rothenberg, 2008; Lin & Wu, 2014; Markides & Williamson, 1996; Wu et al., 2006). Yet it is argued that financial metrics such as Net Profit, ROE & ROA, do not account for the difference in the efficiency of resource utilization among groups of farmers for example, which could be the key source of competitive advantage among such a group (Chen et al., 2015).

To overcome the drawbacks associated with the inability of financial and accounting metrics to address resource use efficiency, Arbelo et al., (2021), propose the use of "profit efficiency" as an innovative performance measurement approach. Here, Profit efficiency is defined as: "a firm's ability to manage its resources and produce outputs with greater economic value". Both input and output side lapses are controlled for under this paradigm. On the input side, profit efficiency deals with measures that comprise the cost side of the profit function, such as input costs, labour, technology and other overheads, and the efficiency to which these are deployed. On the revenue side, the model deals with the firm's ability to generate a larger amount of output. Profit efficiency is an indicator that evaluates both a firm's efficiency and the potential profit that this firm could achieve if it were fully efficient, in contrast to the performance metrics utilized by earlier studies in the Resource-Based View (RBV)-related literature. According to resource-based theory, a corporation is best positioned for long-term success if it has access to resources that are valued, uncommon, challenging to duplicate, and non-substitutable. These strategic assets can serve as the cornerstone for the growth of business capabilities that, over time, may result in improved performance. These strategic resources can provide the foundation to develop firm capabilities that can lead to superior performance over time (Lockett et al., 2009). Profit efficiency is therefore a more accurate predictor of a company's overall profitability than accounting and financial indicators (Arbelo et al., 2020) under these assumptions. This new performance metric is anticipated to yield different findings from earlier empirical research on RBV. Due to inherent variances, financial and accounting metrics typically score differently than profit efficiency and cannot be connected (Han et al., 2012). For instance, a firm with a high ROA may not be efficient when other economic and environmental factors are considered. Therefore, utilizing profit efficiency as a performance indicator can provide RBV research with more empirical evidence than methods currently in use.

Production efficiency is a more commonly estimated metric in RBV research in comparison to profit efficiency. At the ideal point, a firm is supposed to be operating at the most efficient frontier (Llorca et al., 2017). This is the thesis of the frontier methodology as applied in strategic management and management sciences (Chen et al., 2015). In the estimation of the most efficient production frontier for firms within a sector, the Stochastic Frontier Approach is often used. The approach was introduced by Aigner et al (1977) as well as Meeusen and Van den Broeck (1977). Among the various frontier estimation techniques, the stochastic frontier approach is arguably better suited for use with profit efficiency estimation because the performance of each firm can be estimated relative to the most efficient frontier, which in itself adds an additional layer of rigour to the estimation of firms' resource use efficiency and profitability potential (Arbelo et al., 2020). Using a stochastic frontier model also means that it is possible to isolate a compound error term, which then is the sum of random errors and the firm's inefficiency (the difference between a firm's efficiency score and the most efficient frontier). This study utilizes data collected from farmers on farm plots in 15 cocoa growing communities in the Ashanti and Western regions of Ghana, to test the application of the Stochastic Frontier Method (SFM) to estimate profit efficicency of farm plots as business units in the cocoa sector, where the Resource Based View Theory of the Firm applies.

Research Questions

As has been discussed, the importance of cocoa to the Ghanaian economy cannot be over emphasized. Revenues from the sale of cocoa beans plays a key role in balance of payments, financing infrastructure and fiscal stability (Ghana Commercial Bank, 2022). Thus, it is important that the production of cocoa at the farmer level should be sustained and if possible increased. In applying the Theory of the Firm, there is likely to be more farmers (who are the firms in this industry) attracted to this sector if farm profitability is high. However, studies in the Ghanaian cocoa sector point to a high level of income diversification among cocoa farmers (Abdulai et al., 2018). This could be because of a number of reasons including the low profitability of cocoa farm plots. Therefore, the main question that arises is, 'What is the profitability of cocoa farm plots in the main cocoa producing areas of Ghana? Diversification into other income generating farm activities has become a common feature of the cocoa sector in Ghana (Abdulai et al., 2018). Given that undertaking this activity impacts resource availability and distribution between these diversification options and cocoa farm plots by farmers, the question of which is the most profit efficient diversification option for cocoa farmers also arises. Furthermore, what are the factors that affect profit efficiency of cocoa farm plots in Ghana?

