Food and Energy Security

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ORIGINAL ARTICLE OPEN ACCESS

How Sustainable Is Türkiye's Food Import? A Linearized Almost Ideal Demand System Estimation for Food Import Elasticities

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Received: 2 September 2024 | **Revised:** 23 January 2025 | **Accepted:** 29 January 2025

Funding: We gratefully acknowledge the financial support provided by the below-mentioned organizations, which has made this research possible. This research was funded by Scientific Research Project No. 1967 by Anadolu University (Eskisehir, TR). The funding was provided to support the development, execution, and dissemination of this study. The project received additional support from the University of East Anglia (Norwich, UK), which covered the Open Access Charge to ensure the availability of this publication under an open-access format. The views and opinions expressed in this publication are solely those of the authors and do not necessarily reflect the official policy or position of the funding bodies.

Keywords: dynamic AIDS model | food security | import demand elasticities | sustainable agriculture | Türkiye agricultural trade

ABSTRACT

This study examines the import demand for four key agricultural commodities—cereals, meat, sugar, and vegetable oils—in Türkiye, using a Linear Almost Ideal Demand System (AIDS) model. Spanning the period from 1986 to 2020, the analysis focuses on these commodities as they constitute over 90% of Türkiye's food import budget. The results reveal significant long-run own-price elasticities, with vegetable oils and cereals being particularly sensitive to price changes, whereas the impact of price on meat and sugar imports is negligible. The study also highlights the limited role of income and exchange rates on import demand, except for sugar where the exchange rate has a significant but small positive effect. Short-run estimates indicate a heightened responsiveness of budget allocations for cereals and vegetable oils to price fluctuations, suggesting a persistent element in food import patterns over time. The findings underscore the essential nature of these commodities, with low own-price elasticity for cereals and vegetable oils, reflecting their status as necessities. In contrast, short-run elasticity results suggest that cereal imports may be viewed as a luxury, with the potential for domestic production to substitute imports. The study concludes that Türkiye's food security is increasingly vulnerable to global price fluctuations, particularly for vegetable oils, and calls for policies that stabilize exchange rates and inflation while enhancing domestic agricultural productivity to mitigate this risk.

1 | Introduction

Food security refers to the adequacy of food for humanity to lead an active and healthy life, the relative stability of supply when necessary, and the ability of everyone to obtain food (FAO 1996). This definition of food security has become a traditional definition consisting of four components: physical availability, economic access, adequate utilization and stability (Díaz-Bonilla 2015). In developing countries, the relationship between trade reform and food security is important. This relationship is one of the key debates in international trade negotiations. Trade policies have a direct impact on food availability, foreign exchange earnings, incomes and expenditures. It is therefore evident that trade policies, particularly in developing countries, exert a considerable İnfluence on a nation's production, consumption, trade flows and access to food, and consequently have a profound impact on food security (FAO 2003).

Türkiye plays an important role in global agricultural production and trade, particularly in the context of food security and market dynamics. As one of the world's leading producers and consumers of agricultural products, Türkiye's agricultural sector significantly influences global food markets. As a major food supplier to the world food trade, it is also important to address Türkiye's role in importing raw food for processing for trade. Türkiye has faced food security challenges recently such as the Ukraine—Russia war, which have led to price volatility and supply disruptions. Analysing food imports can provide insights into how the country can address these challenges and maintains food security. This paper contributes to the existing literature by analysing import demand for augmented agricultural products by employing a linearized form of AIDS (Almost Ideal Demand System) model for Türkiye for the first time in the literature.

On one hand, Türkiye's geographical location is at the intersection of many historically important trade routes. As a bridge between Europe and Asia, the country is also a central hub for trade due to its proximity to the Mediterranean. Regarding the food trade, Türkiye's geographical advantages have played a significant role. With fertile agricultural lands, diverse climate conditions, and rich biological diversity, Türkiye has been a center for food trade among different cultures throughout history. For instance, as part of the Silk Road, Türkiye served as a transit point for transporting silk, spices, and other valuable goods from Asia to Europe. Similarly, trade routes along the coasts of the Mediterranean have played a significant role in the trade of olive oil, wine, and other Mediterranean cuisine products in Türkiye. Even today, Türkiye possesses a rich heritage in food production and trade, maintaining its position as a significant player in the buying and selling of various food products worldwide.

On the other hand, for countries like Türkiye, which are heavily integrated into global food trade networks, ensuring food security becomes even more pressing. This issue is closely tied to several United Nations Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), which emphasizes the need to end hunger and achieve food security, and SDG 12 (Responsible Consumption and Production), which promotes sustainable food systems. By analysing Türkiye's food import dynamics, this study contributes to understanding how import policies can help mitigate domestic food price volatility, ensure stable food supplies, and strengthen food security, all while supporting the global agenda for sustainable development.

Food security in Turkey is ensured by importing a significant portion of food. This dependence makes Turkey's food security vulnerable to food price fluctuations and supply disruptions, especially during an inflationary period. Besides, according to the World Bank's Food Security Update Report, the country ranks fourth globally in terms of food inflation (World Bank 2024). When accompanied by migration waves into the country, this high inflation rate poses a significant risk factor for food security. Importation policy emerges as a crucial strategy for mitigating this challenge for countries with high inflation in the food sector. By diversifying its sources through imports, Türkiye alleviates domestic price pressures and ensures stable food supplies. Therefore, the results of this study also have implications for the inflationary food sector for Türkiye.

The study is organized as follows. In the following section, we provide a brief examination of the literature focusing on the empirical analysis of import dynamics. Then, we introduce our data and the Almost Ideal Demand System upon which our model is based. In the following section, we expose our estimation results and make a brief discussion. Finally, we reveal our concluding remarks and policy suggestions.

2 | Literature Review

An important part of the literature focusing on imported food price elasticity estimation for Türkiye is dominated by studies employing log–log elasticity models. For example, Uzunoz and Akçay (2009) tried to explain wheat imports for the Turkish economy using a linear logarithmic model. Another study on food imports, again on dairy imports, was conducted by Karkacıer (2000). The method of the study is standard linear regression, without employing a demand forecasting system. Saygı and Hekimoğlu (2011) estimated the imports of aquaculture products, again using a linear logarithmic model.

