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RESEARCH ARTICLE

Estimating the return to scale and elasticity of production among small-scale tomato producers in Kano and Kaduna States, Nigeria

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Abstract

This research study focused on estimating the return to scale (RTS) and elasticity of production (EP) among small-scale tomato producers in Kano and Kaduna States of Nigeria. A multi-stage sampling plan was utilized to select 200 small-scale tomato producers. Primary data of cross-sectional sources were utilized based on a well-planned questionnaire. The data were evaluated using descriptive statistics, RTS, EP, and stochastic frontier production model. The results show that the mean age of tomato producers was 44 years (SD = 6.12). The tomato producers were small-scale growers with a mean farm size of 1.41 hectares. The coefficient of agrochemicals, fertilizer usage, seeds, farm size, and labour were positively and considerably different from zero in affecting the output of tomato growers. The coefficients of elasticity of production were estimated as follows, agrochemicals (0.1674), fertilizer usage (0.2316), farm size (0.1635), seeds (0.1206), and labour (0.1526) respectively. The input elasticities were inelastic for tomato farming; this means a 1% rise in each factor, while keeping all other stimulus constant will result to less than 1% rise in tomato output. The RTS was evaluated at 0.8357, this connotes deceasing RTS, the tomato producers are operating in stage 1 of the production surfaces which is the output of tomato can still be raised by using more of the factors. An increase in all the inputs by 1% raises tomato output by 0.8357 percent. The improved varieties of tomato seeds should be given to producers to increase output. Also, farm technologies such as machines, tractors, new equipment's should be given to farmers for farm mechanization and to increase the tomato output.

Keywords: Return to Scale; Elasticity of Production; Smallholder; Tomato Production; Nigeria

1. Introduction

The tomato (*Lycopersicum esculentum*) is reported as one of the vegetable crops planted almost throughout Nigeria and its farming on a massive scale can generate employment both for the urban and rural populace, providing income, and increasing food and nutritional requirements (Folayimi *et al.*, 2022). Tomato is a source of foreign exchange for the nations, the industries also makes use of raw materials for processing into paste and sauce (Adenuga *et al.*, 2013). Tomato is grown abundantly in Northern region of Nigeria due to their favorable environment for the crop and superior irrigation system to assists all year farming (Obianefo *et al.*, 2021). The

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majority of tomato produced in Nigeria is cultivated mainly by smallholder farmers. These producers planted between 0.5 and 5 hectares of land providing approximately 90% of the total tomato output, with the remaining provided by commercial producers (Norbert *et al.*, 2023). Nigeria was recorded as the 2nd highest tomato producers in Africa, and the 9th in the world with an evaluated total annual output of 3.7 million tons from 702275 hectares of land in 2022 (FAO, 2024). The output or productivity is low, there is a gap shortage between demand and supply of tomato in the country, insecurity in Nigeria broadened the demand-supply shortfall to above 20% in the year 2019 which clarifies the hike in the price of tomato produce in the nation (Ugonna *et al.,* 2015). Currently, the tomato produce per hectare in Nigeria is low, with evaluated at a mean of 20 – 40 tons per hectare per annum, and 40 – 50% of the output is faltered due to the poor handling, preservation and processing activities in Nigeria (Amurtiya and Adewuyi, 2020). According to Umar *et al*. (2017) who documented that in 2016, Nigeria produces an evaluated 1.93 million tons of tomato from 517, 000 hectares of land approximating 3.7 tons per hectare. Similarly, Food and Agriculture Organization FAO (2016) evaluated that 2.33 million metric tons consumption in Nigeria creating 17.20% shortfalls demand-supply gap. According to Murthy *et al*. (2009), the inability of growers to fully use the obtainable technologies which in turn give rise to lower efficiencies of output is responsible for the low productivity experienced in tomato farming. The significant factors accounting for low yield, low output and inconsistent production, elasticity of production (EP) and return to scale (RTS) were shortage of improved seeds, pesticides, fertilizers, climate change, biotic and biotic factors, fluctuation in prices after harvest, perishability nature of the products, post-harvest loss.