Objectives of the Study

The main objective of the study is to analyze the efficiency of profit generation on cocoa farm plots as business units in the Ashanti and Western regions of Ghana.

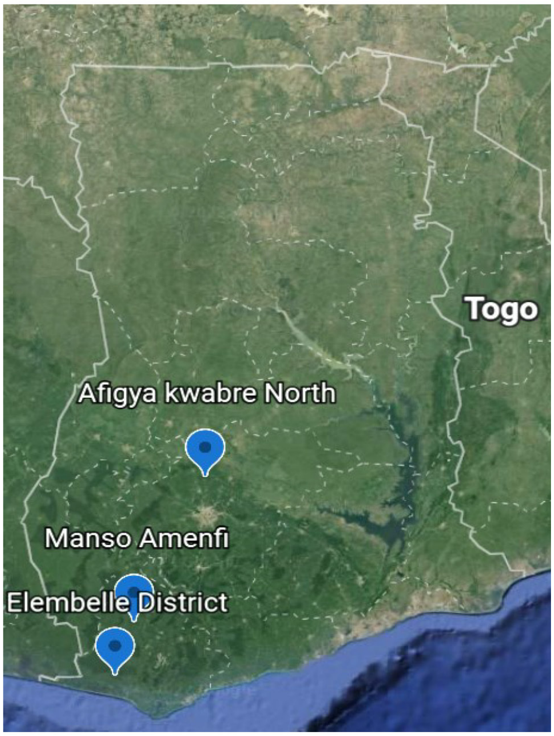
To achieve this objective, the specific objectives addressed are:

1. To estimate the aggregate cocoa farm plot profit efficiency in the Ashanti and Western regions of Ghana
2. To estimate the profit efficiency of cocoa farm plots for identified cocoa farmer diversification strategies in the Ashanti and Western regions of Ghana
3. To identify factors influencing the profit efficiency of cocoa farm plots in the Ashanti and Western regions of Ghana

Data

The data for this analysis was based on primary data collected from 15 communities in 3 districts in the Western and Ashanti regions of Ghana, as part of the Cocoa for Future project (C4F). The C4F project aims to use agroforestry to make cocoa farms in Ivory Coast and Ghana less vulnerable by identifying levers for agricultural and socioeconomic sustainability, while preserving the environment. The project is sponsored by the CIRAD (French Agricultural Research Centre for International Development). The Ashanti and Western regions account for over half of Ghana's cocoa production and by extension, 10 to 15% of global production. In total, 400 farmers were interviewed for the study. In the Ashanti region, the survey took place in 5 communities in the Afigya Kwabre North District. In the Western region, the survey was conducted in 5 communities each in the Elembelle and Manso Amenfi districts

Figure 1: Map of Ghana Showing Study Areas



A multi-stage, mixed sampling method was applied in selecting the sample of farmers interviewed. In the first stage, a purposive sampling approach was used to select districts and communities with high population of cocoa farmers for which it was possible to get farmer lists. Based on this, 15 communities in 3 districts were selected. Subsequently, a total of 150 farmers for each district were selected randomly from the list, resulting in a total of 450 selected farmers. Due to attrition, and budgetary and time constraints, 400 farmers were eventually interviewed. From this sample, information on 552 farm plots was obtained.

Theoretical Framework

The theory underpinning this study at a broad level is the Theory of the Firm. Historically the relative applicability of this theory to farm management has been keenly explored, with the acknowledgement that farm management decision making is driven to a significant extent by potential profit (Schultz, 1939). In more contemporary times, this theory has been built upon to develop new theories which are perhaps more closely linked to the nature of niche industries.

The Resource Based View of the Firm as explained by Peteraf and Barney is "an efficiency-based explanation of performance differences, rather than one relying purely on market power, collusion, or strategic behaviors" (Peteraf & Barney, 2003). To encourage food production and production of agricultural products that serve as raw material to many industries, the analysis of farm enterprises or of smallholder farmers, needs to consider both market forces as external variables and internal management performance of farmers (Richard et al., 2009). In analyzing these dimensions, traditional accounting measures of profit fall short. Profit efficiency is an innovative approach to analyzing the interaction of external factors as captured by the Theory of the Firm, as well as the managerial capacity of actors in generating profit. Here, the ability of a company to manage its resources and produce products with higher economic value is referred to as profit efficiency (Pilar et al., 2018). This concept encompasses errors on the input side as well as on the output side. From an analytical standpoint, the RBV bases its emphasis on the most effective use of these to generate competitive advantage, on the premise that a firm's competitive position depends on how specialized its assets and abilities are. For this, the RBV is founded on two key hypotheses (Barney, 1991):

1) the firms in an industry are heterogeneous with respect to the resources they possess and
2) These resources are not perfectly mobile and, therefore, heterogeneity will persist over time.