It should also be noted that existing literature is a decade old. For instance, one of the most relevant studies to the research presented in this study is conducted by Yen and Bilgiç in 2013. Although Bilgiç and Yen (2013) has one of the most detailed groupings on food and using one of the demand forecasting systems and focuses on household consumption, it does not analyse the food imports. In other words, there is no specific study in the literature that focuses specifically on food imports and explains the demand forecasting system using detailed commodity groups for Türkiye. In this sense, this study will fill the gap in the field both in terms of subject matter and methodology.

Another noteworthy trend for the import demand elasticity literature of Türkiye is the studies employ macro econometric based models. For example, Kavaz (2020), one of the most recent studies, used logarithmic linear regression estimated with the ARDL method to calculate income and price elasticities for energy imports. Since no demand forecasting system was used, the impact of the change in crude oil prices on other imported goods (i.e., cross-price elasticities) and the welfare effect could not be addressed in a broader framework. Similarly, Ozturk and Arısoy (2016) explained the import demand for crude oil by constructing a macroeconomic linear model. More importantly, they did not address the endogenous link between GDP and crude oil and completed their analysis with a model assuming a unidirectional relationship from GDP to crude oil imports. Again, Kalyoncu (2006), Oktay and Gözgör (2013), Çulha, Eren, and Öğünç (2019), and Durmaz and Lee (2015) derived import elasticities based on a grouping other than food through linear regression analyses based on macroeconomic theory.

Although there is a large gap in the literature for Türkiye, the almost ideal demand forecasting system has been used for a long time, including very recent periods, to understand food imports in other countries. There is also important literature employing AIDS model to analyse the effects of import demands. However, these studies have mostly focused on imports of a single type of food. For example, Schalkwyk et al. (2005) investigated the primary oilseeds demand relationship for South Africa by

employing the Linearly Approximated AIDS model covering the 1971–2002 periods. They found a negative relationship between the demand of oilseeds and its own prices. They also show that some oilseeds, especially sunflower and cotton seed, were luxury goods for South Africa. Nzaku et al. (2012) estimated the dynamic AIDS model for US fresh tropical fruits import. They found all price elasticities negative and statistically significant. They also showed that fresh grapes and other fresh fruits were found as luxury goods.

Tshikala and Fonsah (2012) investigated the US demand for imported melons using the dynamic Almost Ideal Demand System (AIDS) method. The findings indicate that all own-price elasticities of the products are negative in both the short and long run, in line with the demand theory. Moreover, expenditure elasticities show that fresh melon and fresh watermelon are luxury goods in both the short and long run, while frozen melons are necessity goods in the short run and low-quality goods in the long run.

Wang and Reed (2013) investigated static and dynamic US import demand for fishery products by employing source differentiated AIDS model covering 1999.1–2012.9 periods. They found that fishery products import is insensitive to the price changes, and they found all the imported fishery products as normal good.

Klonaris (2014) analyses the demand for imported meats in Greece, using a differentiated Almost Ideal Demand System (AIDS). The results show that, consistent with demand theory, all own-price elasticities of these meats are negative and significant. The results for expenditure elasticities indicate that beef from France has the highest expenditure elasticity and that the demand for German beef has a higher expenditure elasticity compared to beef from the rest of the world. Cross-price elasticities suggest that pork from France is a substitute for pork from Denmark and the rest of the world, and that there is a complementary relationship between German and Danish pork and Dutch and French pork.

Akinbode (2015) used the Linear Approximation Almost Ideal Demand System (LA-AIDS) method to investigate household food demand in Nigeria. According to findings, expenditure elasticities indicate that garri and palm oil are considered inferior food items, whereas others can be categorized as normal. Own-price elasticities suggest that beans, plantain, yam flour, and rice are considered luxury items, while others are deemed necessities.

Cupák et al. (2015) estimated the food demand system for Slovakia by using the Quadratic Almost Ideal Demand System (QUAIDS) method. The results reveal that the demand for dairy products, fruits, and vegetables has expenditure and own-price elasticities and that these foods are luxury goods. On the other hand, cereals and other foods such as meat and fish are found to be normal goods with inelastic price elasticity. Finally, when comparing households of different income groups, it is concluded that rural and low-income households are more sensitive to price changes.

Abdul-Mageed and Jabra (2016) examined the elasticities of demand for meat consumption in Iraq using the Linear Approximation Almost Ideal Demand System (LA-AIDS) method. The results show that the demand for imported chicken is elastic, while the demand for imported red meat and fish is inelastic. Moreover, cross-price elasticity findings show that chicken and fish are substitute goods, while fish and chicken are normal and essential goods, and red meat is normal and luxury goods.

Girik Allo et al. (2018) applied the Quadratic Almost Ideal Demand System (QUAIDS) method to examine the impact of price changes in garlic, rice, and red onion on demand for other goods in Indonesia. The findings indicate that an increase in income correlated with higher consumption of rice, red onion, and garlic. The interplay of income, own-price, and cross-price elasticity exhibited diverse dynamics influenced by factors such as demographics, socio-economic status, and geographic location of households. Moreover, the short-term effect of imported products on welfare changes outweighed the immediate impact.

Lopez and Grigoryan (2018) estimated the US demand for imported nuts using the Almost Ideal Demand System (AIDS) method. According to the expenditure elasticities obtained, the expenditure elasticities of all imported nuts except coconut and walnut are positive. Furthermore, expenditure elasticities show that cashew nuts and pistachios are necessity goods, Brazil nuts, almonds, and hazelnuts are luxury goods, and coconuts and walnuts are inferior goods. Finally, the own-price elasticities of all imported nuts except coconuts and chestnuts are negative and significant.

Alnafissa and Alderiny (2020) estimated Saudi Arabia's demand for imported honey using the Almost Ideal Demand System (AIDS) method. According to the elasticity results, the own-price elasticities of honey imported from all countries except Pakistan are significant and negative. Furthermore, the demand for honey imported from Yemen, Argentina, and Mexico is elastic with respect to total expenditure on honey imports, while the demand for honey imported from Pakistan and Germany is inelastic with respect to total expenditure on honey imports.

