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Demand Analysis for Cereal Crops in Ethiopia

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Abstract. Cereals are common in Ethiopian diets, but the people's consumption habits are complex, with no single crop dominating. Empirical analysis of cereal crop household demand is required to quantify household responses to cereal crop value changes and individual income changes. A purpose of this study is to assess demand for major cereal crops in Ethiopia using secondary data from Ethiopian Social Economic Survey 2018/19 (ESS) with 1700 households of cereal-growing consumers. This paper utilises descriptive statistics and Almost Ideal Demand System (AIDS) model to estimate demand parameters for major cereal crops. The empirical results showed that crop prices themselves, prices of other crops and demographic factors influence the share of grain expenditure. The estimated income elasticity of all sampled cereals is positive, and the Marshallian (unpaid) price elasticity is elastic while the compensated cross-price elasticity was inelastic. Household response to cereal crop demand decreases as commodity prices rise. Teff was the most price-sensitive commodity and classified as a luxury good because its income elasticity value was greater than one. Wheat, maize, and sorghum were designated as necessities, and all of the cereal crops studied in this work are considered normal goods. According to the study, the magnitude of price elasticity is greater than the expenditure elasticity of cereal crops. This implies that price has a greater influence than income. As a result, price regulation policies would be more effective than income targeting policies. Furthermore, the positive expenditure elasticity suggests that as income rises, so will demand for cereal crops. Policies aimed at increasing income would increase demand for cereals

Keywords: Almost Ideal Demand System model, elasticity, expenditure shares, price, income

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INTRODUCTION

Cereals are Ethiopia's most important food crops in terms of cultivated area and production output. They are produced in greater quantities than other crops because they are the primary staple crop. Cereals contributed 88.52% of total grain production. Maize, Teff, wheat, and sorghum are the most important crops in Ethiopia, accounting for 28.75%, 17.11%, 15.86%, and 15.71% of grain production in 2019, respectively (CSA, 2019).

Teff is a cultural staple crop in Ethiopia because it is the most consumed cereal in most Ethiopian households (Amare, 2021; Esubalew & Tewabe, 2022). Its demand in Ethiopia has steadily increased due to population growth, average incomes, and urbanisation (Lee, 2018). Wheat and wheat products account for 14% of consumers' total caloric intake (FAO, 2014). Wheat demand rises as incomes rise, and wheat demand has increased significantly over the last decade (USAID, 2021). Maize dominates consumer caloric intake, accounting for 17-20% of total intake (World Bank, 2018). Although maize is the least desired cereal in urban households, it is widely consumed in rural households because maize flour is mixed with teff to make the national staple injera, and maize is half the price of wheat and teff. Sorghum is one of Ethiopia's most affordable cereals (FEDSNET, 2021).

In Ethiopia, economic growth and an increase in individual earnings significantly increase household budgets, food consumption quantities, and calorie intake (Worku *et al.,* 2017). Because food accounts for a larger part of the household budget in both urban and rural settings, Ethiopia experienced an unprecedented food price spike in early 2005, resulting in inflation. Food prices peaked during the 2007/08 global food price crisis and then fell by a negative 20% late in 2009 because of the government's short-term price regulation policy. After control was lifted in early 2011, food prices increased by 34.5 percent in September 2011. Food prices reached a new high of around 16% in September 2015 and February 2018. Food price increases were identified as a major source of concern. In household surveys, rising food prices were ranked as the first most significant economic shock (LSMS-ISA, 2017).

To reduce high and volatile food prices, the government has implemented several policies, including restricting traders from accumulating food in their stores and imposing price ceilings on essential foodstuffs; legal protection; protecting citizens and the business sector from unfair market practices and distorted market conduct; tariff reductions on imported foods, and lower domestic prices. These regulations, however, make it difficult for local farmers to get a better price and reduce biodiversity. Food price increases are harmful to urban consumers and net buyers (Tassew & Yisak, 2020).