This research study differs from the previous work of Obianefo *et al.* (2021) on technical efficiency and technological gap ratios of tomato production in northern Nigeria: a stochastic meta frontier approach. The outcomes show that the return to scale was estimated as follows; Northern Nigeria (2.322), Kano State (.0.988), Plateau State (0.101), and Taraba State (-0.199). In Plateau State, the tomato farming was analyzed at stage one, that is an increasing stage. The study of Folayimi *et al.* (2022) investigated profitability and efficiency of tomato output among female producers in Ibadan north local government area, Ibadan, Oyo State, Nigeria, the result shows that the coefficients of capital, farm size, and labour were found to be positive and remarkable effect on the output of tomato. The work of Asfaw (2021) analyzed technical efficiency of smallholder tomato producers in Asaita District, Afar National Regional State, Ethiopia. The data were analyzed using descriptive statistics and stochastic frontier model. The significant factors influencing output of tomato farmers were oxen, labour, land, and seed. The return to scale and mean technical efficiency was estimated at 2.1, and 0.809, respectively. The work of Nakana et al. (2021) analyzed the economic efficiency of smallholder tomato producers in greater Letaba municipality Limpopo province, South Africa, the outcome shows that the coefficients of land, labour, seedlings, and pesticides were positive and significantly influence the output of tomato. This study fills the research gap that none of the previous studies evaluated the return to scale and elasticity of production among small-scale tomato producers in North West Nigeria.

Table 1. The Output of Tomato in Nigeria and the World

Variables	Output of Tomato in Nigeria (tons)	World Output of Tomato (tons)
Tomato Output in 2021	3477981	189281485.32
Tomato Output in 2022	3684566.41	186107972.48

Source: FAO (2024)

Table 2. The Tomato Cultivated Area in Nigeria and the World

Variables	Area of Tomato in Nigeria (hectares)	World Area of Tomato (hectares)
Tomato Area in 2021	809602	5046596
Tomato Area in 2022	702275	4917735

Source: FAO (2024)

Research Questions

This study gave answers to the under-listed research questions:

(i)What is the farm-specific and farmers' characteristics among small-scale tomato producers?

(ii)What is the elasticity of production among small-scale tomato producers?

(iii)What is the return to scale among small-scale tomato producers?

(iv) What are the input factors (agrochemicals, fertilizer usage, farm size, seeds, and labour) influencing output of small-scale tomato growers?

Objectives of the Study

The major goal of the study focused on estimating the elasticity of production and return to scale among small-scale tomato producers in Kano and Kaduna States, Nigeria. The specific objectives were:

(i) describe the farm specific and farmers' characteristics among small-scale tomato producers,

(ii)estimate the elasticity of production among small-scale tomato producers,

(iii)estimate the return to scale among small-scale tomato producers, and

(iv) evaluate the input factors (agrochemicals, fertilizer usage, farm size, seeds, and labour) influencing output of small-scale tomato producers.

Hypotheses of the Study

The research study was driven by the following null-hypotheses:

(i) The coefficient of elasticity of production for each input is not positive among small-scale tomato producers.

(ii)The return to scale is not greater than zero among small-scale tomato producers.

(iii)There is no significant influence between input factors (agrochemicals, fertilizer usage, farm size, seeds, and labour) and output of small-scale tomato producers.

