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Technical Efficiency and Marketing Performance of Turmeric Production

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Abstract: *The study's major purposes were to assess technical efficiency, determine its causes, and measure the marketing performance of turmeric production in the Sheko and Yeki areas. A two-stage random sampling approach was used to select 300 households. Cobb-Douglas and Tobit model were used to investigate efficiency levels and determinants. As a result, the average technical efficiency was 73.72. The average technical efficiency suggests that it was possible to raise turmeric production by 26.28 percent without utilizing additional inputs. Land, labor, oxen, seeds, herbicide, and urea all had a big impact on how much turmeric was produced. The Tobit model revealed that gender, age, household size, the number of plots, and market information substantially impacted technical efficiency. The structure conduct performance model was used to evaluate the performance of the Turmeric market. The findings showed that the markets for Turmeric in the region were non-competitive, with concentration ratios at the Sheko and Tepi markets of 78.5 and 64.2%, respectively. Policies aimed at motivating and strengthening the existing agricultural extension system, and providing appropriate marketing information, is required to improve Turmeric's efficiency and Marketing performance.*

Keywords: determinant; efficiency; frontier; marketing performance

JEL Classification: Q, D

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Introduction

Agriculture is the mainstay of the Ethiopian economy. More than 66% of the population is employed in agriculture directly or indirectly, which accounts for the sector's approximate 33% of the nation's GDP. The sector also produces 76 % of the nation's foreign exchange profits (Anon 2022). Although agriculture has a high contribution, it is characterized by low production because of technical and socioeconomic reasons. Due to ineffective management, limited use of contemporary agricultural technologies, outmoded farming methods, inadequate supplemental services like extension, credit, marketing, and infrastructure, as well as subpar and biased agricultural policies, most farmers with the same resources produce different outputs (Abate, Dessie, and Mekie 2019).

Ethiopia's agricultural policy is focused on increasing the production of marketable farm goods for both internal and international markets. In this sense, spices are high-value crops grown in a market with significant potential. This is a chance for the country to more effectively connect its numerous farmers to domestic and international markets (Mohammed, Baze, and Ahmed 2016a).

In Ethiopia's southern nation nationality people's region, Oromia, and Amhara regions were the main spice producers. They supplied 37, 32, and 25 percent, respectively, of the average annual spice production (Shimelis 2021). In addition to coffee, the production of spices has provided a different chance to expand smallholders' involvement in commercial agriculture in southwest Ethiopia. Smallholders working on tiny parcels of land near homesteads, as well as certain state and private farms, grow the majority of these spices (Mohammed et al. 2016a).

One of the spices turmeric (Curcuma Longa) is a common spice that is used as curry powder, ground spice, food coloring, a component in textile dyes, and a traditional treatment for several illnesses (Güneri 2021). Turmeric is the most productive spice in the world, second only to ginger, with 65 qt/ha, which product is 45 qt/ha, and this spice can be considered a strategic spice for boosting the productivity and output of spices in the globe. Its relevance has grown in global markets, with the majority of demand coming from households as a coloring agent in food items. Aside from food, it has also been employed in the pharmaceutical and dyeing industries. In terms of the importance of turmeric production, smallholder farmers have produced the plant in various agroecological zones, primarily as a source of revenue as well as food (Tesfa et al. 2017). However, as compared to other nations turmeric productivity in Ethiopia is very low. For instance, Ethiopia produced 24 q/ha of turmeric on average, compared to 40 q/ha in India (Addisu 2014).

Policymakers and researchers are motivated to find a method to increase productivity as a result of declining productivity. The measurement of technical efficiency and its determinants among various types of farmers and countries is a useful source of information for this investigation. Efficiency is relative in this research, though, and it frequently varies depending on the farmer groups involved in the product and the country under investigation. Socioeconomic issues, demographic factors, institutional factors, and management inefficiencies all have an impact on agricultural productivity (Alemu, Angasu, and Sime 2022; Ayele and Tarekegn 2021; Borko, Ameda, and Hutton 2021; Dagar et al. 2021; Economics 2019; Journals 2021; Khatiwada 2022; Lema et al. 2022; Tesema 2022; Zinabu Tesfaw 2021).

Measures of efficiency are crucial because they provide both performance indicators and success indicators, (Lovell 1993). It is impossible to test theories concerning the causes of efficiency differentials without first measuring efficiency and distinguishing its impacts from those of the production environment efficiency measurement aids decision-makers in monitoring the performance of the agriculture sectors. When the causes of inefficiency and marketing are identified, a policy that seeks to improve farmers' performance may be implemented effectively. To boost the production efficiency and marketing performance of turmeric, it is necessary to measure production efficiency and pinpoint the causes of inefficiency and marketing performance. The information from this study helped the government and NGOs make decisions about changing existing regulations and coming up with new ones to improve the performance of the turmeric sub-sector. Therefore, the objectives of this study were to assess the efficency level and major causes of technical inefficiencies and marketing performance in the Sheko and Yaki areas' turmeric producers.

Literature Review

(Tesfa et al. 2017) carried out research on the consumption, marketing, and production of spices. They found that prices varied widely and that traders, not the well-known demand and supply balance, determine prices. The study also showed that spice crops have a huge potential for output, which might help the farming community's economy grow. They advised that research and extension should be used heavily to boost spice production and marketing.

The subsector is a significant component of Ethiopia's agricultural sectors, according to a (Shimelis 2021) study on Spices. However, the country's vast potential and chances for spice crop production, marketing, and revenue generation have been underutilized. He also recommends that governmental entities and all other stakeholders focus on improving and enhancing spice crop output and productivity levels to meet the projected ever-growing domestic market and international trade demand.

According to a (Neuberger 2014) study, has enormous potential for growing a variety of spice crops. The average annual land covered by spices and annual production is approximately 222,700 ha and 244,000 tons, respectively. Ethiopian spice production increased from 107,000 to 153,000 tons between 1995 and 2011, with an annual growth rate of 9.5%, in response to global and domestic consumption(Goshme 2019). According to the Ethiopian Ministry of Industry (EMI 2015), even though Ethiopia possesses favorable or conducive settings for varied spice cultivation, spice output in Ethiopia is generally considerably below expectations (EMI 2015; Neuberger 2014).

