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Sources of Profit Inefficiency for Faba Bean Producers in Ethiopia

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ABSTRACT

This study uses the profit frontier model to assess the profit efficiency and determinants of inefficiency using primary data collected from 334 fababean producers selected from the Amhara and Oromia regions of Ethiopia. The result confirmed that fababean production in Ethiopia is profitable as the profit efficiency score is 86.10%, indicating 14% profit inefficiency. This implies that the enhancement of all the inefficiencies will result in the achievement of the potential profit of 9,360.48 birr/ha. Sex, access to off-farm income, training on pulse production, participation in improved fababean seed production, and the total land owned by the household head were the determinant factors for profit inefficiency. This study suggests that the profit efficiency of fababean farmers will remarkably improve if vocational training is given to farmers, production is planned based on available resources to the farmers, appropriate prices are available for their produce, and households get access to off-farm incomes.

INTRODUCTION

Fababean is the most important food and feed legume crop produced across the globe in Asia, Africa, Europe, South America, Australia, and North America. It is common in various cuisines of national dishes of Africa, mainly in Ethiopia, Egypt, Sudan, Morocco, and Tunisia. China is the leading producer in the world, followed by Ethiopia, Australia, France, Egypt, Morocco, Sudan, and the United Kingdom (Maalouf *et al.*, 2021).

Globally, the area under fababean production showed a slight increment from 2,520,020 to 2,684,296 hectares. However, the total harvest increased from 3,788,072 to 6,144,394 tons from 2000 to 2022. China is the world's leading country in fababean production in terms of area cultivated and total production with an average cultivated land of 922,570.78 hectares, and total production of 1,730,643.80 tons. Ethiopia and Australia are the second and third leading countries in terms of both the area cultivated and the total quantity they produce. The average cultivated land for Ethiopia and Australia was 469416.09 and 196789.91 hectares, while their average total production was 748627.60 and 306775.00 tons respectively between 2000 and 2022. In terms of productivity (tons/hectare), Estonia, Germany, and France were the top three (Table 1).

In Ethiopia, fababean is the most important pulse crop both in terms of area coverage and the volume of annual production. The area of land allotted to fababean production was increased from 492,701.77 hectares in 2021 to 520,551.70 hectares in 2022. Similarly, the total production during the same period also increased from 1,050,927.56 to 1,091,609.335 tons. However, the average productivity declined from 2.133 to 2.097 tons, showing a slight reduction of 1.69 % during the same period (ESS, 2022).

In recent years, the impacts of biotic and abiotic stresses have been increasingly affecting global food production (Yadav *et al.*, 2015). Fababean is among the affected crops. The dominant biotic stresses that affect fababean production are chocolate spot, Ascochyta blight, powdery mildew, root rots, fababean gall, and others. Similarly, the dominant abiotic stresses include heat, drought, salinity, acidity, frost, and others (Maalouf *et al.*, 2021).

Besides serving as a fundamental source of high-quality food and feed, legumes also highly contribute to reducing greenhouse gas emissions, the sequestration of carbon into the soils, fixing the atmospheric nitrogen, and releasing high-quality soil organic matter which helps in facilitating the circulation of soil nutrients and water retention, and this will contribute much in sustainable food production (Stagnari *et al.*, 2017).

Based on national and international data, Ethiopia is on good progress in fababean production. However, the country is producing below its maximum potential. The data in Table 1 confirms this argument that the mean productivity of fababean in Ethiopia is 1.59 tons/ha, and this is below that of the world's average which is 2.10 tons/ha. The authors believe that this will contribute to reducing the revenues and profits of the fababean farmers in Ethiopia. To the best knowledge of the researchers, there has not been research conducted to assess the profit efficiency of fababean farmers in Ethiopia, and the factors affecting the profit efficiency of the fababean farmers.

Since agriculture is the main sector in Ethiopia, considering the profitability of farmers is very important in implementing development strategies. It is also very important for farmers to realize their potential and actual

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profit efficiency levels for informed decision-making in their farming business. This helps them how to maximize their profits and reduce their costs of production.

