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ANALYSIS OF PROFIT EFFICIENCY OF SMALLHOLDER COMMON BEAN FARMERS IN MALAWI

Lawrence Mapemba*, Wisdom Richard Mgomezulu & Gracious Kalua
[1] Department of Agricultural and Applied Economics, Lilongwe University of Agriculture and Natural Resources, Bunda Campus, Malawi

Lawrence Mapemba*, Department of Agricultural and Applied Economics, Lilongwe University of Agriculture and Natural Resources, Bunda Campus, Malawi. Tel: 265-9-9980-3700. E-mail: lmapemba@gmail.com

Wisdom Richard Mgomezulu, Department of Agricultural and Applied Economics, Lilongwe University of Agriculture and Natural Resources, Bunda Campus, Malawi. Tel: 265-8-8452-8590. E-mail: mgomezuluwisdom@yahoo.com

Gracious Kalua, Department of Agricultural and Applied Economics, Lilongwe University of Agriculture and Natural Resources, Bunda Campus, Malawi. Tel: 265-8-8173-3480. E-mail: graciouskalua93@gmail.com

Abstract
Common bean is regarded as one of the most valuable leguminous crops in Malawi because of its nutritional value, ability to improve soil fertility and low production cost. Despite this, the crop is produced in less quantity than what is required due to small profits that farmers obtain from the enterprise. The study analyzed profit efficiency and its determinants for Common Bean smallholder farmers in Malawi by employing Cobb Douglas stochastic frontier model. A Sample of 1,969 common bean farmers was used in the study which was collected across Malawi by the National Statistical Office (NSO) in the year 2016/2017 (IHS4 data). The study found out that there exist profit in-efficiency in Common Bean production with a gamma value of 66 percent. The profit efficiency among Common Bean farmers ranged from 17 to 98 percent with an average of 44 percent indicating that there is still a potential to increase profit efficiency by 56%. Among the factors hypothesized to affect profit efficiency, age of a farmer, marital status, off-farm income, use of extension advice, adoption of agroforestry practices, access to credit, subsidy coupons and use of terraces to control soil erosion were to found significantly improve profit efficiency. The study further looked at regional profit efficiency differences and found out that farmers from Central region of Malawi had the lowest average profit efficiency while those from the southern region had more profit efficiency. The study recommends increasing input use and also improving on the factors that increased profit efficiency in order to improve profit efficiency.
Keywords: Common Bean, Profit efficiency, IHS 4, Malawi

1 Introduction

Common bean is a very important part of Malawi's food security and poverty reduction. It has multiple uses such as enriching soil nutrients, improving health status and being a source of income to smallholder farmers. Given the local and international demand, Common Bean sales have been a major source of income for most smallholder farmers. These smallholder farmers have limited scope to generate cash hence their venture in legume production particularly common bean production offer a valuable source of income (ICRISAT, 2013). This implies that the crop can greatly help in reducing poverty and improving nutritional status in Malawi. Despite being considered as a low status food compared to meaty products, Common Bean provides a rich combination of carbohydrates (60-65%), proteins (21-25%), fats (less than 2%), vitamins and mineral (US dry bean council, 2011). Furthermore, with the increasing health concerns, most urban population are reducing consumption of animal proteins, and are turning to pulses such as dry beans due to their low fat content. In addition, common bean help to fix nitrogen in the soil, which enhances soil fertility. This improves crop yield, while reducing the need for chemical fertilizers and their associated water and soil pollution effects (Zulu, 2011).

Profit efficiency is one of the important factors that help in firm survival and growth of the sector (Vitale *et al*, 2018). Thus, factors deriving the differences in profit efficiency and changes in efficiency between farmers are of major interest to farmers, government, and other stakeholders. Therefore, attaining high profit efficiency is a means to improve incomes and the chances of farmers' continuity to increase production. Profit efficiency at a farm level can be described as how effectively the farmers uses available resources for the purpose of maximizing profits. The potential for Common Bean to create more employment opportunities, improve the livelihoods of smallholder farmers as well as to create wealth in Malawi is enormous. Despite agricultural researchers promoting the crop through release of bean varieties and discovery of markets, its production is fluctuating overtime due to dismal profits (Mtumbuka *et al*, 2014). Hence understanding the profit efficiency of smallholder Common Bean farmers to establish the reasons for the dismal profits is imperative.