Demand elasticity provides information on how individuals regulate their consumption bundles as a result of exogenous shocks in the economic environment. Subsequent changes in food consumption patterns pose considerable risks to the welfare of the poor, who subsist on inadequate calories and are struggling daily to maintain a healthy life (Yekin, 2020). Hence, exploring the responses of vulnerable and poor households to food crises and income change is necessary for designing a suitable policy (income-related policies or price-regulated policies) to improve household food security.

Various attempts on the concepts of demand analysis using a quadratic almost ideal demand system have been made in Ethiopia and other developing countries over time. For instance, Linh (2020); Kharisma et al. (2020); Vigani et al. (2019); and Alexandria et al. (2015) studied the cases of Vietnam, West Java, Kenya, and Romania, respectively. Sara et al. (2018) estimate cereal demand in Morocco using an almost ideal demand system model. In the context of Ethiopia, few studies have been conducted on food demand analysis (Nigussie, 2020; Vigani et al., 2019; and Yekin, 2020). Moreover, earlier studies focused on either food demand as a whole or a combination of them, such as teff, wheat, and other cereals or grains, vs. fruits and vegetables, and root crops.

The purpose of this study is to analyse the demand for cereal crops in Ethiopia using the 2018/2019 Ethiopian Socioeconomic Survey data (ESS).

MATERIALS AND METHODS

Source of information: The data for this empirical study came from the 2018/2019 Ethiopian Socioeconomic Survey (ESS) (fourth wave), which was collected by the Central Statistical Agency (CSA) of Ethiopia in collaboration with World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The estimation sample size was 1700 households chosen based on weekly consumption availability data for cereal crops such as wheat, teff, maize, and sorghum. The sample includes both urban and rural households from seven Ethiopian regions. The consumption data was combined with information on household size, age, gender of the household head, and literacy level of the household head.

Data analysis method. The analysis employed both descriptive and econometric techniques. The descriptive statistics described the sample households' expenditures, budget shares of cereal crops, and demographic characteristics. The specification and estimation of cereal crop demand equations required econometric techniques. It also investigated the impact of various socioeconomic factors on household demand for cereal crops.

Almost ideal demand system model. The use of demand systems allows for the modelling of total expenditure allocation among commodities given a specific budget. An empirical model of the demand system is required to apply demand theory in the real world. The Linear Expenditure System (LES), the Rotterdam model, the Indirect Translog System (ITS), the Almost Ideal Demand System (QUAIDS), and the Quadratic Almost Ideal Demand System (QUAIDS) are some of the most

popular and frequently found in literature demand analysis models.

Based on the characteristics of each model, the study used an almost ideal demand system to analyse consumer expenditure on the four cereal crops chosen. The reason for not using other demand models in this study is that the Linear Expenditure System (LES), linearity is one of the benefits of LES mentioned above, but linear Engel curves have a constraint when the income range is large (Kenneth *et al*., 2020).

The Rotterdam model system is like demand theory and can investigate cross-commodity relationships. However, because it is not derived from a specific utility or cost function, the model contradicts utility-maximising behaviour. Even though translog model has the merit of functional form flexibility, the considerable number of independent parameters causes serious estimation problem. The AIDS demand function is more easily estimated than other models because it adheres to demand theory principles.

The Almost Ideal Demand System (PIGLOG) class of demand models is determined from linear in log total expenditure indirect utility functions (Jean-Marc and Sebastien, 2015). The demand functions are derived from the budget share, which is mathematically explained as follows (1):

$$wi = \alpha i + \sum_{j=1}^{4} \gamma ij ln\,(Pj) + \beta i \ln\left\{\frac{M}{a(P)}\right\} + zk + \varepsilon i \quad (1)$$

where ωi is household expenditure share of teff, wheat, maize, and sorghum; αi is the intercept of the demand function; γij is the parameter of the price of j^{th} cereal crops; j and i, are the list of cereal crops; P_j is price for j^{th} cereal crop; βi is the coefficients parameter in the expenditure share of cereal crops; M is the total expenditure share of the household in all goods; P is the price index; $a(P)$ is the translog of price indices given in Equation (3); zk is the k^{th} household socio-demographic characteristics; εi is the random error with standard properties; αi, γij, βi are the parameters to be estimated in the model; i=1, 2, 3, 4; j=1, 2, 3, 4.