Focusing more recent studies, Abdullah and Mohammed (2023), using the Almost Ideal Demand System (AIDS) method, analysed the elasticities of demand for imported food in Iraq for two different periods, 1980–2003 and 2003–2020. According to the results of the uncompensated demand elasticities obtained in the first period, the own-price elasticities of all food products are significant and negatively signaling, in line with demand theory. The price elasticities of animal products and fruit and vegetables are less than one, that is, they are less sensitive to changes in their own price. Moreover, cross-price elasticities show that vegetable oils and fats and staple foods are complements to livestock products. Additionally, expenditure elasticities indicate that the group of fruit and vegetables is a normal good and all other products are luxury goods and expenditure elasticities indicate that the basic food group is a necessity good, while the other groups are luxury goods. Forgenie et al. (2023) studied the import demand for meat and fish products in Indonesia using the Error Corrected Linear Approximate Ideal Demand System (EC-LAAIDS). The results of the EC-LAAIDS model indicate that imported mutton is the slowest adjusting product in the long run, while all other products are moderately adjusting. Furthermore, the income elasticity coefficients show that the most income-sensitive product in the

short run is imported beef, while the most insensitive product is imported poultry. Moreover, long-run income elasticities indicate that all products except imported beef and seafood are luxury goods and cross-price elasticities show that different imported products are substitutes for each other. Zhu (2023) estimated Korea's import demand for nuts using the Almost Ideal Demand System (AIDS). According to the results, the own-price elasticities of all products are negative and significant. Moreover, except for walnuts and pistachios, the own-price elasticities of all products are inelastic. Cross-price elasticities indicate that imported nuts are both complementary and substitutes, while expenditure elasticities reveal that all imported nuts are inelastic.

Lastly, we found only one paper in the literature that focuses on service import demand by employing the AIDS model instead of good import demand. Kuo et al. (2014) investigate Japan's tourism demand by using Dynamic AIDS model. They found that Japanese outbound tourism market share changes are affected significantly from tourist's expenditure change instead of the relative tourism prices.

3 | Data and Method: An Almost Ideal Demand System (AIDS)

This study uses almost ideal demand system of Deaton and Muellbauer (1980). It is a widely used econometric model that allows for a detailed analysis of consumer preferences and demand elasticity.

The Almost Ideal Demand System (AIDS) model has several advantages over other demand estimation systems. Unlike the Rotterdam model, which focuses on changes in consumption and requires restrictive assumptions on preferences, the AIDS model provides a more comprehensive framework by allowing the direct estimation of expenditure shares and elasticities while remaining consistent with the axioms of choice (Deaton and Muellbauer 1980; Barnett and Seck 2008). Additionally, AIDS is more flexible in accommodating a wide range of commodities and capturing inferior goods compared to simpler models such as the Linear Expenditure System (LES). Furthermore, compared to the Quadratic AIDS (QUAIDS), which adds complexity for higher-order approximations, the AIDS model remains less data-demanding, making it particularly suitable for policy analyses in contexts with limited data. This balance of flexibility, interpretability, and practicality makes the AIDS model as a robust tool for analysing consumption demand patterns.

To note, we use the Stone price index as it aligns with the original methodology proposed by Deaton and Muellbauer (1980) in their introduction of the AIDS model. While alternative indices, such as Laspeyres or Tornqvist (see Buse 1998), are theoretically advantageous in addressing issues like collinearity and endogeneity when working with time series data, the Stone price index remains a widely accepted and practical choice in demand system estimations. Its simplicity and computational efficiency make it specifically suitable when working with datasets, such as those provided by FAO, that offer standardized and globally comparable price data. Furthermore, adopting alternative indices would require highly detailed data on import prices and weights for each trade partner, updated annually, which is not feasible within the scope of this study. Hence, using the Stone price index ensures both methodological consistency and the practicality needed for robust analysis.

3.1 | Mathematical Presentation of Almost Ideal Demand System (AIDS)

As stated in Türkmen-Ceylan (2019), the functional form of the AIDS model is as explained below:

The expenditure function can be expressed as below:

$$c(u,p) = a(p) + b(p)u \tag{1.0}$$

where u denotes the level of utility and p is a price vector.

Since $0 < u < 1$, $a(p)$ can be interpreted as the cost for consumption for basic needs (or autonomous consumption to survive) and $b(p)$ as the additional consumption exceeding the autonomous consumption (i.e., welfare consumption), and both are a function of price. Considering the form of Equation (1.1) in comparison to Equation (1.0), a critical difference can be observed. While in Equation (1.0) utilities u_1, u_2, ... u_n are independent, they are *inter*dependent in Equation (1.1). This highlights the *weak separability* feature of the AIDS utility function. The interdependency of utilities removes the presence of corner equilibrium. In other words, the consumer seeking to maximize utility must consume all of the goods in her commodity bundle (Brown and Deaton 1972). In Deaton and Muellbauer (1980) $ln(a(p))$ and $ln(b(p))$ are defined as, respectively:

$$lna(p) = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2}\sum_k \sum_j \gamma_{kj} \ln p_k \ln p_j \tag{1.1}$$

and

$$\ln b(p) = \ln a(p) + \beta_0 \prod p_k^{\alpha_k} \tag{1.2}$$

Once the equation and (1.1) and (1.2) are combined, the universal form of cost equation for AIDS is obtained:

$$lnc(u,p) = a_0 + \sum_k a_k \ln p_k + \frac{1}{2\sum_k \sum \gamma_{k_j} \ln p_k \ln p_j} + u\beta_0 \Pi p^{k^{\beta^k}} \tag{1.3}$$

Accordingly, when the logarithmic differential of the equation above is computed, the new equation provides the budget share of commodities with respect to the price and utility:

$$w_i = a_i + \sum_k \gamma_{ij} ln\, p_j + \beta_i u \beta_0 \Pi p_k^{b^k} \tag{1.4}$$

α_i: coefficient which shows the autonomous budget share of good i (i.e., share of survival consumption cost for good i in consumer's budget). α_i is equal to zero if this good is not consumed by the household, and α_i is equal to one if the household spends all of her budget on consumption of single good i.

Y: coefficient which measures the effect of own-price (Y_i) and prices of other goods and services (Y_j) on the budget share of good i.

