# ASYMMETRIC EXCHANGE RATE PASS-THROUGH TO FOOD PRICES IN TURKEY: A NARDL APPROACH

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# ASYMMETRIC EXCHANGE RATE PASS-THROUGH TO FOOD PRICES IN TURKEY: A NARDL APPROACH

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## DECLARATION OF ORIGINALITY

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## ABSTRACT

Asymmetric Exchange Rate Pass-Through to Food Prices in Turkey: A NARDL Approach

This paper investigates the asymmetric exchange rate pass-through (ERPT) to food prices in Turkey from July 2018 to December 2023 using the Nonlinear Autoregressive Distributed Lag (NARDL) model. The study focuses on key food commodities including veal, lamb, poultry, fish, eggs, and milk. By examining the differential impacts of positive and negative exchange rate changes, as well as the roles of other macroeconomic variables such as oil prices, money supply (M2), and the output gap, this research aims to provide a comprehensive understanding of ERPT dynamics in Turkey. Structural breaks are incorporated to account for significant economic disruptions during the study period. The results reveal significant asymmetries in the pass-through effects, with exchange rate fluctuations exerting a pronounced influence on food prices. Oil prices and money supply also play critical roles, while the output gap shows varying effects across different food categories. These findings have important policy implications for managing food price volatility and ensuring food security in Turkey.

# ÖZET

Türkiye'de Gıda Fiyatlarına Asimetrik Döviz Kuru Geçişkenliği: NARDL Yaklaşımı

Bu çalışma, Temmuz 2018'den Aralık 2023'e kadar Türkiye'de gıda fiyatlarına asimetrik döviz kuru geçişkenliğini (ERPT) Doğrusal Olmayan Otoregresif Dağıtılmış Gecikme (NARDL) modelini kullanarak incelemektedir. Çalışma dana eti, kuzu eti, kümes hayvanları, balık, yumurta ve süt gibi temel gıda ürünlerine odaklanıyor. Pozitif ve negatif döviz kuru değişikliklerinin farklı etkilerinin yanı sıra petrol fiyatları, para arzı (M2) ve çıktı açığı gibi diğer makroekonomik değişkenlerin rollerini inceleyen bu araştırma, ERPT dinamiklerinin kapsamlı bir şekilde anlaşılmasını sağlamayı amaçlamaktadır. Çalışma dönemi boyunca önemli ekonomik aksaklıkları hesaba katmak için yapısal kırılmalar dahil edilmiştir. Sonuçlar, döviz kuru dalgalanmalarının gıda fiyatları üzerinde belirgin bir etki yarattığı geçişkenlik etkilerinde önemli asimetriler olduğunu ortaya koymaktadır. Petrol fiyatları ve para arzı da kritik rol oynuyor; çıktı açığı ise farklı gıda kategorileri arasında farklı etkiler gösteriyor. Bu bulguların Türkiye'de gıda fiyatlarındaki oynaklığın yönetilmesi ve gıda güvenliğinin sağlanması açısından önemli politika sonuçları bulunmaktadır.

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I dedicate this thesis to the villagers and all the workers knew the value of labor. Your tireless work and dedication have always inspired me. Growing up, I witnessed firsthand the strength, resilience, and perseverance that you embody. This work is a testament to the values you have instilled in me—the importance of hard work, community, and unwavering determination. Your efforts often go unnoticed, but they are the foundation upon which our society is built. This thesis is not only a reflection of my academic journey but also a tribute to your enduring spirit and the lessons I have learned from each of you.

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# CHAPTER 1

# INTRODUCTION

Exchange rate pass-through (ERPT) is a pivotal concept in understanding the transmission of exchange rate fluctuations into domestic prices. This phenomenon is particularly significant for emerging markets, where high volatility and dependency on imports often exacerbate the impact of currency fluctuations on inflation and consumer welfare. In Turkey, the economic landscape has been characterized by substantial exchange rate volatility, especially in recent years, necessitating a closer examination of how these fluctuations affect food prices.

Food prices are a critical component of the consumer price index and have direct implications for inflation and household welfare. Given Turkey's reliance on imported inputs for food production, changes in the exchange rate can significantly alter food prices, affecting both producers and consumers. This study focuses on the asymmetric exchange rate pass-through to food prices in Turkey, employing a nonlinear autoregressive distributed lag (NARDL) model to capture the potential asymmetries in the transmission mechanism.