Model Specification

For this study the Stochastic Frontier Model (SFM) with random coefficients is used. The SFM uses econometric methods to estimate efficiency. Hence it is a better fit this study as compared to alternatives such as Data Envelopment Techniques (DEA) and Ordinary Least Square Regression (Nguyen & Pham, 2020; Strange et al., 2021). The DEA for example would be inappropriate because it relies on linear programming and is a nonparametric method. Thus, it is limited to the estimation of technical efficiency without considering price and hence total revenue (Powar et al., 2020; Salahi et al., 2021). Also, the DEA is unable to decompose the error term, thus implying that the difference between the measured efficiency and the maximum efficiency frontier is inefficiency. However, the error term consists of both the firm's efficiency and a random error term. According to the SFM, a company is deemed to be inefficient in profit if its profit is lower than the profit that would be obtained using best practices after removing random error term. Thus, an estimated SFM model is able to estimate a compound error term, consisting of firm's inefficiencies, which is the difference between the firm's estimated efficiency and the most efficient frontier, as well as a random error term (Spiegelhalter et al., 2002). However, a deviation from traditional assumptions of the SFM that this study adopts is the model proposed by Battese and Coeli that suggests that the determinants the determinants of inefficiency can be expressed as a linear function of a set of explanatory variables that reflect the inherent characteristics of a firm (Battese & Coelli, 1995). This study estimates the alternative profit frontier function and the inefficiency impacts function using the Battese and Coelli model from 1995. Here, the alternative profit model can be specified as:

$$\pi_i = \alpha + \beta_i X_i + v_i - u_i \qquad (1)$$

Where i = 1. . . N firms, where π_i is the profit of firm i, α is an intercept, X_i is the vector of the explanatory variables, β_i is the vector of the parameters to be estimated, u_i represents inefficiencies found that reduce profit, and v_i represents random error. In this study, the explanatory variables used are as shown in Table 4. In this study, profit is expressed as a function of Earnings Before Interest, Tax, Depreciation and Amortization (EBITDA). The log linear model used expresses the percentage change in efficiency given a unit change in an explanatory variable. Thus, in the functional model, log of EBITDA replaces profitability and all other parameters remain the same as found in equation (1):

$$lnEBITDA = \alpha + \beta_i X_i + v - u \qquad (2)$$

Applying the RBV Theory of the Firm to this estimation, the following key assumptions apply which again may be considered a deviation from the traditional SFM. Firstly, the RBV assumes heterogeneity of resources between firms (Peteraf & Barney, 2003; Tsionas, 2002). This is especially true in this study, as cocoa farmers have different levels of quality, types and access to input, land characteristics, and other demographic factors that affect managerial decision making. Thus, the possibility of firms operating on different profit efficiency frontiers is a more realistic assumption. The premise that all firms face the same efficiency frontier would have been erroneous if the traditional SFM assumption of homogeneity of resources were to be applied.

Based on literature reviewed for this study, the functional form that best fits this study is the translog (Spiegelhalter et al., 2002). Bayesian techniques which incorporate the translog functional form used in the SFM are considered to follow a multivariate normal distribution, such that, the parameter estimates are a function of parameter means and their positive definite covariance matrix.

The profit function based on which the profit efficiency frontier estimations will be made has the log mean of EBITDA as the output variable and the positive definite covariate matrix of the log means of revenue (lnmtotrev, X_1), expenditure on fertilizer (lnmfert, X_2), pesticides (lnmpest, X_3), fungicides (lnmfung, X_4), herbicides (lnmherb, X_5), labour (lnmlab, X_6) and overheads (lnmovhd, X_7) as input variables. The model is hence specifed as:

$$
\begin{gathered}
\ln(EBITDA) = \alpha + \beta_1 lnmX_{1i} + \beta_2 lnmX_{2i} + \beta_3 lnmX_{3i} + \beta_4 lnmX_{4i} + \beta_4 lnmX_{4i} + \\
\beta_5 lnmX_{5i} + \beta_6 lnmX_{6i} + \beta_7 lnmX_{7i} + \beta_8 (lnmX_{1i})^2 + \beta_9 (lnmX_{2i})^2 + \beta_{10} (lnmX_{3i})^2 + \\
\beta_{11} (lnmX_{4i})^2 + \beta_{12} (lnmX_{5i})^2 + \beta_{13} (lnmX_{6i})^2 + \beta_{14} (lnmX_{7i})^2 + \beta_{15} (lnmX_{1i}.lnmX_{2i}) + \\
\beta_{16} (lnmX_{1i}.lnmX_{3i}) + \beta_{17} (lnmX_{1i}.lnmX_{3i}) + \beta_{18} (lnmX_{1i}.lnmX_{3i}) + \\
\beta_{19} (lnmX_{1i}.lnmX_{4i}) + \beta_{20} (lnmX_{1i}.lnmX_{5i}) + \beta_{21} (lnmX_{1i}.lnmX_{6i}) + \\
\beta_{22} (lnmX_{1i}.lnmX_{7i}) + \beta_{23} (lnmX_{2i}.lnmX_{3i}) + \beta_{24} (lnmX_{2i}.lnmX_{4i}) + \\
\beta_{25} (lnmX_{2i}.lnmX_{5i}) + \beta_{26} (lnmX_{2i}.lnmX_{6i}) + \beta_{27} (lnmX_{2i}.lnmX_{7i}) + \\
\beta_{28} (lnmX_{3i}.lnmX_{4i}) + \beta_{29} (lnmX_{3i}.lnmX_{5i}) + \beta_{30} (lnmX_{3i}.lnmX_{6i}) + \\
\beta_{31} (lnmX_{3i}.lnmX_{7i}) + \beta_{32} (lnmX_{4i}.lnmX_{5i}) + \beta_{33} (lnmX_{4i}.lnmX_{6i}) + \\
\beta_{34} (lnmX_{4i}.lnmX_{7i}) + \beta_{35} (lnmX_{5i}.lnmX_{6i}) + \beta_{36} (lnmX_{5i}.lnmX_{7i}) + \\
\beta_{37} (lnmX_{6i}.lnmX_{7i}) + v_i - u_i \qquad (3)
\end{gathered}
$$

Results and Discussion

One of the most important contributions this study makes to literature is the use of profit efficiency estimation using a stochastic frontier estimation as a means of comparing the profitability of cocoa farm plots. This provides empirical evidence to support previous studies that propose the use of profit efficiency as an alternative to financial measures such as Net Profit, ROE and ROA, especially for firms operating in resource-based industries (Barney et al., 2001; Pilar et al., 2018; Wernerfelt, 1984).

A total of 400 farmers with 552 farm plots from 15 communities and 3 districts in the Ashanti and Western Regions of Ghana were surveyed for this study. The average age and experience for the sample was 49 and 18 years respectively. Also, the average land size of farmers surveyed was 5.343 acres (2.163 hectares), with a standard deviation of 5.395 acres (2.183 hectares). This indicates that majority of farmers are small holder, with land sizes of between 2 and 5 hectares, which is consistent with available literature (Attipoe et al., 2020; Ghana Commercial Bank, 2022). Also, the average yield of 2.512 bags per acre (393.523 kilograms per hectare) from the survey is consistent with studies done in the sector, which indicates yields far below the achievable levels as outlined by the Ghana Cocoa Board (COCOBOD) (Asante et al., 2022; Wainaina et al., 2021). A noteworthy factor in the cocoa production sector of Ghana is the pricing regime. The cocoa sector of Ghana is a monopsony, where the government, through the Ghana COCOCBOD is the sole buyer and sets the price of the output. Prices of cocoa at the time of the study were set at GHS660 per 64kg bag of cocoa or GHS 10,560 per ton ($1,320 per ton given an exchange rate of GHS8 per dollar as at July 2022). Hence, in the profitability model of farmers, cost minimization and quantity of output maximization become the key sources of variation in profit efficiency of farm plots. Another key descriptive statistic is the distance to farm. Most of the farmers interviewed live within proximity of their farm plots (average 1.964 miles). A good number live in farmsteads within or very close to their farm plots. This is especially true for farmers who have migrated from other communities to settle in the communities visited for economic reasons. These variables are important determinants of farm plot profit efficiency and have been interacted with the profit efficiency estimates calculated from the stochastic frontier model.

