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Unraveling the Major Determinants behind Price Changes in Four Selected Representative Agricultural Products †

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Abstract: This study aims to analyze the drivers behind price changes in agricultural products in Türkiye from 2002 to 2021, considering the impacts of three crises of different causes which are the global food crisis, the Russia–Türkiye aircraft crisis, and the COVID-19 pandemic. The potential factors are categorized into four subgroups: governmental effects, agricultural inputs, macroeconomic indicators, and climatic conditions. The selected agricultural goods for price change measurement include wheat and maize representing subsistence goods, and olive oil and cotton as marketing goods. The autoregressive distributed lag (ARDL) model is applied to observe both the short- and long-term impacts of the variables on price developments. The results suggest that government effectiveness, regulatory quality, nitrogen use, water price, money supply, exchange rate, and GDP under the related categories are the most effective factors in price changes. Among the variables under the category of climatic conditions, significant values are obtained only in the analysis of the temperature impact on olive oil. The analysis also reveals the variable impact of crises on the prices of the chosen products, depending on the goods involved. The maize and wheat analyses yield particularly noteworthy results. In the long run, nitrogen use demonstrates a substantial positive impact, registering at 29% for wheat and 19.47% for maize, respectively. Conversely, GDP exhibits a significant negative impact, with 26.15% and 20.08%. Short-term observations reveal that a unit increase in the governmental effect leads to a reduction in inflation for these products by 17.01% and 21.42%. However, changes in regulatory quality result in an increase in inflation by 25.45% and 20.77% for these products, respectively.

Keywords: agricultural commodity price; global food crisis; Russia–Türkiye aircraft crisis; COVID-19 pandemic; governmental effect; agricultural inputs; macroeconomic indicators; climate change; sustainable development goals (SDGs); ARDL model

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Citation: Tandogan Aktepe, N.S.; Kayral, İ.E. Unraveling the Major Determinants behind Price Changes in Four Selected Representative Agricultural Products. *Agriculture* **2024**, *14*, 782. https://doi.org/10.3390/agriculture14050782

Academic Editors: Encarnación Moral-Pajares and Leticia Gallego-Valero

Received: 23 March 2024
Revised: 14 May 2024
Accepted: 16 May 2024
Published: 19 May 2024

1. Introduction

Food supply and security discussions have remained at the forefront as a panhuman issue across the board. Although their popularity has increased with the COVID-19 pandemic, it is a longstanding issue that becomes more visible during crisis periods. Particularly after the COVID-19 pandemic, this problem has been triggered and it has become a more complex issue with global stockpiling and speculative news. In addition to unsettling societies, it stimulates a preexisting and deeper food inflation problem. Although mostly seen and evaluated as a macroeconomic issue, it is more of a basic need because extreme price movements endanger food security and increase poverty [1–3]. As a new phenomenon in the changing world, sustainable development goals (SDGs) defined as a 'universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity' by the UNDP [4], focus on this issue. Hence being able to analyze its drivers plays a crucial role in human life rather than simply reducing prices for economic indicators. There have been many studies in the literature focusing on the determinants of food inflation from different perspectives. According to these studies, the determinants can be categorized mostly as climatic conditions [5–7], supply and demand-side factors [8–10], changes in input prices [11,12], external factors such as crises [13–15], and macroeconomic factors [16,17]. Undoubtedly, any change in these factors exerts either a positive or negative influence on agricultural production, consequently impacting food inflation. Climate change attributed to global warming both changes crop physiology and affects growth processes such as photosynthesis, transpiration, and maturation [18]. Extreme temperatures also contribute to loss in grain weight, nutrition value, and protein inclusion, impairing overall crop quality [19] Moreover, climate-driven extremes like floods and intense rainfall decrease the potential production yield [20] by damaging the crops and agricultural community assets [21]. From another perspective, input prices play an important role in agricultural production. Increases in the prices of fertilizers, energy, and other inputs cause an incremental cost resulting in lower production [22,23] and decreased crop yields [24]. Energy prices, in particular, have attracted attention in recent times due to supply constraints and their susceptibility to political and geopolitical conditions, which often dictate price fluctuations [25]. From a different standpoint, in an interlinked and globalized world, international prices affect domestic prices and volatility [26–28]. In this sense, this volatile structure shows its power and redound on prices. Also, external factors such as wars and pandemics spark this volatility, leading to price spikes as disruptions in production, supply chains, and logistics processes ensue [29,30]. Given the importance of policymaking aimed at increasing production and decreasing prices, changes in macroeconomic variables such as interest rates, exchange rates, money supply, and foreign income patterns wield considerable influence over the price analyses [31–33].

As an agricultural country, Türkiye, where the weights of food and non-alcoholic beverages group in inflation and annual contribution of this group to the total change are 24.98 percent and 18.51 percent, respectively [34], is one of the nations where this issue is at the forefront. However, this is not a recent concern for Türkiye when considering previous periods. Given Türkiye's geopolitical and the various influencing factors, there are different determinants affecting prices. As a result, food inflation has been relatively higher in Türkiye compared to the European Union in terms of both level and volatility [35]. Additionally, while the World Bank's agricultural price index increased by 6 percent in 2020, Türkiye experienced a rate of 18 percent [36]. The primary reason for this discrepancy is attributed to domestic factors, particularly the weak exchange rate, as indicated by Demirkilic et al. [37]. Trade restrictions such as import quotas and high tariffs rates are also cited as contributing factors to domestic inflation in Türkiye by IMF [38] and WTO [39]. From another perspective, the decline in the agrarian population, the rise in input prices, and the changes in global warming and climate conditions further trigger inflation [40].

With the crises experienced, this issue has become more complicated. Among the crises having the most penetrating impact on prices of agricultural products, the Asian crisis (1997–1999), Turkish economic crisis (2001), global food crisis (2008–2009), Russia–Türkiye aircraft crisis (2015–2016), and COVID-19 pandemic (2019–2021) can be cited for the recent years. Although each crisis stems from different reasons, all have an impact on price developments.

The Asian crisis, mostly grounded in excess foreign borrowing, inadequate audit of banking systems, and massive exchange rate devaluation, increased prices in different ways depending on the fiscal and monetary policy responses of the crisis countries. Knowles et al. [41] reveal that agriculture was profoundly affected because of the rise in input prices and livestock input prices being connected with the high exchange rate. While the increase in farm input prices is 15–100 percent, it is approximately 100 percent for the price of animal feeds and farm labor in the Philippines [42]. In Indonesia, the depreciation of the exchange rate and the increase in CPI for food was 80 percent and more than 50 percent respectively, in this crisis period [43].

The reasons for the 2001 Turkish economic crisis can be attributed to internal debates within the government, resulting in the depreciation of the Turkish lira. This led to a significant shift towards foreign currency, pulling the withdrawal of foreign investors from the market, overnight interest rates in interbank markets exceeding 1000 percent, and a decline in the reserves of the Central Bank [44]. Moreover, while inflation was approximately 30 percent, it exceeded 70 percent in the post-crisis period [44,45].

The global food crisis can be defined as one of the most impactful crises in terms of price fluctuations. Food commodity prices and the index for all commodities increased by 98 percent and 286 percent, respectively [8], during this crisis which stemmed from various factors including a decline in agricultural production growth and global grain stocks, higher production costs due to energy prices, and increased demand from emerging economies, etc. [46].

While the impact of Russia–Türkiye aircraft crisis on price movements cannot be clearly observed, this crisis, which erupted from the downing of a Russian bomber aircraft by a Turkish fighter jet due to airspace violation, notably affected the most imported and exported agricultural products. For instance, prices of tomatoes, eggplant, squash, oranges, and grapefruits, among the most exported agricultural products by Türkiye, decreased by approximately 29%, 26%, 46%, 29%, and 25%, respectively, in the post-crisis period [47]. The Borsa Istanbul (BIST) food and beverage index was also negatively affected [48].

Although the COVID-19 pandemic is primarily considered a health crisis, its impact has reverberated across the globe, affecting all sectors due to disruptions in workflow, production systems, logistic sectors, and supply processes. Restrictions, leading to a sharp decline in the supply side of agricultural production in countries regarding entry and exit, have significantly driven prices up for the long term. While the prices of perishable goods and basic food items have been strongly affected and increased due to the pandemic [14,15], the prices of cotton have decreased due to a decline in demand in the textile and apparel sector [49].

In this study, we analyze the drivers of price changes for four selected representative agricultural products within the context of crises. Factors considered in accordance with the existing literature are categorized into four subgroups: governmental effects, agricultural inputs, macroeconomic indicators, and climatic conditions. We evaluate the impacts on four goods: wheat, maize, olive oil, and cotton. These goods are chosen because they effectively represent price movements owing to their important shares in both global agricultural production and Turkish exports, as depicted in Table 1.

According to data from the Turkish Statistical Institute [50], cereal exports constitute approximately one-quarter of Turkish total exports. Among cereals, wheat and maize have the largest shares, accounting for 28.1% and 12.1%, respectively, in 2023. Türkiye hold a significant position in cotton, contributing 3% to global cotton production and ranking 7th [51]. Similarly, Türkiye ranks 4th in the world for olive oil production for the 2021–2022 period [52].

The present study comprehensively addresses the issue of price development across different dimensions, making its results highly significant for the literature and serving as a guide for policymakers. With this purpose, this paper focuses on identifying the factors influencing price changes during the period of 2002–2021, taking into account three distinct crises. The study analyzes four variables representing both subsistence and marketing goods, categorizing them into four groups: governmental effects, inputs, macroeconomic indicators, and climatic conditions. Compared to the literature mostly focusing on the impacts of agricultural inputs and macroeconomic variables on agricultural commodity prices, this paper presents a more comprehensive analysis by including both overlooked factors and crises of different causes. Hence, the findings are expected to contribute to the gap in the literature to a great extent.

Table 1. Top countries having the largest shares in the production of chosen products in the world production.

Wheat		Maize		Olive Oil		Cotton	
Top Countries	**Share in the World**	**Top Countries**	**Share in the World**	**Top Countries**	**Share in the World**	**Top Countries**	**Share in the World**
1. China	17.3%	1. US	26.4%	1. Spain	42.0%	1. China	24.4%
2. EU	17.0%	2. Brazil	25.7%	2. Italy	10.2%	2. India	22.6%
3. India	14.1%	3. Argentina	20.8%	3. Tunisia	7.7%	3. Brazil	12.9%
4. Russia	11.6%	4. Ukraine	12.1%	**4. Türkiye**	**7.4%**	4. US	10.7%
5. US	6.2%	5. Russia	2.6%	5. Greece	7.3%	5. Pakistan	5.9%
6. Canada	4.1%	6. EU	2.1%	6. Morocco	6.5%	6. Australia	4.3%
7. Pakistan	3.6%			7. Portugal	3.9%	**7. Türkiye**	**2.8%**
8. Australia	3.3%	9. Burma	1.1%	8. Algeria	3.2%	8. Uzbekistan	2.6%
9. Ukraine	3.0%	10. Serbia	1.0%	9. Argentina	1.0%	9. Argentina	1.4%
10. Türkiye	**2.5%**	**11. Türkiye**	**0.9%**	10. Egypt	0.7%	10. Mali	1.2%

Source: USDA [51] for wheat, maize, and cotton; International Olive Council [52] for olive oil.

In this context, Section 2 presents the literature review, while Section 3 provides information about the data and methodology. Section 4 gives the results and Section 5 presents all of the findings and evaluates them. The study is concluded in the final section.

2. Literature Review

2.1. Literature in the World

Although the factors influencing price changes vary across countries, there are common determinants that affect countries universally, as illustrated in Table 2. This table, which presents studies analyzing various periods and countries or groups of countries, highlights the consistent drivers of inflation. Regardless of the sample and timeframe, variables such as CPI, GDP, exchange rates, oil price, and money supply are frequently used to examine this relationship. Although many studies affirm the significant role of exchange rates in driving inflation [53–55], there is no consensus about the impact of money supply on food inflation. While some studies assert its positive correlation with food inflation [56,57], others contest this assertion [58]. Additionally, the impact of crude oil price on production costs contributes to a decline in agricultural supply, and this is seen as another additive effect on prices [59–61]. Supply-side factors, including trade restrictions, declining in agricultural productivity, and inadequate reserves, along with demand-side factors like population growth, shifting consumption patterns, and urbanization also significantly stimulate inflation pressures [9,62,63]. Table 2 summarizes a comprehensive overview of the literature by presenting studies using different periods, methodologies, and variables.

Table 2. Some studies on the determinants of food price inflation in the world.