The theoretical foundation of ERPT is rooted in the law of one price and purchasing power parity, suggesting that exchange rate changes should proportionally affect domestic prices. However, empirical evidence often deviates from this theory due to market imperfections, nominal rigidities, and strategic pricing behaviors. Previous studies have highlighted various factors influencing ERPT, including the level of economic development, inflation environment, and monetary policy credibility. In emerging markets like Turkey, ERPT tends to be higher due to greater economic volatility and reliance on imports.

Research on ERPT has evolved to consider asymmetric pass-through, where the impact of currency appreciations differs from depreciations. This asymmetry can arise from factors such as market power, pricing strategies, and the structure of the economy. Studies have shown that depreciations often have a more immediate and pronounced effect on prices compared to appreciations, complicating the formulation of monetary policy.

While extensive research has explored ERPT in various contexts, there is a notable gap in understanding its asymmetric nature in the context of Turkey's food prices. This study aims to fill this gap by examining the asymmetric ERPT to specific food items in Turkey using the NARDL model. By focusing on key food commodities such as veal, lamb, poultry, fish, eggs, and milk, this research provides a detailed analysis of how exchange rate fluctuations differentially impact food prices.

The primary research problem addressed in this study is the asymmetric impact of exchange rate changes on food prices in Turkey from July 2018 to December 2023. The specific research questions include:

1. How do positive and negative changes in the exchange rate affect food prices differently?

2. What is the role of other macroeconomic variables such as oil prices, money supply (M2), and the output gap in influencing food prices?

3. How do structural breaks in the economic environment alter the dynamics of ERPT to food prices?

The structure of the paper is as follows:

1. Literature Review: This section provides an overview of the existing research on ERPT, emphasizing the theoretical foundations and empirical findings related to asymmetric pass-through and its determinants.

2. Methodology: The methodology section details the NARDL model employed to analyze the data, including the steps for conducting the analysis and the rationale for selecting the specific model.

3. Data and Descriptive Statistics: This section describes the data sources, variables included in the analysis, and the preliminary statistical analysis conducted to ensure the data's suitability for the NARDL model.

4. Results: The results section presents the findings of the NARDL analysis, highlighting the asymmetric effects of exchange rate changes on food prices and the influence of other macroeconomic variables.

5. Conclusion: The conclusion summarizes the key findings, discusses their policy implications, and suggests directions for future research.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction to ERPT

Exchange Rate Pass-Through (ERPT) refers to the degree to which exchange rate fluctuations are reflected in domestic goods and services prices. This concept is critical in understanding the transmission mechanisms of monetary policy, inflation dynamics, and international trade. The ERPT is an essential factor in macroeconomic analysis as it directly impacts consumer prices, trade balances, and overall economic stability.

The theoretical underpinnings of ERPT are rooted in the law of one price and purchasing power parity (PPP). According to the law of one price, identical goods should sell for the same price when expressed in a common currency, assuming no transportation costs and no differential taxes across regions. However, empirical evidence often deviates from this theory due to various frictions and market imperfections. PPP suggests that exchange rate changes should proportionally affect the price levels between two countries. Nevertheless, deviations from PPP are common, leading to incomplete pass-through of exchange rate changes to domestic prices.

One primary reason for incomplete ERPT is the presence of nominal rigidities and market segmentation, which allow firms to set different prices in different markets. Bacchetta and van Wincoop (2003) highlight that nominal price stickiness and strategic complementarities in price setting contribute to the slow adjustment of prices in response to exchange rate movements. Burstein, Eichenbaum, and Rebelo (2005) emphasize the role of non-tradable goods and distribution costs in dampening the ERPT, as these factors insulate domestic prices from exchange rate changes.

The degree of ERPT can vary significantly across countries and over time, influenced by several factors, including the level of economic development, the structure of the economy, and the monetary policy framework. Taylor (2000) posits that low and stable inflation environments tend to exhibit lower ERPT due to the reduced volatility in exchange rates and prices. Gagnon and Ihrig (2004) support this view, demonstrating that countries with credible monetary policies and low inflation rates tend to have lower pass-through rates.