Table 1: Summary Statistics of Key Variables

Variable	Measurement	Mean (n=552)	Std.dev	Min	Max
Age	Years	49.152	14.483	17	93
Experience	Years	18.545	11.715	1	66
Education	Levels of education	3.71558	2.094997	0	9
FBO	1 = Yes; 0 = Otherwise	0.7481884	0.434447	0	1
Credit	1 = Yes; 0 = Otherwise	0.4021739	0.490781	0	1
farm_dist	Miles	1.964	2.427	0	36
farm_area	Acres	5.343	5.395	0	50
diverse_all	1 = Yes; 0 = Otherwise	0.6702899	0.470534	0	1
diverse_food	1 = Yes; 0 = Otherwise	0.2880435	0.453262	0	1
diverse_tree	1 = Yes; 0 = Otherwise	0.0416667	0.200008	0	1
diverse_live	1 = Yes; 0 = Otherwise	0.0597826	0.237299	0	1
Tot_Prod	Bags (64kg)	12.597	16.357	0	180
Yield	Bags/acre	2.512	2.012	0	10
EBITDA	GHS	5138.392	8773.805	-28050	8112
Tot_Rev (X1)	GHS	7809.841	10141.220	0	1116
Cost_Fert (X2)	GHS	448.704	1897.63	0	3200
Cost_Pest (X3)	GHS	449.7192	1093.762	0	1200
Cost_Fung (X4)	GHS	185.0815	561.7347	0	864
Cost_Herb (X5)	GHS	255.8759	1146.039	0	2400
Cost_Lab (X6)	GHS	664.4453	1699.36	0	2290
Cost_Ovr (X7)	GHS	667.6232	1320.741	0	1800

The stochastic frontier model with random coefficients was estimated using the STATA® application *sfcros*. The application goes through multiple iterations to arrive at a solution that guarantees convergence. The overall model is significant at 1% with a Wald chi-square estimate of 2762.767. As discussed earlier, the model is able to provide two error terms, Sigma U, with a estimated at 0.128 and Sigma V, with a value of 1.136. Sigma U represents the inefficiencies found that reduce profit, whilst Sigma V represents the random error term.

Table 2: Parameter Estimates of Stochastic Profit Frontier Model

Parametre	Co-efficient	Robust Standard Error
Frontier		
lnmtotrev	7.085***	-0.488
lnmfert	-0.466**	-0.205
lnmpest	-1.272***	-0.185
lnmfung	-0.474**	-0.208
lnmherb	-0.468**	-0.232
lnmlab	-1.348***	-0.16
lnmovhd	-1.492***	-0.175
lnmtotrevsq	-4.494***	-0.442
lnmfertsq	-0.026	-0.082
lnmpestsq	0.022	-0.042
lnmfungsq	0.01	-0.03
lnmherbsq	0.199**	-0.093
lnmlabsq	-0.022	-0.043
lnmovhdsq	-0.049	-0.045
lntotrev_fert	0.407***	-0.127
lntotrev_pest	0.767***	-0.126
lntotrev_fung	0.306**	-0.141
lntotrev_herb	0.255*	-0.155
lntotrev_lab	0.647***	-0.104
lntotrev_ovhd	0.844***	-0.111
lnfert_pest	0.041	-0.034
lnfert_fung	-0.036	-0.029
lnfert_herb	0.011	-0.025
lnfert_lab	-0.01	-0.033
lnfert_ovhd	-0.059	-0.047
lnpest_fung	-0.042*	-0.024
lnpest_herb	-0.053**	-0.024
lnpest_lab	-0.106***	-0.022
lnpest_ovhd	-0.201***	-0.035
lnfung_herb	-0.043**	-0.017
lnfung_lab	-0.040**	-0.019
lnfung_ovhd	-0.046	-0.032
lnherb_lab	-0.040*	-0.022
lnherb_ovhd	-0.090**	-0.036
lnlab_ovhd	-0.194***	-0.026
Constant	1.720***	-0.242
Observations	552	
Wald chi-square	2762.767	
p-value	0.0000	
Log likelihood	-857.526	

Sigma U	0.128
Sigma V	1.136
Lambda	0.113

*Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01*
Source: Produced by the author using Primary Data 2022