2. Materials and methods

This study was carried out in Kano and Kaduna States, Nigeria. Tomatoes are planted in most states in Nigeria, however, the northern part of the nation is where tomatoes are primarily grown. Approximately 80% of the tomatoes in the nation are grown in Northern region (Akinola et al., 2023). The study selected Kano and Kaduna states because they are predominantly known for tomato farming in the North West region, Nigeria. The two states were chosen due to their favorable climate for the crop and better irrigation systems to support all year farming (Obianefo *et al.*, 2021). A multi-stage sampling strategy was utilized. A multi-stage sampling strategy was utilized because of a variety of reasons, such as cost reduction, time efficiency, flexibility, and increase reliability. The technique can be used when you have a large geographically dispersed samples and you can get a probability sample without a complete list of respondents, and obtain a more reliable estimate of population parameters like the mean, in this sampling design you draw a sample from a population using smaller and smaller groups (unit) at each stage. In the first stage, two states were purposively selected being known predominantly for tomato farming in Nigeria. In the second stage, 2 local government areas were randomly selected in each state. In the third stage, 5 villages for each local government area were randomly selected making a total of 20 villages. In the fourth stage, a proportionate and simple random sampling technique was employed, approximately 10 tomato growers were selected from each village making a total of 200 tomato producers. The sample frame of tomato producers approximately 400 respondents. The total sample number consists of 100 tomato producers selected each from the two states, respectively. Primary data of cross-sectional sources were utilized based on a well-designed questionnaire that was subjected to reliability and validity test. The questionnaire was validated by the team of experts and appropriate reliability test was carried out. The questionnaire was pre-tested on selected tomato growers to evaluate the appropriateness of the design, clarity, and relevance of the questions. The appropriate modification was made on the pre-tested questionnaire in order to capture the relevant information required to achieve the objectives of the study, questions that proved vague or ambiguous, attracted additional corrections on the questionnaire to ensure its appropriateness, and reliability. The result of the pre-test was collated and subjected to reliability test using Pearson product moment correlation analysis. The correlation coefficient of 0.93 (93%) shows that there was a strong degree of correlation between the variables tested. The Cronbach's alpha coefficient for the variables was 0.879 (87.9%), suggesting that the variables included in the research instrument had relatively high internal consistency and highly reliable for the analysis. This sample number was estimated based on the established formula of Yamane (1967) as follows:

$$n = \frac{N}{1+N(e^2)} = \frac{400}{1+400(0.05)^2} = 200 \ldots\ldots(1)$$

Where,
n = The Sample Number
N = The Total Number of Tomato Producers (Number)
e = 5%

The data obtained were evaluated using descriptive statistics, RTS, EP and stochastic production frontier model.

2.1. The SPEFM (Stochastic Production Efficiency Frontier Model)

According to Alabi et al. (2022), the SPEFM is stated thus:

$$Y_i = f(X_i, \beta_i)e^{v_i - u_i} \ldots\ldots\ldots\ldots(2)$$

$$Ln\, Y_i = Ln\, \beta_0 + \sum_{j=1}^{5} \beta_i\, LnX_i + (v_i - u_i) \ldots(3)$$

$$TE_i = \frac{Y_i}{Y_i^*} \ldots\ldots\ldots.(4)$$

$$TE_{ij} = \frac{F(X_i, \beta)\exp(v_i - u_i)}{F(X_{i,}\beta)\exp(v_i)} \ldots\ldots..(5)$$

$$TE_{ij} = \exp(-u_{ij}) \ldots\ldots..(6)$$

where,
Y_i = Output of Tomato (Kg)
Y_i^* = Unobserved Frontier Output of Tomato (Kg)
X_i = Inputs
β_i = Vectors of Estimated Parameters
V_i = Random Errors
U_i = Error Term as a result of TIE (Technical Inefficiency)
X_1 = Agrochemicals (Litres)
X_2 = Fertilizer Usage (Kg)
X_3 = Farm Size (Ha)
X_4 = Seeds in Kg
X_5 = Labour (Mandays)

2.2. Return to Scale (RTS) and Elasticity of Production (EP) Model

Elasticity of production (EP) is a measure of a farm success in yielding maximum output from a given set of factors. The (E_P) and (RTS) was estimated following the model of Alabi et al. (2022) as:-

$$E_{P_{X_i}} = \frac{\partial Y}{\partial X_i} \cdot \frac{\overline{X}}{\overline{Y}}, i = 1, 2 \ldots k \qquad (7)$$

$$\sum_{i=1}^{K} E_{P_{x_i}} = RTS \quad (8)$$

Where;
$\bar{X}$ = Mean of Inputs (Units)
$\bar{Y}$ = Mean of Output (Units)
$E_{P_{x_i}}$ = Elasticity of Production of Input x_i
$\sum_{i=1}^{K} E_{P_{x_i}}$ = Return to Scale i.e Sum of Elasticity of Production

The documents of Sanusi et al. (2016) and Alabi et al. (2021) suggested that return to scale of the farm operations can either be decreasing, increasing, or constant RTS based on the value of the estimated coefficients.