Reference	Title	Years	Period	Region	Method	Variable
Baek and Koo [64]	Analyzing Factors Affecting U.S. Food Price Inflation	1989–2008	Monthly	US	• Johansen cointegration analysis • VEC model	• US food prices • Agricultural commodity prices • Energy prices • Ethanol production • Exchange rates
Davidson et al. [55]	Explaining UK Food Price Inflation	1990–2010	Annually	UK	Cointegrated Vector Autoregressive (C-VAR)	• UK retail food price index • Domestic producer prices • World commodity prices • Dollar price of oil • Exchange rate • Labour costs • Unemployment rate

Table 2. *Cont.*

Reference	Title	Years	Period	Region	Method	Variable
Huh and Park [65]	Examining the Determinants of Food Prices in Developing Asia	1995–2011	Quarterly	11 Developing Asian Countries	Vector Autoregression	• Oil price • World GDP • World food price • Food price future • Asian GDP • Asian food price • US exchange rates • Real GDP • Money supply • Individual food prices
Irz et al. [66]	Determinants of food price inflation in Finland—The role of energy	1995–2010	Monthly	Finland	Vector Error-Correction Model (VEC)	• Farm Price • Food Price • Energy Price • Wage
Lee et al. [67]	Food Prices and Population Health in Developing Countries: An Investigation of the Effects of the Food Crisis Using a Panel Analysis	2001–2010	Annually	Developing Countries	Panel analysis	• Government Health Expenditure per capita • GDP per capita • Political score • Armed conflict dummy • Youth population share • Improved sanitation facilities • Value-added agriculture
Ahmed and Singla [68]	An Analysis of Major Determinants of Food Inflation in India	2006–2013	Monthly	India	• Johansen cointegration technique • Error corection model	• Food price index • Oil price index • World food price index • Rainfall • Broad money • Interest rate on the short term loan • Nominal effective exchange rate
Bhattacharya and Sen Gupta [69]	Drivers and Impact of Food Inflation in India	2006–2013	Monthly	India	• Structural Vector Autoregression (SVAR) • Structural Vector Error Correction Model (SVECM)	• Global food prices • Fuel prices • Agricultural wages • Demand for food products
Ismaya and Anugrah [70]	Determinant of Food Inflation The Case of Indonesia	2008–2017	Quarterly	Indonesia	GMM Estimator	• GDP agriculture • GDP consumption • Domestic retail fuel price • Food imports • Narrow money • Credit agriculture • M1 to GDP consumption ratio
Norazman et al. [53]	Food Inflation: A Study on Key Determinants and Price Transmission Processes for Malaysia	1991–2013	Monthly	Malaysia	Vector Error-Correction Model (VECM)	• Malaysian food price index • World food price index • Labor cost • Real effective exchange rate • World oil price
Qayyum and Sultana [58]	Factors of Food Inflation: Eviden from Time Series of Pakistan	1970–2017	Annually	Pakistan	Regression Analysis	• CPI • GDP in GDP growth • Food export • Food imports • Money supply • Taxes

Table 2. *Cont.*

Reference	Title	Years	Period	Region	Method	Variable
Caklovica and Efendic [71]	Determinants of Inflation in Europe: A Dynamic Panel Analysis	2005–2015	Annually	28 European countries	Dynamic panel analysis	• Economic openness • Unemployment rate • Real wage growth • Institutional effects • Prices of food • Oil prices • Growth of real GDP per capita • Income growth per capita • Growth rate of monetary aggregate • Change in real exchange rate • Policy framework • Inflation • Fiscal balance/GDP • Terms of trade • Political stability • Exchange rate regime • Central bank independence • EBRD index of structural and institutional reforms • Food prices • EU membership • Domestic credit to private sector • Western Balkan regime • CIS group • General government expenditures • Current account balance • Share of agriculture • Population growth • Territory area • Index of economic freedom • Nominal or real exchange rate index
Adjemian et al. [72]	Factors Affecting Recent Food Price Inflation in the United States	2004–2022	Monthly	United States	Structural Vector Autoregressive Models – SVAR	• Core prices • M2 money supply • Per capita income • Wage • Energy price • GSCI • Transport price • Farm product price • Food price
Köse and Ünal [54]	The effects of the oil price and temperature on food inflation in Latin America	2003–2020	Monthly	Latin America	• Structural Vector Autoregression (SVAR) • Panel Granger Causality test	• Temperature change • Oil price • Nominal exchange rate • Wages in the agricultural industry • Food price
Kohlscheen [73]	Understanding the Food Component of Inflation	1990–2020	Annually	35 Countries	Local projection method	• CPI inflation • Expected inflation • Output gap • Domestic crop growth • Food exports growth • Food imports growth • Oil price change • Global food price inflation
Samal et al. [57]	The Impact of Macroeconomic Factors on Food Price Inflation: An Evidence from India	2006–2019	Monthly	India	ARDL Bounds Test	• Per capita GDP • Real exchange rate • Money supply • Global food price index • Per capita net availability of food grain • Agricultural wages • Combined price index-industrial workers for food indices
Kuma and Gata [56]	Factors Affecting Food Price Inflation in Ethiopia: An Autoregressive Distributed Lag Appoach	1990–2021	Annually	Ethiopia	ARDL	• Food Price Index • Real GDP • World food price • Rainfall amount • Population number • Money supply • Exchange rate • Interest rate

Table 2. *Cont.*

Reference	Title	Years	Period	Region	Method	Variable
Kornher and Kalkuhl [26]	Food Price Volatility in Developing Countries and Its Determinants	2000–2012	Annually	53 Countries	• System GMM • Two-step IV estimation	• Domestic commodity prices • International export prices • National food price indices • Relative level of beginning stocks • Production shortfall • Market performance index • Liner shipping connectivity index • Herfindahl index • Political stability • Governance • Public storage • Overall tade restrictiveness index • Trade balance of the country
Lee and Park [27]	International Transmission of Food Prices and Volatilities: A Panel Analysis	2000–2011	Annually	72 countries	Panel analysis	• Global food price inflation rates • Intraregional food price inflation rates • Extra-regional food price inflation rates • GDP per capita • Population • Food production index • Share of food in merchandise imports • Exchange rates • Money growth rates • Political stability

2.2. Literature on Türkiye

Among the studies on inflation in Türkiye, their focuses can be categorized into determinants of inflation in a general context, the impact of specific variables on prices, the analysis of macroeconomic indicators' impact, the examination of other relevant factors, and the relationship analysis with prices.

The determinants in a general context are mostly identified as the exchange rate, consumer price index (CPI) or food price index, GDP, and money supply [35,37,74–77]. On the other hand, findings obtained by Tay Bayramoglu and Koc Yurtkur [74] show that the dollar and euro exchange rate are the most important international factors affecting food industry prices in the short term. Despite their limited impact, oil prices, international food prices, and agricultural producer prices are found to affect food prices in the long term. Similarly, Sahin Kutlu [77] and Demirkilic et al. [37] highlight the significance of the exchange rate on food prices. Alev [75] asserts that while inflation is positively affected by the interest rate applied to money supply, budget deficit, and general purpose loans in the long run, it is positively affected only by the money supply and budget deficit (balance) variables in the short run. Aytekin and Hatirli [76] emphasize the significance of the import unit variable of food production on unprocessed food inflation. In addition to these studies, some studies analyze the factors affecting the prices of specific products. In this sense, while Mat et al. [78] examine the factors of raw milk price, Bayramoglu et al. [79] analyze tomato prices.

From the studies focusing on the impacts of specific inputs on prices, Altintas [80] prefers oil prices as a variable and concludes that while a negative change in oil prices has a negative impact on prices, positive change also has a positive impact. However, the effect of positive changes in oil prices is greater on prices than negative changes. Gokce's study [81], which evaluates the exchange rate in addition to oil prices, reaches the same result as Altintas [80] in terms of the relationship direction, emphasizing that their relationship with food prices is asymmetric. Baskaya et al. [82] focus on global warming, globalization, and food crisis rather than the impacts of inputs. The findings indicate that supply-side factors are more determinant in the high rise of processed food prices. Among these factors, drought precedes supply-side shocks and a high rise in international food prices stemming from the drought. Similarly, Bayramoglu et al. [83] handle the issue by adding ecological factors to economic factors to estimate their impacts on wheat prices. The results obtained present that the most effective factor in wheat prices is precipitation. Guloglu and Nazlioglu [84] directly analyze the impact of inflation on agricultural prices and assert that inflation has a positive impact on the prices in the low-inflation regime and a negative impact in the high-inflation regime. Specifically, Ozayturk [85] examines the impact of energy inflation and presents its positive impact on agricultural products' inflation.

Because prices are influenced by many factors, as mentioned in the literature above, some studies explore the relationship among those factors. Of them, Icen et al. [86] aimed to study the relationship among food prices, the exchange rate, and oil prices in Türkiye. The findings reveal that positive changes in the long-term trend of oil prices and the exchange rate have a greater impact on food prices than negative changes. The same relationship was also analyzed by Gungor and Erer [87]. The paper finds that the real exchange rate effect on food inflation increased during the COVID-19 pandemic period. Karacan [88] specifically examined the prices of grains, crude oil, and real effective exchange rates as examples. It is revealed that there is a unidirectional causality from REER to crude oil, wheat, corn, and rye prices, and from wheat, barley, and rice prices to Brent oil prices. Moreover, bidirectional causality is found between REER and barley, rice, and durum wheat prices.

3. Data and Methodology

3.1. Data

The data set used in this paper comprises annual data for Türkiye, spanning from 2002 to 2021. The preceding years were not be incorporated into the analysis because of the outbreak of the 2001 Turkish economic crisis. Including this crisis in the analysis could have led to potentially misleading results. In order to mitigate this risk, earlier data should have been included; however, regrettably, the absence of such data necessitated the exclusion of the period before 2002. Although many papers focusing on the agricultural issues utilize quarterly or monthly data, our goal was to evaluate less-examined variables and more interrelated factors. Hence, we chose to use annual data, following the approach of numerous other studies [12,56,57,89].

The dependent variables chosen to measure price developments are the price of wheat (*Wheat*) and the price of maize (*Maize*), representing subsistence goods, as well as the price of olive oil (*OliveOil*) and the price of cotton (*Cotton*), representing marketing goods. The independent variables, as can be seen in Figure 1, are categorized into four groups: governmental effects, agricultural inputs, macroeconomic indicators, and climatic conditions, allowing for evaluation based on the specific fields. These categories have been named *Group I*, *Group II*, *Group III*, and *Group IV*, respectively, for evaluation purposes. Compared to the existing literature, variables under *Group III* are most frequently used for analyzing price changes [56–58,65,70]. Input-related variables, especially oil prices, under *Group II*, are also often examined [53,69,73]. However, studies focusing on the impact of *Group I* and *Group II* are relatively scarcer than those examining other groups. Although there are some analyses on political stability [67,71] and climatic conditions [54,68], they are very limited in scope. Thus, our study gains significance in terms of bridging this gap, particularly as these issues have become more pressing in recent times with the escalation of climate change and the increasing complexity of governmental effects.

Among them, the governmental effect includes government effectiveness (*GovEff*), political stability and absence of violence/terrorism (*PolS*), regulatory quality (*Reg*), and stocks traded (*Stocks*). The inputs cover crude oil import prices (*Oil*), nutrient nitrogen (*Nitr*), pesticide use (*Pest*), and the water price index (*WPI*). The macroeconomic indicators consist of money supply (*M1*), official exchange rate (*Exc*), GDP (*GDP*), and interest rate flow (*Int*). The climatic conditions are represented by the impact of rainfall (*Rain*) and temperature *(Temp).* Detailed explanations and sources of the variables are shown in Table 3.

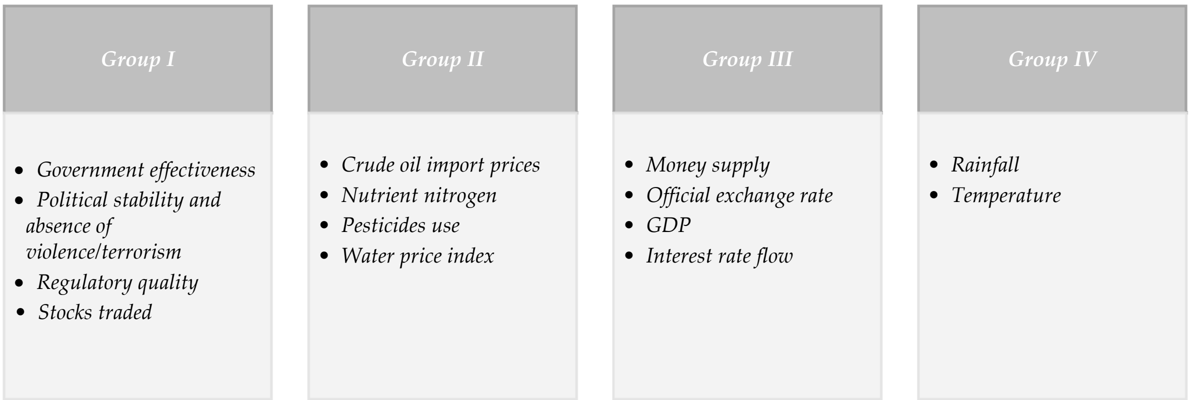

Figure 1. Independent variables.