Therefore, this research aimed to assess the profit efficiency of fababean farmers in Ethiopia, and the factors responsible for farmers' inefficiency in fababean production using the stochastic frontier model and contribute to filling the existing information gap.

Table 1: Average area, production, and productivity of fababean for world's top producers from 2000 to 2022

S.N	Country	Cultivated Land And Its Rank		Yield In Tons And Its Rank		Yield/Ha And Its Rank	
		Cultivated Land	Rank	Total Yield	Rank	Yield/Ha	Rank
1	China	922570.78	1	1730643.80	1	1.8759	15
2	Ethiopia	469416.09	2	748627.60	2	1.5948	19
3	Australia	196789.91	3	306775.00	3	1.5589	20
4	Morocco	153756.48	4	104947.61	8	0.6826	29
5	UK	92174.52	5	299348.97	4	3.2476	4
6	France	74688.00	6	257203.82	5	3.4437	3
7	Egypt	65551.91	7	204875.73	6	3.1254	5
8	Sudan	63944.25	8	154679.44	7	2.4190	10
9	Tunisia	52634.83	9	56271.74	16	1.0691	25
10	Peru	50486.74	10	57086.48	14	1.1307	23
11	Italy	49856.13	11	89354.14	11	1.7922	17
12	S/Sudan	49217.09	12	86078.33	12	1.7490	18
13	Algeria	35980.35	13	36155.40	21	1.0049	27
14	Brazil	31425.39	14	11672.83	29	0.3714	30
15	Latvia	30480.00	15	66860.00	13	2.1936	12
16	Spain	29289.09	16	57066.40	15	1.9484	13
17	Germany	28675.26	17	102183.30	9	3.5635	2
18	Mexico	22167.74	18	28224.94	23	1.2732	21
19	Guatemala	19928.83	19	20961.66	26	1.0518	26
20	Paraguay	16992.65	20	21431.49	25	1.2612	22
21	Syria	15879.91	21	30870.64	22	1.9440	14
22	Sweden	14102.17	22	40827.83	17	2.8951	6
23	Lithuania	14046.09	23	37226.09	19	2.6503	9
24	Estonia	13846.00	24	101178.60	10	7.3074	1
25	Bolivia	13589.09	25	13150.28	28	0.9677	28
26	Poland	13354.30	26	37921.53	18	2.8396	8
27	Finland	12830.00	27	37086.56	20	2.8906	7
28	Russian	10569.26	28	11497.89	30	1.0879	24
29	Ecuador	10268.83	29	18484.75	27	1.8001	16
30	Romania	10000.00	30	23818.00	24	2.3818	11
	World	86150.39		159750.36		2.1040	

Source: Authors computation using FAOSTAT data (FAOSTAT, 2024)

MATERIALS AND METHODS

Data

In this study, primary data collected from sample households randomly selected from the Amhara and Oromia regions was used. A multi-stage random sampling procedure was followed. The two giant regions, namely Oromia and Amhara were the regions purposively selected based on their high potential in fababean production at the first stage. Then one zone from the Amhara region purposively (as the result of security issues in the region), and three zones from the Oromia region were randomly selected out of the potential fababean-producing zones of the two regions. In the third stage, six districts from Oromia and two districts from Amhara regions were randomly selected. Then two peasant associations from each district, a total of sixteen districts were randomly selected. Finally, a total of 334 sample households, (106 (31.74%) from Amhara region and 228 (68.36%) from Oromia region) were randomly selected and interviewed for the data collection.

Variables
Based on the literature reviewed, the production variables and the inefficiency variables listed in Table 2 were selected to be included in this study.