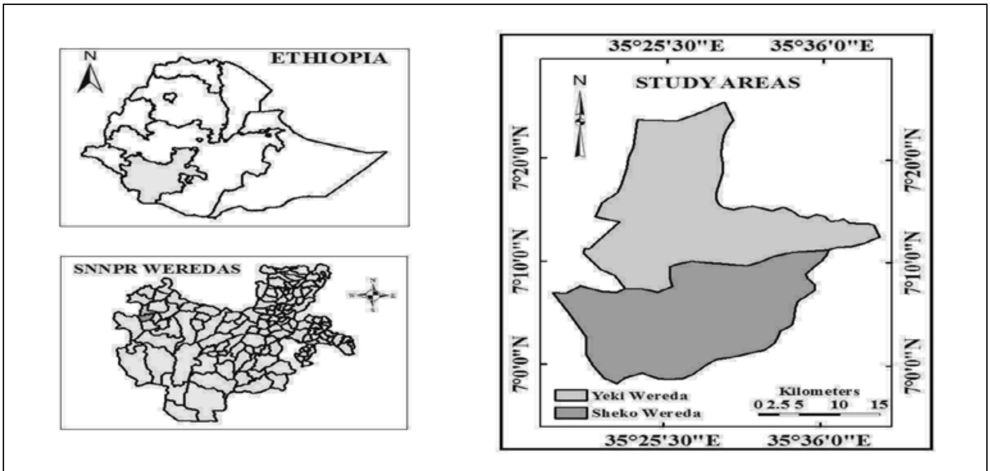
(Hailemichael, Kifelew, and Mitiku 2016)attempted to address the production difficulty of turmeric production; according to them, turmeric has faced the challenge of declining output volume and discontinuity of technology adoption by most farmers due to weak marketing incentives.

Methodology

Research Topic Description

This study was conducted in the South West Ethiopia Region, namely in the Bench-Sheko and Sheka zones. Where spices, particularly turmeric, are widely grown. Both zones are well known for their abundant forest resources and significant potential for coffee and spice production. The majority of smallholder farmers in the studied areas cultivate coffee, cereals, spices, and livestock. Coffee and lowland spices constitute the majority of monetary earnings, whereas maize, sorghum, and imitation banana are primarily grown for domestic use. Furthermore, the research location is one of the most appealing in the South West Ethiopia Region for purchasing many large-scale commercial farms and committing a significant quantity of land to commercial agriculture (Mohammed, Baze, and Ahmed 2016b).

Figure 1: Map of the research region



The Sheka and Bench-Sheko zones cover around 30.9 percent of the region's total area, with a total size of 225,966.23 kilometers. The two zones receive evenly enough distributed rainfall with only a brief dry period and moderate to hot temperatures. With an average rainfall of 400 to 2200 mm, the zones' mean temperatures range from 10.1 to 29.5°C (SNNPRs website). The two zones' combined population is expected to be 1,017,260 people, with 501,630 men and 515,630 women; 15.8% of the population resides in cities, while 84.2 percent lives in rural areas (CSA 2013).

Data Type and Source

Primary and secondary sources of data were used to examine the technical efficiency of turmeric in the Bench-Sheko and Sheka zones, both qualitatively and quantitatively. Personal interviews with farmers and a questionnaire with semi-structured were used to obtain primary data. These questionnaires were used to gather demographic, institutional, farm features, and socioeconomic aspects and turmeric yields and inputs used by each household head to cultivate turmeric. A focus group discussion and key informant interview with model farmers, agricultural office representatives, and a few chosen household heads (HH) with knowledge of turmeric cultivation were conducted.

Data collecting method

The pre-tested questionnaires were distributed across the research zone with the help of well-trained enumerators once the necessary questionnaire revisions and adjustments had been performed.

Sampling technique and sample size determination

To generate an adequate sample, a purposive and two-stage random sampling strategy was applied. Bench-Sheko and Sheka zones were chosen. Because of the massive amount of output, geographical distribution, and large number of turmeric growers. Depending on the study objectives, the Sheko and Yeki districts were chosen purposively. Turmeric is grown in 10 of the 24 kebeles in the Sheko district, and 20 of the 22 kebeles in the Yeki district.

Because the focus of this study was on the efficiency and marketing of smallholder turmeric growers, the key goals in sample selection were turmeric producer kebeles. In the **first step**, two kebeles from the Sheko and four from the Yeki districts were picked randomly. In the **second step**, using a sampling frame that has a list of turmeric producers a total of 300 sample farmers were selected proportionality by considering the number of farmers found in each selected kebeles.

Data analysis method

The data were examined using econometric models and descriptive statistics. Descriptive statistics (mean, standard deviation, frequency, and percentage) were used. S-C-P, concentration ratio, marketing margin, and percentage values were employed as descriptive statistics.

Structure, behavior, and performance (S-C-P): (Shoa et al. 2021) all used this model to examine the food grain, pepper, teff, and wheat markets, respectively. As a result, the S-C-P model was used to examine the turmeric market in this study. The core concept of the S-C-P approach is that there is a link between a market's structural organization and its members' competitive behaviors, which can affect market performance (Neuberger 2014).

Concentration proportion: It is the proportion of overall market sales accounted for by a particular number of large farms. It is one of the most often used market structure measurements, and it is commonly referred to as the number and size distribution of market suppliers and purchasers. In general, a concentration ratio of 50% or above among the four largest firms indicates a strong oligopolistic industry, 33-50% suggests a weak oligopolistic industry and less than that implies no concentrated sector (M. Mkpado Anzaku T. A. K. 2011), the standard metric of market concentration ratio is used to assess firm concentration in the market. It was calculated for this inquiry as follows:

$$Cr = \sum_{i=1}^{n} Msi \tag{1}$$

where

Cr - is the concentration ratio

Msi - is the ith firm's market share, and n- is the total number of significant firms for whom the ratio will be calculated.

Marketing Margin: The amount that separates what the consumer pays for the finished good from what the producer receives is known as the marketing margin(M. Mkpado Anzaku T. A. K. 2011). The TGMM, as calculated (Ayele 2017) is always proportional to the final cost incurred by the end user.

$$\text{TGMM} = \frac{\text{END BUYER TURMERIC} - \text{PRODUCER'SPTURMERIC}}{\text{END BUYER PTURMERIC}} * 100 \tag{2}$$

The amount of the price paid by the final consumer or final buyer that belongs to the farmer as a producer is known as the producer's participation or producer's gross margin.

$$\text{GMM}_{\text{P}} = \frac{\text{END BUYER PTURMERIC} - \text{GTMM}}{\text{END BUYER PTURMERIC}} * 100 \tag{3}$$

Where: Farmers' component of the GMMp (producers' participation)

The following formula is used to calculate market intermediaries' shares of consumer price (in this case, retailer selling price):

$$GMM = \frac{SP - BP}{EBP} * 100 \tag{4}$$

Where: Gross Marketing Margin (GMM) = (%), Buying price is BP,
SP stands for the level's selling price, End buyer price (EBP)
Another way to determine producer share is as follows:

$$PS = \frac{Px}{\Pr} = 1 - \frac{MM}{\Pr} \tag{5}$$

Where: PS = Producer's share, Px = Price of turmeric at retail stores
Pr = Turmeric produced price and MM = Marketing margine

Econometric Model specification

We can test for the optimal specification while taking measurement error and random effects into account using the stochastic frontier technique. As a result, the stochastic frontiers approach was employed in this work because of the unpredictability of agricultural productivity. The stochastic technique accounts for both random error and the inefficiency component (Md, Anton, and Mohammad 2009). The functional form of the model for this investigation was established following (Aigner, Lovell, and Schmidt 1977).

$$y_i = f(X_i.\beta) + \varepsilon_i \tag{6}$$

Where: - y I = the ith sample farmer's outcome, Xi = vector and f()=functional form and ei = error terms.