Malawi, like most developing countries depend on agriculture for its national economic growth. Over the past decade, the country has been relying on Tobacco as the main cash crop. However, due to world-wide anti-smoking campaigns, the focus has been turned to leguminous crops. Common Bean is among the leguminous crops that are of high importance. The effort to increase Common Bean production needs first to motivate farmers to expand production, of which increasing profit levels in Common Bean production is deemed one of the motivating factors to farmers.

High production of Common Beans entails high income to farmers and also promising immediate outcome of economic growth through exports. Therefore, there is need to assess the profit efficiency of common bean farmers and factors that drive the profit efficiency of smallholder farmers. The study thus answered the underlying questions as to whether common bean farmers in Malawi are profit efficient; and which socioeconomic and institutional factors affect the profit efficiency of common bean farmers in the country.

2 Methodology

2.1 Empirical Framework

This section presents the theoretical and analytical technique used by the study to meet its objectives. It should be noted that the goal of every rational producer is to maximize profit. Profits are vital to agriculture because they act as incentives to farmers to produce more. This imply that the greater the profit a farmer can make from selling the crop, the more the production in the next growing season. The subsections introduces and specifies the Cobb-Douglas stochastic frontier model to efficiency analysis and the sources of data used.

2.1.1 The Cobb Douglas Stochastic Frontier Model

According to Tijan *et al*. (2013), modelling profit efficiency emanates from the producer profit maximization theory and can best be explained by the Cobweb model. The model provides a theoretical explanation of the cyclic component of certain price-quantity paths through time. Prices and quantities are viewed as being linked in a causal chain. A higher price leads to higher profits which are incentives for large production. This can be presented as follows;

$$Q_t^s = f_1(P_{t-1}) + e_t \qquad t = 1,\dots, n \qquad (1)$$

Where Q_t^s is current production which is determined by previous season price function $f_1(P_{t-1})$, such that the higher the previous season price (which ensures higher profits), the more the current production. e_t is the stochastic error term. The frontier is based on the micro economic assumption that all rational firms are producing in an efficient manner and that variations from the frontier are random hence observations from the frontier are considered to be inefficient. This implies that from an estimated production frontier approach, it is possible to measure the relative efficiency of certain groups or a set of practices from the relationship between observed production and some ideal or potential production. The model can be presented as follows;

$$\Pi i = f(P_i Z_i \beta_i) E_i \qquad (2)$$

where π = normalized profit defined as gross revenue less variable cost divided by output price; P_i= normalized price of variable inputs by the farm divided by output price; Z_i= level of kth fixed factor on the farm; β_i= Vectors of parameters to be estimated; and E_i= stochastic disturbance term consisting of two independent elements v and μ.

$$E_i = v_i + \mu_i \qquad (3)$$

v_i is assumed to be independent and identically distributed random errors having normal $N\ (0,\ \sigma^2)$ distribution independent of the u_i while the u_i is the one-sided disturbance form used to represent profit inefficiency and is assumed to be non-negative truncation of the half normal distribution N $(u,\ \sigma^2 u)$.

This follows that the profit efficiency of an individual farmer is defined as the ratio of predicted actual profit to the predicted maximum profit for the best practical Common Bean farmer and this is represented as follows;

$$E\Pi = \frac{\Pi}{\Pi^{\max}} = \frac{\exp[\Pi(p,z)\exp(\ln \nu)\exp(\ln \mu)\theta]}{\exp[\Pi(p,z)\exp(\ln \nu)\theta]} \qquad (4)$$

Where π= predicted actual profit while π^{max} = predicted maximum profit. The profit function can be estimated by the maximum likelihood technique given the density function of u_i and v_i. The profit efficiency $E(\pi)$ takes the value between 0 and 1. Therefore if u_i=0 that is lying on the frontier, the farmer has potential maximum profit given the price he/she faces and the level of fixed factors of production, while if u_i>0, the farmer is inefficient and operates on lower profit as a result of inefficiency. Following Nmadu and Garba (2013) and Coelli et al. (2009), the stochastic frontier function with behavioral inefficiency components will be used to estimate all parameters together in one step maximum likelihood estimation procedure.