Table 3. The explanations of the variables.

Wheat	Price of wheat (USD 1000) [90]
Maize	Price of maize (USD 1000) [90]
OliveOil	Price of olive oil (USD 1000) [90]
Cotton	Price of cotton (USD 1000) [90]
GovEff	Government effectiveness: The quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies [91]
PolS	Political stability: The perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism [91]
Reg	Regulatory quality: The ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development [91]
Stocks	Stocks traded: The value of shares traded is the total number of shares traded, both domestic and foreign, multiplied by their respective matching prices [91]
Oil	Crude oil import prices (USD/barrel) [92]
Nitr	Nutrient nitrogen used in agriculture [90]
Pest	Pesticide use, including the major pesticide groups (insecticides, herbicides, fungicides, plant growth regulators, and rodenticides) and relevant chemical families, in agriculture [90]
WPI	Water supply price in the context of CPI [34]
M1	M1 money supply including money in circulation and current deposit [90]
Exc	Official exchange rate: the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages [91]
GDP	Gross domestic product: the sum of the value added by all of its producers (USD) [91]
Int	Interest rate flow: The weighted average interest rates of deposits calculated for each deposit (stock) and maturity segment [93]
Rain	Average annual rainfall [94]
Temp	Average annual temperature [94]

Note: The explanations of *GovEff*, *PolS*, *Reg*, *Stocks*, *Pest*, *Exc*, and *GDP* are given as defined in the source from which the data were taken.

To measure the impact of crises, three crises of distinct causes are included in the equations as dummies. These include the global food crisis (2008–2009), also called the global financial crisis but with a focus on the food aspect, the Russia–Türkiye aircraft crisis (2015–2016), and the COVID-19 pandemic (2019–2021). These crises are incorporated into all equations to observe their effects, represented as *GFC*, *Aircraft* and *COVID* in the equations and analysis. Except for the independent variables under the category of governmental effects, all the series are converted into logarithmic form. Data are sourced from the databanks of WorldBank, FAO, OECD, the Turkish Statistical Institute, and the Central Bank. EViews 12 software package is used for the analysis. Descriptive statistics related to the data are given in Appendix A.

3.2. Methodology

In the context of this paper, the ARDL model proposed by Pesaran et al. [95] is preferred for analyzing the short-term and long-term relationships between price changes' inputs and crises. The ARDL approach outperforms other possible models in several aspects: It facilitates cointegration analysis across different orders of stationarity, yields better results with limited data, obtains more reliable results compared to the Engle–Granger causality test when data are scarce, and enables the estimation of whether the model has an autocorrelation problem or not through the Breusch–Godfrey LM test [96]. A general form of ARDL model is given below:

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{i=0}^{p} \alpha_{2i} x_{t-i} + \varepsilon_t \tag{1}$$

where y and x represent the dependent and independent variables, respectively, α_0 is a constant term, p denotes the autoregressive order of the ARDL, α_i and α_{2i} are coefficients associated with a linear trend, and ε_t is the error term.

The error correction model showing how long the shocks occurred for in a short period reaching the equilibrium point over the long period is formulated as follows:

$$\Delta y_t = \alpha_0 + \alpha_1 EC_{t-1} \sum_{i=1}^{p} \alpha_{2i} \Delta y_{t-i} + \sum_{i=0}^{p} \alpha_{3i} \Delta x_{t-i} + \varepsilon_t \tag{2}$$

where α_i represents the spread of adjustment of the parameter and EC is a residual from the equation.

Because the existence of the differences between the number of observations and the number of variables is important in terms of preventing biased results, a new model is estimated for each group of variables. The equation used for the analysis can be essentially shown as follows:

For *Group I*,

$$\begin{aligned} ln\mathrm{FI}_t = \alpha_1 + \alpha_{GE} GovEff_t \quad & + \alpha_{PS} PolS_t + \alpha_R Reg_t + \alpha_S lnStocks_t + \alpha_A Aircraft_t + \alpha_C COVID_t \\ & + \alpha_{GF} GFC_t + \sum_{h=1}^{m_1} \beta_h lnFI_{\ t-h} + \sum_{i=0}^{n_1} \beta_i GovEff_{t-i} + \sum_{j=0}^{o_1} \beta_j PolS_{t-j} \\ & + \sum_{k=0}^{p_1} \beta_k Reg_{t-k} + \sum_{l=0}^{q_1} \beta_l lnStocks_{t-l} + \sum_{m=0}^{r_1} \beta_m Aircraft_{t-m} + \sum_{n=0}^{s_1} \beta_n COVID_{t-n} \\ & + \sum_{o=0}^{t_1} \beta_o GFC_{t-o} + \varepsilon_{1t} \end{aligned} \tag{3}$$

For *Group II*,

$$\begin{aligned} ln\mathrm{FI}_t = \alpha_2 + \alpha_{CO} lnOil_t \quad & + \alpha_N lnNitr_t + \alpha_{PU} lnPest_t + \alpha_{WP} lnWPI_t + \alpha_A Aircraft_t + \alpha_C COVID_t \\ & + \alpha_{GF} GFC_t + \sum_{h=1}^{m_2} \beta_h lnFI_{\ t-h} + \sum_{i=0}^{n_2} \beta_i lnOil_{t-i} + \sum_{j=0}^{o_2} \beta_j lnNitr_{t-j} \\ & + \sum_{k=0}^{p_2} \beta_k lnPest_{t-k} + \sum_{l=0}^{q_2} \beta_l lnWPI_{t-l} + \sum_{m=0}^{r_2} \beta_m Aircraft_{t-m} + \sum_{n=0}^{s_2} \beta_n COVID_{t-n} \\ & + \sum_{o=0}^{t_2} \beta_o GFC_{t-o} + \varepsilon_{2t} \end{aligned} \tag{4}$$

For *Group III*,

$$lnFI_t = \alpha_3 + \alpha_M lnM1_t + \alpha_{ER} lnExc_t + \alpha_{GD} lnGDP_t + \alpha_{IR} lnInt_t + \alpha_A Aircraft_t + \alpha_C COVID_t + \alpha_{GF} GFC_t + \sum_{h=1}^{m_3} \beta_h lnFI_{t-h} + \sum_{i=0}^{n_3} \beta_i lnM1_{t-i} + \sum_{j=0}^{o_3} \beta_j lnExc_{t-j} + \sum_{k=0}^{p_3} \beta_k lnGDP_{t-k} + \sum_{l=0}^{q_3} \beta_l lnInt_{t-l} + \sum_{m=0}^{r_3} \beta_m Aircraft_{t-m} + \sum_{n=0}^{s_3} \beta_n COVID_{t-n} + \sum_{o=0}^{t_3} \beta_o GFC_{t-o} + \varepsilon_{3t} \quad (5)$$

For *Group IV*,

$$ln\mathrm{FI}_t = \alpha_4 + \alpha_{RF} lnRain_t + \alpha_T lnTemp_t + \alpha_A lnAircraft_t + \alpha_C lnCOVID_t + \alpha_{GF} GFC_t + \sum_{h=1}^{m_4} \beta_h lnFI_{t-h} + \sum_{i=0}^{n_4} \beta_i lnRain_{t-i} + \sum_{j=0}^{o_4} \beta_j lnTemp_{t-j} + \sum_{k=0}^{p_4} \beta_k Aircraft_{t-k} + \sum_{l=0}^{q_4} \beta_l COVID_{t-l} + \sum_{m=0}^{r_4} \beta_m GFC_{t-m} + \varepsilon_{4t} \quad (6)$$

where FI_t represents the price of the chosen dependent variable; α_1, α_2, α_3, and α_4 are the constants; other α_x terms and β_x show the long-run and short-run coefficients, respectively; ε_t terms denote the error terms.

4. Results

4.1. Unit Root Tests

To implement the ARDL model successfully, ensuring stationarity is crucial. Unlike the prerequisites of traditional cointegration tests such as the Engle Granger [97] and Johansen [98] tests, which require the variables to be stationary at I(0), the ARDL model enables for cointegration analysis even if the variables are stationary at different levels, such as I(0) and I(1). Hence, this paper examines the stationarity of the dependent variables at both I(0) and I(1) levels using the augmented Dickey Fuller (ADF) unit root test [99] and Phillips–Perron (PP) unit root test [100] as can be seen in Table 4.

Table 4. Unit root tests for the variables.

Unit Root Tests	ADF				PP			
	I(0)		I(1)		I(0)		I(1)	
Variables	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Intercept	Trend and Intercept
lnWheat	−5.3438 ***	−5.8411 ***	−5.0456 ***	−4.8031 ***	−3.3695 **	−4.9201 ***	−7.0292 ***	−7.3019 ***
lnMaize	−0.1160	−4.1266 **	−4.9221 ***	−4.8584 ***	−2.9655 *	−4.5816 ***	−10.7074 ***	−10.2056 ***
lnOliveOil	−0.9164	−2.1474	−1.6802	−6.5761 ***	−0.9402	−2.4228	−6.1610 ***	−6.1148 ***
lnCotton	−2.2449	−2.8796	−6.4637 ***	−3.8689 **	−2.2449	−2.8796	−7.0035 ***	−19.6503 ***
GovEff	−1.5624	−1.1898	−4.2080 ***	−4.9308 ***	−1.0086	−1.1632	−4.2427 ***	−4.9376 ***
PolS	−1.4927	−2.1918	−3.8467 **	−3.7696 **	−1.4651	−1.8906	−3.9347 ***	−4.4314 **
Reg	0.1164	−0.2221	−3.1681 **	−3.2829	−0.9522	−0.8728	−2.8771 *	−3.8570 **
lnStocks	−1.9534	−2.7419	−3.6538 **	−3.2984 *	−1.9388	−2.7045	−3.6538 **	−3.2173
lnOil	−2.4841	−2.1538	−3.6217 **	−3.6960 **	−2.4920	−2.0841	−3.5450 **	−3.5195
lnNitr	0.5177	−4.3684 **	−7.9176 ***	−4.6653 **	−2.3281	−4.5360 ***	−8.7712 ***	−9.5052 ***
lnPest	−1.0697	−5.7521 ***	−10.5544 ***	−2.7557	−2.4430	−5.6881 ***	−14.6800 ***	−14.0909 ***
lnWPI	0.1799	−3.0950	−3.9285 **	−4.2392 **	0.4070	−2.6237	−3.1263 **	−2.8059
lnM1	0.4509	−1.4952	−2.8855 *	−2.7739	0.0339	−1.7746	−2.8929 *	−2.7040
lnExc	−0.2578	−0.4408	−0.8061	−6.4791 ***	4.2022	0.2932	−2.0353	−13.7321 ***
lnGDP	−5.1657 ***	−2.8848	−3.0221 *	−3.8424 **	−6.5906 ***	−6.0155 ***	−2.9778 *	−3.7552 **
lnInt	−3.1495 **	−1.1006	−3.2240 **	−5.4897 ***	−3.3270 **	−2.5539	−3.0890 **	−6.1067 ***
lnRain	−4.4481 ***	−4.6459 ***	−5.1711 ***	−5.0400 ***	−4.4630 ***	−4.7290 ***	−17.4911 ***	−18.3060 ***
lnTemp	−3.2700 **	−5.9474 ***	−4.6999 ***	−4.4940 **	−3.2676 **	−7.0547 ***	−23.7940 ***	−22.8425 ***

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The findings present that all variables exhibit stationarity at the first difference based on both the ADF and PP unit root tests.

4.2. Lag Length Criteria and Bounds Test

The optimal lag length is chosen based on the Akaike information criteria (AIC). For the measurement of long-run relationship and cointegration, the F-bounds test is applied as can be seen in Table 5.

Table 5. F-bounds test.

F-Bounds Test							
Dependent Variable: lnWheat		Dependent Variable: lnMaize		Dependent Variable: lnOliveOil		Dependent Variable: lnCotton	
Variable Group	F-Stat	Variable Group	F-Stat	Variable Group	F-Stat	Variable Group	F-Stat
Group I	7.0492 ***	*Group I*	33.5497 ***	*Group I*	26.3861 ***	*Group I*	10.9923 ***
Group II	4.2257 *	*Group II*	3.6251 *	*Group II*	1.7744	*Group II*	21.7804 ***
Group III	6.7250 ***	*Group III*	5.1116 **	*Group III*	6.6230 ***	*Group III*	21.1098 ***
Group IV	2.8097	*Group IV*	1.8711	*Group IV*	3.9751 *	*Group IV*	6.2298 **

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The findings indicate that the null hypothesis (H_0), which asserts no cointegration, is rejected for *Group I* and *Group III* across all selected goods. Although a long-term relationship is found for all variables concerning cotton, it is observed across all groups except for *Group IV* for wheat and maize. Regarding olive oil, the long-run relationship is established in all groups except for *Group II*. Notably, the results for *Group IV* concerning the price of wheat and maize lead to the rejection of the alternative hypothesis (H_1) referring to the presence of a long-term relationship.