The dependent variable is the expenditure share for the i^{th} cereal crops, and is defined as follows (2):

$$Wi = \frac{Pi*Qi}{M} \quad (2)$$

where P_i is the price of i^{th} goods at time t; Q_i is the quantity of i^{th} goods at time t; M is the total expenditure of all commodities.

Price index can be defined as follows (3):

$$lnP *= \alpha + \sum ak\ lnPk + 1/2 \sum\sum \gamma jklnPk\ lnPj \quad (3)$$

Since Equation (1) is highly nonlinear, Stone's index may be substituted by the price index in empirical extensions. Hence the Stone's index is explained as follows (4):

$$lnP = \sum Wi\ lnPi \quad (4)$$

when the Stone's index is used in Equation (1), the model is termed as linear approximation of almost ideal demand system (LA/AIDS).

First, if $\Sigma\alpha j$=1, $\Sigma\gamma ij$=0, and $\Sigma\beta i$=0, the sum of budget shares is 1. Second, the homogeneity condition requires $\Sigma\gamma ij$ to be zero. Third, the symmetry constraint holds if γij=γij.

The Marshallian and Hicksian elasticities are estimated using the LA/AIDS model's estimated parameters; in this study case, the Marshallian (uncompensated) own price, cross-price, and expenditure elasticity of demand for cereal crops is given in equations (5), (6), and (7), as follows:

$$\varepsilon ii = -1 + \frac{\gamma ii}{wi} - \beta i \quad (5)$$

$$\varepsilon ij = \frac{\gamma ij}{wi} - \frac{\beta i}{wi} wj \quad (6)$$

$$\eta = 1 + \frac{\beta i}{wi} \quad (7)$$

On the other hand, the Hicksian (compensated) own price and cross price elasticity (eij) were also explained in equation (8):

$$eij = \varepsilon ij + \eta iwj \quad (8)$$

RESULTS AND DISCUSSION

Household characteristics. Table 1 revealed that the mean values of age of household heads and the family size were 43.2 years and 4, respectively, for the households surveyed. Out of the 1,700 sample respondents, 72.18% were male-headed and the rest 27.82%, were female-headed households. The location of the sampled households indicates that about 67.65% of the respondents were from rural Ethiopia and 27.82% were from urban areas. The educational level of the respondents also indicates that 93.4% of them were illiterate.

Table 1. *Demographic characteristics of household*

Variable	Obs	Mean	Std. Dev.	Min	Max
Household size	1,700	4.267059	2.233665	1	16
Age of household	1,700	43.24176	15.09884	15	97
		Frequency	Percent		
Sex	Male	1,227	72.18		
	Female	473	27.82		
Education	Illiterate	1,589	93.47		
	Literate	111	6.53		
Location	Rural	1,150	67.65		
	Urban	550	32.35		

Source: *own calculation from CSA data on 2018/19*

Expenditure shares and price of major cereal crops. The results in Table 2 indicate that the average expenditure of a household on cereal crops was 18.25 USD/week with a minimum expenditure of 2.77 USD/week and a maximum expenditure of 32.83 USD/week. On average, out of the total expenditure of households for cereal crops, 60% is spent on sorghum and maize while 40% is spent on *teff* and wheat. This implies that sorghum and maize earn the highest budget share as compared to *teff* and wheat, which account for 37% and 23%, respectively. As presented in Table 2, the price of teff has the largest mean and standard deviation, followed by wheat, while the price of maize has the smallest mean and standard deviation.