3. Results and discussion

3.1. *The Descriptive Analysis of Continuous Variables of Farm Specific and Farmers Characteristics among Small-Scale Tomato Producers*

Table 3 displayed the descriptive analysis of continuous variables of farm-specific and farmers' characteristics among tomato producers. The average age of small-scale tomato producers was 44 years having standard deviation (SD) of 6.12. The age of the farmers was expected to influence his or her labor productivity and output. The result implies that producers in the area are relatively young, a condition that may contribute to their overall efficiency in tomato farming. This result agrees with Nakana (2021) who reported that about 79% of small-scale tomato farmers in South Africa were above 35 years of age. According to Younas *et al.* (2024) the age of a producer plays a critical role in the decision-making process, affecting their willingness to resist or embrace new technologies. It also imparted to an individual's learning attitudes and personal growth, ultimately helping their overall performance as producers. It is expected that age can have both negative and positive effects on productivity and technical efficiency of producers. Older producers may possess more farm experience but may tend to be more risk-averse, adhering to conservative and traditional practices, while being unwilling to adopt new ones. Conversely, younger producers are often more ready to take risk, seize opportunities, search for new initiatives, and easily adopt advanced farming technologies, committing them to be more technically efficient. The average farm size was 1.41 hectares (SD = 1.41). The outcome shows that the small-scale tomato producers were predominantly smallholder farmers based on the category of farm holdings in Nigeria by Olayide (1980) who reported that small, medium, and large scale producers hold 0.1 – 5.99, 6.0 – 6.99, and above 10 ha, respectively. According to Ahmed and Oyewole (2012) the small farm size is an obstacle to mechanization of agricultural farms because it will be hard to use farm machines on fragmented and small individual farms.

Averagely, the small-scale farmers had 14 years (SD = 5.09) experience in tomato farming. This means that the tomato producers have accumulated significant years of experience in the tomato farming and they would have possessed the necessary expertise to adapt and adjust to any improved technologies. According to Fikadu *et al.* (2022) a good experience in tomato farming would enhance the farmers' output and efficiency since experienced producers can use improved agronomic practices, inputs, pest and disease management efficiently in their fields. This work aligns with outcomes of Ijigbade *et al.* (2023) who documented a mean of 8 years for small-scale tomato producers in southwest, Nigeria. This outcome is also supported with result of Saliu *et al.* (2017) who reported that the number of years' experience in farm activities determines the producers' ability to make farm management decision effectively not only to adhere to agronomic practices but also with respect to resource allocation or input combinations. The small-scale tomato producers were literate with an average of 13 years of attending school education. According to Girei et al. (2018), educations is a key socio-economic factor that affect producers' decision because of its effect on the perception, reception, awareness, and quick processing and adoption of innovation that led to efficient farm management and improved productivity. The previous studies of Younas *et al.* (2024) raised the continuous issue of ignoring education leading to adverse effect on agricultural output. Engaging educated producers in the agricultural sector and implementing suited policies for them holds the potentials for achieving higher output and can be a valuable strategy for policy makers. The average household size was 11 persons. This outcome is supported with works of Olorunsanya *et al.* (2009) who documented that large households appeared to save more extra cost for engaging labour than small families.

Table 3. The Descriptive Analysis of Continuous Variables of Farm Specific and Farmers Characteristics among Tomato Producers

Variables	Unit of Measurement	$\bar{X}_i$	SD
Age	Years	44	6.12
Farm Size	Hectare	1.41	0.67
Farming Experience	Years	14	5.09
Formal Education	Years	13	3.11
Household Size	Number	11	4.02

Source: Field Survey (2024)

3.2. The Descriptive Analysis of Categorical Variables of Farmers Characteristics among Tomato Producers

Table 4 presented the descriptive analysis of categorical variables of farmers' characteristics among tomato producers. The categorical variables under consideration in this research study include marital status, members of cooperatives, and sex. About 89% of tomato producers were married, while 11% of them were single. This result aligns with findings of Aphunu and Otoikhian (2008) who reported that marital status is a key factor which is likely to inspire the sustainability of adoption decision. Approximate 87% of tomato producers were members of cooperative organization, while 13% of them do not belong to any cooperative association. According to Saliu *et al.* (2017) who reported that the cooperatives provide groups of farmers with the privilege to own and control businesses close to their farming activities, this allowing them to address common problems or develop market opportunities. Furthermore, 82% of small-scale tomato producers were male, while 18% of them were female. This outcome agrees with the works of Ijigbade *et al.* (2023) who documented that the majority of tomato producers in southwest, Nigeria (75%), processors (70%), and input suppliers (60%) were predominantly male. This outcome is also supported with results of Noad and Bamlaku (2017) who reported that the field of agricultural farming is more dominated by male.