4.3. ARDL Model

Based on the results of the bounds test, the ARDL model is evaluated for both short- and long-term analysis with the lowest AIC value, as detailed in Appendix B. The Breusch–Godfrey LM test shows that the null hypothesis meaning no serial correlation cannot be rejected for wheat, maize, and olive oil at the 5% significance level. However, for cotton, it can only be rejected for inputs at a 5% significance level, indicating the existence of autocorrelation. The Ramsey Reset test findings prove no specification problem in the model except for Group III specific to the price of cotton, where all other probabilities are greater than 0.05. The Breusch–Pagan–Godfrey (BPG) heteroskedasticity test reveals no heteroskedasticity problem for any of the variables, except for Group II specific to the price of olive oil.

4.4. Long-Run Relationship

Upon analyzing the price movements of the selected variables as outlined in Appendix C, it is observed that the price fluctuations of maize and wheat show similarities. However, while maize prices have followed a fluctuating trajectory thus far, wheat prices have shown a moderate course, albeit not as stable as the cotton price. In the course of cotton prices, volatilities have remained range-bound for an extended period but have had a tendency to increase in recent years. Although olive oil has followed a fluctuating course for the years, it shows more stability in recent years. Starting from this point, it can be evaluated that subsistence goods tend to follow a more volatile trajectory compared to marketing goods.

However, these observations are not explanatory in themselves and do not help to unravel the underlying causes behind price changes in selected agricultural products. Hence, empirical studies and findings are essential to understand this phenomenon.

As given in Table 6, regarding the results of wheat, we can evaluate all groups except *Group IV* without encountering a lack of cointegration problem. In *Group II*, while crude oil and nitrogen use exhibit positive relationships with the rate of wheat price increasing by 5.32% and 29%, respectively, the WPI shows a negative relationship, decreasing by 10.29%.

Group III propounds striking results about the impact of macroeconomic indicators on price. Contrary to the strong positive impact of money supply by 18.93%, the exchange rate and GDP show a negative impact of 22.44% and 26.15%, respectively. Additionally, the Russia–Türkiye aircraft crisis and COVID-19 contributed to price declines of 2.66% and 8.82%, respectively.

Table 6. Long-run relationship.

ARDL Long Run Results							
Dependent Variable: lnWheat							
Group 1		**Group II**		**Group III**			
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**		
GovEff	−34.4375	***lnOil***	5.3207 **	***lnM1***	18.9344 ***		
PolS	−3.0724	***lnNitr***	28.9994 *	***lnExc***	−22.4379 ***		
Reg	41.1295	***lnPest***	12.2228	***lnGDP***	−26.1514 **		
lnStocks	−1.8230	***lnWPI***	−10.2934 *	***lnInt***	2.8473		
Aircraft	−4.3567	***Aircraft***	2.0609	***Aircraft***	−2.6552 *		
COVID	6.3222	***COVID***	−0.2128	***COVID***	−8.8226 *		
GFC	4.4976	***GFC***	2.3200	***GFC***	−0.7226		
Dependent Variable: lnMaize							
Group 1		**Group II**		**Group III**			
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**		
GovEff	−19.8404 **	***lnOil***	1.3259	***lnM1***	8.5622 *		
PolS	−1.8595	***lnNitr***	19.4751 **	***lnExc***	−8.0163		
Reg	23.6453 **	***lnPest***	2.9215	***lnGDP***	−20.0751 *		
lnStocks	−0.4553	***lnWPI***	−3.5376	***lnInt***	−3.6687		
Aircraft	−1.7212	***Aircraft***	−0.5512	***Aircraft***	−1.2464		
COVID	1.3076	***COVID***	−0.2192	***COVID***	−6.0654		
GFC	2.0874 **	***GFC***	1.7946	***GFC***	0.2351		
Dependent Variable: lnOliveOil							
Group 1				**Group III**		**Group IV**	
Variable	**Coefficient**			**Variable**	**Coefficient**	**Variable**	**Coefficient**
GovEff	−2.8344 ***			***lnM1***	0.8338 **	***lnRain***	1.8026 *
PolS	−0.3995 ***			***lnExc***	−0.4630	***lnTemp***	8.7144 ***
Reg	1.5979 ***			***lnGDP***	−0.7345	***Aircraft***	0.4494 **
lnStocks	0.4748 ***			***lnInt***	0.5713 **	***COVID***	0.7157 ***
Aircraft	−0.4118 **			***Aircraft***	0.0386	***GFC***	−0.5962 *
COVID	−0.3338 **			***COVID***	−0.1270		
GFC	0.3095 ***			***GFC***	−0.0703		
Dependent Variable: lnCotton							
Group I						**Group IV**	
Variable	**Coefficient**					**Variable**	**Coefficient**
GovEff	−3.7489 **					***lnRain***	0.8302
PolS	−0.9168 **					***lnTemp***	2.0535
Reg	2.3037					***Aircraft***	0.1416
lnStocks	−0.3591					***COVID***	0.6713 ***
Aircraft	−1.5058 **					***GFC***	−0.5460 *
COVID	1.2283 **						
GFC	0.2054						

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Similar to the findings for wheat, the positive effects of nitrogen and money supply, along with the negative effect of GDP, are observed in the impacts on maize prices. A unit increase in nitrogen use and money supply leads to an incremental impact of 19.48% and 8.56%. GDP shows a strong negative impact again, with a rate of 20.08%, as in its impact on wheat prices. Unlike wheat, however, government effectiveness and regulatory quality are found to be significant for maize prices, with substantial impacts. While a unit increase in government effectiveness decreases maize prices by 19.84%, an increase in regulatory quality has a similar effect, reducing prices by 23.65%. Moreover, the impact of the GFC, in this category, is positively related to inflation. These rates are noteworthy due to their impacts on maize prices. Variables under *Group IV* cannot be evaluated due to the autocorrelation problem.

Except for *Group II*, having heteroskedasticity and autocorrelation problems, the validity tests of olive oil prices show that they meet all the model's preconditions, enabling the evaluation of all variables. The values of all factors in *Group I* and *Group IV* are significant. In *Group I*, government effectiveness and political stability negatively affect the price of olive oil by 2.83% and 0.40%, while regulatory quality and stocks have positive effects, with rates of 1.60% and 0.48%, respectively. Among the crises, the aircraft crisis and COVID-19 led to a decrease in inflation, while the GFC caused an increase. In *Group III*, the only significant and positively effective variables are money supply and the interest rate, with impact ratios of 0.83% and 0.57%, respectively, on olive oil inflation. In *Group IV*, the impacts of rainfall and temperature are observed as positive, with rates of 1.80% and 8.71%, respectively. However, the signs of the crises show exact opposition compared to Group I.

The findings regarding the drivers of cotton inflation reveal that a unit increase in government effectiveness and political stability slow down the rate of price increase by 3.75% and 0.92%, respectively, in *Group I*. Among the crises within this group, the aircraft crisis has a negative impact, while COVID-19 has a positive effect. However, the other variables cannot be evaluated because of the serial correlation problem in *Group II* and the specification problem on *Group III*. In *Group IV*, where only COVID-19 and GFC are significant, they have an impact on the price increase of olive oil by 0.67% and −0.55%, respectively.

4.5. Short-Run Relationship

A short-run relationship analysis is conducted using the error correction model. As can be seen in Table 7, the coefficient sign of *CointEq(-1)* is negative and significant, meaning that deviations from the long-run equilibrium in the selected agricultural product prices can be restored in the short-run, stabilizing the standard deviation and mitigating the shocks. Compared to the long-term results, the short-term values are notably promising, as all coefficients are significant except for a few variables.

In detail, a unit increase in the government effectiveness and stocks leads to a reduction in wheat inflation by 17.01% and 6.28%, while political stability and regulatory quality have increasing impacts with rates of 5.22% and 25.45%, respectively. The impact of COVID-19 is observed as positive on *Group II* with a rate of 2.36%. In *Group II*, except for the WPI, which shows a negative sign with a rate of 22%, the signs of all of the other significant variables are positive. A unit increase in crude oil has a positive impact on wheat inflation of 4.81%, while the impact of nitrogen use (20.64%) on wheat inflation is remarkable among the other variables in this group. The only effective crisis found is the aircraft crisis, with a rate of 5.87%. We also encounter noteworthy results in *Group III*. A unit increase in money supply rises wheat inflation by 17.20%, while an increase in GDP reduces it by 28.12%. Additionally, COVID-19 has a negative impact of 4.94%.

For maize, all variables are significant in *Group I*. Among them, the most striking results are the negative impact of government effectiveness (21.42%) and the positive impact of regulatory quality (20.77%). In *Group I*, all crises are positively related. In *Group II*, three significant and strong effective factors are nitrogen use, WPI, and aircraft crisis. A unit increase in nitrogen use leads to a 14.11% increase in the rate of change in maize price, while a unit increase in the WPI results in a decrease by 18.73%. The Russia–Türkiye aircraft crisis is also positively related, with a rate of 1.78%. In *Group III*, the only significant and positive variable is the GFC, with its impact on maize inflation being 2.71%.

Table 7. Error correction models.

Error Correction Model Results							
Dependent Variable: lnWheat							
Group 1		**Group II**		**Group III**			
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**		
D(GovEff)	−17.0136 **	***D(Oil)***	4.8049 **	***D(lnM1)***	17.1996 ***		
D(PolS)	5.2184 ***	***D(lnNitr)***	20.6407 ***	***D(lnGDP)***	−28.1222 ***		
D(Reg)	25.4486 **	***D(lnPest)***	5.9568 **	***D(lnInt)***	−1.1334		
D(lnStocks)	−6.2819 **	***D(lnWPI)***	−22.0011 **	***D(Aircraft)***	−0.5280		
D(COVID)	2.3551 *	***D(Aircraft)***	5.8689 ***	***D(COVID)***	−4.9441 ***		
D(GFC)	−1.1958	***D(GFC)***	−0.9675	***CointEq(-1)***	−1.4030 ***		
CointEq(-1)	−1.3732 ***	***CointEq(-1)***	−1.3579 ***				
Dependent Variable: lnMaize							
Group 1		***Group II***		***Group III***			
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**		
D(GovEff)	−21.4179 ***	***D(lnOil)***	0.0257	***D(COVID)***	0.2715		
D(PolS)	1.0241 **	***D(lnNitr)***	14.1047 ***	***D(GFC)***	2.7121 ***		
D(Reg)	20.7717 ***	***D(lnPest)***	0.4266	***CointEq(-1)***	−0.8082 ***		
D(lnStocks)	2.2542 ***	***D(lnWPI)***	−18.7280 ***				
D(AirCraft)	0.4709 *	***D(Aircraft)***	1.7760 **				
D(COVID)	5.3984 ***	***CointEq(-1)***	−1.4066 ***				
D(GFC)	1.7996 ***						
CointEq(-1)	−1.7125 ***						
Dependent Variable: lnOliveOil							
Group 1				***Group III***		***Group IV***	
Variable	**Coefficient**			**Variable**	**Coefficient**	**Variable**	**Coefficient**
D(GovEff)	−2.1325 ***			***D(lnExc)***	−2.1728 ***	***D(lnTemp)***	3.4734 ***
D(Reg)	0.2437 *			***D(lnGDP)***	−2.0659 ***	***D(Aircraft)***	−0.0089
D(lnStocks)	−0.1512 ***			***D(COVID)***	−0.2550 ***	***D(COVID)***	−0.0064
D(Aircraft)	−0.1912 ***			***CointEq(-1)***	−0.8120 ***	***D(GFC)***	0.2218 **
D(COVID)	0.0592 *					***CointEq(-1)***	−0.5740 ***
D(GFC)	0.3914 ***						
CointEq(-1)	−1.2652 ***						
Dependent Variable: lnCotton							
Group 1						***Group IV***	
Variable	**Coefficient**					**Variable**	**Coefficient**
D(GovEff)	−0.7206					***D(Aircraft)***	−0.1676
D(PolS)	−2.0945 ***					***D(GFC)***	0.4147 **
D(Reg)	−0.2369					***CointEq(-1)***	−1.2936 ***
D(lnStocks)	−1.5762 ***						
D(Aircraft)	−0.9610 ***						
D(COVID)	−0.2254						
CointEq(-1)	−1.4894 ***						

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The majority of the results obtained for olive oil are significant and hence valuable for the literature. In *Group I*, a unit increase in government effectiveness and stocks leads to a fall in the rate of olive oil inflation by 2.13% and 0.15%, respectively, whereas regulatory quality has a positive impact of 0.24%. Among the crises, only the Russia–Türkiye aircraft crisis is negatively related to the price of a given good. In *Group III*, all of the significant variables, which are the exchange rate, GDP, and COVID-19, show negativity. Contrarily, in *Group IV*, all of the significant variables are positively related to olive oil inflation. While the impact of temperature is 3.47%, the GFC affects it by 0.22%.