The most often used functional forms for selection and estimation in empirical production analysis research have been the Cobb-Douglas and Translog functions. There are benefits and drawbacks to each active kind. According to some scholars, the Cobb-Douglas functional form is superior to the others. It permits a comparison of suitable data fit and computational efficiency. In terms of degrees of freedom, it is relatively conservative and good for interpreting production elasticity. It is frequently used to study border production processes(Sarker and De 2004). However, the elasticity of substitution is equal to one, this simplicity has severe drawbacks(Coelli 1998). The estimated Cobb-Douglas production model is provided by:

$$Y_i = \beta_o * \prod_{i=1}^{n} X_i^{\beta_i} * e^{(V_i} - U_i) \tag{7}$$

To "estimate the level of efficiency in turmeric production of smallholder farmers in the research region," a stochastic frontier with a Cobb-Douglas production function type was transformed into a double log-linear form using the methods of (Aigner et al. 1977).

$$"lny_i = In\beta_0 + \sum_{j=1}^{6} \beta_j \, lnx_{ij} + v_i - u_i = \cdots \ldots, \quad (8)$$

Where: ln = natural logarithm; Y = the output; X_1 = the area in ha; X_2 = the number of man-days employed by hired and family labor; X_3 = kg of seed used; X_4 = the kilograms of fertilizers (Urea) used; X_5 = herbicide in a litter X_6 = the amount of oxen, j = is a vector of parameters that need to be estimated. V_i is an asymmetric error term that accounts for the departure from the frontier caused by variables beyond the farmer's control.

The Translog functional form, on the other hand, has no constraints on returns to scale or replacement options. The problem of degrees of freedom and multicollinearity, on the other hand, is a severe issue with the Translog production function(Coelli 1998).

The ratio of observed production values to the estimated frontier values yields the technical efficiency (TE) for specific farms. If and only if TE = 1, the value obtains its maximum possible value; otherwise, TE_i.=0. The TE for the ith farm may be calculated as follows:

$$TE = \frac{\log y_i = \beta_0 + \sum_{j=1}^{n} \beta_j \, logx_{ij} + v_i - u_i}{\log y_i = \beta_0 + \sum_{j=1}^{n} \beta_j \, logx_{ij} + v_i} \ldots .. \quad (10)$$

Factors affecting effectiveness

The two-limit Tobit model was used to regress technical efficiency scores on a collection of explanatory variables. This model is ideally suited for such research because of the nature of the dependent variable (efficiency scores), which can take values between 0 and 1, and gives trustworthy estimates for the unknown parameter vector (Maddala 1986). The two-limit Tobit model is as follows:

$$Y^*_{i\,(TE,AE,EE)} = \delta_0 + \sum_{j=1}^{10} \delta_j{}' \; X_{jK} + \mu_i \quad (11)$$

Where Y (i)* is the latent variable representing the efficiency scores, 0 and (1), are parameters to be estimated, Xj represents the institutional, socioeconomic, and demographic factors that influence efficiency level, and μ_i = an error term that is independently and normally distributed with mean zero and constant variance.

Result and Discussion

Smallholder farmers' sex: In terms of gender, about (57) 15.83 percent of smallholder farmers were female, while the rest (303) 84.17 percent were male. Female smallholder farmers confront more hurdles in agricultural output than their male colleagues. Because females are responsible for numerous household domestic duties, and they may not complete farming activities on time and efficiently. Additionally, compared to male smallholder farmers, female smallholder farmers are more likely to use fewer inputs and have less practical knowledge of farming practices.

One of the biggest obstacles to smallholder farmers' successful participation in agricultural output that is market-oriented is access to market information. Furthermore, market access has a significant impact on how integrated they are. One of the key policy targets that must be taken into account in efforts to increase the marketing, resource use efficiency, and productivity of smallholder farmers is market intelligence. The survey's findings so demonstrate that 48 (13.33%) of farmers have access to precise market data regarding turmeric production. However, the reaming 312(86.67) did not yield any information.

Table 1: Major turmeric production constraints

Major constraint	Rank	Their share in%
Labor consuming	1st	53
Low price	2nd	20
Inadequate market knowledge	3rd	11
Insufficient transportation	4th	9
Water shortage	5th	5
Insufficient storage options	6th	2

As shown in Table 1, one of the key issues impeding turmeric production in the research region was the high labor force needed for turmeric production. This outcome was also corroborated by the information gathered during the focus group. Because turmeric is a bulky product, it needs additional effort for digging, collecting, watering, boiling, polishing, and drying. The second significant limitation was low pricing, followed by a lack of market knowledge, a lack of transportation, a scarcity of water, and a lack of storage facilities, resulting in low turmeric crop yield.

Market Performance of Turmeric Products in Yeki and Sheko Districts

Market Structure: The major turmeric output market chain actors were the following. **Producers:** In Yeki and Sheko districts, on average, sample turmeric producers produce 47636qt per year in the 2020/21 production season. Out of their produce, 20,102.39qt was sold to big wholesalers, 15,348.32qt to local wholesalers 11,337.37qt to local collectors, and the rest to small processors.

Local Collectors: They bought 23.8 % of producers' amount of turmeric sold in the 2020/21 production season. Of their total purchase in the districts, 64.72% was sold to local wholesalers, and the rest 35.28% were too big for wholesalers.

Local wholesalers: The total quantity of turmeric purchased by local wholesalers from sample producers during the 2020/21 production season was 32.22% on average. In turn, local wholesalers supplied 100% of their turmeric produce to Tepi traders

Big wholesalers: They bought turmeric from Yeki and Sheko towns. But, Most of the big processors are found in the Tepi market. They sold their 100% produce directly to exporters in Addis Ababa.