ERPT tends to be higher in emerging markets due to higher inflation volatility, less developed financial markets, and greater dependency on imported goods. Choudhri and Hakura (2006) show that the pass-through is more pronounced in developing countries, where exchange rate movements significantly affect domestic inflation. Additionally, the composition of imports, market competition, and trade openness play crucial roles in determining the extent of ERPT. Coulibaly and Kempf (2010) find that countries with a high degree of trade openness and competitive markets exhibit higher pass-through rates.

Furthermore, ERPT is subject to asymmetries depending on the direction of exchange rate changes. Bussière (2013) reveals that appreciations and depreciations may have different impacts on domestic prices, influenced by factors such as market power and strategic pricing behavior of firms. This asymmetry in ERPT complicates the formulation of monetary policy, as policymakers must consider the differential effects of exchange rate movements on inflation.

Recent studies have also explored the dynamic aspects of ERPT in the context of global supply chains and production networks. For instance, Campa and Goldberg (2005) analyze the impact of global value chains on the transmission of exchange rate changes, highlighting that the international fragmentation of production can either amplify or mitigate the pass-through depending on the nature of the supply chain linkages.

## 2.2 Asymmetry of ERPT

Asymmetric Exchange Rate Pass-Through (ERPT) refers to the phenomenon where the impact of exchange rate appreciations on domestic prices differs from the impact of depreciations. This asymmetry poses significant challenges for economic modeling and policy formulation, as it suggests that the transmission of exchange rate changes to prices is not uniform and can vary in magnitude and speed depending on the direction of the exchange rate movement.

Pollard and Coughlin (2004) provide early evidence of asymmetric ERPT, demonstrating that appreciations and depreciations have different effects on U.S. import prices. They find that depreciations tend to have a larger and more immediate impact on import prices compared to appreciations. This asymmetry is attributed to factors such as market power and the strategic pricing behavior of exporters, who may be more reluctant to reduce prices during currency appreciations to maintain profit margins.

Campa and Goldberg (2005) further explore the asymmetry in ERPT in the context of EU import prices. Using a nonlinear error correction model, they find that appreciations tend to pass through to import prices more slowly than depreciations. This behavior is consistent with the notion that firms adjust prices more rapidly to cost increases (resulting from depreciations) than to cost decreases (resulting from appreciations) due to downward price rigidity and the desire to stabilize profit margins.

Bussière (2013) investigates the asymmetry of ERPT in G7 countries, showing that the degree of asymmetry varies significantly across countries. The study reveals that the structural characteristics of each economy, such as market competition, monetary policy credibility, and the degree of openness, play crucial roles in determining the extent and direction of asymmetric pass-through. These findings underscore the importance of considering country-specific factors when analyzing ERPT dynamics.

Brun-Aguerre et al. (2017) focus on the long-run asymmetry in ERPT and find that import prices rise more quickly in response to depreciations than they fall in response to appreciations. This differential response can be attributed to the pricing-to-market behavior of exporters, who adjust their prices to maintain competitiveness in foreign markets. The study highlights that the asymmetry in ERPT is not only a short-term phenomenon but can persist over longer periods, influencing long-term price stability and inflation dynamics.

In the context of emerging markets, Hasan and Masih (2018) examine the asymmetric ERPT in Malaysia using the Nonlinear Autoregressive Distributed Lag (NARDL) model. Their results indicate that while the long-run relationship between exchange rates and consumer prices is symmetric, the short-run adjustments exhibit significant asymmetry. Depreciations lead to a quicker and more substantial increase in prices compared to the decrease observed during appreciations. This finding aligns with the notion that firms in emerging markets are quicker to pass on cost increases to consumers due to weaker competitive pressures and higher inflation expectations.

Zmami and Ben-Salha (2019) investigate the asymmetric pass-through of oil prices to food prices, finding significant long-term asymmetric relationships. Although their study primarily focuses on oil prices, the methodological insights and empirical results are relevant to understanding the broader implications of asymmetric ERPT. The study demonstrates that the asymmetric adjustment of prices to exchange rate changes can lead to persistent inflationary pressures, complicating monetary policy decisions.

### 2.3 ERPT to Food Prices

Exchange Rate Pass-Through (ERPT) to food prices is a critical area of study due to its significant implications for inflation, consumer welfare, and economic stability. Food prices are often more volatile and sensitive to exchange rate fluctuations compared to other goods, given the sector's dependency on imported inputs, global commodity prices, and varying degrees of market competition. The following literature review synthesizes key findings from various studies on ERPT to food prices, highlighting the mechanisms, determinants, and empirical evidence from different regions and methodologies.