Table 2*. Expenditure shares and price of major cereal crops*

Variable	Obs	Mean	Std. Dev.	Min	Max
Expenditure share of teff (W_i teff)	1,700	0.2022	0.1757	0.0043	0.9509
Expenditure share of wheat (W_i wheat)	1,700	0.1965	0.1642	0.0007	0.9476
Expenditure share of sorghum (W_i sorghum)	1,700	0.3687	0.2030	0.0023	0.9863
Expenditure share of maize (W_i maize)	1,700	0.2326	0.1686	0.0032	0.9034
Price of maize (P_m)	1,700	0.4073	0.1812	0.1935	1.0271
Price of sorghum (P_s)	1,700	0.5095	0.2035	0.1935	1.1519
Price of teff (P_t)	1,700	0.9839	1.4257	0.6774	1.7742
Price of wheat (P_w)	1,700	0.6729	0.2082	0.3226	1.3426
Non-food expenditure	1,700	336.507	459.057	0.0000	51.9581
Total expenditure of household	1,700	18.246	16.8365	2.7742	32.8352

Note*: Price, non-food and total expenditure measured in USD. Expenditure share expressed in percentage*
Source*: Own calculation from CSA data on 2018/19*

Econometrics result. Estimated coefficients for AIDS model of cereal crops. The results in Table 3 show that the expenditure share of teff was decreased by 6.8% as the price of teff increased by 1%. A 1% increase in teff price increases sorghum expenditure share by 11.17% while decreasing maize expenditure share by 2.62%. Therewith, a 1% increase in sorghum prices reduces the expenditure share of sorghum by 2.9% and increases the expenditure of wheat by 3.05%. Similarly, 1% increase in maize price results in a 2.85% decrease in maize expenditure share, an 8.2% increase in teff expenditure share, and a 4.8% decrease in wheat expenditure.

Table 3*. Almost ideal demand system (AIDS) results*

Variable	Wi teff	Wi wheat	Wi sorghum	Wi maize
ln P_t	-.0681806***	-.017337	.1117001***	-.0261825*
ln P_w	-.0092193	-.0037448	.0027321	.010232
ln P_s	-.0132088	.0305426***	-.0297763**	.0124425
ln P_m	.0820025***	-.0480644***	-.0053979	-.0285401**
βlnx	.0557046***	-.002643	-.013028	-.0400336***
Family size	-.0032534	.0001565	.0016775	-.0020704
Age	.0007554***	.0000463	-.0005286	-.0002732
Sex	-.0279423***	.0133254	.0084813	.0061355
Edu	.0002364**	.0046042***	.0019459	-.0032967**
A	.1057278	.2859425***	.126516	.4818136***

Note*: (***), (**), (*) denotes the level of confidence at 1%, 5%, and 10%*
Source*: own calculation from Stata 15*

Table 3 indicates that the coefficients of total expenditure were significant and positive for *teff*, but they were negative for maize. This implies that, as the total expenditure increases by 1%, the budget share of teff also increases by 5.57%. In another way, if total expenditure increased by 1%, the maize budget share decreased by 4% by holding other factors constant. From the demographic characteristics, age and education positively affect the expenditure share of *teff* while sex negatively affects the expenditure share of *teff*. The *education* level of the household has positively and significantly affected wheat and *teff* expenditure shares and negatively affected maize expenditure shares.

Price elasticity of demand for cereal crops in the Marshallian model (uncompensated). The Marshallian own-price, cross-price, and expenditure elasticity for major cereal crop demands such as teff, wheat, sorghum, and maize are shown in Table 4.

Cereal price elasticity of demand. Own price elasticity refers to the proportion in a household's consumption in response to changes in food commodity prices.

The sign of one's own price elasticity should be negative, according to economic theory. Table 3 shows that the uncompensated own price elasticity demands of major cereal crops (teff, wheat, sorghum, and maize) are negative and elastic.