Table 4. The Descriptive Analysis of Categorical Variables of Farmers Characteristics among Tomato Producers

Farmers Characteristics	Frequency	Percentages
Marital Status		
(a) Married	178	89.00
(b) Single	22	11.00
Members of Cooperatives		
(a) Yes	174	87.00
(b) No	26	13.00
Sex		
(a) Male	164	82.00

(b) Female	36	18.00
Total	120	100.00

Source: Field Survey (2024)

3.3. The Factors Influencing the Output of Small-scale Tomato Producers

Table 5 presented the MLE (maximum likelihood estimates) using stochastic production frontier model (SPFM) in examining the predictors affecting the output of small-scale tomato growers. The coefficients of all the independent variables (agrochemicals, fertilizer usage, farm size, seeds, and labour) in the model have expected positive signs. The estimated coefficients in the technical efficiency component called the marginal product fall between 0 and 1, thus all marginal products (MPs) are positive and falling at the mean of factors. This aligns with a priori expectations; this outcome is supported by results of Abdulai and Abdulahi (2016) who reported the notable and positive effect of frontier predictors on output of maize producers in Zambia. The mean technical efficiency is less than 1.0 suggesting that all the tomato producers were producing lower than the maximum efficiency frontier. The mean-TE was (0.76) of 76%, this means that averagely the smallholder tomato farmer in the sample needs about 24% additional stimulus to get to the frontier, in other terms, a small-scale tomato farmers lost on equilibrate of 24 percent of produce due to technical inefficiency (TIE).

The coefficient of agrochemicals (0.1674) was positive and was considerably different from zero at 1% probability level. This means the higher the use of pesticides, the more productive the small-scale tomato producers become. This implies that when the small-scale tomato producers adopt and use the agrochemicals appropriately, it would lead to increased output. A 1% increase in agrochemicals applied on the farm, while keeping all other predictors constant will give rise to 16.74% increase in the output of tomato. This result is in line with findings of Nakana et al. (2021) who achieved 15.7% rise in output from 1% increase in pesticides among tomato producers in South Africa.

The coefficient of fertilizer usage as measured in kilograms (0.2316) was positive and was remarkably different from zero at 5% probability level. This means the higher the use of fertilizer, the more productive the tomato farmers become. This implies that when the tomato producers adopt and use the fertilizer appropriately, it would lead to increased output. A 1% increase in fertilizer usage, while keeping all other predictors constant will give rise to 23.16% rise in output of tomato. This result is supported with findings of Fikadu *et al.* (2022) who achieved 38.4% rise in output of tomato from 1% rise in fertilizer usage among producers in Ethiopia.

The coefficient of farm size as measured in hectares is positive (0.1635), and statistically and significantly different from zero in increasing the output of tomato at 1% level of probability. This signifies that as farm size rises by 1% keeping other predictors constant will give rise to 16.35% rise in output of tomato. This result agrees with Folayimi *et al.* (2022) who achieved 29.43% rise in output of tomato from 1% rise of farm size among farmers in Oyo state, Nigeria.

The coefficient of seed (0.1206) is positive and was considerably different from zero at 1% probability level in affecting the output of tomato among producers. The signifies that if quantity of improved seed used increased with required rate by 1%, while keeping all other factors constant, will lead to 12.06% rise in output of tomato farmers. This result is supported with findings of Asfaw (2021) who obtained a 23% rise in output of tomato from a 1% rise in quantity of improved seed used among small-scale producers in Ethiopia.

The coefficient of labour as measured in man-days is positive (0.1526) and significantly different from zero in increasing the output of tomato at 5% probability level. This means that as labour rise by 1% while keeping all other factors constant will lead to 15.26 % rise in output of tomato. This result is similar with findings of Degefa *et al.* (2020) who obtained a positive and notable relationship between labour and output of tomato among smallholder farmers in Ethiopia.