Market concentration

Table 2: Concentration of Yeki Market

No traders (A)	**Cumulative frequency of traders** (B)	**%shares of traders** $(D=\frac{A}{24})$	**Cumulative % of traders** (E)	**Quantity purchased in Qt** (F)	**Total Quantity purchased In Qt** (G=A*F)	**%shares of Quantity purchased** $Si=(\frac{G}{61,728})$	**% Cumulative purchased** $C=\Sigma_{i=0}^{r}Si$
1	1	4.2	4.2	13400	13400	21.7	21.7
1	2	4.2	8.4	12008	12008	19.7	41.4
1	3	4.2	12.6	12000	12000	19.4	60.8
1	**4**	4.2	16.8	2100	2100	**3.4**	**64.2**
1	5	4.2	21	2000	2000	3.2	67.4
1	6	4.2	25.2	1970	1970	3.2	70.6
1	7	4.2	29.4	1870	1870	3	73.6
1	8	4.2	33.6	1760	1760	2.9	76.6
1	9	4.2	37.8	1600	1600	2.6	79.1
3	12	12.5	50.3	1200	3600	5.8	84.9
4	16	16.7	67	980	3920	6.3	91.2
3	19	12.5	79.5	780	2340	3.8	95
2	21	8.3	87.8	760	1520	2.5	97.5
1	22	4.2	92	560	560	0.9	98.4
2	24	8.3	100	540	1080	1.7	100
24		100			61,728	100	

Source: Own survey (2021)

Tables 2 and 3 showed that, in the Yeki and Shko marketplaces, respectively, the four biggest turmeric traders held 64.2% and 78.5% of the total amount of purchases annually. According to the rule of thumb criteria, both the Yeki and Sheko turmeric markets displayed a significant oligopolistic market structure.

Table3: Concentration ratio of traders in the Sheko market

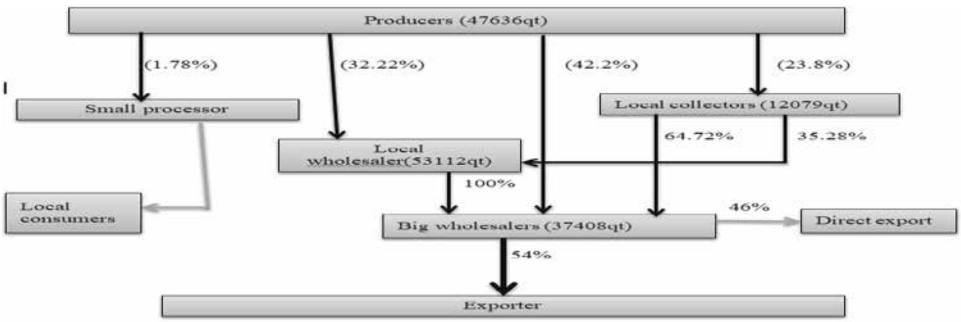
No traders (A)	**Cumulative frequency of traders** (B)	**%shares of traders** $(D=\frac{A}{12})$	**Cumulative % of traders** (E)	**Quantity purchased in Qt** (F)	**Total Quantity purchased In Qt** (G=A*F)	**%shares of Quantity purchased** $Si=(\frac{G}{21,680})$	**% Cumulative purchased** $C=\Sigma_{i=0}^{r} Si$
1	1	8.3	8.3	7000	7,000	32.3	32.3
2	3	16.7	25	4500	9,000	41.5	73.8
1	**4**	**8.3**	**33.3**	**1008**	**1,008**	**4.7**	**78.5**
1	5	8.3	41.6	699	699	3.2	81.7
1	6	8.3	49.9	680	680	3.1	84.8
2	8	16.7	66.6	600	1,200	5.5	90.3
1	9	8.3	75	560	560	2.6	92.9
1	10	8.3	83.3	540	540	2.5	95.4
2	12	16.7	100	500	1,000	4.6	100
12		100			21,680	100	

Source: survey result, 2021

Major Channels for Turmeric Products in the study area

The majority of the routes began with manufacturers and travel through significant wholesalers to reach terminal markets in a major city (Addis). So, in the study area, the following four turmeric market channels were identified.

Figure 2: Marketing channels of turmeric



Channel I: Producers ⟶ Big wholesalers ⟶ Exporters (42.2%)

Channel II: Producers ⟶ Local Collectors ⟶ Big wholesalers ⟶ Exporters (23.8%)

Channel III: Producers ⟶ Local Collectors ⟶ wholesalers ⟶ Big wholesalers ⟶ Exporters(23.8%)

Channel IV: Producers ⟶ Local wholesalers ⟶ Big wholesalers ⟶ Exporters (32.22%)

Among the four channels observed in the study areas, channel one (channel I) is very important in terms of volume.

Structure, Conduct, and Performance of Turmeric Markets

Structure of Turmeric Markets: Degree of transparency, in the research area, there was no formal structure in place to give trustworthy market information to all market players. Approximately 89 and 11% of sample traders, respectively, acquired pricing information over the phone and in the market.

B. Barriers to Entry and Exit in the Turmeric Market: Approximately 89.8% of the sample trader respondents were not licensed in spice dealing, whereas 10.2% of the traders had licenses. The majority of the traders in the research areas are exporters, large whole salters, and minor processors. As a result, the license is not a barrier to entry into the turmeric trade.

Capital: Capital is the foundation for considering any type of company initiative. In the research areas, 77.9, 16.6, and 5.5% of sample merchant respondents used their money, loans, and friends, respectively. The collateral demanded by money lenders such as banks and micro-financial institutions (MFI) complicates and bores the system. As a result, one of the major barriers to entry into the turmeric trade in the research regions was a lack of cash

Access to the channel: Through long-standing agreements, a few large wholesalers, no more than four, dominate access to distribution channels in Ethiopia's major cities. This suggests that to gain entry into a new market, it is critical to identify a reliable partner with whom to collaborate.

Lack of trading experience: The sample traders have between 2 and 30 years of trading experience, with an average of 9.8 years. The fact those dealers' years of experience span a wider range suggests that expertise is not a barrier to entry into the spice market.

Conduct of Turmeric Traders: This study's analysis of market behavior revealed elements like price-setting methods, transaction transparency, and payment terms.

Mechanisms for Setting Prices: In line with (Olwande and Mathenge 2011) result, 75% of producers said they negotiated a price that was set by large wholesalers; the remaining 10% and 15% said the market price was determined by the market and negotiation, respectively.

Trading approach for purchases and sales: Buyers and the market (demand and supply), according to approximately 75, 17, and 8% of sample trader respondents, negotiate the purchase price, respectively. This conclusion is consistent with the price-setting practices of the producers, demonstrating that the turmeric market was opaque in the research locations.

Sources and Transparency of Information: Out of all responders, 83.34% identified information access as one of the marketing challenges for turmeric. This suggests that one of the reasons for a flawed market was imperfect information. Regarding price and the state of the market as a whole, producers had no official source of information. This result is consistent with that of (Kassa and Alemayehu 2017).