Table 4 *Uncompensated (Marshallian) and expenditure elasticity for cereal crops*

	Pt	Pw	Ps	Pm	Expenditure elasticity
W_i teff	-1.347***	-0.116	-0.139*	0.285***	1.28***
	(0.079)	(0.06)	(0.058)	(0.054)	(0.039)
W_i wheat	-0.088	-1.016***	0.159**	-0.24***	0.987***
	(0.077)	(0.059)	(0.057)	(0.053)	(0.037)
W_i sorghum	0.304***	0.016	-1.071***	0.001	0.965***
	(0.051)	(0.039)	(0.038)	(0.035)	(0.025)
W_i maize	-0.107	0.087	0.099*	-1.047***	0.828***
	(0.066)	(0.051)	(0.049)	(0.046)	(0.032)

Note*: (***), (**), (*) denotes the level of confidence at 1%, 5%, and 10%*
Source*: own calculation from Stata 15*

This implies that demand for these cereal crops is sensitive to changes in price. When the price of a crop rises by one unit, the quantity demanded drops by more than one unit. This contradicts T. Nigussie (2020) findings that demand for teff wheat and maize is inelastic in price results. Teff demand became more sensitive to price fluctuations as a result. A one-unit increase in the price of teff results in a 1.35-unit decrease in the quantity demanded by households.

Cereal demand elasticity of income (expenditure): *Income elasticity is defined as the percentage change in quantity consumed of a given commodity in relation to the percentage change in the household's income. One can determine whether cereal crops are inferior, essential, or luxurious to typical farm households using income elasticity*. The income elasticity of major cereal crops is presented in Table 4. The empirical results showed that the income elasticity of all selected cereal crops was positive and significant at 1% level of significance, indicating that these crops are normal goods. As we see from the result, the income elasticity of *teff* was 1.28, which is greater than one, implying *teff* is a luxury good to the household, while the income elasticity of wheat, sorghum, and maize were 0.987, 0.965, and 0.828, respectively. Therefore, maize, wheat, and sorghum are necessities. This result is in line with the finding of T. Nigussie (2020). He found that *teff* is considered a luxury good in most households in Ethiopia while maize and sorghum are necessities. Wheat, on the other hand, is a luxury good, which contradicts his discovery.

Cross-price elasticity of cereal crops. Cross-price cereal crops demonstrate the substitutability and complementarity effects of commodities by measuring the percentage relationship between price and quantity consumed in response to price changes. The value of zero indicates that the two products are independent, Positive cross-price elasticity indicates substitutability, whereas negative cross-price elasticity indicates complementarity. According to the empirical review findings, the uncompensated cross-price elasticity of teff with sorghum was negative, indicating that teff was consumed in addition to sorghum. However, it can be substituted for maize. Wheat is consumed in addition to maize and is substituted with sorghum. Sorghum was replaced with maize.

Estimation of cereal crops' compensated price elasticity. The percent change in demand for a good because of a price change that excludes the income effect is known as compensated or substitution elasticity. According to Table 5, the compensated own price elasticity of demand for teff,

wheat, sorghum, and maize is (-1.09, -0.822, -0.716, and -0.854). This showed that the elastic demand of teff was elastic (hence its elasticity is greater than zero in the absolute term), while the demands for wheat, sorghum, and maize were inelastic. The consequences of inelastic demand in wheat, sorghum, and maize demonstrate that these crops are critical to life. Household demand for those crops was less sensitive to price fluctuations. The decrease in quantity change in demand for those crops was less than the decrease in quantity change in price.

Table 5. *Estimated coefficient of compensated elasticity*

	Pt	Pw	Ps	Pm
W_i teff	-1.09***	0.135*	0.331***	0.582***
	(0.079)	(0.061)	(0.06)	(0.054)
W_i wheat	0.111	-0.822***	0.523***	-0.009
	(0.076)	(0.059)	(0.059)	(0.053)
W_i sorghum	0.499***	0.206***	-0.716***	0.226***
	(0.052)	(0.039)	(0.039)	(0.035)
W_i maize	0.06	0.25***	0.405***	-0.854***
	(0.066)	(0.051)	(0.051)	(0.046)

Note*: (***), (**), (*) denotes the level of significance at1%, 5% and (10%) level*
Source*: own calculation from Stata 15*

The compensated cross-price elasticity of teff to wheat, maize, and sorghum had positive signs, indicating that these goods are substitutes for one another in the estimated mean shares. Teff, wheat, and maize are used in place of sorghum in households. Similarly, wheat and sorghum were discovered to be maize substitutes. On the contrary, T. Nigussie (2020) results reveal that teff and wheat is complementary to each other but substitutable for maize and sorghum.