ERPT to food prices operates through several channels. When a local currency depreciates, the cost of imported food items and agricultural inputs increases, leading to higher domestic food prices. Conversely, appreciations can reduce these costs, although the downward adjustment may be less pronounced due to price rigidities and other factors.

Several determinants influence the extent of ERPT to food prices. Market structure, including competition among food producers and retailers, plays a crucial role. In highly competitive markets, firms may absorb exchange rate fluctuations to maintain market share, leading to lower ERPT. Conversely, in less competitive markets, firms have more pricing power and can pass on cost changes to consumers more fully.

The degree of import dependency is another critical factor. Economies heavily reliant on food imports or agricultural inputs will likely experience higher ERPT to food prices. Furthermore, price controls and government interventions, common in many developing countries, can modulate the pass-through effect.

Studies by Esmaeili and Shokoohi (2011) and Zmami and Ben-Salha (2019) provide a global perspective on the relationship between exchange rates and food prices. Esmaeili and Shokoohi analyze data from 1961 to 2015 using principal component analysis and Granger causality tests. They find that exchange rate fluctuations significantly influence food prices, with the impact varying across different food categories and regions. Similarly, Zmami and Ben-Salha investigate the asymmetric pass-through of oil prices to food prices, highlighting significant long-term asymmetric relationships. Although their study primarily focuses on oil prices, it provides insights into the broader dynamics of ERPT to food prices.

Several studies have examined the ERPT to food prices in the United States. Baek and Koo (2010) analyze the impact of agricultural and energy prices on the U.S. economy using Johansen cointegration and PVECM methods. They find that exchange rate changes significantly affect food prices, with notable differences across various food categories. Chen et al. (2010) use an ARDL approach to examine the effect of food and oil prices on the U.S. economy. Their results indicate that exchange rate fluctuations substantially and immediately impact food prices, particularly in the short run.

Gilbert (2010) employs Granger causality tests to study the causal relationship between agricultural commodity prices and macroeconomic variables in the U.S. The study finds a strong causal link between exchange rate movements and food prices, emphasizing the importance of exchange rates in determining domestic food price levels.

Krätschell and Schmidt (2012) investigate the linkage between food and oil prices in the European Union using Johansen cointegration and DCCA methods. Their study finds a significant ERPT to food prices, with oil prices also playing a crucial role. The results suggest that exchange rate movements directly and substantially impact food prices in the EU, influenced by both global oil prices and domestic market conditions.

Emerging markets often exhibit higher ERPT to food prices due to greater economic volatility and higher dependency on food imports. Abdlaziz et al. (2016) study the impact of food prices and macroeconomic variables in Indonesia using a NARDL model. Their findings indicate significant pass-through effects of exchange rate changes on food prices, with asymmetric adjustments observed in the short and long run.

Fowowe (2016) examines the relationship between food prices and oil prices in South Africa through Gregory-Hansen cointegration and Diks-Panchenko causality tests. The study reveals that exchange rate fluctuations significantly influence food prices, with higher pass-through observed during periods of currency depreciation.

In Malaysia, Hasan and Masih (2018) use ARDL and NARDL approaches to study the relationship between food prices, oil prices, and macroeconomic variables. Their results highlight a long-run symmetric relationship between exchange rates and food prices, but with significant short-run asymmetries. Depreciations lead to quicker and more substantial increases in food prices than appreciations.

Research also indicates that ERPT to food prices varies significantly across food categories. London Economics (2004) and Vavra and Goodwin (2005) provide detailed analyses of pass-through rates for various food categories in the EU and the U.S., respectively. London Economics find that pass-through rates differ among food items, with some categories, such as cereals and meat, exhibiting higher sensitivity to exchange rate changes. Vavra and Goodwin show similar variability in the U.S. beef, poultry, and egg markets, emphasizing that exchange rates affect food items differently based on factors like import dependency and market supply-demand elasticity.