Turmeric Market Performance Analysis in the study areas

Marketing margin: The top channels II and III (51.32%) in terms of total gross marketing margin. The lowest TGMM, 46.05%, was recorded by Channel I. The greater marketing margins in all three channels, according to(Sicelo Ignatius Dlamini and Wen-Chi Huang 2020), were reliable signs that the research area's marketplaces for turmeric were unsatisfactory.

Regarding the producers' percentage of the final price for the turmeric market chain, producers made up 53.95% of it in channel I, which connected them to exporters via large wholesalers, and 52.63% in channel IV, which connected them to exporters via small and large wholesalers.

Table 4: Gross marketing margins of turmeric market chain actors

Actors	**Birr per quintal**	**I**	**II**	**III**	**IV**
Producers	Selling price	410	370	370	400
	GMMp (%)	53.95	48.68	48.68	52.63
local collectors	Purchase price		370	370	
	Selling price		400	400	
	GMMr (%)		7.5	7.5	
Wholesalers	Purchase price			400	400
	Selling price			510	510
	GMMw (%)			27.5	27.5
Big processor	Purchase price	410	400	510	510
	Selling price	760	760	760	760
	GMMr (%)	46.05	47.37	32.90	32.90
TGMM	%	46.05	51.32	51.32	47.37

TGMM, GMMp, GMMlc, GMMlw, and GMMbw represent the gross marketing margin of the total, producers, local collectors, local wholesalers, and big wholesalers, respectively.

Econometric Results and Test of Hypothesis

Before determining the model parameters from which individual-level efficiencies were derived, numerous model definition assumptions must be considered. As a result, two possibilities were investigated as indicated in Table 5.

Table 5: GLR hypothesis testing for SPF parameters

Null hypothesis	LH_O	LH_1	Calculated X^2 (LR) value	Critical value ($\chi 2$, 0.95)	Decision
H0: = β_{ij} = 0	-214.89	-230.54	31.3	40.11	Accept
H0: = = ... = 0	-230.54	-198.05	64.98	16.92	Reject Ho

Source: model output (2021)

Estimate of the production function

Table 6: Production function estimation for the Cobb-Douglas frontier

Ln Output	Coeffi.	Std. Err.
Cons	1.35***	0.401
LN Seed	0.131**	0.054
LN Land	0.143***	0.036
LN Oxen power	0.281***	0.055
LN Labor	0.243***	0.059
LN Urea	0.015***	0.005
LN Herbicide	0.032***	0.008
Sigma v	0.3706	0.0327
Sigma u	0.4222	0.0801
sigma2	0.32***	0.100
Lambda	1.14	0.110
Log-likelihood function	-230.89	
Return to scale	0.845	

Source: Model output; ***, ** denotes significance at 1 and 5 percent (2021)

The calculated model's dependent variable was turmeric output (Qt) produced during the 2020/21 production year. The area under turmeric (ha), labor (man-days), two oxen-days, urea (kg), seed (kg), and herbicide (L/kg) were the input factors.

The output level of turmeric was absolutely and meaningfully predisposed by all of the input variables in the production function, including land under turmeric, oxen power, labor, seed, herbicide, and urea, according to the results of the frontier model study. The production function's coefficients serve as a representation of elastic properties. Because of this, the output of oxen was highly elastic, which demonstrated how sensitive the production of turmeric was to oxen power (0.281). When all other variables were constant, a 1% increase in oxen power over two oxen days led to a 0.3% increase in turmeric yield.

Scores of sample households' efficiency

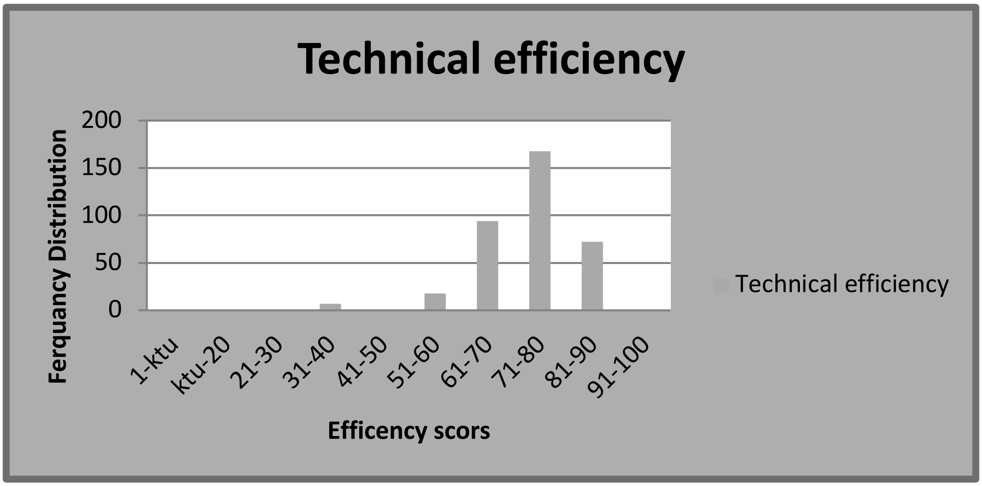
Table 7: Efficiency score in summary

Efficiency scores	Technical efficiency	Mean	Std. Deviation	Minimum	Maximum
1-10	0	73.72	0.0937	31.89	91.22
10-20	0				
21-30	0				
31-40	7				
41-50	0				
51-60	18				
61-70	94				
71-80	168				
81-90	72				
91-100	1				

Source: model output (2021)

According to the efficiency ratings, there were significant disparities in TE across turmeric producer families, and TE was found to have a mean of 73.72 percent. The typical TE demonstrates that farmers may lower inputs (land, urea nitrogen, labor, herbicide, and seed) by 26.28 percent and yet generate the same yield. According to the model output (table 7), sample farmers in the study region were reasonably proficient in TE.

Figure 3: Frequency distribution of technical efficiency



Most sample farmers have a technical efficiency score between 71 and 80 percent, according to the frequency distribution of those values in Figure 2. However, several study households only had TE levels between 31 and 70, or 33.06 percent. Sample producers in this group have the potential to increase their output of turmeric by an average of at least 30%. 0.28 percent of the households in the entire sample have TEs that are higher than 90%. It suggests that approximately 99.27 percent of the sample farmes can boost their output by 10%.