Table 2: Lists of variables and their expected effect on the profit efficiency of fababean producers

Var. code	Description	Measurement	Expected effect
π	Profit	Birr	
p_i	Prices of inputs		
p_1	Price of fertilizer	Birr	-
p_2	Price of seed	Birr	-
p_3	Prices of oxen	Birr	-
p_4	Prices of labor	Birr	-
p_5	Prices of agrochemicals	Birr	-
p_6	Fababean plot size	Hectares	+
x_i	Variables affecting inefficiency		
x_1	Age of the household head	Years	+
x_2	Education of the household head	Years	+
x_3	Membership in improved seed production	No/Yes	+
x_4	Experience in fababean farming	Years	+
x_5	Access to extension services	No/Yes	+
x_6	Market distance	Minutes	+
x_7	Access to credit service	No/Yes	+
x_8	Sex of the household head	Female/Male	-/+
x_9	Participation in contract farming	No/Yes	+
x_{10}	Livestock owned	TLU	+
x_{11}	Off-farm income	Birr	+/-
x_{12}	Total land owned	Hectares	+
x_{13}	Adoption of fababean technologies	No/Yes	+
x_{14}	Training in pulse production	No/Yes	+

Source: Authors' compiled based on reviewed literature

Analytical Framework
The stochastic frontier model was employed to estimate the profit efficiency of fababean producers and factors determining efficiency. The stochastic frontier model assumes that the error term is a composite of the inefficiency of the farmers and the random error. Therefore, a farm household can deviate from its optimal profit frontier as the result of both the inefficiency of the household itself and possible random fluctuations that are out of the control of the farmers. For this specific paper, the frontier alternative profit function specified by (Berger & Mester, 1997) was used. In this function, profit is taken as a dependent variable while the amount of outputs and the price of inputs are taken as independent variables. It also considers that outputs remain constant, while the price of input varies freely and affects the profit. The functional form of the alternative profit function can be expressed as:

$$\pi_i = f(y_i, w_i)^{(v_i - u_i)} \quad (1)$$

Where: π_i is the profit of farmer i, f is the functional form to be used, y_i is the quantity of fababean produced by farmer i, w_i is the prices of vector input variables for farmer i, u_i is the inefficiency that reduces farm profit of farmer i, and v_i is the random error.

Efficiency varies between companies and over time (Battese & Coelli, 1992). Therefore, it is logical to ask about what factors are responsible for the variations in efficiency. Battese and Coelli further extended the stochastic frontier model and suggested that the determinants of inefficiency can be expressed as a linear function of a set of explanatory variables that reflect the characteristics inherent to a company (Battese & Coelli, 1995). The extended form of Battese and Coelli allows the estimation of the efficiency and the factors affecting the inefficiency in a single-stage step. This will overcome the estimation bias of the widely used two-step approach (Battese & Coelli, 1995; Kumbhakar *et al.*, 1991; Wang & Schmidt, 2002).

The transcendental logarithmic function is the functional form commonly used in efficiency studies. Therefore, the alternative profit frontier function can be expressed as:

$$ln\pi_i = \beta_0 + \sum_{j=1}^{n} \beta_j lny_j + \sum_{l=1}^{n} \delta_l lnw_l + \frac{1}{2}\sum_{j=1}^{n} \sum_{k=1}^{n} \theta_{jk} lny_j\, lny_k + \frac{1}{2}\sum_{l=1}^{n} \sum_{s=1}^{n} \gamma_{ls} lnw_l lnw_s + \sum_{j=1}^{n} \sum_{l=1}^{n} \alpha_{jl} lny_j lnw_l + v_i - u_i \quad 2$$

The alternative profit function can be expressed as the ratio of the observed profit of the farmer to the maximum achievable profit that the farmer could earn if he/she produces on the efficient frontier (u_i=0). This can be expressed as:

$$\pi_i = \frac{\pi_{actual}}{\pi} = \frac{f(y_i\ ,\ w_i)^{(v_i - u_i)}}{f(y_i\ ,\ w_i)^{(v_i)}} = e^{-u_i} \quad 3$$

The inefficiency function in equation 3 can be expressed as:

$$u_i = \delta_o + \sum_{k=1}^{n} \delta_k z_i + \varepsilon_i \quad 4$$

Where: δk is a vector of parameters (regression coefficient) to be estimated, z_i is a vector of inefficiency variable (institutional, demographic, and socio-economic variables), and ε_i is the random error of the model. Finally, the maximum likelihood estimation was done using Stata V.16.

Hypothesis

To attain the objectives of this study, the following null hypotheses were tested:

H_{01}: $\delta_1 = \delta_2 = \ldots \delta_n = 0$. (All the factors do not affect the efficiency of fababean producers).