Sector-specific dynamics also play a crucial role in determining the extent of ERPT to food prices. Studies such as those by Tekoğlu et al. (2017) and Meyer et al. (2018) highlight the influence of sectoral characteristics on ERPT. Tekoğlu et al. examine the cointegration between food prices and CO2 emissions in OECD countries using Pedroni and Kao tests. Their findings suggest that environmental factors and trade openness significantly influence the ERPT dynamics. Meyer et al. employ a Panel NARDL model to examine the pass-through effect of oil prices on food prices in oil-exporting countries, revealing significant sectoral asymmetries in the pass-through process.

Various methodological approaches have been employed to study ERPT to food prices, ranging from cointegration and error correction models to more advanced techniques like TVP-VAR and wavelet analysis. For instance, Jebabli et al. (2014) use a TVP-VAR model to examine the relationship between food prices, oil prices, and stock indices globally. Their results indicate dynamic interactions and time-varying ERPT effects, highlighting the complexity of the pass-through process.

Similarly, Pal and Mitra (2018) utilize DCCA to analyze the relationship between world food price indices and crude oil prices. Their findings suggest that the pass-through of exchange rate changes to food prices exhibits significant temporal and spatial variations influenced by global commodity market dynamics.

## 2.4 The NARDL Model

The Nonlinear Autoregressive Distributed Lag (NARDL) model is an econometric technique designed to capture asymmetric adjustments and nonlinear dynamics in time series data. Developed by Shin, Yu, and Greenwood-Nimmo (2014), the NARDL model extends the traditional ARDL framework to allow for the separate modeling of positive and negative changes in explanatory variables. This feature makes the NARDL model particularly suitable for investigating the asymmetric impacts of various economic factors on a dependent variable.

The NARDL model builds upon the ARDL bounds testing approach introduced by Pesaran, Shin, and Smith (2001). The key innovation of the NARDL model is its ability to decompose the independent variables into positive and negative partial sums, thereby capturing potential asymmetries in the relationship between the variables. This allows researchers to test for both short-run and long-run asymmetries and to estimate asymmetric cumulative dynamic multipliers, which show how positive and negative shocks to explanatory variables impact the dependent variable over different time horizons.

Shin et al. (2014) formalized the NARDL model by incorporating asymmetric cointegration techniques, which enable the identification of long-run equilibrium relationships despite nonlinearity. The model's flexibility allows it to be applied to a wide range of economic and financial research, particularly in areas where asymmetries and nonlinearities are expected to play a significant role.

Ibrahim (2015) uses the NARDL model to analyze the impact of food and oil prices on the Malaysian economy. The study reveals significant long-run asymmetries, with increases in oil prices having a more pronounced effect on food prices than decreases. This finding underscores the importance of accounting for nonlinearities and asymmetries in modeling economic relationships, particularly in commodity-dependent economies.

Similarly, Wong and Shamsudin (2017) apply the NARDL model to investigate the effects of food and oil prices on the Malaysian economy. Their results indicate that oil prices exhibit asymmetric pass-through to food prices, with positive oil price shocks leading to more significant increases than the reductions caused by negative oil price shocks. This asymmetry suggests that policymakers must consider the differential impacts of oil price movements when formulating economic policies.

Hasan and Masih (2018) extend the application of the NARDL model to study the relationship between exchange rates, oil prices, and food prices in Malaysia. Their findings reveal that while the long-run relationship between these variables is symmetric, the short-run adjustments exhibit significant asymmetry. This study highlights the NARDL model's capability to capture complex dynamics in macroeconomic variables, providing valuable insights for policymakers and researchers.

Algan et al. (2021) use the NARDL model to investigate the relationship between exchange rates, oil prices, and food prices in a broad context. Their results indicate that the asymmetric pass-through effects are robust across different food categories, suggesting that the NARDL model can effectively capture the heterogeneity in price transmission mechanisms across sectors.

Burakov (2016) applies the NARDL model to study the relationship between exchange rates and agricultural prices in Russia. The study finds no significant effect of exchange rates on agricultural prices, suggesting that other factors, such as domestic policies and market conditions, play a more critical role in determining agricultural prices in Russia. This finding contrasts with the results of other studies, highlighting the importance of context-specific factors in ERPT analysis.

Fousekis and Trachanas (2016) investigate price transmission asymmetries in the U.S., EU, and Oceania dairy markets. Using the NARDL model, they find that positive price shocks are transmitted with higher intensity than negative shocks in the short and long run. This study illustrates the NARDL model's utility in capturing the asymmetric transmission of price shocks across different regions and sectors, providing insights into the underlying market dynamics.