The findings regarding cotton inflation present negative impacts of political stability, stocks, and the Russia–Türkiye aircraft crisis, with rates of 2.10%, 1.58%, and 0.96%, respectively. In *Group IV*, the only variable with a positive sign is the GFC, with an impact of 0.42%.

5. Discussion

Upon examining all of the results, it becomes clear that the findings propound striking contributions to the literature and enhance analyses regarding the determinants behind price changes in chosen agricultural products. In the general context, the effective factors on inflation have been observed among both subsistence goods (wheat, maize) and marketing goods (olive oil, cotton). When evaluating the common results, the role of government effectiveness, political stability, and regulatory quality as macroeconomic indicators on the inflation of the chosen agricultural products is quite obvious. However, there are some important points of distinctions among them. Firstly, although the impact of political stability may not be high, the other factors have a sizeable effect on inflation. Secondly, political stability is positively related to wheat and maize inflation but negatively related to olive oil and cotton inflation. Although this positive result may seem unexpected, findings from Lee et al. [67] support this variability, as suggested in their study about food prices and population health in developing countries. They assert that there is an inconsistency in its impacts because while a high level of democracy is found to be negatively related to infant and child mortality, a political score is positively related to the prevalence of undernourishment. Thirdly, the government effectiveness of all of the variables shows a negative impact, while regulatory quality is found to be positively related to all goods except for cotton, which has insignificant values. Laborde et al. [101] explain that during price plunges, government encouragement of more exports and global supply leads to a decrease in prices. Similarly, the impact of stocks varies depending on both agricultural products and the terms. However, the considerable values among them prove its negative precedence over its expected positivity. This impact is consistent with the literature [102,103], which asserts that high stock levels are very important to depress price inflation. In terms of inputs, we have obtained two impressive results for the inflation of wheat and maize. Nitrogen use has affected wheat inflation by more than 20% and maize inflation by an average of 17%, positively influencing both short- and long-term scenarios. This is not a surprising result because as the input price increases, costs and, correspondingly, prices will also increase. However, the WPI has a strong negative impact on the inflation of goods mentioned with at least a 10.29% decrease. Contrary to these results, the negativity of WPI on price movements is unexpected. However, it should be noted that we used accessible tap water data. Unfortunately, the data may have misled the results because of the existence and high usage of external water sources without tap water.

Examining the macroeconomic indicators, the impacts of money supply and GDP have attracted attention regarding wheat and maize inflation. The positive impact of money supply on wheat inflation in both the short and long terms, as well as for maize in the long term, has been distinguished. Additionally, the impact rates indicate quite an impressive impact of money supply on wheat and maize inflation. With some exceptional studies indicating a negative impact of money supply such as Qayyum and Sultana [58], most of the literature presents that an increase in money supply tends to lead to an increase food inflation [65,72], especially in the long run [57,68]. GDP has been found to have a decreasing impact on the inflation of wheat, maize, and olive oil. Its impact is very strong on wheat and maize despite being comparatively slightly effective on olive oil inflation. Even if there is no consensus about the impact of GDP on food inflation, our findings are consistent with the majority of the literature [17,70,75]. Although its sizeable impact is found only on wheat inflation in the long term, the exchange rate is a crucial driver for the analysis of food inflation. Its negative impact on food inflation, observed as 22.44%, is also supported by the literature [55,64,65]. However, there is no consensus about its impacts, as some studies assert its positive effect on food inflation, while others claim the opposite. Among them, besides the study by Norazman et al. [53] which found its impact to be negative in both terms, many papers present its positive impacts on food inflation [56,77,104]. In addition to them, some papers observe a positive relationship only in the long run [68] or the short run [57]. The reason for the positive impact is explained as the rise in costs, especially for importing countries and, correspondingly, the rise in domestic demand.

Except for its impact on olive oil inflation, climatic conditions have not been found to be highly correlated with inflation. For olive oil alone, the positive impact of temperature is remarkable and the impact of rainfall is partially effective in line with the literature supporting the increasing impact of temperature and rainfall on food inflation [54,56,68]. This does not mean that they do not have any impact on agricultural product prices, but they can be evaluated as less effective factors.

Based on the categories, the impacts of the crises on the prices of the chosen products have varied. While it is challenging to draw a common inference, these differences can be understood. In general, during periods of crises, investments in agriculture decrease, demand for agricultural products declines, and public intervention increases, leading to a negative influence on productivity growth [105]. In this respect, less productivity growth may induce inflation. From another perspective, reduced demand for goods and services, problems in credit availability, and rising protectionism stemming from the financial crisis may cause a fall in prices [106].

6. Conclusions

As is commonly known, the importance of agriculture and agricultural production has become increasingly evident over time. Periods of crises are pretty instructive for economies and countries regarding the deficiencies in this field. The impacts of crises vary depending on the resilience and structure of countries. Understanding the drivers of agriculture production and the effects of crises on agriculture is more important than ever.

Moreover, the analyses of the factors influencing agricultural production and agricultural commodity prices have gained increasing importance due to inflation and food security problems. It is tough to explain the exact factors because of many external factors, such as political issues, climatic conditions, various crises and governmental effects, etc., alongside main inputs like agriculture and labor which play a role. Even if these factors are interrelated, and identifying the main effective factors is complex, each analysis aiming to understand the framework plays a crucial role in producing solutions to overcome these problems.

For this purpose, the current paper endeavors to shed light on the drivers behind the price changes of agricultural products for the annual period from 2002 to 2021. During this period, three different crises are also taken into consideration to analyze their impact on prices. These crises include the global food crisis (2008–2009), the Russia–Türkiye aircraft crisis (2015–2016), and the COVID-19 pandemic (2019–2021). The analysis is implemented by taking four representative agricultural products: wheat, maize, olive oil, and cotton, as a base. Fourteen possible factors categorized into four groups, titled as governmental effectiveness, inputs, macroeconomic indicators, and climatic conditions and labeled as Group I, Group II, Group III, and Group IV, have been examined within the scope of the study.

Depending on the findings obtained, the present paper first proves the power of governmental effects and regulatory quality on price developments. The negative impacts of governmental effects are undoubtedly related to mismanagement, because its positive impacts rely on appropriate policy implementations which may rectify the problems directly in the missing points and produce results-oriented and effective solutions. This principle also applies to the regulatory quality of the government. For instance, Mittal [46] asserts that one factor contributing to the decline in investment in agricultural production is the reduced regulatory quality in agricultural production by the state. However, the key point mentioned here is that appropriate policies can benefit production and decrease inflation. From another perspective, the positive impact of regulatory quality on prices may be interpreted as a response to the increasing value of the goods due to regulations. Regulations mostly require meeting specific conditions and rules, which may increase costs and induce inflation.

Secondly, the impact of inputs on price movements is evident according to the findings. The incremental effect of nitrogen use and the decremental effect of the WPI should be carefully evaluated by the government, and the target-oriented regulations should be implemented to enhance their positive impacts and advantages for the goods while prevent their disadvantages. Because their impacts are not negligible, switching over their disadvantages to advantages can significantly contribute to production levels and prices more than anticipated. Moreover, careful and decisive policymaking is imperative, especially concerning nitrogen use. While nitrogen fertilizers contribute to soils, water ecosystems, oceans, and environmental degradation, decreasing their use with inappropriate implementation could lead to a 13% decrease in agricultural production and a 26% increase in prices until 2050 [107]. Hence, governments should ameliorate nitrogen-use efficiency through initiatives via manure recycling, sewage treatment and recycling, falling harvest loss and food waste, etc. [107]. Similarly, addressing water pricing requires efforts to prove efficient and equitable water use, incentivize investment expenditure recovery rates, and allocate more resources to prevent water losses stemming from the irrigation infrastructure [108].

Money supply, exchange rate, and GDP comprise the strongest elements of food inflation, within the category of macroeconomic factors. Therefore, providing stability and sustainability in economies are crucial prerequisites for maintaining agricultural commodity prices at optimum levels.

All of these results emphasize a notion crucial for the sustainability and resilience of economies in the future, known as the SDGs (sustainable development goals) in the agenda. A major part of the findings obtained is closely connected with the goals outlined in these SDGs. A thorough analysis of the components of price changes is not only beneficial to maintaining price stability but also crucial for increasing welfare, equity, and quality of life. It consists of the first link in the life cycle chain, because proper nourishment is the most essential requirement for human beings. Therefore, increasing agricultural production, providing essential support, and keeping agricultural prices remain accessible level to anyone can make a huge difference on Earth. Considered in parallel with the SDGs, these efforts may directly or indirectly contribute to the following goals:

- (SDG 1) Preventing the fall into poverty, through employment opportunities provided by support for agricultural production and the agriculture sector;
- (SDG 2) Alleviating hunger by reducing prices and increasing food accessibility, thus enhancing food security;
- (SDG 3 and SDG 4) Increasing good health and well-being, as well as the quality of education, through adequate and balanced nutrition;
- (SDG 6 and SDG 15) Providing clean water, sanitation, and sustainable land use through well-planned and controlled input use.

Considering the limitations of the study, because of incomplete data and it only being possible to take the period up to 2021, the impact of COVID-19 could not be thoroughly investigated. Hence, including data from periods after the COVID-19 pandemic may yield better results regarding its impact. Similarly, the lack of data hindered us from analyzing a larger period, which could have included other important crises such as the Asian crisis and the Turkish economic crisis, both of which have had a sizeable impact on price movements.

Additionally, because there are many other potential factors influencing price changes in agricultural products, these factors may be included and analyzed for a better understanding of the components of price changes. For instance, among them, world demand, environmental rules, changing consumption habits and their impacts on production, land degradation, and crop characteristics would greatly contribute to insight into the issue.

Furthermore, considering external issues such as the impact of the Russia–Ukraine war would be beneficial to take a step further on the issue. If we could have, our analysis would have provided more detailed and comprehensive perspectives on the impact of drivers. In this sense, future studies may widen the scope of this study by taking a longer period and possible factors to pave the way for achieving SDGs and improving the standard of living for human beings through optimal pricing strategies.

Author Contributions: Conceptualization, N.S.T.A.; methodology, N.S.T.A. and İ.E.K.; software, N.S.T.A. and İ.E.K.; validation, İ.E.K.; formal analysis, N.S.T.A. and İ.E.K.; investigation, N.S.T.A.; resources, N.S.T.A.; data curation, N.S.T.A.; writing—original draft preparation, N.S.T.A.; writing—review and editing, N.S.T.A. and İ.E.K.; visualization, N.S.T.A.; supervision, İ.E.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The original data presented in the study are openly available at [34,90–94].

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Descriptive statistics.

Descriptive Statistics																					
	lnCotton	*lnMaize*	*lnOliveOil*	*lnWheat*	*GovEff*	*PolS*	*Reg*	*lnStocks*	*lnOil*	*lnNitr*	*lnPest*	*lnWPI*	*lnM1*	*lnExc*	*lnGDP*	*lnInt*	*lnRain*	*lnTemp*	*Aircraft*	*COVID*	*GFC*
Mean	11.516	10.801	0.928	10.210	0.149	−1.098	0.199	26.355	4.107	14.213	10.624	5.327	18.949	0.828	27.233	2.689	6.426	2.628	0.100	0.150	0.100
Median	11.460	10.967	0.798	10.420	0.125	−1.058	0.269	26.574	4.147	14.193	10.587	5.329	18.955	0.551	27.374	2.670	6.455	2.620	0.000	0.000	0.000
Maximum	12.351	13.323	1.810	13.249	0.432	−0.590	0.463	27.490	4.716	14.535	11.002	6.104	21.470	2.180	27.588	3.981	6.680	2.710	1.000	1.000	1.000
Minimum	10.812	8.823	0.000	.6.035	−0.159	−2.007	−0.101	24.942	3.161	13.940	10.219	4.605	16.58	0.264	26.205	2.103	6.200	2.550	0.000	0.000	0.000
Std. Dev.	0.428	1.470	0.461	1.974	0.190	0.370	0.180	0.565	0.451	0.151	0.228	0.489	1.291	0.608	0.375	0.498	0.110	0.045	0.308	0.366	0.308
Observations	20	20	20	20	20	20	20	19	20	20	20	20	20	20	20	20	20	20	20	20	20

Appendix B

Table A2. ARDL Results.