CONCLUSIONS

The analysis of the determinants of cereal crop demand and estimation of elasticity, especially with respect to income and prices, provides vital information regarding the consumption behaviour of society in general. In this regard, the authors estimated the demand for cereal crops in Ethiopia based on secondary data obtained from the 2018/2019 Ethiopian Socioeconomic Survey (ESS) fourth wave with a sample size of 1700 households. To examine household demand for cereal crops, the study implemented the Almost Ideal Demand System (AIDS). The AIDS results revealed that price, expenditure, and demographic factors such as age, sex, and education level of household headed influenced Ethiopian household demand for cereal crops. The results of uncompensated own-price elasticity revealed that all selected cereal crops had elastic demand.

Household response to the demand for cereal crops decreases as the commodity price increases. The most responsive commodity to price change was *teff*, followed by sorghum, maize, and wheat. However, all cereal crops except teff were inelastic in the compensated price elasticity result. All the cereal crops chosen were classified as normal goods, with an income elasticity value greater than zero. Wheat, maize, and sorghum were classified as necessity goods due to their commodity nature, while teff was classified as a luxury good due to its income elasticity value being greater than one. The cross-price elasticity result showed that most of the sampled crops were substituted for each other. Teff was consumed with sorghum and substituted for maize. Wheat and sorghum were substituted for maize. Wheat and maize are also substituted for each other.

The implications derived from this finding were that the magnitude of price elasticity is greater than the expenditure elasticity of cereal crops. It can be inferred from these results that price has a higher impact than income. Thus, the price regulating policy would be effective over income targeting policies. The positive expenditure elasticity suggests that the demand for cereal crops is likely to expand as income increases. Policies that target income growth would lead to higher demand for cereals.

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Аналіз попиту на зернові культури в Ефіопії

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Анотація. Зернові культури поширені у раціоні харчування жителів Ефіопії, проте споживчі звички населення складні, і жодна з культур не переважає. Емпіричний аналіз попиту домогосподарств на зернові культури є необхідним для кількісної оцінки реакції на зміну вартості зернових культур та індивідуальних доходів. Мета даного дослідження – оцінити попит на основні зернові культури в Ефіопії, використовуючи вторинні дані Ефіопського соціально-економічного дослідження 2018/19 (ESS) із 1700 домогосподарств споживачів зернових культур. У цій роботі використовується описова статистика і модель майже ідеальної системи попиту (AIDS) з метою оцінки параметрів потреби в основних зернових культур. Емпіричні результати показали, що на частку витрат на зерно впливають самі ціни на зернові культури, ціни на інші культури та демографічні фактори. Розрахункова еластичність доходу всіх відібраних зернових є позитивною, а еластичність маршаллівської (неоплачуваної) ціни є еластичною, тоді як компенсована перехресна цінова еластичність виявилася нееластичною. Реакція домогосподарств на потребу в зернових культурах знижується зі зростанням ціни товару. Тефф був найбільш чутливим до цін товарів і класифікувався як предмет розкоші, оскільки значення еластичності доходу було більше одиниці. Пшениця, кукурудза та сорго були визначені як предмети першої необхідності, а всі зернові культури, досліджувані в цій роботі, вважаються звичайними товарами. Згідно з дослідженням, величина цінової еластичності більша, ніж еластичність витрат зернових культур. Це означає, що ціна має більший вплив, ніж дохід. У результаті, політика цінового регулювання буде більш ефективною, ніж політика цільового доходу. Крім того, позитивна еластичність за витратами передбачає, що зі зростанням доходів зростатиме і попит на зернові культури. Політика, спрямована на підвищення прибутків, збільшить попит на зернові культури

Ключові слова: модель майже ідеальної системи попиту, еластичність, частка витрат, ціна, дохід