Technical Efficiency Factors in Turmeric Production

Table 8: Estimates from the Tobit model

Technical efficiency			
Variables	Coef.	Std. Err.	ME $[\partial(\varphi(Z_U) - \varphi(Z_L)]$
SEX	0.032**	0.0134	0.0256
AGE	0.002***	0.0004	0.0012
Education	0.002	0.002	0.0012
NOFIC	0.010	0.030	0.0001
Household Size	0.003***	0.001	0.0016
No. plots	-0.011***	0.003	-0.0068
Extension	-0.003	0.011	- 0.0017
Livestock	0.005	0.010	0.0034
Ln credit	0.001	0.001	0.0005
MKT info	0.060***	0.014	0.0237

1%, 5%, and 10% are represented by ***, **, and *, respectively. Results of the model (2021).

Discussion

The findings of the Tobit model are reported in (table 8), and only the important explanatory factors expected to influence the technical efficacy of smallholder turmeric producers were investigated.

The hypothesis stated that the head of the household's sex would significantly and favorably affect TE at a rate of 5%. Male HH fared better than female HH, according to the findings. The most likely explanation is that male households handled the majority of farm work, particularly land preparation, and had more regular follow-up and farm supervision, allowing them to complete agricultural activities faster and more successfully than female farmers.

The likelihood that male farmers will be wealthy and able to use new, expensive agricultural technology may also have a favorable effect. The marginal effect also shows that the risk of becoming efficient is increased by increasing the dummy variables that reflect the male and female HH order with 1 and 0, respectively. This result contrasts with that of Muluken and Twodros, who showed that the sex of the respondent statistically significantly negative impact on technical inefficiency at a 10% level of significance. It provides a great opportunity for female-led farmers to regularly monitor and oversee their crops (Philipos 2021) and also (Asfaw and Ali 2022) showed that when families were headed by a man, their level of efficiency was generally higher than when they were headed by a woman. Thus, the average technical efficiency for male- and female-headed people was 83% and 67%, respectively.

Household age: In Table 8, it was determined that the computed age-technical efficiency connection was favorable and significant at 1%. This result indicates that HH's technical efficiency increases with age and is related to the level of its agricultural proficiency. Furthermore, the marginal effect of age on technical efficiency (TE) demonstrates that, for the sample period, each additional year of age is associated with a 0.12% increase in the likelihood of being technically effective. This result is in agreement with those of (Baloyi 2011; Begum et al. 2019) findings, who described that the coefficients of age were positively significant at 1 and 5 %, respectively. And as opposed to the result of (Zewdie et al. 2021) finding, who investigated age has a statistically significant and negative association with teff production technical efficiency at a 5% level of significance (Baloyi 2011; Begum et al. 2019; Zinabu Tesfaw 2021).

Family size: At the 1% level of significance, the number of family members residing in the farmers has a positive and substantial effect on technological efficiency. The results show that involvement in the labor force has a greater impact on turmeric output than on consumption. This result may be explained by the fact that having a bigger household size ensures there will be enough family labor to complete farm work on time. Because turmeric is a large commodity, production during busy times requires a lot of labor. Due to the labor scarcity, homes with big family sizes would need more labor than their counterparts to complete necessary farming tasks like a plow, cutting finger rhizomes, gathering by digging, boiling, drying, and up to loading activities on schedule. Tenaya, 2020 discovered that the technical efficiency coefficient of family size was 5%, both positive and significant, which is consistent with the findings.

They reasoned that farmers with large family sizes are more productive than those with small families because they can manage their crop plots more effectively and apply the correct input combination (Tenaye 2020). This result also contradicted the findings of (Zewdie et al. 2021), who discovered that TE was positive and significant at a 1% significance level. According to him, smallholder farmers in the research area grow crops on plots of land that are typically less than half a hectare in size, making it difficult to employ many workers in the crop production process. The number of workers (household members who are actively employed) increases with family size and decreases with the dependence ratio. As a result, a small farm plot size results in poor TE when the workforce for agricultural production is increased (Zewdie et al. 2021).

Land Fragmentation (LFRG): It has a significant and negative impact on the technical efficency of turmeric production, contrary to the predicted outcome. The marginal effect finding also indicated that increasing the number of plots by one results in a 0.68 drop in the chance of being technically efficient It might be because fragmented land makes families less productive, wastes time, and diverts resources that ought to be available simultaneously. This outcome was consistent with Bati's 2017 conclusion. According to him land fragmentation had a detrimental effect on TE. Technical efficiency fell by 0.31% for every unit increase in the number of plots. Additionally, if the farmer operates more plots, it can become more challenging to manage. Farmers that have a lot of plots, in his opinion, can squander time traveling between them(Bati, Mulugeta Tilahun, and Parabathina 2017). This outcome did not coincide with Tolesa's 2022 and Alemu, Angasu, and Sime's 2022 analysis results showing a positive association between farm size and production efficiency. He discovered that this variable was significant at a 1% level of significance. A 1% increase in the quantity of land used for producing different crops results in a 0.97% improvement in the farmer's productivity, according to the coefficient of the size of the farm used for crop production (Tesema 2022; Alemu, Angasu, and Sime 2022).

Market information (MKT): It was the last but certainly not least explanatory factor that contributed to the technical efficency. The result demonstrates that, at the 5% level of significance, market information availability has a significant and positive impact on TE. The ME results also reveal that the likelihood of farmers being technically efficient rises by 2.37 for every unit increase in the dummy variable indicating access and lack of availability of market data, classified from 1 to 0. It was comparable to the findings of (Mulatu 2019) which showed that having access to market knowledge had a good and significant impact on how efficient a company was (Mulatu 2019; Weldegiorgis 2019).

Conclusion

This study shows that turmeric growers have a great deal of space for technical efficiency improvement. The Cobb-Douglas production function had a positive sign, which means that the primary limitations were related to land, labor, and oxen power. Positive coefficients for these variables imply that output was elevated to a higher level by using more of these inputs. The typical technical efficiency of the study households was 73. Technically efficency farmers might increase turmeric production by an average of 26.28 percent without increasing input costs.

Producers, local collectors, local wholesalers, and big wholesalers were identified as market chain participants in the research areas, according to the S-C-P results. Tepi and Sheko markets have market concentration percentages of 64.2% and 78.5%, respectively. This indicates that both marketplaces had an oligopolistic market structure. The Total growth market margin suggested that the turmeric marketplaces were imperfect. Seasonal price fluctuations, the presence of a few large dealers, restricted access to information, and the lack of an organized market center all had a significant impact on the functioning of the turmeric market in the research area. As a result, turmeric marketing in the research locations was shown to be ineffective.

The important elements influencing the degree of efficiency improvements were found to assist various stakeholders in increasing the current efficiency level in turmeric production. As predicted, gender, age, household size, number of plots, and market knowledge all positively and substantially influenced technical efficiency. This means that older male farmers with larger family sizes (man-equivalent), had access to more market knowledge and were more technically efficient than their peers. The number of plots, on the other hand, hurt technical efficiency. As a result, farm households with more plots were technically less efficient than others.