H_{02}: $\gamma = 0$. (There is no inefficiency among smallholder fababean farmers).

RESULTS AND DISCUSSIONS

Descriptive Results

Male-headed households dominate the fababean production in the study area (n = 310, 92.8%). In terms of age, 231 (69%) were aged between 30 to 50 years, with an average age of 45 years. The result also revealed that there is a high illiteracy rate, in which 99 (30%) of respondents were not able to read and write, while only 7 (2%) attended tertiary education (See Table 3).

Revenues are the key determinant factors in assessing the efficiency and sustainability of the farm. Table 3 revealed that fababean is cultivated on 0.3 ha of land, and the average yield of 345 kg harvested enabling the household to earn an average profit of 8059 birr.

The majority of respondents (91%) had an experience of 10 years and above in fababean production, and the minimum, maximum, and mean experience were 3, 55, and 24 years respectively. The household size of more than 91% of households ranged from 1 to 8 with an average of 5 members, while the rest (9%) ranged from 9 to 14. The average land holding in the study areas is about 1 ha (See Table 3).

Table 3: Descriptive results

Variable	Obs.	Mean	Std. Dev.	Minimum	Maximum
Farm revenue (birr)	334	9471.686	9887.898	200	75850
Profit (birr)	334	8059.383	9380.483	45	70582
Fababean yield (kg)	334	345.42	297.89	10	2050
Hired labor (hr.)	334	10.342	30.015	0	213
Fertilizer used (kg)	334	30.849	52.936	0	640
Seed used (kg)	333	51.141	36.468	0	300
Market distance (min)	334	86.302	61.795	10	320
Plot distance (minute)	334	17.118	20.057	0	200
Hired oxen (hr.)	334	23.293	18.078	1.5	200
Livestock (TLU)	334	8.0390	4.3220	.04	28
Age of the head	334	45.766	11.232	21	82
Agrochemical (lit)	334	.2710	1.246	0	20
Family size (AE)	334	5.749	1.958	1	14
Education (years)	334	5.979	3.480	0	14
Experience (years)	334	23.91	11.30	3	55
Land owned (ha)	334	1.179	1.445	0	15
Plot size (ha)	334	.342	.203	.06	2
Credit access (no/yes)	334	.195	.396	0	1
Extension (no/yes)	334	.916	.278	0	1
Of farm income (no/yes)	334	.293	.456	0	1
Sex of the head (female/male)	334	.928	.259	0	1

Contract farm (no/yes)	334	.117	.322	0	1
Seed production (no/yes)	334	.317	.466	0	1
Fababean adoption (no/yes)	334	.596	.491	0	1
Training on pulse (no/yes)	334	.482	.500	0	1

Source: Authors' survey result

Econometric Results

For the profit efficiency estimation, the study used the stochastic profit frontier to assess the profit efficiencies of fababean producers in the study area. Fababean plot size, selling price, price of seeds, price of fertilizer, prices of agrochemicals, price of oxen, and price of labor were included as first-order variables (production variables), while sex, age, education, livestock holding, experience in fababean production, off-farm income, plot distance, distance from the main market, access to extension, access to credit, participation in contract farming, adoption of fababean technologies, training in pulse production, land ownership and participation in fababean improved seed production were included as variables affecting the efficiency of fababean producers. The Single-step estimation method was employed, and the result is presented in Table 4.