In the diagnostic statistics parts, the coefficient of variance ratio (γ) also termed gamma is 0.8543, this means that 85.43% variations of tomato production from frontier (potential) output was as a result of technical inefficiency, while the balance 14.57% of tomato production deviation from the potential level was due to random noises such as frost, unexpected rainfall, and other natural disaster outside the control of tomato farmers. Therefore, reducing the extent of the effect of variance or gamma ratio will enhance the tomato production and greatly improve the productivity of the producers. The coefficient of total variance (σ^2) also termed sigma square is 2.5683, which is statistically different from zero at 1% level of probability. This hypothesized that perfect goodness of data conform with the Cobb-Douglas stochastic frontier model and the assumptions of the composite error term was correctly specified. The LLF (Log-Likelihood function) is -649.68. The finding is supported with outcomes of Asfaw (2021) who reported the estimated Sigma-squared of 0.57, and Gamma value of 0.89 among tomato producers in Ethiopia.

Table 5. The Factors Influencing the Output among Small-Scale Tomato Producers

Variables	Coefficient	Std. Error.	*P*-value
Agrochemicals	0.1674***	0.0468	0.000
Fertilizer Usage	0.2316**	0.0926	0.021
Farm Size	0.1635***	0.0430	0.000
Seeds	0.1206***	0.0309	0.000
Labour	0.1526**	0.0605	0.034
Constant	2.607***	0.6684	0.000
RTS	0.8357		
Diagnostic Statistics			
δ^2	2.5683***		
Gamma	0.8543		
Log-Likelihood Function	-649.68		
Mean Efficiency Score	0.76		

*Source: Field Survey (2024);*Significant at* $(P < 0.10)$., ***Significant at* $(P < 0.05)$, ****Significant at* $(P < 0.01)$.

3.4. The Return to Scale (RTS) and Elasticity of Production (EP) among Small-Scale Tomato Producers

Table 6 displayed the EP of factor inputs and RTS among small-scale tomato producers. The coefficients of elasticity for significant factors shows that the tomato production is inelastic to changes in all the used factors. The RTS analysis which function as an estimate of total resource productivity. The production function can be used to evaluate the magnitude of the RTS. The constant RTS holds if the sum of all the EP or partial elasticity is equal to one. If the sum is less than one, the function has a decreasing RTS, if more than one, an increasing RTS exists. The partial derivatives are called the EP, marginal product or the partial elasticity. The EP for the factor inputs were agrochemicals (0.1674), fertilizers (0.2316), land (0.1635), seeds (0.1206), and labour (0.1526), respectively. The summation of first order partial derivatives of the output predictors which is termed the RTS or scale efficiency shows the decreasing RTS in the frontier model adding up to 0.8357. This shows that raising all predictors by a certain proportion will lead to a less than proportionate rise in output of the small-scale tomato producers.

The explanation of the estimates that enter directly the production function is reported as partial EP. Additionally, this is documented as a way of examining the degree of responsiveness of a relative change in the output of tomato as a result of a relative change in the factors, this also serves as an estimate of resource productivity of inputs. The estimated coefficients in the TE component fall between 0 and 1, thus all elasticity of productions or marginal products (MPs) are positive and diminishing at the mean of predictors. The sum of the first order derivatives of the output predictors which is termed the scale efficiency shows the decreasing RTS in the frontier model adding up to 0.8357. Increasing all predictors by a certain number will lead to a less than commensurate increase in the output of the small-scale tomato growers. In other words, the summation of the EP or partial elasticities $(\sum \boldsymbol{\varepsilon_p})$ of inputs is 0.8357. This signifies than an increase in all factor at the sample average by 1% will give rise to an increase in the output of tomato by 0.8357 which is significantly different from zero. This outcome is in line with works of Fikadu *et al.* (2022) who achieved RTS of 0.994 which is decreasing return to scale among tomato producers in Ethiopia.