Government attention is required to engage and assemble the pastoral people, especially the young, in agronomic activities through incentives due to the positive influence of family size on farm producers' technical efficiency.

Market information was discovered to impact smallholder turmeric growers' technical efficiency positively. As a result, policymakers must provide appropriate marketing information to smallholder turmeric growers to support market participation and integration.

Finally, by adopting technology that lowers labor costs as well as the price of wood and water, there is tremendous potential to increase the technical efficiency of turmeric production. For academics and politicians trying to boost the productivity of turmeric producer farmers, this study served as a benchmark.

Recommendations

Policy changes are made in the research region to improve efficiency and marketing performance based on the study's findings.

The efficiency of older farmers was lower than that of younger farmers. As a result, older farmers need ongoing training and support while running their farms, which the Woreda agricultural office, development agents, and NGOs may be able to supply. However, the younger one should also be taken into account.

Technically speaking, female smallholder farmers were less effective than male smallholder farmers. Therefore, encouraging new technologies that lessen the domestic responsibilities of female smallholder farmers would raise their technical efficiency level in the production of turmeric. For male smallholder farmers to increase their technical efficiency level, it is also crucial to strengthen their ability for resource allocation in a way that minimizes costs and for crop management through training and experience sharing from these farmers.

Policy attention is needed to inspire and organize the rural population, especially the youth, in agricultural activities by offering incentives, as family size positively impacts farm farmers' technical efficiency.

Market information was discovered to have a favorable impact on smallholder turmeric growers' technical efficiency. As a result, policymakers must focus on providing appropriate marketing information to smallholder turmeric growers to support market participation and integration.

The functioning of the turmeric market in the research area was significantly impacted by seasonal price variations, the existence of a few large dealers, the restriction of information access, and the absence of a well-organized market center. To improve the performance of the turmeric market, efforts must be taken to address the problems.

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Conflicts of interest/Competing interests

There is no conflict of interest/Competing interests.

Availability of data and material

The data that support the findings of this study are openly available in the website of World Bank (www.worldbank.org).

Code Availability

The computer program results are shared through the tables in the manuscript.

Authors' Contributions

Tsegaye Melese: perform tasks like, Model selection, Data analysis, report writing, article preparation and selection and communication with journal editors and reviewer comments.
Nigus Gurmis: contribute in literature review, data collection and data entry to the computer.

REFERENCES

Abate, Tadie Mirie, Abebe Birara Dessie, and Taye Melese Mekie. 2019. "Technical Efficiency of Smallholder Farmers in Red Pepper Production in North Gondar Zone Amhara Regional State, Ethiopia." *Journal of Economic Structures* 8(1):1–18.

Addisu, A. 2014. "Spice, Herbs and Aromatic Plants Subsector Platform." in *First Ethiopian Spice Platform Stakeholders Meeting*.

Aigner, Dennis, C. A. Knox Lovell, and Peter Schmidt. 1977. "Formulation and Estimation of Stochastic Frontier Production Function Models." *Journal of Econometrics* 6(1):21–37.

Alemu, Gosa, Birhanu Angasu, and Nimona Sime. 2022. "Economic Efficiency of Smallholder Farmers in Maize Production in West Hareghe Zone , Oromia National Regional State , Ethiopia." 11(2):98–104. doi: 10.11648/j.jwer.20221102.14.

Anon. 2022. "The Ethiopian Agricultural Transformation Institute (ATI)." 39.

Asfaw, Dagmawe Menelek, and Abdurhman Kedir Ali. 2022. "Review on Economic Efficiency of Vegetable Production in Ethiopia." 3(1):16–24. doi: 10.11648/j.advances.20220301.14.

Ayele, Assefa, and Kassa Tarekegn. 2021. "Comparative Analysis of Technical Efficiency of Wheat Production in Row Planting and Broadcasting Methods : Empirical Evidence from Southern Ethiopia." *African Journal of Science, Technology, Innovation and Development* 0(0):1–10. doi: 10.1080/20421338.2021.1890899.

Ayele, Solomon. 2017. "Analysis of Market Structure , Conduct and Performance of Beef Cattle : The Case of Dugda District , East Shoa Zone , Oromia Regional State , Ethiopia." (1):5–11.

Baloyi, Rebecca Tshilambilu. 2011. "Technical Efficiency in Maize Production by Small-Scale Farmers in Ga-Mothiba, Limpopo Province, South Africa."

Bati, Mustefa, Dr Mulugeta Tilahun, and Raja Kumar Parabathina. 2017. "Economic Efficiency in Maize Production in Ilu Ababor Zone, Ethiopia." *Research Journal of Agriculture and Forestry Sciences ISSN* 5(12):8.

Begum, M. E. A., M. A. Monayem Miah, M. A. Rashid, M. T. Islam, and M. I. Hossain. 2019. "Economic Analysis of Turmeric Cultivation: Evidence from Khagrachari District." *Bangladesh Journal of Agricultural Research* 44(1):43–58.

Borko, Muluken Philipos, Tewodros Tefera Ameda, and James Hutton. 2021. "Technical Efficiency of Maize Production in MeskanWoreda of Gurage Zone Technical Efficiency of Maize Production in MeskanWoreda of Gurage Zone." (February). doi: 10.14662/IJEBM2020.125.

Coelli, Tim. 1998. "A Multi-Stage Methodology for the Solution of Orientated DEA Models." *Operations Research Letters* 23(3–5):143–49.

CSA. 2013. *Ethiopia Rural Socioeconomic Survey (ERSS) Survey Report*.

Dagar, Vishal, Muhammad Kamran, Rafael Alvarado, Muhammad Usman, Abdulrasheed Zakari, Abdul Rehman, Muntasir Murshed, and Brayan Tillaguango. 2021. "Variations in Technical Efficiency of Farmers with Distinct Land Size across Agro-Climatic Zones : Evidence from India." *Journal of Cleaner Production* 315(June):128109. doi: 10.1016/j.jclepro.2021.128109.

Economics, Agricultural. 2019. "Economic Efficiency of Smallholder Farmers in Rice Production : The Case of Guraferda Woreda , Southern Nations Nationalities People ' s Region ,." 8(2):151–67.

EMI. 2015. *Export-Volume-and-Value-of-Ethiopian-Spice-Crops-from-the-Cropping-Year-2007-08-To*.

Goshme, Dagnaygebaw. 2019. "Review on Factors Affecting Production and Marketing of Spices in Ethiopia." 9(6):13–17. doi: 10.7176/JBAH.