The difference in the parameter estimates confirms the heterogeneity of the resources available to the firm, which is a prerequisite for the RBV Theory of the Firm. A greater number of the posterior estimates are also significant, further providing credence to the strength of the model in estimating the profit efficiency estimate generated. The random effects model is preferred over a fixed effects model because due to the fixed coefficient frontier model's failure to account for heterogeneity, making its efficiency estimations inaccurate, and its inefficiency estimates too high. In other words, the fixed coefficient model considers firm homogeneity when estimating a common efficient frontier for the entire sample and calculates each firm's (or in this case each plot's) efficiency as a function of its distance from this common frontier. The random coefficient model, on the other hand, assumes that firms (plots) have a variety of resources, therefore each firm (or plot) will have its own efficient frontier. Efficiency in this situation is determined by how far away each firm is from its efficient frontier.

The estimated mean, minimum and maximum profit efficiency frontiers are retrieved from the results of the model as presented in Table 3. The mean profit efficiency level for the sample is 55.24%. This indicates that 44.86% of potential profit efficiency of the farm plots studied is lost and hence there exists a significant margin available to increase profits. This is consistent with the average yields calculated for the sample, which falls significantly short of achievable yield levels for cocoa in Ghana, according to the Ghana COCOCBOD. As explained earlier, given that the price of cocoa in Ghana is fixed, quantity and therefore yield, becomes an important variable in increasing profitability. The maximum profit efficiency possible is also estimated at 99.66%. Comparing this level of efficiency to the mean level, it means that on average, farmers have significant room to improve. In terms of diversification of type, Farmers who are diversified into a combination of all 3 identified farm-based income diversification options, tree crops, food crops and livestock, have the highest mean profit efficiency. This is likely because full diversification provides a more even flow of earnings across the year, part of which can then be reinvested into inputs for the cocoa farm plot. Given the seasonality of cocoa revenues and inadequacy of credit to farmers, this potential year-round access to earnings is instrumental in ensuring that farmers can afford inputs in the essential months of the year where pest and disease control as well as labour for weed control is needed. On the other hand, plots whose owners diversified into food crops alone have the lowest mean profit efficiency. From field observation, a significant number of farmers who diversify into food crops expend labour and other resources into food crop production but do not make significant earnings from the production of food crops. Furthermore, a good portion of food crops produced are not marketed but kept for subsistence.

Also, from Table 3, farm plots in the Ashanti region have a significantly higher mean average profit efficiency than in the Western region. Here a difference in management ability of farmers in the Ashanti region districts surveyed based on their higher experience levels and broader diversification may be responsible for this difference. The results show a 17% difference between mean profit efficiency of farm plots in Ashanti region and farm plots in Western region.

Table 3: Profit Efficiency Estimations

Variable	Mean	Std. Dev	Min	M
efficiency	0.5524168	0.2308764	0.1109304	0.99(

sification type	Mean (profit efficiency)
	0.5587773
rop	0.6262241
;rop	0.4588878
rop+foodcrop	0.6429116
:ock	0.6344239
rop+livestock	0.6321887
;rop+livestock	0.5930178
rop+Foodcrop+Livestock	0.6532323

n code	Region	Mean (profit efficiency)
	Ashanti	0.6514781
	Western	0.4887346

ct code	District	Mean (profit efficiency)
	Wassa Amenfi Central	0.4944997
	Ellembelle	0.4806635
	Afigya Kwabre North	0.6514781