Table 4: Maximum likelihood estimation results

Profit	**Coef.**	**St. Err.**	**z**	**P>z**
Fababean Yield	1.041***	0.000	4694.870	0.000
Selling price	1.049***	0.000	3830.150	0.000
Plot size	-0.034***	0.000	-107.860	0.000
Labor cost	-0.00***	0.000	-8.360	0.000
Fertilizer cost	-0.015***	0.000	-86.390	0.000
Chemical cost	-0.001***	0.000	-7.060	0.000
Seed cost	0.043***	0.000	140.060	0.000
Hired oxen cost	0.119***	0.001	209.830	0.000
Labor squared	-0.004***	0.000	-241.560	0.000
Fertilizer squared	-0.002***	0.000	-93.670	0.000
Seed squared	-0.009***	0.000	-249.030	0.000
Plot size squared	-0.007***	0.000	-49.670	0.000
Hired oxen cost squared	-0.023***	0.000	-253.250	0.000
Chemical cost squared	-0.002***	0.000	-181.240	0.000
Labor cost X Fertilizer cot	0.003***	0.000	144.540	0.000
Labor cost X Seed cost	-0.001***	0.000	-66.390	0.000
Labor cost X Plot size	0.004***	0.000	58.870	0.000
Labor cost X Hired oxen cost	-0.002***	0.000	-155.990	0.000
Labor cost X Chemical cost	0.001***	0.000	148.300	0.000
Fertilizer cost X Seed cost	0.002***	0.000	92.210	0.000
Fertilizer cost X Plot size	0.001***	0.000	13.240	0.000
Fertilizer cost X Hired oxen cost	-0.004***	0.000	-325.060	0.000
Fertilizer cost X Chemical cost	0.002***	0.000	96.450	0.000
Seed cost X Plot size	0.011***	0.000	150.670	0.000
Seed cost X Hired oxen cost	-0.000***	0.000	-2.990	0.003
Seed cost X Chemical cost	0.002***	0.000	167.870	0.000
Plot size X Hired oxen cost	-0.002***	0.000	-13.320	0.000
Plot size X Chemical cost	0.002***	0.000	32.300	0.000
Hired oxen cost X Chemical cost	0.006***	0.000	302.930	0.000
Constant	-0.305***	0.001	-217.270	0.000
Sex of the head	-15.772 *	9.340	-1.690	0.091
Age of the head	0.131	0.432	0.300	0.761
Livestock owned	-1.025	0.905	-1.130	0.258

Education of the head	-2.109	1.286	-1.640	0.101
Experience in fababean	-0.265	0.492	-0.540	0.591
Off-farm income	-17.787 *	9.383	-1.900	0.058
Market distance	0.063	0.056	1.130	0.260
Extension contact	-3.394	0.022	-0.340	0.735
Land owned	3.786 **	1.856	2.040	0.041
Access to credit service	1.838	8.661	0.210	0.832
Contract farming	-23.607	5.017	-1.570	0.116
Seed production	-22.813 *	1.924	-1.910	0.056
Fababean adoption	-2.454	7.183	-0.340	0.733
Training in pulse	-16.997 *	9.416	-1.810	0.071
Constant	-18.498	2.788	-0.810	0.417
U sigma _constant	2.534 ***	0.283	8.950	0.000
V sigma _constant	-22.437 ***	3.696	-6.070	0.000
Sigma _u	3.551 ***	0.503	7.060	0.000
Sigma _v	0.000	0.000	0.540	0.588
Lambda	2.65e+05 ***	0.503	5.30e+05	0.000
	Log-likelihood = 238.2183, No. of observations = 334 and Prob > chi2 = 0.0000			

Source: Authors' survey result

All the production variables, the squared values of all the production variables, and their interactions, along with the inefficiency variables were fitted in the model. The assumption behind this is that there are multiple relationships among the variables and the possibility that linear and quadratic associations may co-exist amid the variables and their interactions with the dependent variables. The result of this study indicated that fababean yield, selling price, price of seed, and price of oxen positively and significantly related to profit (p = 0.000, 0.000, 0.000, and 0.001, respectively), while the plot size, prices of labor, price of fertilizer, and price of chemicals are negatively and significantly related with profit (p = 0.000 for all variables). The squared values of all the first-order variables are negatively and significantly related to profit at 1% (See Table 4).

The interaction effect of the variables denotes that there are complementarities of different inputs in agricultural production. The negative complementary suggests that a joint increase of the variables leads to a reduction in profit, and conversely positive complementary suggests that a joint increase of the variables leads to an increase in profits. The finding of this study showed that the complementary effects of labor cost and fertilizer cost, labor cost and plot size, labor cost and chemical cost, fertilizer cost and seed cost, fertilizer cost and plot size, fertilizer cost, and chemical cost, seed cost and plot size, seed cost and chemical cost, plot size and chemical cost, and hired oxen cost and chemical cost positively and significantly related with profit at 1%, while the rest interactions negatively and significantly related with profit at 1%.