2.1.2 The Stochastic Profit Efficiency Model

This paper adopts a two-stage approach, in which the first stage involves the specification and estimation of the stochastic frontier production function and the prediction of profit efficiency effects, under the assumption that the inefficiency effects are identically distributed. The second stage involves the specification of a regression model for the predicted profit efficiency effects. The farm specific profit efficiencies of Common Bean producers will be derived from the stochastic frontier production model of the Cobb-Douglas function form. Profit efficiency and its determinants were analyzed simultaneously using stochastic frontier analysis (SFA) method. The stochastic profit efficiency model used can be presented as follows:

$$ln\Pi_i = \beta_0 + \beta_1 lnFsize + \beta_2 lnLab + \beta_3 \ln Seed + \beta_4 Fert + \beta_5 Herb + \beta_6 Pest + (v - \mu) \quad (5)$$

where *ln Π* is restricted normalized profit which is defined as gross revenue less variable costs divided by farm specific common bean output price (MK per ha); $F_{\_size}$ is Farm size (ha); *Lab* is Costs of labour normalized by price of beans (MK per man day of labour); *Seed* is costs of seed normalized by price of beans (MK per kg of seed), *Fert* is Costs of fertilizer normalized by price of beans (MK per kg of fertilizer); *Herb* is cost of herbicides normalized by price of beans (MK per litre of herbicide-chemical); *Pest* is cost of pesticides normalized by price of beans (MK per litre of pesticide); β_0 is constant parameter to be estimated; β_1 to β_6 are scalar parameters to be estimated; v is the symmetric component of the error term capturing factors outside the control of the farmer; and μ is the non-negative random variable under the control of the farmers.

The next step was to analyze the factors that influence profit efficiency in common bean farmers. This can be presented as follows;

$$U_i = \beta_0 + \beta_i X_i + e_i \quad (6)$$

Where β_0 is the constant parameter, β_i are the slope parameters to be estimated, X_i is the vector of socioeconomic and institutional factors assumed to affect profit efficiency. U_i is profit efficiency and e_i is the stochastic error term.

2.2 Sources of Data

The study used the Fourth Integrated Household Survey (IHS4) data. The IHS 4 is a nationally representative survey administered to 12,447 randomly selected households from 26 districts from Southern, Central and Northern regions in Malawi. The data was collected by the National Statistical Office (NSO) in the period between 2016 and 2017. Although the IHS data are primarily collected to provide benchmark poverty and vulnerability indicators for Malawi through its household and community questionnaires, they also include data from separately administered agriculture questionnaires which, among other things, capture detailed information on crop land allocation, crop production, crop selling prices, inputs access and the socio-economic and institutional factors. The study used a sample size of 1,969, which represented number of common bean growers captured in Malawi.

3 Results and Discussion

3.1 Descriptive Statistics

Table 1 shows the descriptive statistics of the variables used in the study. Land size was a continuous variable which measured size of the farm in acres. Since most of the farmers were smallholder farmers, the average land size was 1.42 acres. With regards to the variable costs considered in the study; labour, seed, fertilizer, transportation, pesticides and herbicides costs were among the costs considered to affect profit efficiency. The costs were measured in Malawi Kwacha (MWK) were US$1 is equivalent to MWK 740. Labour costs averaged MWK 27952; seed cost averaged MWK1409; fertilizer costs averaged MWK 56773; transportation cost averaged MWK579; pesticides costs averaged MWK114; and herbicides costs averaged MWK61. Age of the farming household head was another continuous variable measured in number of completed years. The average age of the household head was 44 years. Off-farm income measured income (money) earned through sources that were not farm based. The average off-farm income was MWK 400. Household size recorded the number of people living under the same roof and was used as proxy for family labour. The average household size was thus 5 people in the same house. With regards to binary variables; gender, marital status, extension access, credit access, membership of farmer organization, land access and access to Farm Input Subsidy (FISP) Coupons were among the binary variables used in the study taking a value of 1 and 0. 76.95 percent of the common beans farmers were male; 79.64 percent were married; 41.81 percent had access to extension; 82.06 percent used the extension advice they received; 19.7 percent had access to credit; 97.8 percent were members of farmer organizations; 36.19 percent had access to FISP coupons; and 57.06 percent practiced agroforestry in their farms. In addition, another variable to carter for the regions in Malawi was included to assess the variations of profit efficiency across regions. Of the sampled Common Bean farmers, 46 percent were from the central region, 30 percent from the northern region and 23 percent were from the southern region. Lastly, farmers practiced a number of erosion control measures despite that a majority 54.47 percent did not practice any soil erosion control measures.