Bronmann and Bittman (2019) employ the NARDL model to examine the asymmetry in price transmission in the German cod market. Their empirical results indicate long-run price transmission asymmetry in fishmongers, supermarkets, and discounters, with short-run asymmetries observed in discounters and the average retailer. This study demonstrates the NARDL model's effectiveness in identifying sector-specific asymmetries, informing both market participants and policymakers.

Cherif et al. (2021) analyze the asymmetric pass-through of exchange rates to food prices in MENA countries using a Panel NARDL model. Their findings highlight significant asymmetries, with currency depreciations leading to larger increases in food prices than the decreases resulting from appreciations. This study underscores the relevance of the NARDL model in capturing the complex dynamics of ERPT in diverse macroeconomic contexts.

Olayungbo (2021) applies the NARDL model to investigate the pass-through of oil prices to food prices in 21 oil-exporting countries. The study finds significant long-run asymmetries, with positive oil price shocks having a more substantial impact on food prices than negative shocks. This asymmetric pass-through is attributed to the strategic pricing behavior of firms and the varying degrees of market competition across countries.

## 2.5 Context of Turkey

Exchange Rate Pass-Through (ERPT) in Turkey has been a significant area of research, primarily due to the country's high exchange rate volatility and its substantial reliance on imports for essential goods, including food. The Turkish economy presents a unique case for studying ERPT because of its frequent currency fluctuations, inflationary pressures, and evolving monetary policy frameworks. This section synthesizes the findings of various studies on ERPT in Turkey, highlighting the mechanisms, determinants, and empirical evidence from different periods and methodological approaches.

Çiçek and Boz (2013) employ the NARDL model to examine asymmetric ERPT in Turkey during its inflation-targeting period. Their findings indicate that depreciation effects have a long-run impact on prices, particularly during economic expansions, while appreciations affect prices over more extended periods. This suggests that Turkish prices are more responsive to upward movements (depreciations) than to downward adjustments (appreciations), indicating downward price stickiness.

Karamelikli and Korkmaz (2016) demonstrate that consumer prices in Turkey can fluctuate symmetrically in the short run following any exchange rate rise or decline. This symmetric reaction indicates that Turkish prices adjust similarly to both appreciations and depreciations in the short term. However, in the long run, the relationship between the exchange rate and consumer prices turns positive, suggesting a long-term symmetry in the pass-through effect.

Nazlıoğlu and Soytaş (2011) study the impact of oil prices on food prices in Turkey using the Toda-Yamamoto causality approach. They find that oil prices significantly influence food prices, with exchange rate fluctuations playing a crucial intermediary role. This study underscores the importance of considering sector-specific dynamics, particularly in commodity-dependent sectors like agriculture.

Altıntaş (2016) employs the NARDL model to analyze the impact of real income and energy prices on food prices in Turkey. The results indicate significant long-run asymmetries, with increases in energy prices and income levels leading to more pronounced effects on food prices than decreases. This finding highlights Turkish food prices' sensitivity to domestic economic conditions and external shocks.

Çınar and Hushmat (2017) examine the volatility in food prices and its relation to global oil prices in Turkey using a GARCH model. Their results reveal that global oil price volatility significantly affects the volatility of Turkish food prices. This relationship is further complicated by exchange rate movements, which are a transmission channel for global price shocks. The study suggests that managing exchange rate volatility is crucial for stabilizing domestic food prices.

Kutlu (2021) explores the impact of global food prices and exchange rates on Turkish food prices through an SVAR model. The findings indicate that global food prices and exchange rate movements jointly influence Turkish food prices, with significant spillover effects observed from global markets to domestic prices. This study underscores the interconnectedness of global and domestic markets and the importance of exchange rate management in mitigating external shocks.

Özkan and Erden (2015) find that ERPT increases when inflation crosses a threshold of 14% for Turkey. This conclusion suggests that firms are more likely to pass on currency fluctuations to prices under high inflation conditions, indicating that inflationary expectations significantly affect ERPT dynamics. The study highlights the importance of maintaining low and stable inflation to mitigate the adverse effects of exchange rate volatility on domestic prices.