Güneri, Nilgün. 2021. "REVIEW A Review on Turmeric (Curcuma Longa L .) and Usage in Seafood." 10:71–84. doi: 10.33714/masteb.771756.

Hailemichael, Girma, Habtewold Kifelew, and Haimanot Mitiku. 2016. "Spices Research Achievements, Challenges and Future Prospects in Ethiopia." 4(January):9–17. doi: 10.14662/ARJASR2015.061.

Journals, Quest. 2021. "Analysis of Technical Efficiency of Coffee Producers in Chire Woreda of Sidama Zone , Southern Ethiopia : A Stochastic Frontier Approach." 9(3):33–39.

Kassa, Getahun, and Desalegn Alemayehu. 2017. "Market Chain Analysis of HighValue Fruits in Bench Maji Zone , Southwest Market Chain Analysis of HighValue Fruits in Bench Maji Zone , Southwest Ethiopia." (May). doi: 10.5539/ijms.v9n3p124.

Khatiwada, Dikshya. 2022. "Technical Efficiency of Ginger Production in Ilam District of Nepal : A Stochastic Production Frontier Approach." 2022.

Lema, Tadesse Zenebe, Solomon Estifanos Masresha, Markew Mengsitie, and Eshetu Molla Demeke. 2022. "Analysis of the Technical Efficiency of Barley Production in North Shewa Zone of Amhara Regional State , Ethiopia Analysis of the Technical Efficiency of Barley Production in North Shewa Zone of Amhara Regional State , Ethiopia." *Cogent Economics & Finance* 10(1). doi: 10.1080/23322039.2022.2043509.

Lovell, C. A. Knox. 1993. *PRODUCTIVE EFFICIENCY*. Oxford University Press.

M. Mkpado Anzaku T. A. K., and A. Achike. 2011. "No TitleECONOMICS OF MARKETING BENNISEED IN NASARAWA STATE, NIGERIA." 9(1):1–13.

Maddala, Gangadharrao S. 1986. *Limited-Dependent and Qualitative Variables in Econometrics*. First. Cambridge university press.

Md, Azizul Baten, Abdulbasah Kamil Anton, and Anamul Haque Mohammad. 2009. "Modeling Technical Inefficiencies Effects in a Stochastic Frontier Production Function for Panel Data." *African Journal of Agricultural Research* 4(12):1374–82.

Mohammed, Abdu, Melkamu Baze, and Mohammed Ahmed. 2016a. "Smallholder Commercialization and Commercial Farming in Coffee-Spice Based Farming System of South West Ethiopia." 2(5):13–26.

Mohammed, Abdu, Melkamu Baze, and Mohammed Ahmed. 2016b. "Smallholder Commercialization and Commercial Farming in Coffee-Spice Based Farming System of South West Ethiopia." *International Journal of Research Studies in Agricultural Sciences* 2(5):13–26. doi: 10.20431/2454-6224.0205003.

Mulatu, Mebratu and Alemu Belete. 2019. "Determinant of Turmeric Producers Market Outlet Choice Insheka and Majang Zones of South West of Ethiopia." 09:31033–38.

Neuberger, Doris. 2014. "Structure , Conduct and Performance in Banking Markets Thünen-Series of Applied Economic Theory Thünen-Reihe Angewandter Volkswirtschaftstheorie Working Paper No . 12 Structure , Conduct and Performance in Banking Markets by Doris Neuberger Universität Rostock Wirtschafts- Und Sozialwissenschaftliche Fakultät Institut Für Volkswirtschaftslehre." (February 1997).

Olwande, John, and Mary K. Mathenge. 2011. *Market Participation among Poor Rural Households in Kenya*.

Philipos, Muluken. 2021. "Management Technical Efficiency of Maize Production in MeskanWoreda of Gurage Zone." 9(January):1–13. doi: 10.14662/IJEBM2020.125.

Sarker, Debnarayan, and Sudpita De. 2004. "High Technical Efficiency of Farms in Two Different Agricultural Lands: A Study under Deterministic Production Frontier Approach." *Indian Journal of Agricultural Economics* 59(902-2016–68043).

Shimelis, Tsegaye. 2021. "Spices Production and Marketing in Ethiopia : A Review Spices Production and Marketing in Ethiopia : A." *Cogent Food & Agriculture* 7(1). doi: 10.1080/23311932.2021.1915558.

Shoa, West, West Shoa, Melaku Challa, Mulu Debela Ofolsha, and Paul Mansingh. 2021. "MARKET CHAIN ANALYSIS OF TEFF AND WHEAT PRODUCTION IN DENDI MARKET CHAIN ANALYSIS OF TEFF AND WHEAT PRODUCTION IN DENDI DISTRICT." (December).

Sicelo Ignatius Dlamini and Wen-Chi Huang. 2020. “A Gross Marketing Margin and Producers ’ Share Descriptive Analysis of the Beef A GROSS MARKETING MARGIN AND PRODUCERS ’ SHARE DESCRIPTIVE ANALYSIS OF THE BEEF VALUE CHAIN IN ESWATINI.” (March).

Tenaye, Anbes. 2020. “Economies Technical E Ffi Ciency of Smallholder Agriculture in Developing Countries : The Case of Ethiopia.” (Fao 2016):1–27.

Tesema, Tolesa. 2022. “Heliyon Are Farmers Technically Ef Fi Cient in Growing Sorghum Crops ?: Evidence from Western Part of Ethiopia Gudeya Bila District.” *Heliyon* 8(December 2021):e09907. doi: 10.1016/j.heliyon.2022.e09907.

Tesfa, Tiru, Wondimu Bayu, Arega Gashaw, and Hassen Beshir. 2017. “Spice Production, Marketing, and Utilization in South Wollo, Ethiopia.” *East African Journal of Sciences* 11(1):27–36.

Weldegiorgis, Leake Gebresilassie. 2019. “Efficiency of Male and Female as Irrigated Onion Growers.” (January). doi: 10.1080/19315260.2019.1565794.

Zewdie, Markose Chekol, Michele Moretti, Daregot Berihun Tenessa, Zemen Ayalew Ayele, Jan Nyssen, Enyew Adgo Tsegaye, Amare Sewnet Minale, and Steven Van Passel. 2021. “Agricultural Technical Efficiency of Smallholder Farmers in Ethiopia : A Stochastic Frontier Approach.” 1–17.

Zinabu Tesfaw, Lemma Zemedu &. Bosena Tegegn. 2021. “Technical Efficiency of Teff Producer Farmers in Technical Efficiency of Teff Producer Farmers in Raya Kobo District , Amhara National Regional State , Ethiopia.” *Cogent Food & Agriculture*. doi: 10.1080/23311932.2020.1865594.