Table 1. Socioeconomic and Institutional Characteristics of Respondents

Variable	Mean/Percent	Std. Dev
Continuous		
Land size (acres)	1.42	1.88
Labour cost (MWK)	27952.95	24978.9
Seed cost (MWK)	1409.78	4175.71
Fertilizer cost (MWK)	56773.99	54525.4
Transport cost (MWK)	579.59	5827.91
Pesticides cost (MWK)	114.69	1489.5
Herbicides cost (MWK)	61.02	711.27
Age of Household head (years)	44.17	15.28
Off-farm income per month (MWK)	400	8.8
Household size	4.6	1.95
Binary		

Gender (male=1)	0.7695	0.42
Marital status (married=1)	0.7964	0.41
Extension access (yes=1)	0.4181	0.49
Credit access (yes=1)	0.1966	0.39
Membership of farmer organization (yes=1)	0.9778	0.15
Use of extension advice (yes=1)	0.8206	0.38
FISP coupon access (yes=1)	0.3619	0.48
Agroforestry practice (yes=1)	0.5706	0.49
Categorical		
Erosion control measures		
No erosion control	0.5447	
Terraces	0.348	
Erosion control bunds	0.2449	
Gabions / Sandbags	0.128	
Vetiver grass	0.0716	
Tree belts	0.0079	
Water harvest bunds	0.0272	
Drainage ditches	0.056	
Common beans farmers by region		
North	30.46	.
Central	46.06	.
South	23.48	.

Source: Author's computation

3.2 *Results of the Econometric Model*

Table 2 shows the results of Cobb-Douglas stochastic estimation model. The diagnostic analysis showed Variance Inflation Factor (VIF) of 1.12 which revealed that there was no problem of multicollinearity. The statistical significance ($p<0.01$) of sigma squared indicated a good fit and the correctness of the specified distributional assumptions of the composite error term. The gamma value of 0.6693 was significant at 1 percent implying that about 66.93% of the variation in common bean profit efficiency is attributed to variations in economic efficiencies of common bean producers, with one sided error and that only 33.07% variations were due to stochastic disturbances with the composite error term. This result is consistent with Chikobola (2016) who reported the gamma value of 0.6445 among groundnuts producers in Eastern province of Zambia.

Out of the variables hypothesized to affect profit in the stochastic profit frontier function, the coefficients of normalized price of labour, fertilizer and seed were negative and significant. On the other hand, normalized price of transport and pesticides were negative and insignificant. Only the coefficient for land size was positive and significant. The elasticity of seed cost was 0.099 implying that a 1% increase in cost of seeds is associated with 0.099% decrease in profit. This result is consistent with the findings of Simtowe and Bocher (2016) who reported that an increase in seed cost reduces profit of groundnuts (a legume) farmers in Malawi. In addition, elasticity of labour cost was 0.114 implying that a 1% increase in cost of labour is associated with a 0.114% decrease in profit of Common bean farmers. Furthermore, elasticity of fertilizer cost was 0.118, so a 1% increase in cost of fertilizer is associated with 0.118% decrease in profit of Common bean farmers. This is again consistent with the findings of Simtowe and Bocher (2016) who found out that fertilizer cost has negative effect on profits of groundnuts producers in Malawi. Finally, a positive relationship between land size and profit imply that one 1% increase in land size increases profit by 0.13% holding other factors constant. The result is consistent with Nmadu and Garba (2013) who did a study on profit efficiency of spinach producers in Niger state and reported that increase in land size increases the profit of spinach producers.