β_i: coefficient which measures the effect of real income when determining budget share of the good *i*.

$$\gamma_{ij} = \frac{1}{2\left(\gamma^*_{ij} + \gamma^*_{ji}\right)} \tag{1.5}$$

The above equations express that the cost (c) is equal to the total expenditure (Y) of the consumer who pursues the utility maximization.

$$\left[c(u,p)\right] = Y \tag{1.6}$$

By reworking u in terms of price and total expenditure with the help of equation[1] above, and accommodating it in Equation (1.4) the *universal form of AIDS demand function* is obtained:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{Y}{P}\right) \tag{1.7}$$

Here, w_i is the budget-share term of good i while p_j is the price of good j. Y is the total expenditure of household and P is the price index. α_i, γ_i, β_i are the parameters to be estimated. A variety of price indices of different complexity can be employed, as discussed by Kebede (2005). Deaton and Muellbauer (1980) proposed the Stone price index below as it does not distort the estimation outcome:

$$\ln(P) = \sum_i w_i \ln\left(P_i\right) \tag{1.8}$$

Once the Stone index is accommodated in Equation (1.8), the budget-share of a good becomes a *linear* function of the logarithm of the total expenditure. This ensures that demand for a particular good is affected by the prices of all goods consumed by the household and by the total expenditure (Kebede 2005).

Furthermore, the parameters which are estimated via Equation (1.7) reflect the constraints of the utility function introduced above. Thus:

$$\sum_i \alpha_i = 1,\ \sum_i \gamma_{ij} = 0,\ \sum_j \gamma_{ij} = 0\ \sum_i \beta_i = 0, \gamma_{ij} = \gamma_{ji}$$

The first three expressions represent the additivity constraint, the fourth the homogeneity constraint, and the fifth the symmetry constraint.

Finally, aforementioned income and price elasticities have the following expressions in terms of the coefficients of the AIDS[2] as explained in:

$$\text{Own Price Elasticity} = \frac{\gamma_{ii}}{w_{ii}} - \beta_i - 1$$

$$\text{Compensated Own Price Elasticity} = w_i + \frac{\gamma_{ii}}{w_{ii}} - 1$$

$$\text{Cross Price Elasticity} = \left[\frac{\gamma_{ij} - \beta_i w_j}{w_i}\right]$$

$$\text{Compensated Cross Price Elasticity} = w_j + \frac{\gamma_{ij}}{w_i}$$

$$\text{Income Elasticity} = 1 + \frac{\alpha_i}{w_i}$$

We obtained the data from FAOSTAT's database on international trade of agricultural output, These data were derived from publicly available resources[3]. We have annual data spanning a period of 35 years, starting with 1986 and ending in 2020. Food import data has 10 different commodity subgroups, yet considering that we have observation of 35 years, we dropped 10 items in order to prevent any multicollinearity problem and focused on 4 items which correspond more than 90% of the food import budget of Türkiye. The commodity subgroups and their average share in total food import expenditure is shown below in Table 1.

Among these subgroups, we purposefully selected subgroups corresponding to 2, 5, 8, and 9. Although our overarching research question is obtaining food import elasticities for main food items, we also aimed to observe the significance of meat import which has recently gained an increasing trend as the country has a growing demand for its consumption as explained in Karaman et al. (2023, p.671) and Akin et al. (2020). In the same manner, we also included sugar and honey imports as their import share has been steadily increasing over the course of the analysis.

3.2 | Descriptive Analysis of the Import Shares and Prices

As explained above, our analysis is built on 4 specific commodity subgroups. Figure 1 presents how the shares of cereals, meat, sugar and vegetable oils fluctuate over the course of analysis. Accordingly, apart from a relatively stable period between 1998 and 2005, the remaining periods witnessed remarkable shifts in

TABLE 1 | Commodity subgroups and their average share in food import expenditure for 1986–2020.

#	Commodity	Average share in food imports by total expenditure	Median share in food imports by total expenditure
1	Animal fats and oils (excl. Butter)	0.002	0.002
2	Cereals and preparations	0.518	0.562
3	Dairy products and eggs	0.003	0.003
4	Fruit	0.009	0.009
5	Meat and meat preparations	0.001	0.000
6	Nuts	0.007	0.005
7	Pulses	0.010	0.010
8	Sugar and honey	0.003	0.001
9	Vegetable oil and fat	0.447	0.411
10	Vegetables	0.000	0.000

the shares, yet the cereals have been the least fluctuating commodity subgroup for the whole period of analysis.

Figure 2 presents the fluctuations in the price levels between 1986 and 2020. The price data used in this analysis is the import value base period price. A rising trend for the prices following the worldwide drought in 2007 has been remarkable. Although there is a rising trend in the cereals' price as shown in Figure 2, its share relatively remained the same in total import expenditure (see: Figure 1). These finding forms evidence that cereals are staple for Türkiye, and AIDS estimation results are expected to report an own-price elasticity that is less than one.

4 | Estimation Results

4.1 | Model Presentation

The long-run model is estimated with the data at levels, its formulation is as follows:

$$w_i = a_i + \sum_j \ln\gamma_{ij} \ln p_{ij} + \beta_i \ln(\exp) + \lambda_i \ln(\text{exrate})$$

$$i = 1, \ldots, n$$

$$j = 1, \ldots, n$$

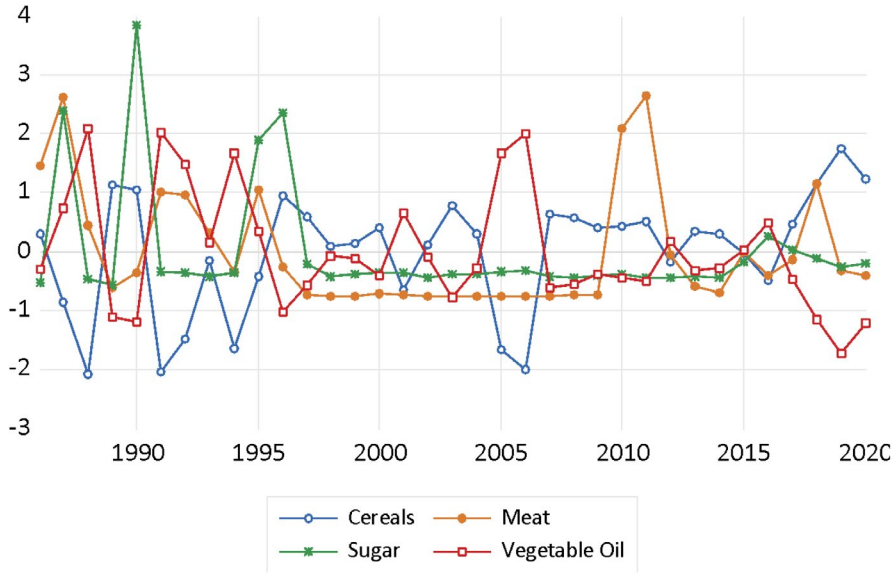

FIGURE 1 | Fluctuations in Import Shares of Four Commodity Subgroups (1986–2020). Authors' own figure. Data: https://www.fao.org/faostat/en/#data/TI, last access: 06.02.2024.