Karaoğlu and Kılıçkaplan (2018) discover that ERPT is non-linear and that the pass-through increases when the annual growth rate of consumer inflation exceeds 7%. This finding is consistent with Taylor's (2000) hypothesis that higher inflation environments tend to exhibit higher pass-through rates. The study suggests that controlling inflation is critical for reducing the sensitivity of domestic prices to exchange rate movements.

Simonyan (2020) investigates the impact of exchange rate changes on import and export prices in Turkey, finding significant asymmetric effects. The study reveals that depreciations lead to quicker and more substantial increases in import prices compared to the reductions caused by appreciations. This asymmetry complicates monetary policy and trade balance management, as policymakers must consider the differential impacts of exchange rate movements.

Gökçe (2021) assesses the impact of exchange rate fluctuations on food and energy prices in Turkey using a NARDL approach. The results indicate significant asymmetric pass-through effects, with positive exchange rate shocks (depreciations) leading to higher price increases than the decreases caused by negative shocks (appreciations). This study highlights the critical role of exchange rate management in ensuring price stability in essential sectors like food and energy.

Güngör and Erer (2022) investigate the dynamic relationship between food prices, oil prices, and exchange rates in Turkey with a TVP-VAR model. Their findings reveal that the pass-through effects are time-varying and significantly influenced by global oil prices and domestic economic conditions. The study emphasizes the importance of considering the temporal dynamics of ERPT when formulating economic policies.

# CHAPTER 3

# DATA

## 3.1 Data and Descriptive Statistics

This study examines the exchange rate pass-through (ERPT) to food prices in Turkey using monthly data spanning from July 2018 to December 2023. The data were sourced from the Turkish Statistical Institute (TURKSTAT) and the Central Bank of Turkey. The variables included in the analysis are oil prices (WTI), the nominal exchange rate (USD/TRY), money supply (M2), GDP, and food prices.

The oil price (OIL) variable represents the West Texas Intermediate (WTI) crude oil prices, reflecting the international oil market conditions. The exchange rate (EXC) variable represents the nominal exchange rate of USD to TRY, capturing the value of the Turkish Lira against the US Dollar. The money supply (M2) variable includes the total money supply in the Turkish economy, sourced from the Central Bank of Turkey.

Since GDP data is available quarterly, we used the Chow-Lin procedure to convert it into monthly data. This procedure involves regressing the quarterly GDP on a higher-frequency indicator, the Industrial Production Index (IPI) for Turkey. The regression results are then used to disaggregate the quarterly GDP into monthly series. Subsequently, we applied the Hodrick-Prescott (HP) filter to the estimated monthly GDP series to calculate the output gap, which measures the difference between actual and potential economic output. This method ensures a more accurate and timely representation of the economic activity influencing food prices.

Table 1. Descriptive Statistics of the Variables

| | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 11.75 | 71.81 | 5050 | -0.16 | 107.69 | 125.94 | 41.09 | 77.56 | 25.50 | 10.54 |
| Median | 8.09 | 72.82 | 3550 | 0.32 | 60.29 | 73.73 | 27.02 | 65.12 | 16.24 | 5.63 |
| Maximum | 29.07 | 125.53 | 13700 | 1.92 | 307.53 | 460.48 | 122.00 | 199.99 | 75.47 | 40.36 |
| Minimum | 4.76 | 14.85 | 1870 | -11.46 | 52.43 | 60.17 | 13.96 | 12.32 | 10.52 | 2.78 |
| Std. Dev. | 7.16 | 21.59 | 3340 | 2.21 | 79.95 | 96.54 | 31.23 | 51.99 | 17.21 | 9.76 |
| Skewness | 1.01 | -0.11 | 1.11 | -2.90 | 1.40 | 1.81 | 1.18 | 0.92 | 1.23 | 1.34 |
| Kurtosis | 2.80 | 3.49 | 3.08 | 13.54 | 3.43 | 5.25 | 3.24 | 3.17 | 3.35 | 3.74 |
| Jarque-Bera | 11.34 | 0.79 | 13.47 | 398.15 | 21.95 | 49.75 | 15.49 | 9.34 | 17.03 | 21.26 |
| Probability | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| Observations | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |

We utilized the web-scraped dataset developed by Soybilgen, Yazgan, and Kaya (2023) for food prices. This dataset includes daily prices for various food items from the five major online retail companies in Turkey, covering the period from July 2018 to the present. The high frequency of this data allows for a detailed analysis of food price movements. The dataset calculates the daily geometric average of all subcategory prices and indexes them to January 2020, with an index of 100. This approach ensures consistency in capturing relative price changes over time. Linear interpolation was employed to fill in missing values on days with incomplete price data, thereby maintaining dataset continuity.