Table 2. Estimates of the profit function model for common bean producers in Malawi

Variable in profit function	Coefficient	Stand. Error
Constant	2.640***	0.111
Log of farm size (acres)	0.133***	0.038
Log Labour cost (Mk)	-0.114***	0.021
Log Fertilizer cost (Mk)	-0.118***	0.012
Log Seed Cost (Mk)	-0.099***	0.0153
Log Transport cost (Mk)	-0.002	0.021
Log Herbicide cost (Mk)	0.067	0.065
Log Pesticides cost (Mk)	-0.157	0.076
Model diagnostics		
Sigma squared ($\sigma^2 = \sigma_u^2 + \sigma_v^2$	8.53***	0.064
Gamma ($\gamma = \sigma_u^2/\sigma_u^2 + \sigma_v^2$)	0.6693***	0.006
Lambda	1.42***	0.007
Wald chi2 (10)	229.52	
Log likelihood value	-4914.86	
Mean VIF	1.12	

*** Significant at 1 percent, ** significant at 5 percent
Source: Author's computation

3.2.1 Determinants of Profit Efficiency

The results in table 3 represent the sources of variation in profit efficiency estimates of common bean farmers. The variables used in the profit inefficiency model are the determinants of profit inefficiency. This means that a negatively signed variable increases profit efficiency level whilst a positively signed variable decreases profit efficiency level of common bean farmers. Table 3 shows that age significantly ($p<0.01$) influenced profit efficiency. The negative coefficient implies that profit efficiency increases with the additional age of the household head of common bean farmers. This suggests that efficiency in common bean farming in Malawi is highly dependent on the age of farmers. Increase of age in common bean production may lead to greater experience and matured decisions which help to eliminate unnecessary costs which farmers encounter in the process of production. The results on age of farmers agree with a prior expectation that increase in age would lead to increase in efficiency mainly because of experience that farmers gain through previous production activities and also established markets for commodities which mainly depend on how long farmers have been trading. This result agrees with the findings of (Lawall & Ayuba, 2014) who found that an increase in age increases efficiency in Catfish farming. However, the results are contrary to the assertions of Igwe (2012) who found that young farmers were more efficient in minimizing costs in Yam production in Nasarawa state. Similarly, Tanko (2017) who used the Cobb Douglas stochastic frontier approach to determine profit efficiency of Shea butter and reported that an increase in age of farmers reduces profit efficiency.

Off-farm income was another variable that positively and significantly determined profit inefficiency at 1 percent. Results show that off-farm income of Common Bean farmers reduces the profit efficiency. These results are also consistent with Sadiq et al. (2015) who found that off-farm income activities deviate farmer's attention from farming and start focusing on things other than farm activities. This could be more negative if farmers have higher chances of obtaining greater off-farm income. Tsue et al. (2012) reported similar results for Catfish farmers in Benue state, Nigeria.

The coefficient of access to credit was found to affect profit inefficiency negatively. That is, access to credit increased the profit efficiency of a farmer. This is in agreement with Maganga *et al*. (2012), in the study of Unexploited profit among smallholder farmers in central Malawi who found out that credit access reduces financial constraints and eases the acquisition of much needed inputs. Likewise, access to farm input subsidy coupons also increased the level of profit efficiency in common bean production. Thus those farmers who had access to coupons to purchase seed and fertilizer realize better profits than those who do not have access to the fertilizer and seed coupons. Furthermore, use of extension advice was found to affect profit efficiency at 10 percent level of significance. Thus farmers who used the advice from extension workers experienced higher profit efficiency than those who did not. This is so as extension advice helps farmers to use the right mix of resources in order to experience more output and economic gains. To add, farmers who practiced agroforestry on their farms experienced higher profit efficiency than those who did not. Agroforestry practices are deemed as soil conservation measures and also improves yield and incomes of farmers. Mgomezulu et al. (2018) studied the impact of fertilizer tree technologies on economic livelihood of smallholder farmers and found out that fertilizer tree technologies or agroforestry increased smallholder farmer's monthly income. Thus the agroforestry technologies improved efficiency by minimizing the production costs of the farmers.

Again, soil erosion control measures were also found to significantly affect profit efficiency. Soil erosion affects fertility of the soil hence reducing the productivity of the piece of land. Employing no soil erosion control practice was the reference category and hence was omitted from the model. Use of terraces improved profit efficiency more than those farmers who did not use any soil control measures. Thus terraces improved the productivity of the land and hence the profits realized by the farmers. However, drainage ditches reduced profit efficiency. This can be due to the fact that drainage ditches take much of the land and hence reduced profit efficiency.