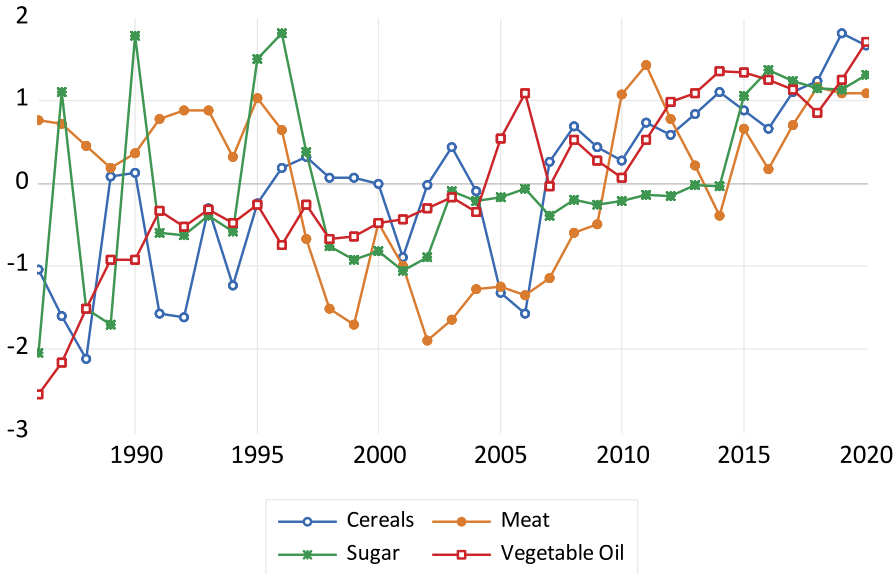

FIGURE 2 | Prices (in logs, normalized) between 1986 and 2020. Authors' own figure. Data: https://www.fao.org/faostat/en/#data/TI, last access: 06.02.2024.

w_i is the budget-share term of good i while p_j is the price of good j, *and exp* is total import expenditure. The AIDS model allows us to incorporate other explanatory variables and in our case, we added the exchange rate as the imports are expected to be responsive to the fluctuations in the currency.

Previously, several studies presented dynamic form of AIDS model such as Karagiannis et al. (2000), Eakins and Gallagher (2003), Nzaku et al. (2012), Sulgham and Zapata (2006), Nzuma and Sarker (2010), Singh et al. (2011). Based on model specifications presented in these studies, the short-run model, a general dynamic error-correction form for the AIDS model could be formulised as below:

$$\Delta w_{it} = c_{it} + \gamma_{ij}\Delta(\ln pij)_t + \beta\Delta(\ln exp)_t + \lambda(Inexrate)_t + \theta U_{i(t-1)} + \mathscr{E}$$

$$i = 1, \ldots, 4 \text{ and } j = 1, \ldots, 4$$

By rewriting the equation in matrix form for the representation of the model as a system of simultaneous equations estimated with three-stage least squares estimator, we obtain:

$$\begin{bmatrix}\Delta w_i \\ \vdots \\ \Delta w_j\end{bmatrix}t = \begin{bmatrix}c_i \\ \vdots \\ c_j\end{bmatrix}t + \gamma\begin{bmatrix}\Delta\ln p_i \ldots \Delta\ln p_j \\ \vdots \\ \Delta\ln p_i \ldots \Delta\ln p_j\end{bmatrix} + \beta\begin{bmatrix}\Delta\ln exp_i \\ \vdots \\ \Delta\ln exp_j\end{bmatrix}t + \lambda\begin{bmatrix}\Delta\ln exrate_i \\ \vdots \\ \Delta\ln exrate_j\end{bmatrix}t + \theta\begin{bmatrix}u_i \\ \vdots \\ u_j\end{bmatrix}(t-1) + \begin{bmatrix}r_i \\ \vdots \\ r_j\end{bmatrix}t.$$

In the equation, c, γ, β, λ, and $_\theta$ are coefficients to be estimated. For diagonal elements of the price matrix, the γ coefficient is used for calculating own or cross-price elasticity of demand. $_\beta$ is used to calculate the budget elasticity of demand. As to λ, it measures how the exchange rate affects the budget share devoted to the relevant food type in the short run. Lastly, $_\theta$ is the error-correction term that shows the duration of achieving equilibrium once a shock on prices, on income or on exchange rate is observed.

The estimation of the AIDS model is performed employing the seemingly unrelated regression (SUR) method, as proposed by Zellner (1962). In STATA, this is implemented through the sureg command, which employs a feasible generalized least-squares (FGLS) estimator and supports iteration. The iterated FGLS estimator is equivalent to a maximum likelihood estimator, addressing the singularity issue inherent in the AIDS model. This singularity arises due to the additivity restriction, as highlighted by Poi (2002). To overcome this, one common approach is to drop one equation from the system arbitrarily and estimate the remaining equations. However, such an arbitrary exclusion may influence the results for the remaining equations. To mitigate this issue, the maximum likelihood estimator is applied, ensuring consistency and robustness in the estimates.

4.2 | Coefficient Estimates

4.2.1 | Long—Run Parameter Estimates

According to long-run model results presented in Table 2, as anticipated, own-price parameters are found to be significant. The greatest impact of price on budget shares is observed for vegetables, followed by cereals. The impact of price on sugar and meat import shares is negligible. The intercept is found to be insignificant for all commodity types, indicating there is no autonomous level of import for any of these commodities. The expenditure parameter estimate is also insignificant, suggesting that the import of these commodities is not linked to the country's income when using annual data; in other words, the impact of income is both minor and statistically insignificant. Regarding the exchange rate, its impact on import budget shares is somewhat mixed: it is insignificant for cereals, vegetable oils, and meats. However, for sugars, the exchange rate has a statistically significant positive impact on the budget share, although the size of the impact is negligible. Lastly, the R-Square figures form evidence in favor of estimating a dynamic model for cereals, vegetable oils, and sugars, as it is close to 1. A super consistent model (i.e., R-Square is closed to 1) may indicate the presence of unit roots, as explained by Ng and Perron (2001). Therefore, parameter estimates may vary in the long and short run. Considering this finding, we also provided short-run parameter estimates in the next subsection.