The stochastic frontier model estimation was also used to investigate factors that account for the variation observed in levels of profit inefficiency of farm plots. This used a translog linear regression model with log of profit, expressed here as Earnings Before Interest, Tax, Depreciation and Amortization (EBITDA) as the dependent variable. From the results obtained, 5 variables were significant in determining profit inefficiency of farm plots. These were level of education, farm distance from household, farm plot size, diversifying into food crops and region where farm plot is located. Level of education was significant at the 5% margin of error and had a positive coefficient of 0.068. This implies that an additional level of education yields an additional 6.85% increase in profit inefficiency. This contrasts with apriori expectations as education was expected to have a positive relationship with profit efficiency. Distance from the farm was significant at 5% and had a coefficient of 0.038, indicating that an additional mile from the household was likely to result in a 3.8% increase in profit inefficiency. As the distance from the household to the far increases it becomes less convenient to visit and thus visits become infrequent. Also, the cost involved in transport inputs and produce between the home and market centres increases, increasing profit inefficiency. The farm plot size was also found to have a significant effect on profit inefficiency at 1% margin of error. From the results an additional acre of farm plot size reduces profit inefficiency by 12%. This implies that larger farm plot sizes are better managed or are more profit efficient. Thus, the widely theorized notion of poor farm management of smallholder farmers in general, may be true as well in the cocoa sector. Diversifying into food crops was also found to be significant at 5% margin of error. Per the results, farm plots where farmers have diversified into food crops are likely to be 39.7% more inefficient than those who do not diversify at all, which is quite a significant statistic. This is consistent with the mean profit inefficiency computer, which also shows that farm plots where farmers have diversified into food crops have the least mean profit efficiency. Again, the region where farm plot is located in also significant in determining proficient inefficiency at the 5% margin of error. Farm plots located in the Western region are 58.2% more likely to be profit inefficient compared to plots located in the Ashanti region. The model has 2 error terms; Vsigma, which represents factors accounting for profit inefficiency, which was statistically significant at 10% and the general error term, Usigma which was significant at 5% margin of error.

Table 4: Factors Affecting Profit Inefficiency of Cocoa Farm Plots

	Co-efficient	**Robust Standard Error**
Mu		
Age	0.005	-0.005
Experience	-0.009	-0.007
Education	0.068**	-0.031
FBO	0.185	-0.134
Credit	0.086	-0.106
farm_dist	0.038**	-0.016
farm_area	-0.120***	-0.021
diverse_all	-0.16	-0.161
diverse_food	0.387**	-0.164
diverse_tree	-0.036	-0.353
diverse_live	0.078	-0.279
region	0.582**	-0.234
district	0.079	-0.116
Constant	0.256	-0.517
Usigma	-4.111***	
Constant	-1.188	
Vsigma	0.255*	
Constant	-0.143	
Observations	552	
Wald chi-square	2762.767	
p-value	0.0000	
Log likelihood	-857.526	

*Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01*
Source: Produced by the author using Primary Data 2022

Conclusions and Recommendations

Conclusions

This work further lends credence to the use of the stochastic frontier model with random coefficients to estimate profit efficiency as an informative approach to analyzing the efficiency with which firms in a resource-based industry generate profits. This study also provides further empirical evidence to support the Resource Based View Theory of the Firm, in this instance applying it to agriculture. A significant innovation that paper adopts, away from existing literature is analyzing profit efficiency at the plot level in the cocoa sector of Ghana, and not at the farmer or household level. By adopting this view, this paper is able to provide insight into current mean profit efficiency, minimum profit efficiency and the maximum frontier of profit efficiency for famers in the Western and Ashanti regions of Ghana.

In terms of the results of the study itself, the study establishes that cocoa farmers in the regions under study are operating at woefully profit inefficient frontiers and are losing a lot of profit in comparison to what is attainable. However, cocoa farm plots in the Western region are significantly less profit efficient than cocoa farm plots in the Ashanti region.

Also, the study by comparing the livelihood diversification strategies of the managers of the plots to the mean profit efficiency generated under each diversification strategy, can conclude that diversifying with food crops alone results in the least profit efficiency frontier. On the other hand, plots where farmers are diversified into all three options, that is, food crops, livestock and tree crops, have the highest mean profit efficiency. Generally, farmers whose diversification strategies include tree crops have a higher mean profit efficiency, and where diversification options of farmers include food crops, mean profit efficiency is lower.

From the log linear regression with log of EBITDA at the dependent variable, it can be concluded that distance from household to the farm, diversifying into food crops and into location of farm plot being in the Western region have a significant and positive relationship with profit inefficiency. Farm plot size was also found to have a significant and negative relationship with profit inefficiency.

Recommendations

Based on the results and the conclusions inferred, the following recommendations can be made:

- Studies which seek to provide learnings for project/program design and policy intervention in the agricultural sector should adopt the use of profit efficiency.
- Whilst farmers grow food crops for subsistence, farmers should be encouraged to diversify into other alternatives as well, including livestock and non-farm alternatives
- Further studies need to be done to investigate the nature of farm operations of cocoa farmers, especially in the Western region, to identify and correct farm management inefficiencies and address other production related shortcomings such as incidence of disease and pests.
- Considering that yield levels among farmers are far below attainable levels as per the Ghana COCOBOD's studies, practices that boost yield, such as pollination and fertilizer use should be encouraged.

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