The study also revealed regional (Northern, Central and Southern) profit efficiency differences. From the study, central region has significantly ($P<0.001$) positive impact on profit inefficiency as compared to Northern region. Thus farmers from Central region experience a reduction in profit efficiency of 0.069% as compared to farmers from Northern region. The results agrees are in line with the theory that high production is associated with low price and hence low profits. This is consistent with the literature by Moyo (2016), in a study on situation analysis of Common Bean production, marketing and consumption in Malawi found out that Central region has greater common bean production quantity than other regions. Thus 60 percent of the total Common Bean cultivated in 2015/2016 season was from the central region, and this explains the registered low profits as compared to Northern region. On the other hand, Southern region though not significant but showed that a farmer from this region is more profit efficient than one from Northern region.

Table 3. Determinants of profit inefficiency among common bean producers in Malawi

Profit Efficiency	Coefficient	Stand. Error
Age of a household head (years)	-0.0015***	.0005
Household size (Number of people)	-0.001	0.004
Gender of a household head (1=Female, 0=Male)	0.0399	0.034
Marital status of farmer (1=Married, 0=Not married)	-0.1124***	0.0366
Education level of household head (years)	0.0037	0.0037
Size of cultivated land (acres)	0.0009	0.004
Off farm income of a farmer (Mk)	0.001***	0.0002
Access to extension (1=Yes, 0=No)	0.0112	0. 0163
Use of extension advice (1=Yes, 0=No)	-0.0514*	0.0292
Access to credit (1=Yes, 0=No)	-0.0337**	0.017
Access to Subsidy Coupons	-0.0748***	0.0166
Regional belonging:		
Central	0.065***	0.0188
South	-0.048**	0.022
Membership of farm organization (1=Yes, 0=No)	0.012	0.045
Agroforestry (1=Yes, 0=No)	-0.042*	.022
Erosion control measures		
Terraces	-0.0992*	0.0543
Bunds	-0.0341	0.0279
Sandbags	0.1151	0.1123
Vetiver glass	-0.0256	0.0334
Tree Belts	0.0561	0.1351
Water harvest	0.1778	0.1163
Drainage ditches	0.2429***	0.0485
Access to market (1=Yes, 0=No)	0.0668	0.073

*** Significant at 1 percent, ** significant at 5 percent, *significant at 1 percent
Source: Author’s computation

4 Conclusions and Recommendations

The study used a Cobb Douglas stochastic profit frontier function to analyze the profit efficiency of sampled Common Bean farmers in Malawi. Using data from Fourth Integrated Household Survey (IHS4), the study found out that there is a wide variability in profit efficiency which varied among the sampled smallholder Common Bean farmers. The results showed a gamma ratio of 0.66 implying that there is a high level of inefficiency in common bean farming. This implies that profit inefficiency at the given level of inputs and prices is more pronounced than the pure noise effect. This result helped to answer the question that smallholder farmers are not profit efficient in common bean production. Profit efficiency ranged from 17% to 98% with a mean of 49%. The mean level of profit efficiency indicates that there exists room to increase profit by improving technical and allocative efficiency.

The study went further and identified determinants of profit efficiency, which included age of a farmer, marital status, off-farm income, use of extension advice, adoption of agroforestry practices, access to credit, subsidy coupons and use of terraces to control soil erosion. Furthermore, the study showed that farmers from Central region have lower profit efficiency as compared to those from Northern and Southern region. The study recommends (1) implementing extension policies that ensure that farmers use the advice given to them by extension workers; (2) promoting adoption of agroforestry practices in order to improve productivity and profit efficiency of Common Bean farmers; (3) improving smallholder famers access to credit through promotion of microfinance institutions; (4) enhancing smallholder Common Bean farmers access to cheap inputs through FISP or other measures; (5) promoting use of terraces as a soil erosion control measure to prevent run-off and hence profits realized in Common Bean farming; and (6) providing on-farm incentives in Common Bean production to minimize smallholder farmers interest in off-farm income that reduces their time allocated to Common Bean production and hence their profit efficiency. It is through such policies that profit efficiency in Common Bean production can be improved and hence make Common Bean production much more profitable.

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