TABLE 2 | Long-run model parameter estimates.

Long-run model	**Dependent variable: Budget shares**			
Independent variables	**Cereals**	**Meats**	**Sugars**	**Vegetable oils**
Price of cereals	0.185***	0.000	0.000	−0.185***
Price of meats	0.000	0.000***	−0.000**	0.000
Price of sugars	0.000	−0.000**	0.003***	−0.003***
Price of vegetable oils	−0.185***	0.000	−0.003***	0.188***
Exchange rate	0.003	0.000	−0.001***	−0.002
Expenditure	−0.007	0.000	0.000	0.008
Intercept	0.763	0.007	0.015	0.215
R-Sq	0.932	0.499	0.857	0.922

Significance: (*10% , ** 5% , ***1%).

4.2.2 | Short—Run Parameter Estimates

As presented in Table 3, a remarkable finding is that the budget allocations for cereals and vegetable oils are more responsive to short-term changes in their own prices compared to the longer-term estimates. This suggests the presence of a persistent element in food import patterns over the long run, where price effects are limited. This conclusion is reinforced by the statistically significant and theoretically consistent error correction terms. Specifically, the error correction term for cereals and vegetable oils indicates a recovery period of approximately 1.5 years from shocks to prices, exchange rates, or GDP. This indicates a stable demand for food imports, with equilibrium taking at least 1 year to restore, highlighting a long-term demand pattern for Turkish food imports. Like the long-term estimates, neither budget nor exchange rates are statistically significant factors influencing the budget shares of these commodities.

4.3 | Elasticities

4.3.1 | Long-Run Elasticities

As observed in Table 4, all elasticity estimates are both statistically significant and theoretically consistent: Income elasticity is positive, indicating that none of the imported commodity groups are inferior goods. Instead, they are almost equal to 1, suggesting that Türkiye imports these goods as they are considered essential. Particularly, the Marshallian own-price elasticity is remarkably low for cereals and vegetable oils. When these figures are coupled with the income elasticity values, it becomes evident that these commodity groups are apparent necessities.

Another important point is the pure income effect which refers to the impact of a change in income on consumption, assuming that prices remain constant. It measures the change in consumption when income changes, assuming that the relative prices of goods and services do not change. Accordingly, as anticipated the pure income effect estimates are found to be positive which implies that as income increases, consumption of the imported food items presented above rises, assuming that prices remain constant.

4.3.2 | Short-Run Elasticities

Table 5 presents the short-run elasticity results. Once compared to the long-run elasticities, it is seen that the short-run income elasticity figures are remarkably elastic for cereals. This indicates that in the short-run cereal import can be luxury and when coupled with the negative pure income effect, in the short-run

TABLE 3 | Short-Run Parameter Estimates.

Short-run model	Dependent variable: Budget shares			
Independent variables	**Cereals**	**Meats**	**Sugars**	**Vegetable oils**
Price of cereals	0.199***	0.000	0.000	−0.199***
Price of meats	0.000	0.001*	0.000	0.000
Price of sugars	0.000	0.000	0.004***	−0.004***
Price of vegetable oils	−0.199***	0.000	−0.004***	0.202***
Exchange rate	−0.007	0.002	0.000	0.006
Expenditure	−0.029	0.000	−0.002	0.030
Error Correction Term	*−0.629****	*−1.009**	*−0.586****	*−0.624****
Intercept	0.007	0.000	0.000	−0.007
R-Sq	0.958	0.555	0.947	0.959

Significance: (*10% , ** 5% , ***1%).

TABLE 4 | Long-Run Elasticity Estimates.

Long-Run Elasticities	Income Elasticity	$p>\|z\|$	Marshallian (Uncompensated) Own-Price Elasticity	$p>\|z\|$	Hicksian (Compensated) Own-Price Elasticity	$p>\|z\|$	Pure Income Effect
Cereals	0.984	0.000	−0.591	0.000	−0.137	0.000	0.454
Meats	1.000	0.000	−0.999	0.000	−0.538	0.000	0.461
Sugars	1.000	0.000	−0.993	0.000	−0.532	0.000	0.461
Vegetable Oils	1.016	0.000	−0.599	0.000	−0.130	0.000	0.469

TABLE 5 | Short-Run Elasticity Estimates.

Short-Run Elasticities	Income Elasticity	$p>\|z\|$	Marshallian (Uncompensated) Own-Price Elasticity	$p>\|z\|$	Hicksian (Compensated) Own-Price Elasticity	$p>\|z\|$	Pure Income Effect
Cereals	2.830704	0.808	−53.163	0.000	−53.17426	0.000	−0.011
Meats	0.564729	0.568	−1.177	0.000	−1.178669	0.000	−0.002
Sugars	1.063772	0.093	−1.948	0.000	−1.951688	0.000	−0.004
Vegetable Oils	−0.68657	0.952	−53.957	0.000	−53.9539	0.000	0.003

cereals' import can be replaced by domestic production whereas there was not such observation for the aforementioned long run elasticity figures. Given that the pure income effect is found to be negative for cereals, meats, and sugars, it can be said that Turkish economy can tolerate replacing imports of these goods with domestic production. Besides, the long-run estimates are the opposite of short-run estimates in terms of domestic production's role to replace imports. Nevertheless, the positive pure income effect of vegetable oils, coupled with its negative income elasticity estimate, implies that Turkish consumers continue to consume imported vegetable oils even if they become inferior goods in the short run. In this sense, we can conclude that among all commodity types in question, it can be said that vegetable oil consumption in Türkiye arises to be as an import-dependent commodity type. Import dependency increases vulnerability to fluctuations in global vegetable oil prices and supply disruptions. Sudden price rises or supply shortages can have severe consequences for consumers, particularly low-income households, who may struggle to afford essential food items, particularly when the imported vegetable oils are more inferior when compared to the long run.