The inefficiency variables fitted in the single-step estimation model for the maximum likelihood estimation revealed that sex, off-farm income, total land owned, participation in fababean improved seed production, and participation in pulse production training were the variables that significantly affected profit inefficiency. The sex of the household head had a negative and significant effect on profit inefficiency indicating that being a male-headed household would increase the profit efficiency by 10.77. This result is in support of the finding reported by (Wongnaa *et al.*, 2019). This might be because females perform housework that reduces family-sourced labor, and increases hired labor which negatively affects the profit efficiency of the farmer. Similar result on off-farm income was reported by (Adnan *et al.*, 2021), and the result of land owned is in contrary with the result reported by (Mujuru *et al.*, 2022).

Estimation of The Profit Efficiency Scores

The profit efficiency score was estimated and presented in Table 5. The results show that the average profit efficiency score is 86.10% with a standard deviation of 18.44%, and the minimum and maximum efficiency scores are 2.01% and 99.99%, respectively. This indicates that farmers are producing below the profit frontier, and the fababean production in the study area is 14.10% short of the maximum possible profit. This result implies that farmers would be able to increase their profits by 14.10% through efficient utilization of their resources.

The result indicated that fababean producers in the study area are getting an average profit of 8059.38 birr/hectare. This implies that the maximum possible level of profit is 9,360.48 birrs. Therefore, solving all the inefficiencies problems will add 1,301.48 birr to the profit of the farmers on average.

Table 5: Summary of profit efficiency scores

Efficiency score range		Frequency		Percent (%)
< 0.2		004		1.20
0.2 – 0.3		006		1.80
0.3 – 0.4		005		1.50
0.4 – 0.5		002		0.60
0.5 – 0.6		019		5.69
0.6 – 0.7		013		3.89
0.7 – 0.8		022		6.59
0.8 – 0.9		065		19.46
> 0.9		198		59.28
Total		334		100
Mean	0.8610	Minimum	0.0201	
Std. dev	0.1844	Maximum	0.9999	

Source: Authors' survey result

CONCLUSIONS

This study was designed to assess factors determining the profit efficiency of fababean producers in Ethiopia. The results of this study are paramount important as in filling the existing information gap and serve as a source of information for the required policy intervention. From the result, male-headed households are more profitable than female-headed households in fababean production. Households having access to off-farm income are more profitable in their agricultural production as it enables them to access agricultural inputs. Seed cost and hired oxen cost for land preparation were found to be the most important variables that positively and significantly influenced the profit efficiency of fababean producers. This signifies the role that agricultural technologies play in boosting farm profitability, improving the livelihood of farm households, transforming the agricultural sector, and contributing much to achieving national developmental goals even if their prices are higher. Fertilizer cost, chemical cost, and labor cost were found to be negative influencers of the profit efficiency of the fababean producers in the study area. These results are in support of the reports stating the deterioration of soil fertility and the escalating infestation of plant pests and diseases that demand farmers use more amounts of fertilizers and agrochemicals on their farm plots. It also depicts that deploying extra labor force on a piece of land will result in inefficiency in the profitability of their farming business. Moreover, the result of this study confirmed that the complementarities of the agricultural inputs are very important as the interactions of all the first-order variables significantly affected the profit efficiency of fababean producers at 1%. The interactions of labor with fertilizer, plot size, and chemical; the interactions of fertilizer with seed, plot size, and chemical; the interactions of seed with plot size and chemical; the interaction of plot size with chemical, and the interaction of hired oxen cost with chemical positively and significantly affected profit efficiency of the farm households while the rest interactions negatively related to profit.

Based on the findings of this research, farm households having access to training were found to be profitable compared to those households not having access to training. Therefore, delivering technologies along with their packages will contribute to the profitability of crop production, and giving vocational training to farm households can open prospects for farmers to become more profitable. Similarly, households having access to off-farm income were also found to be more profitable compared to others. Hence, policies and incentives promoting off-farm income-generating activities will positively impact the profit efficiency and speed up the transformation of smallholder farmers.

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