ARDL Results											
Dependent Variable: lnWheat											
Model	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Model**	**Model**	**Variable**	**Coefficient**
ARDL (1, 1, 1, 1, 1, 1, 1, 1) AIC (−4.1274)	*lnWheat(-1)*	−0.3732	**ARDL (1, 1, 0, 1, 1, 1, 0)** AIC (−3.2161)	*lnWheat (-1)*	−0.3579	**ARDL (1, 1, 0, 1, 1, 1, 0)** AIC (−6.8981)	*lnWheat(-1)*	−0.4030	**ARDL (1, 0, 0, 0, 0, 0)** AIC (−0.0573)	*lnWheat(-1)*	0.0826
	GovEff	−17.0136		*lnOil*	4.8049		*lnM1*	17.1996 **		*lnRain*	3.7562
	GovEff(-1)	−30.2759		*lnOil(-1)*	2.4199		*lnM1(-1)*	9.3663 *		*lnTemp*	21.3338
	PolS	−0.3068		*lnNitr*	20.6407 *		*lnExcRate*	−31.4813 **		*Aircraft*	−0.2904
	PolS(-1)	−3.9123		*lnNitr(-1)*	18.7366		*lnGDP*	−28.1222 **		*COVID*	0.4179
	Reg	25.4486		*lnPest*	5.9568		*lnGDP(-1)*	−8.5694		*GFC*	0.2944
	Reg(-1)	31.0303		*lnPest(-1)*	10.6401		*lnInt*	−1.1334		*C*	−70.9138
	lnStocks	−6.2819		*lnWPI*	−22.0011		*lnInt(-1)*	5.1283			
	lnStocks(-1)	3.7785		*lnWPI(-1)*	8.0241		*Aircraft*	−0.5280			
	Aircraft	−0.4908		*Aircraft*	5.8689		*Aircraft(-1)*	−3.1974 *			
	Aircraft(-1)	−5.4917		*Aircraft(-1)*	−3.0705 *		*COVID*	−4.9441			
	COVID	2.3551		*COVID*	−0.2889		*COVID(-1)*	−7.4344 **			
	COVID(-1)	6.3266		*GFC*	−0.9675		*GFC*	−1.0138			
	GFC	−1.1958		*GFC (-1)*	4.1177 *		*C*	528.7231 **			
	GFC(-1)	7.3718		*C*	−677.7797 **						
	C	70.9475									
	LM(1) = 38.5628 (0.1016) Ramsey Reset test = 0.0919 (0.8127) BPG = 0.1954 (0.9798)			LM(1) = 1.8061 (0.3111) Ramsey Reset Test = 2.3071 (0.1474) BPG = 3.1253 (0.1892)			LM(1) = 0.0132 (0.9140) Ramsey Reset Test = 0.4923 (0.5216) BPG = 2.1462 (0.2051)			LM(1) = 0.6749 (0.4288) Ramsey Reset Test = 0.4869 (0.4998) BPG = 1.7166 (0.2004)	
Dependent Variable: lnMaize											
Model	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**
ARDL (1, 1, 1, 1, 1, 1, 1, 1) AIC (−7.4539)	*lnMaize(-1)*	−0.7125 *	**ARDL (1, 1, 1, 1, 1, 0, 0)** AIC (−4.3392)	*lnMaize(-1)*	−0.4066	**ARDL (1, 0 , 0, 0, 0, 1, 1)** AIC (−7.8251)	*lnMaize(-1)*	0.1918	**ARDL (1, 1, 0, 0, 1, 1)** AIC (−2.0885)	*lnMaize (-1)*	−0.1820
	GovEff	−21.4179 **		*lnOil*	0.0257		*lnM1*	6.9200 **		*lnRain*	−8.1191
	GovEff(-1)	−12.5592		*lnOil(-1)*	1.8393		*lnExc*	−6.4788 *		*lnRain(-1)*	−10.2601 *
	PolS	1.0241		*lnNitr*	14.1047 *		*lnGDP*	−16.2247 ***		*lnTemp*	−5.8631
	PolS(-1)	−4.2086 **		*lnNitr(-1)*	13.2890 *		*lnInt*	−2.9650 *		*Aircraft*	0.8981
	Reg	20.7717 **		*lnPest*	0.4266		*Aircraft*	−1.0074		*COVID*	3.8056 **
	Reg(-1)	19.7214 *		*lnPest(-1)*	3.6827		*COVID*	0.2715		*COVID(-1)*	−2.7715
	lnStocks	2.2542		*lnWPI*	−18.7280 *		*COVID(-1)*	−5.1735 **		*GFC*	−2.9221
	lnStocks(-1)	−3.0339		*lnWPI(-1)*	13.7521		*GFC*	2.7121 **		*GFC(-1)*	3.8836
	Aircraft	0.4709		*Aircraft*	1.7760		*GFC (-1)*	−2.5221 *		*C*	145.8996
	Aircraft(-1)	−3.4185 *		*Aircraft(-1)*	−2.5513		*C*	333.4524 ***			
	COVID	5.3984 **		*COVID*	−0.3084						
	COVID(-1)	−3.1591		*GFC*	2.5242						
	GFC	1.7996 *		*C*	−397.9657						
	GFC(-1)	1.7751									
	C	31.3386									
	LM(1) = 2.4626 (0.3612) Ramsey Reset test = 0.2459 (0.7069) BPG = 0.5673 (0.7947)			LM(1) = 4.9309 (0.1130) Ramsey Reset test = 1.8061 (0.2716) BPG = 4.7642 (0.0717)			LM(1) = 0.0398 (0.8476) Ramsey Reset Test = 1.4421 (0.1925) BPG = 0.5715 (0.7994)			LM(1) = 0.3523 (0.5692) Ramsey Reset Test = 0.6863 (0.4314) BPG = 1.0522 (0.4704)	

Table A2. *Cont.*

ARDL Results											
Dependent Variable: lnOliveOil											
Model	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**
ARDL (1, 1, 0, 1, 1, 1, 1, 1) AIC (−13.3036)	*lnOliveOil(-1)*	−1.4309 ***	**ARDL (1, 1, 1, 0, 1, 0, 1, 0)** AIC (−8.8352)	*lnOliveOil(-1)*	0.7738 *	**ARDL (1, 0, 1, 1, 0, 0, 1, 0)** AIC (−12.4628)	*lnOliveOil(-1)*	0.1880	**ARDL (1, 0, 1, 1, 1, 1)** AIC (−6.5721)	*lnOliveOil(-1)*	0.4260 **
	GovEff	−2.1325 **		*lnOil*	−0.1998		*lnM1*	0.6770 **		*lnRain*	1.0348 **
	GovEff(-1)	−4.7576 ***		*lnOil(-1)*	0.2248		*lnExc*	−2.1728 **		*lnTemp*	3.4734 **
	PolS	−0.9712 ***		*lnNitr*	−0.5906		*lnExc(-1)*	1.7968 **		*lnTemp(-1)*	1.5290
	Reg	0.2437		*lnNitr(-1)*	0.4964 *		*lnGDP*	−2.0659 ***		*Aircraft*	−0.0089
	Reg(-1)	3.6406 ***		*lnPest*	0.4964 *		*lnGDP(-1)*	1.4695 **		*Aircraft(-1)*	0.2669 *
	lnStocks	−0.1512		*lnWPI*	−2.8356 *		*lnInt*	0.4639 **		*COVID*	−0.0064
	lnStocks(-1)	1.3054 ***		*lnWPI(-1)*	2.6977 *		*Aircraft*	0.0313		*COVID(-1)*	0.4172 **
	Aircraft	−0.1912 *		*Aircraft*	0.2201		*COVID*	−0.2550		*GFC*	0.2218 *
	Aircraft(-1)	−0.8100 ***		*COVID*	−0.2369		*COVID(-1)*	0.1518		*GFC(-1)*	−0.5641 ***
	COVID	0.0592		*COVID(-1)*	0.4973 *		*GFC*	−0.0571		*C*	−19.2299 **
	COVID(-1)	0.7522 *		*GFC*	0.1999		*C*	3.5656			
	GFC	0.3914 **		*C*	−12.1579						
	GFC(-1)	0.3610 **									
	C	−28.9651 **									
	LM(1) = 5.1623 (0.1510) Ramsey Reset test = 3.5755 (0.1992) BPG = 2.3630 (0.2607)			LM(1) = 6.8651 (0.0588) Ramsey Reset test = 0.9381 (0.3876) BPG = 4.8353 (0.0.0468)			LM(1) = 0.7298 (0.4257) Ramsey Reset test = 0.4451 (0.5295) BPG = 0.3864 (0.9231)			LM(1) = 0.2460 (0.6351) Ramsey Reset Test = 0.0025 (0.9614) BPG = 0.3360 (0.9453)	
Dependent Variable: lnCotton											
Model	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**	**Model**	**Variable**	**Coefficient**
ARDL (1, 1, 1, 1, 1, 1, 1, 0) AIC (−8.2823)	*lnCotton(-1)*	−0.4894 *	**ARDL (1, 1, 1, 0, 1, 1, 1, 1)** AIC (−10.0201)	*lnCotton(-1)*	−1.0997 **	**ARDL (1, 1, 1, 1, 0, 0, 0, 1)** AIC (−11.6691)	*lnCotton*	−0.5292 **	**ARDL (1, 0, 0, 1, 0, 1)** AIC (−4.7990)	*lnCotton(-1)*	−0.2936
	GovEff	−0.7206		*lnOil*	−0.0999		*lnM1*	−0.6299 *		*lnRain*	1.0740
	GovEff(-1)	−4.8631 **		*lnOi(-1)*	−0.8439 **		*lnM1(-1)*	1.0069 **		*lnTemp*	2.6564
	PolS	−2.0945 **		*lnNitr*	3.2767 **		*lnExc*	−2.6147 *		*Aircraft*	−0.1676
	PolS(-1)	0.7290		*lnNitr(-1)*	−2.3431 **		*lnExc(-1)*	3.0944 *		*Aircraft(-1)*	0.3508
	Reg	−0.2369		*lnPest*	0.7400 **		*lnGDP*	−2.0736 *		*COVID*	0.8684 ***
	Reg(-1)	3.6681 **		*lnWPI*	8.3946 ***		*lnGDP(-1)*	1.1358		*GFC*	0.4147
	lnStocks	−1.5762 **		*lnWPI(-1)*	−8.0411 ***		*lnInt*	0.3701		*GFC(-1)*	−1.1210 ***
	lnStocks(-1)	1.0414 **		*Aircraft*	−0.7021 *		*Aircraft*	−0.0860		*C*	0.9469
	Aircraft	−0.9610 *		*Aircraf(-1)*	−0.6455 **		*COVID*	0.3053			
	Aircraft(-1)	−1.2819**		*COVID*	1.6962 ***		*GFC*	0.3538			
	COVID	−0.2254		*COVID(-1)*	−1.6966 ***		*GFC(-1)*	−0.5565 ***			
	COVID(-1)	2.0550 **		*GFC*	0.3125		*C*	35.2437 **			
	GFC	0.0801		*GFC(-1)*	−1.1714 ***						
	C	30.2240 **		*C*	4.4707						
	LM(1) = 2.7651 (0.2382) Ramsey Reset test = 0.6253 (0.5956) BPG = 1.4600 (0.4241)			LM(1) = 66.1355 (0.0148) Ramsey Reset test = 0.0257 (0.8874) BPG = 1.2309 (0.4920)			LM(1) = 2.9560 (0.1462) Ramsey Reset test = 9.2570 (0.0287) BPG = 0.5009 (0.8549)			LM(1) = 0.0004 (0.9853) Ramsey Reset Test = 0.2713 (0.6151) BPG = 1.4525 (0.2848)	

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Appendix C

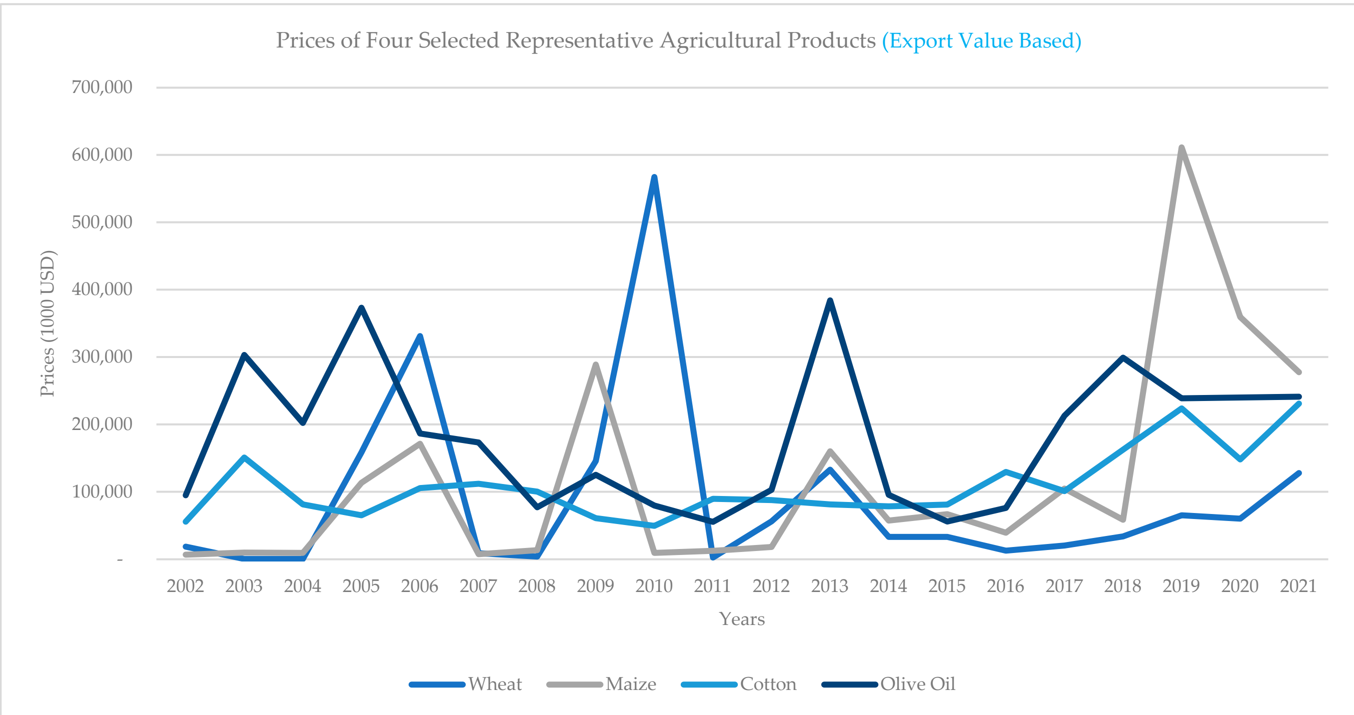

Figure A1. Prices of four selected representative agricultural products.