Low-income elasticities estimated in this study are not surprising when we consider that Türkiye is a developing country. El-Shagi et al. (2021) show that the income elasticity of import demand is lower in developing country contexts. Low import demand elasticity for a good indicates that the associated good is a necessity for the country. If import markets are not diversified, this dependency could expose the country to significant risks in the face of price fluctuations. The notably lower long-run elasticity estimates we observe for these sectors in Türkiye may indicate a need for improvements in domestic production capacity, supply chain efficiency, and incentive mechanisms within Türkiye to mitigate the risks against food security in the country. These differences suggest that these sectors could benefit from targeted reforms to strengthen domestic output, reduce reliance on imports, and enhance competitiveness.

According to Suanin (2021), the income elasticity of demand for sugar preparations is estimated to be 3.72 in the long run for the US. The price elasticity of sugar preparations is estimated to be −1.39 in the long run. In contrast, our long-run estimates for price elasticity for sugars is 0.99, which is less elastic. Our estimated income elasticity is around one, suggesting a lower response to income changes. These differences could be attributed to Suanin's focus on the U.S., which is a developed country. Besides, regional variations and membership in trade unions or agreements might have also played significant roles in the difference between the two studies.

Song (2020) reported an import demand price elasticity exceeding −7.5 and an expenditure elasticity of about 2 for beef in the livestock sector of South Korea. When compared to elasticities estimated for Türkiye for meat, elasticities for Turkish imports are significantly lower. This could stem from variations in economic structures and differences in market development between the two countries. The results may suggest that South Korea, which shared a somewhat similar level of economic development with Türkiye in the 1980s but grew faster later, has a stronger livestock sector.

Our study finds that short-run income elasticity for meats is at 0.56, indicating that imported meat is a necessity in Türkiye in the short term. In contrast, Wang and Reed's (2013) results demonstrate that fishery products have import income elasticities above 1.00 in the short run. In terms of long-run income elasticities, meats in our study have a long-run elasticity of around 1.00, classifying them as unitary elastic. In contrast, Wang and Reed find much higher income elasticities, positioning these imports as luxury goods in the U.S. market. These differences likely stem from economic development levels, consumption patterns, and the availability of substitutes in each market.

Klonaris (2014) reports higher expenditure elasticities for meats than Türkiye in Greece, particularly, classifying them as luxury goods, for Greece. This also suggests that meat imports are more of a necessity for Türkiye than Greece. One reason for this necessity could be the insufficiency of the livestock sector in meeting domestic demand in Türkiye. Additionally, as a predominantly Muslim country, in Türkiye pork is not a viable substitute, further reinforcing the reliance on imported meats to satisfy local consumption needs. The results reflect a greater sensitivity of imports in Greece to income changes. Regarding price elasticities, import in Türkiye and Greece are similarly responsive to price changes in the short term.

Our short-run price elasticities for cereals and vegetable oils are larger than short-run elasticities. The availability of well-known substitutes, such as alternative grains or cooking oils, may have enabled faster adjustments in the short run. Additionally, specific short-term trade policies or quota adjustments might have accelerated short-run price responses that diminish as markets stabilize over time, driving long-run estimates down. Notably, short-run elasticities often reflect immediate market reactions,

which can occasionally appear larger due to import flow volatility. Similar patterns, though less pronounced, are observed in Forgenie, Hutchinson, and Muhammad (2024) analysis of Caribbean food import demand.

Another reason why long-term elasticities are smaller than short-term elasticities might be Türkiye's self-sufficiency in agricultural production for most products, especially during the period covered in this study, and the fact that imports are concentrated on genuinely necessary goods in the long term. While Türkiye may more easily shift to alternatives in the short term, rigidities in foreign trade relations could make these needs even more essential in the long term. In other words, as a developing economy with a chronic trade deficit, Türkiye may aim to maintain its position as a net exporter in agriculture and reduce its trade deficit through agricultural production. Therefore, in the long term, it is likely to prioritize the importation of only truly essential agricultural goods. In fact, as expressed by International Fund for Agricultural Development (IFAD) (n.d.), and United Nations Development Programme (UNDP) (n.d.) Türkiye remains a global player in agricultural production and its food import is mainly limited with intermediate goods for agricultural production. This suggests that while Türkiye aims to maintain its position in global agricultural production and food security, it may also depend on the importation of certain products in the long term due to changing conditions.

The low import income elasticity for meat indicates that meat imports are a necessity. As one of the countries with the highest food inflation in the world, Türkiye faces challenges in meeting domestic demand for certain food products. Our results suggest that livestock production is one of these areas. Therefore, in the short term, Türkiye needs to diversify its import sources. In this way, resilience against supply shocks can be improved. Additionally, flexibility can be achieved through short-term stock management and import tariffs. In the long term, the country must strengthen domestic production in the livestock sector. Incentive programs, such as subsidies for feed prices, low-interest loans, and infrastructure support, can be implemented for the livestock sector.

Both our estimation results and policy suggestions are verified by the literature on the Turkish livestock industry. Bozma et al. (2023) address the problems in the industry by highlighting several critical issues affecting Türkiye's livestock sector. The major problem presented by the study is the volatility in beef and lamb prices. The authors also identify rising energy prices as a major factor contributing to higher production expenses and price instability in the meat market. Additionally, the COVID-19 pandemic exacerbated supply chain disruptions. The study also underscores Türkiye's reliance on carcass imports to stabilize domestic prices, but this negatively impacted local producers through low market prices (Bozma et al. 2023). On the other hand, Bor (2024) underscores the critical role of cattle feed prices in price fluctuations, revealing that changes in feed costs are quickly transferred to carcass prices. The study also highlights misguided policy interventions in the dairy sector, such as maintaining farm-gate milk prices below cost. Due to this policy, low milk prices compel dairy farmers to cull their herds, leading to an initial stabilization of carcass prices but eventually resulting in a decline in the cattle population and a subsequent rise in meat prices (Bor 2024).

The price elasticities for cereals are low, reflecting Türkiye's dependency on imports. Factors such as the COVID-19 pandemic and the Russia-Ukraine war pose significant risks for a country with such high import reliance (Urak 2023). While Türkiye mitigated part of this risk by leading the grain corridor agreement, it must strengthen its domestic production structure, as we suggested for the livestock sector. Additionally, the supply chain needs to be reinforced to ensure resilience against external shocks. Revisiting incentive policies is imperative to support farmers who are struggling with rising energy costs.