Table 6. Elasticity of Production (EP) of Factor Inputs and RTS (Return to Scale)

Elasticity(ε_p)	Agrochemicals	Fertilizer	Land	Seeds	Labour	RTS= $(\sum \varepsilon_p)$
Estimates	0.1674	0.2316	0.1635	0.1206	0.1526	0.8357

Source: Field Survey (2024)

4. Conclusion

The This study estimated the return to scale and elasticity of production among small-scale tomato producers in Kano and Kaduna States, Nigeria. A multi-stage sampling strategy was utilized to select 200 tomato producers. Primary data from cross sectional sources were utilized based on a well-planned questionnaire. The data were evaluated using descriptive statistics, RTS, EP, and stochastic production frontier model. The following conclusion were made based on the research hypotheses of the study stated in null form:

$\mathrm{H0_1}$:*The coefficient of elasticity of production for each input is not positive among small-scale tomato producers.*

The coefficients of EP were all positive and this is in line with expected signs. The null hypothesis ($\mathrm{H0_1}$) was rejected, while the alternative hypothesis ($\mathrm{Ha_1}$) was accepted. The coefficient shows that all the factor elasticities were inelastic for tomato output, this implies that a 1% rise in each input keeping all other inputs constant will result in a less than 1% increase in tomato yield, where production and resources are believed to be efficient. The coefficients of EP among tomato farmers were agrochemicals (0.1674), fertilizer (0.2316), land (0.1635), seeds (0.1206), and labour (0.1526). This outcome is in line with Nakana *et al.* (2021) who evaluated the elasticities of production among tomato farmers in South Africa and obtained the positive values as follows, land (0.501), capital (0.006), labour (0.192), fertilizer (0.016), seedlings (0.265), and pesticides (0.157), respectively.

$\mathrm{H0_2}$:*The return to scale is not greater than zero among small-scale tomato producers.*

The RTS which is the addition of all input elasticities, was evaluated to be positive and greater than zero. The null hypothesis ($\mathrm{H0_2}$)was rejected, while the alternative hypothesis ($\mathrm{Ha_2}$)was accepted. The RTS was estimated at 0.8357, this indicated decrease RTS. Therefore, a rise in all factors by 1% increases the tomato output by 0.8357. This shows that tomato producers are operating in stage 1 of the production surfaces which is the production that can still be enhanced by using more of the factors. This outcome is in line with outcomes of Fikadu et al. (2022) who obtained return to scale

(RTS) of 0.994 among tomato producers in Ethiopia.

$H0_3$: *There is no significant influence between input factors (agrochemicals, fertilizer usage, farm size, seeds, and labour) and output of small-scale tomato producers*

The input factors included in the stochastic production frontier model had positive coefficients and were decisive. The significant input factors affecting the output of tomato farmers were agrochemicals ($P < 0.01$), fertilizer usage ($P < 0.05$), farm size ($P < 0.01$), seeds ($P < 0.01$), and labour ($P < 0.05$). Therefore, the null hypothesis ($H0_3$) was rejected, while the alternative hypothesis (Ha_3) was accepted. This study confirms with the outcome of Asfaw (2021) who documented that the oxen ($P < 0.05$), labour ($P < 0.01$), land ($P < 0.01$), and seed ($P < 0.01$) were significant input factors affecting output of tomato producers in Ethiopia.

The following suggestions were made based of the findings:

(i) Mechanized Farming: Farm technologies such as machines and tractors should be provided for tomato producers to raise output and efficiency.

(ii)Improved Seeds: High yielding and drought resistant varieties of tomato seeds should be provided for producers to increase output.

(iii) Fertilizers and Other Input: Fertilizers and other farm inputs such as agrochemicals should be made available to tomato producers at appropriate time to increase output and productivity.

(iv) Extension Service Delivery: Extension officers or agents should be engaged to disseminate technologies and new research outcomes to farmers.

(v)Credit Facilities: Credit at single digit interest rate should be provided by public and private organizations to tomato farmers to enable them purchase farm inputs at appropriate time.

(vi) Farmers Group: Tomato producers are encouraged to form cooperative organizations, this group will enable them have access to credit and farm inputs, it will also enable to jointly sell their products in bulk.

Authors' Contributions

All authors are contributed in this research

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Institutional Review Board Statement

All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement

Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable.

Conflicts of Interest

The authors disclosed no conflict of interest.

5. References

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