References

1. Anoruo, E.; Elike, U. An empirical investigation into the impact of high oil prices on economic growth of oil-importing African countries. *Int. J. Econ. Perspect.* **2009**, *3*, 121–129.
2. Headey, D.; Ruel, M. Food inflation and child undernutrition in low and middle income countries. *Nat. Commun.* **2023**, *14*, 5761. [CrossRef] [PubMed]
3. Birhane, T.; Shiferaw, S.; Hagos, S.; Mohindra, K.S. Urban food insecurity in the context of high food prices: A community based cross sectional study in Addis Ababa, Ethiopia. *BMC Public Health* **2014**, *14*, 680. [CrossRef] [PubMed]
4. UNDP. What Are the Sustainable Development Goals? Available online: https://www.undp.org/sustainable-development-goals?gad_source=1&gclid=CjwKCAiA0bWvBhBjEiwAtEsoW21jeoiGilCV0PIoPD4JwyGyzzzPSVBoeFPQDwG3lKpa5CbePSYKvxoC6ccQAvD_BwE (accessed on 10 March 2024).
5. Bandara, J.S.; Cai, Y. The impact of climate change on food crop productivity, food prices and food security in South Asia. *Econ. Anal. Policy* **2014**, *44*, 451–465. [CrossRef]
6. Mavejje, J. Food prices, energy and climate shocks in Uganda. *Agric. Food Econ.* **2016**, *4*, 1–18.
7. Cevik, S.; Tovar Halles, J. *Eye of the Storm: The Impact of Climate Shocks on Inflation and Growth*; IMF Working Paper WP/23/87; IMF: Washington, DC, USA, 2023.
8. Trostle, R. *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices*; WRS-0801; USDA Economic Research Services: Washington DC, USA, 2008.
9. Tadesse, G.; Algieri, B.; Kalkuhl, M.; von Braun, J. Drivers and triggers of international food price spikes and volatility. *Food Policy* **2014**, *47*, 117–128. [CrossRef]
10. Aday, S.; Aday, M.S. Impact of COVID-19 on the food supply chain. *Food Qual. Saf.* **2020**, *4*, 167–180. [CrossRef]
11. Lee, C. The impact of intermediate input price changes on food prices: An analysis of “From-the-ground-up” effects. *J. Agribus.* **2002**, *20*, 85–102.
12. Isik, S.; Ozbugday, F.C. The impact of agricultural input costs on food prices in Turkey: A case study. *Agric. Econ.* **2021**, *67*, 101–110.
13. Espitia, A.; Rocha, N.; Ruta, M. *COVID-19 and Food Protectionism the Impact of the Pandemic and Export Restrictions on World Food Markets*; World Bank Group Policy Research Working Paper 9253; World Bank: Washington DC, USA, 2020.
14. Mead, D.; Ransom, K.; Reed, S.B.; Sager, S. *The Impact of the COVID-19 Pandemic on Food Price Indexes and Data Collection*; U.S. Bureau of Labor Statistics Monthly Labor Review; Bureau of Labor Statistics: Washington, DC, USA, 2020.
15. Bairagi, S.; Mishra, A.K.; Mottaleb, K.A. Impacts of the COVID-19 pandemic on food prices: Evidence from storable and perishable commodities in India. *PLoS ONE* **2022**, *17*, e0264355. [CrossRef]
16. Apergis, N.; Rezitis, A. Food price volatility and macroeconomic factors: Evidence from GARCH and GARCH-X estimates. *J. Agric. Appl. Econ.* **2011**, *43*, 95–110. [CrossRef]
17. Ur Rehman, F.; Khan, D. The determinants of food price inflation in Pakistan: An econometric analysis. *Adv. Econ. Bus.* **2015**, *3*, 571–576. [CrossRef]
18. Mahato, A. Climate change and its impacts on agriculture. *Int. J. Sci. Res. Publ.* **2014**, *4*, 1–6.
19. Kim, C.; UN.ESCAP. The Impact of Climate Change on the Agricultural Sector: Implications of the Agro-Industry for Low Carbon, Green Growth Strategy and Roadmap for the East Asian Region. 2012. Available online: https://hdl.handle.net/20.500.12870/4032 (accessed on 14 February 2024).
20. Habib-ur-Rahman, M.; Ahmad, A.; Raza, A.; Hasnain, M.U.; Alharby, H.F.; Alzahrani, Y.M.; Bamagoos, A.A.; Hakeem, K.R.; Ahmad, S.; Nasim, W.; et al. Impact of climate change on agricultural production; Issues, challenges, and opportunities in Asia. *Front. Plant Sci.* **2022**, *13*, 925548. [CrossRef] [PubMed]
21. Squires, V.R.; Gaur, M.K. Agricultural Productivity and Food Security. In *Food Security and Land Use Change under Conditions of Climatic Variability*; Squires, V., Gaur, M., Eds.; Springer: Cham, Switzerland, 2020. [CrossRef]
22. Alexander, P.; Arneth, A.; Henry, R.; Maire, J.; Rabin, S.; Rounsevell, M.D.A. High energy and fertilizer prices are more damaging than food export curtailment from Ukraine and Russia for food prices, health and the environment. *Nat. Food* **2022**, *4*, 84–95. [CrossRef] [PubMed]
23. Soliman, A.M.; Lau, C.K.; Cai, Y.; Sarker, P.K.; Dastgir, S. Asymmetric effects of energy inflation, agri-inflation and CPI on agricultural output: Evidence from NARDL and SVAR models for the UK. *Energy Econ.* **2023**, *126*, 106920. [CrossRef]
24. Brunelle, T.; Dumas, P.; Souty, F.; Dorin, B.; Nadaud, F. Evaluating the impact of rising fertilizer prices on crop yields. *Agric. Econ.* **2015**, *46*, 653–666. [CrossRef]
25. Shahbaz, M.; Sharif, A.; Soliman, A.M.; Jiao, Z.; Hammoudeh, S. Oil prices and geopolitical risk: Fresh insights based on Granger-causality in quantiles analysis. *Int. J. Financ. Econ.* **2023**. [CrossRef]
26. Kornher, L.; Kalkuhl, M. Food price volatility in developing countries and its determinants. *Q. J. Int. Agric.* **2013**, *4*, 277–308.
27. Lee, H.H.; Park, C.Y. *International Transmission of Food Prices and Volatilities: A Panel Analysis*; ADB Economics Working Paper Series No. 373; ADB: Manila, Philippines, 2013.
28. Dawe, D.; Morales-Opazo, C.; Balie, J.; Pierre, G. How much have domestic food prices increased in the new era of higher food prices? *Glob. Food Secur.* **2015**, *5*, 1–10. [CrossRef]
29. Ozkanlisoy, O. The COVID-19 outbreak’s effects and new inclinations in terms of logistics and supply chain activities: A conceptual framework. *J. Manag. Mark. Logist.* **2021**, *8*, 76–88. [CrossRef]

30. Janzen, J.; Zulauf, C. The Russia-Ukraine War and Changes in Ukraine Corn and Wheat Supply: Impacts on Global Agricultural Markets. *Farmdoc Dly.* **2023**, *13*, 34.
31. Awokuse, T.O. Impact of Macroeconomic Policies on Agricultural Prices. *Agric. Resour. Econ. Rev.* **2005**, *34*, 226–237. [CrossRef]
32. Kadir, S.U.S.A.; Tunggal, N.Z. The impact of macroeconomic variables toward agricultural productivity in Malaysia. *South East Asia J. Contemp. Bus. Econ. Law* **2015**, *8*, 21–27.
33. Oluwatoyese, O.P.; Applanaidu, S.D.; Razak, N.A.A. Macroeconomic factors and agricultural sector in Nigeria. *Procedia Soc. Behav. Sci.* **2016**, *219*, 562–570. [CrossRef]
34. TUIK. Data Portal for Statistics. 2024. Available online: https://data.tuik.gov.tr/Kategori/GetKategori?p=enflasyon-ve-fiyat-106&dil=1 (accessed on 11 February 2024).
35. Erol, E. The Determinants of Food Inflation in Turkey. Master's Thesis, University of Kentucky, Lexington, KY, USA, 2017.
36. World Bank. *Commodity Markets Outlook—Persistence of Commodity Shocks*; World Bank: Washington, DC, USA, 2020.
37. Demirkilic, S.; Ozertan, G.; Tekguc, H. The evolution of unprocessed food inflation in Turkey: An exploratory study on select products. *New Perspect. Turk.* **2022**, *67*, 57–82. [CrossRef]
38. IMF. *Turkey: Staff Report for the 2011 Article IV Consultation*; IMF Country Report 12/16; IMF: Washington, DC, USA, 2011.
39. WTO. *Trade Policy Review: Turkey*; World Trade Organization: Geneva, Switzerland, 2012.
40. Kiymaz, T.; Sacli, Y. *Tarım ve Gıda Ürünleri Fiyatlarında Yaşanan Sorunlar ve Öneriler*; No. DPT-2767; Republic of Turkey Undersecretariat of State Planning Organization: Ankara, Turkiye, 2008. (In Turkish)
41. Knowles, J.C.; Pernia, E.M.; Racelis, M. *Social Consequences of the Financial Crisis in Asia*; Papers 60; Asian Development Bank: Manila, Philippines, 1999.
42. Reyes, C.M.; Manasan, R.G.; Orbeta, A.C.; de Guzman, G.G. *Social Impact of the Regional Financial Crisis in the Philippines*; Paper prepared for RETA 5799; Asian Development Bank: Manila, Phillippines, 1999.
43. Atinc, T.M.; Walton, M. *Social Consequences of the East Asian Financial Crisis*; World Bank: Washington, DC, USA, 1998.
44. Turan, Z. Dünyadaki ve Türkiye'deki krizlerin ortaya çıkış nedenleri ve ekonomik kalkınmaya etkisi. *Niğde Üni. İİbf Derg.* **2011**, *4*, 56–80.
45. Temiz, D.; Gokmen, A. The 2000–2001 financial crisis in Turkey and the Global Economic Crisis of 2008–2009: Reasons an comparison. *Int. J. Soc. Sci. Humanit. Stud.* **2009**, *1*, 1–16.
46. Mittal, A. *The 2008 Food Price Crisis: Rethinking Food Security Policies*; United Nations G-24 Discussion Paper Series. No. 56; UN: New York, NY, USA, 2009.
47. Oguz, I. Rusya krizinin tarım sektörüne etkisi ve çözüm odaklı öneriler. *International Journal of Crop Production and Animal Breeding* **2016**, *19*, 48–50.
48. Sahin, E.; Konak, F.; Karaca, S.S. Türkiye ve Rusya arasındaki "Uçak krizinin" Borsa İstanbul gıda, içecek ve turizm endeksleri üzerine etkisi. *Bus. Econ. Res. J.* **2017**, *8*, 473–485. [CrossRef]
49. WTO. Impacts of the COVID-19 Pandemic on Cotton and Its Value Chains: The Case of the C-4 and Other LDCs. 2021. Available online: https://www.wto.org/english/tratop_e/agric_e/covidinpactstudyc4ldcscotton_e.pdf (accessed on 10 January 2024).
50. Turkish Statistical Institute. Dış Ticaret İstatikleri. Available online: https://data.tuik.gov.tr/Kategori/GetKategori?p=Dis-Ticaret-104 (accessed on 18 March 2024).
51. USDA. Production—Cotton. Available online: https://fas.usda.gov/data/production/commodity/2631000 (accessed on 18 March 2024).
52. International Olive Council. The World of Olive Oil. Available online: https://www.internationaloliveoil.org/the-world-of-olive-oil/ (accessed on 18 March 2024).
53. Norazman, O.Z.; Khalid, H.; Mat Ghani, G. Food inflation: A study on key determinants and price transmission processes for Malaysia. *Int. J. Bus. Soc.* **2018**, *19*, 117–138.
54. Kose, N.; Unal, E. The effects of the oil price and temperature on food inflation in Latin America. *Environ. Dev. Sustain.* **2022**, *26*, 1–17. [CrossRef] [PubMed]
55. Davidson, J.; Halunga, A.; Lloyd, T.A.; McCorriston, S.; Morgan, C.W. *Explaining UK Food Price Inflation*; Transparency of Food Pricing (TRANSFOP) Working Paper 1; University of Exeter Press: Exeter, UK, 2012.
56. Kuma, B.; Gata, G. Factors affecting food price inflation in Ethiopia: An autoregressive distributed lag approach. *J. Agric. Food Res.* **2023**, *12*, 100548. [CrossRef]
57. Samal, A.; Ummalla, M.; Goyari, P. The impact of macroeconomic factors on food price inflation: An evidence from India. *Future Bus. J.* **2022**, *8*, 1–14. [CrossRef]
58. Qayyum, A.; Sultana, B. Factors of food inflation: Evidence from time series of Pakistan. *J. Bank. Financ. Manag.* **2018**, *1*, 23–30. [CrossRef]
59. von Braun, J.; Pachauri, R.K. *The Promises and Challenges of Biofuels for the Poor in Developing Countries*; IFPRI: Washington, DC, USA, 2006.
60. Wang, Y.; Wu, C.; Yang, L. Oil price shocks and agricultural commodity prices. *Energy Econ.* **2014**, *44*, 22–35. [CrossRef]
61. Baffes, J. Oil spills on other commodities. *Resour. Policy* **2007**, *32*, 126–134. [CrossRef]
62. Obadi, S.M.; Korček, M. Are food prices affected by crude oil price: Causality investigation. *Rev. Integr. Bus. Econ. Res.* **2014**, *3*, 411–427.