5 | Conclusion

The food sector in Türkiye faces multifaceted challenges that demand careful consideration and strategic planning. The food security in Türkiye is important, not only domestically but also globally when the migration dynamics in the region is considered. Moreover, Türkiye grapples with soaring food inflation rates, necessitating the urgency of addressing food security concerns. In this context, the international trade dynamics of the country need careful examination.

This study analyses the import demand for key agricultural commodities in Türkiye, focusing more than 90% of the food import budget of Türkiye including cereals and preparations, meat and meat preparations, sugar and honey, and vegetable oils. Utilizing the Dynamic Almost Ideal Demand System (AIDS) model, the analysis spans the period from 1986 to 2020, offering the first comprehensive application of this model to Türkiye's food imports. Key findings reveal that cereals and vegetable oils exhibit significant sensitivity to price changes, highlighting their critical role as staples in the country's food import portfolio. Conversely, meat and sugar imports show minimal price elasticity, indicating their relative stability in consumption patterns.

The research findings for the long-run model reveal significant own-price elasticity parameters, with vegetables showing the greatest sensitivity to price changes, followed by cereals. However, the impact of price on sugar and meat imports is negligible. Importantly, the insignificant intercept coefficient shows that there's no autonomous level of import for any commodity type, indicating no inherent import demand. Income's influence on imports is minor and statistically insignificant. Exchange rate effects vary; while significant for sugar, they're inconsequential in cereals and vegetable oils. Conversely, the short-term analysis highlights the heightened responsiveness of budget allocations for cereals and vegetable oils to price fluctuations, suggesting a persistent element in food import patterns over time with limited price effects. Statistically significant error correction terms reinforce this conclusion, indicating a stable demand for food imports in Türkiye, with equilibrium taking at least 1 year to restore following the shocks to prices, exchange rates, or GDP, while neither budget nor exchange rates significantly influence the budget shares of these commodities.

When we analyse the elasticity coefficients, the long-term elasticity results indicate statistically significant and theoretically consistent findings, with positive income elasticity suggesting that imported commodity groups are essential rather than inferior goods, particularly evident for cereals and vegetable oils

with remarkably low own-price elasticity. The short-term elasticity results reveal remarkably elastic income elasticity for cereals, implying potential luxury status in short-run imports, with negative pure income effects indicating a possibility of domestic production substitution. Conversely, the positive pure income effect for vegetable oils, alongside negative income elasticity, highlights their import dependency, increasing vulnerability to global price fluctuations and supply disruptions, particularly impacting low-income households reliant on essential food items.

The long-term elasticity results present a positive pure income effect for cereals, meats, sugars, and vegetable oils along with a negative income elasticity for each of the agricultural subgroups investigated in the study. These results identify a growing susceptibility to worldwide price fluctuations and disruptions in supply chains, which disproportionately affect low-income households depending on essential food items. Furthermore, the long-run elasticity results indicate that domestic production substitution is not likely for all the agricultural subgroups provided in the study. Strengthening domestic production capacity is essential to reduce reliance on imports, particularly for critical commodities like cereals and vegetable oils. Investment in agricultural infrastructure, research, and development, as well as targeted subsidy programs, could enhance domestic supply resilience. Moreover, diversifying import sources and engaging in international trade partnerships can bolster food security and reduce vulnerabilities to global supply disruptions.

Policy implications suggest the need for strategies to stabilize exchange rates and control inflation to mitigate uncertainties in food trade. These results highlight the potential risk to food security in Türkiye. Policymakers need to develop policies to stabilize exchange rates to reduce uncertainties in the trade of food commodities as volatile exchange rates can lead to fluctuating import costs, which may affect the affordability of food items for consumers. Besides, policies need to be adopted to control inflation rates, as high inflation can reduce purchasing power and make essential food items less affordable for consumers. Strong coordination between monetary and fiscal policies needs to be ensured to manage inflationary pressures effectively. Strengthening domestic production capacity is essential to reduce reliance on imports, particularly for critical commodities like cereals and vegetable oils. Investment in agricultural infrastructure, research, and development, as well as targeted subsidy programs, could enhance domestic supply resilience. Moreover, diversifying import sources and engaging in international trade partnerships can bolster food security and reduce vulnerabilities to global supply disruptions.

Our results show that long-term estimates from our study underscore the limitations of domestic production in effectively substituting imports, which is important for countries experiencing high inflation and exchange rate volatilities, thereby posing a potential risk to food security. To mitigate this risk, the country should implement policies aimed at enhancing agricultural productivity by focusing on research and development, modernization of farming techniques, and investment in infrastructure. Furthermore, proactive measures should be adopted to diversify and strengthen trade relations, including the entrance into new markets. Ultimately, a holistic approach integrating both reforms on domestic production and strategic engagement in international trade is essential for safeguarding Türkiye's food security and fostering long-term sustainability in the food sector.

Future research can expand the scope by including additional food categories and exploring regional or household-level data to better capture variations in import demand. Incorporating dynamic models that account for changing consumer preferences and dietary trends would offer deeper insights. Furthermore, studies assessing the impact of trade agreements and geopolitical factors on Türkiye's food import dynamics could provide a more holistic understanding. Finally, exploring the interplay between climate change, domestic agricultural output, and import dependency would be valuable for long-term policy planning.

Author Contributions

F.T.C. captured the main idea of the study, formulated the methodology and conducted the data analysis, H.M.E. combined the relevant data and conducted literature review, I.O.B. and H.U. were responsible for overall study design. All the authors contributed to draft preparation, revising and editing. All the authors read and approved the final version of the manuscript and are guarantors of the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available in FAOSTAT at https://www.fao.org/faostat/en/#data. These data were derived from publicly available resources in the domain, specifically: FAOSTAT, https://www.fao.org/faostat/en/#data.

Endnotes

[1] For a detailed discussion the mathematical foundation of AIDS, please see Deaton and Muellbauer (1980).

[2] The elasticity formulae presented here are derived from the work of-Green and Alston (1991) and Kebede (2005) in which the author present the elasticity calculations for QUAIDS model.

[3] The data that support the findings of this study are available in FAOSTAT at https://www.fao.org/faostat/en/#data.

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