63. Demirtas, C.; Soylu Yildirim, E.; Tuglu Dur, D. Do oil prices have an effects on food prices? Fresh evidences from Türkiye. *J. Bus. Res. Turk* **2023**, *15*, 79–91. [CrossRef]
64. Baek, J.; Koo, W.W. Analyzing factors affecting U.S. food price inflation. *Can. J. Agric. Econ.* **2010**, *58*, 303–320. [CrossRef]
65. Huh, H.; Park, C. *Examining the Determinants of Food Prices in Developing Asia*; ADB Economics Working Paper Series No. 370; ADB: Manila, Philippines, 2013.
66. Irz, X.; Niemi, J.; Liu, X. Determinants of food price inflation in Finland—The role of energy. *Energy Policy* **2013**, *63*, 656–663. [CrossRef]
67. Lee, S.; Lim, J.; Lee, H.; Park, C. *Food Prices and Population Health in Developing Countries: An Investigation of the Effects of the Food Crisis Using a Panel Analysis*; ADB Economics Working Paper Series No. 374; ADB: Manila, Philippines, 2013.
68. Ahmed, M.; Singla, N. An analysis of major determinants of food inflation in India. *Indian J. Econ. Dev.* **2014**, *10*, 275–282. [CrossRef]
69. Bhattacharya, R.; Sen Gupta, A. *Drivers and Impact of Food Inflation in India*; MPRA Paper No. 88721; MPRA: Munich, Germany, 2017.
70. Ismaya, B.I.; Anugrah, D.F. Determinant of food inflation: The case of Indonesia. *Bull. Monet. Econ. Bank.* **2018**, *21*, 81–94. [CrossRef]
71. Caklovica, L.; Efendic, A. Determinants of inflation in Europe: A dynamic panel analysis. *Financ. Internet Q.* **2020**, *16*, 51–79. [CrossRef]
72. Adjemian, M.K.; Arita, S.; Meyer, S.; Salin, D. Factors affecting recent food price inflation in the United States. *Appl. Econ. Perspect. Policy* **2024**, *46*, 648–676. [CrossRef]
73. Kohlscheen, E. *Understanding the Food Component of Inflation*; BIS Working Papers No. 1056; BIS: Basel, Switzerland, 2022.
74. Tay Bayramoglu, A.; Koc Yurtkur, A. Türkiye'de gıda ve tarımsal ürün fiyatlarını uluslararası belirleyicileri. *Anadolu Üni Sos. Bilim. Derg.* **2015**, *15*, 63–74.
75. Alev, N. Türkiye'de enflasyonun belirleyicileri: ARDL sınır testi yaklaşımı (2006:Q1-2018:Q2 dönemi). *Uluslararası Ekon. İşletme Polit. Derg.* **2019**, *3*, 1–18. [CrossRef]
76. Aytekin, M.; Hatirli, S.A. Türkiye'de işlenmemiş gıda enflasyonunu etkileyen faktörlerin analizi: ARDL yaklaşımı. *Eurosian J. Res. Soc. Econ.* **2021**, *8*, 203–216.
77. Sahin Kutlu, S. Türkiye'de gıda enflasyonunun belirleyicileri: SVAR modelinden kanıtlar. *EKEV Akad. Derg.* **2021**, *25*, 581–598.
78. Mat, B.; Arikan, M.A.; Cevrimli, M.B.; Akin, A.C.; Tekindal, M.A. Factors affecting the price of raw milk in Turkey using panel data analysis. *Ciência Rural* **2021**, *51*, 1–10. [CrossRef]
79. Bayramoglu, Z.; Karakayaci, Z.; Agizan, K.; Agizan, S.; Bozdemir, M. Domates fiyatları üzerinde etkili olan faktörlerin belirlenmesi. In Proceedings of the 12. Uluslararası Güncel Araştırmalarla Sosyal Bilimler Kongresi Tam Metinleri, Rize, Türkiye, 5–7 June 2020.
80. Altintas, H. Petrol fiyatlarının gıda fiyatlarına asimetrik etkisi: Türkiye için NARDL modeli uygulaması. *Yönetim Ve Ekon. Araştırmaları Derg.* **2016**, *14*, 1–24.
81. Gokce, C. Petrol fiyatı ve döviz kurunun gıda fiyatları üzerine asimetrik etkisi: Türkiye örneği. *Bus. Econ. Res. J.* **2021**, *12*, 599–611. [CrossRef]
82. Baskaya, Y.S.; Gurgur, T.; Ogunc, F. Küresel ısınma, küresellesme ve gıda krizi Türkiye'de islenmis gıda fiyatları üzerine ampirik bir çalısma. *Cent. Bank Rev.* **2008**, *2*, 1–32.
83. Bayramoglu, Z.; Agizan, K.; Eroglu, O. Buğday fiyatlarının tahmin edilmesinde ekonomik ve ekolojik faktörlerin etkisi. In Proceedings of the 3rd International Cukurova Agriculture and Veterinary Congress, Adana, Türkiye, 9–10 October 2021.
84. Guloglu, B.; Nazlioglu, S. Enflasyonun tarımsal fiyatlar üzerindeki etkileri: Panel yumuşak geçiş regresyon analizi. *Siyaset Ekon. Yönetim Araştırmaları Derg.* **2013**, *1*, 1–20.
85. Ozayturk, G. Enerji enflasyonunun tarım ürünleri enflasyonu üzerine etkisi: Türkiye örneği. *Fiscaoeconomia* **2023**, *7*, 708–727. [CrossRef]
86. Icen, H.; Esenyel Icen, N.M.; Polat, B. Türkiye'de gıda fiyatları, döviz kuru ve petrol fiyatları arasındaki asimetrik ilişki. *Ekoist: J. Econom. Stat.* **2022**, *37*, 149–169. [CrossRef]
87. Gungor, S.; Erer, D. Türkiye'deki gıda fiyatları ile petrol fiyatları ve döviz kuru arasındaki doğrusal olmayan ilişkinin incelenmesi: Zamanla-değişen parametreli VAR modelleri. *Alanya Akad. Bakış Derg.* **2022**, *6*, 2481–2497. [CrossRef]
88. Karacan, S. Relationship between the prices of grains, crude oil and real effective exchange rates: Evidence from Fourier Toda-Yamamoto causality test. *Dumlupınar Üni. Sos. Bilim. Derg.* **2022**, *74*, 282–292. [CrossRef]
89. Dumrul, Y.; Kilicarslan, Z. Economic impacts of climate change on agriculture: Empirical evidence from ARDL approach for Turkey. *J. Business. Econ. Financ. (JBEF)* **2017**, *6*, 336–347. [CrossRef]
90. FAO. FAOSTAT. 2024. Available online: https://www.fao.org/faostat/en/#data (accessed on 10 January 2024).
91. World Bank. DataBank, World Development Indicators. 2024. Available online: https://databank.worldbank.org/source/world-development-indicators (accessed on 10 January 2024).
92. OECD. OECD Data. 2024. Available online: https://data.oecd.org/ (accessed on 10 January 2024).
93. The Central Bank of the Republic of Türkiye. Statistical Data. 2024. Available online: https://evds2.tcmb.gov.tr/index.php (accessed on 10 January 2024).

94. Turkish State Meteorological Service. Resmi İstatistikler. 2024. Available online: https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?k=parametrelerinTurkiyeAnalizi (accessed on 10 January 2024).
95. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
96. Narayan, S.; Narayan, P.K. Determinants of Demand of Fiji's Exports: An Empirical Investigation. *Dev. Econ.* **2004**, *17*, 95–112. [CrossRef]
97. Engle, R.F.; Granger, C.W. Co-integration and error correction: Representation, estimation, and testing. *Econometrica* **1987**, *55*, 251–276. [CrossRef]
98. Johansen, S. Statistical analysis of cointegration vectors. *J. Econ. Dyn. Control* **1988**, *12*, 231–254. [CrossRef]
99. Dickey, D.A.; Fuller, W.A. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* **1981**, *49*, 1057–1072. [CrossRef]
100. Phillips, P.C.; Perron, P. Testing for a unit root in time series regression. *Biometrika* **1988**, *75*, 335–346. [CrossRef]
101. Laborde, D.; Lakatos, C.; Martin, W. *Poverty Impact of Food Price Shocks and Policies*; World Bank Policy Research Working Paper No. 8724; World Bank: Washington, DC, USA, 2019.
102. FAO. *The State of Agricultural Commodity Markets High Food Prices and the Food Crisis—Experience and Lessons Learned*; FAO: Rome, Italy, 2009.
103. Hathaway, D.E. Food prices and inflation. *Brook. Pap. Econ. Act.* **1974**, *1*, 63–116. [CrossRef]
104. Akcaglayan, A. Ham petrol fiyatlarından gıda fiyatlarına asimetrik geçişkenlik: Türkiye örneği. *Bankacılık Derg.* **2021**, *118*, 18–30.
105. Swinnen, J.F.M.; van Herck, K. The Impact of the Global Economic and Financial Crisis on Food Security and the Agricultural Sector of Eastern Europe and Central Asia in FAO. In Proceedings of the UN Ministerial Conference on the Social Impact of the Economic Crisis in Eastern Europe, Central Asia and Turkey, Almaty, Kazakhstan, 7–8 December 2009.
106. Massa, I. The Impact of the Global Financial Crisis: What Does This Tell Us about State Capacity and Political Incentives to Respond to Shocks and Manage Risks? Literature review. Part 1: The Effects of the Global Financial Crisis on Developing Countries. 2012. Available online: https://www.gov.uk/research-for-development-outputs/the-impact-of-the-global-financial-crisis-what-does-this-tell-us-about-state-capacity-and-political-incentives-to-respond-to-shocks-and-manage-risks-literature-review-part-1-the-effects-of-the-global-financial-crisis (accessed on 18 March 2024).
107. Baldock, C.; Grassi, F.; Willis, J.; Financial markets need focus on nitrogen–Fixing Nitrogen. Planet Tracker. 2023. Available online: https://planet-tracker.org/wp-content/uploads/2023/11/Nitrogen.pdf (accessed on 1 May 2024).
108. Cakmak, E.H. *Agricultural Water Pricing: Turkey*; OECD Publishing: Paris, France, 2010.