The decision to use Soybilgen, Yazgan, and Kaya's dataset was driven by the fact that TURKSTAT ceased to publish itemized food prices after March 2022. The web-scraped data provides a more comprehensive and up-to-date source for analyzing food prices.

The analysis focuses on specific food categories: veal, lamb, poultry, fish, egg, and milk. These categories were chosen because they are widely consumed across Turkey and their prices are relatively stable and reflect exchange rate effects. Additionally, these items have consistent availability and are less influenced by seasonal variations than other food products. Including these categories allows for a more accurate assessment of the ERPT to food prices, as they better capture the transportation and logistical costs associated with imported inputs. All variables, except for the output gap, were transformed into their logarithmic forms.

# CHAPTER 4

# METHODOLOGY

## 4.1 General form of NARDL Model

To develop the NARDL, we start with a simple regression model that specifies the dependent variable as ($y_t$), which is a function of one or more independent variables ($x_t$):

$$y_t = \alpha + \beta x_t + \epsilon_t$$

where $\alpha$ is the intercept, $\beta$ denotes the slope coefficient, and $\epsilon_t$ is the error term.

The ARDL model generalizes this approach by incorporating lagged values of the dependent and independent variables to analyze dynamic relationships.

$$y_t = \alpha + \sum_{i=1}^{p} \phi_i y_{t-i} + \sum_{j=0}^{q} \theta_j x_{t-j} + \epsilon_t$$

Here, $p$ and $q$ are the lag lengths, $\phi_i$ are the coefficients of the lagged dependent variable, and $\theta_j$ are the coefficients of the lagged independent variable.

The non-linear ARDL (NARDL) model, introduced by Shin et al. (2011), is a further extension of the ARDL that allows for an asymmetric effect of the independent variable. This is achieved by splitting the independent variable into the positive and negative changes as the partial sums of positive and negative changes are defined as:

$$\mathrm{x}_t^+ = \sum_{i=1}^{t} \max(\Delta \mathrm{x}_i, 0), \quad \mathrm{x}_t^- = \sum_{i=1}^{t} \min(\Delta \mathrm{x}_i, 0)$$

Then, we integrate decomposed variables into the equation as:

$$y_t = \alpha + \sum_{i=1}^{p} \phi_i y_{t-i} + \sum_{j=0}^{q} \left( \theta_j^+ x_{t-j}^+ + \theta_j^- x_{t-j}^- \right) + \epsilon_t$$

In this equation, $x_t^+$ is the partial sum of positive changes in $x_t$, $x_t^-$ is the partial sum of negative changes in $x_t$, $\theta_j^+$ and $\theta_j^-$ are the coefficients for positive and negative changes, respectively.

The long-run asymmetric equation can be integrated into the ARDL framework to model both long-run and short-run dynamics. The general form of the NARDL equation is as:

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \sum_{j=0}^{q} \theta_j^+ \Delta x_{t-j}^+ + \sum_{j=0}^{q} \theta_j^- \Delta x_{t-j}^- + \rho y_{t-1} + \beta^+ x_{t-1}^+ + \beta^- x_{t-1}^- + \epsilon_t$$

## 4.2 Steps for Conducting NARDL Analysis

### 4.2.1 Unit Root Tests

When estimating the NARDL model, the order of integration of the variables must first be established so that none is integrated of order two (I(2)) because this would lead the bounds test for cointegration performed later to be invalid. The unit root test is performed using the Augmented Dickey-Fuller ADF test. The ADF test is used to detect a unit root in the series. The null hypothesis ($H_0$) is that the series has a unit root. The alternative hypothesis ($H_1$) is that the series is stationary, which means it does not have a unit root.

$$H_0 : \gamma = 0 \quad \text{(unit root)}, \quad H_1 : \gamma < 0 \quad \text{(stationary)}$$

PP Test is similar to the ADF test but adjusts for any serial correlation and heteroskedasticity in the error terms.

### 4.2.2 Estimate Initial NARDL Model

After we are confident that the variables are stationary, we proceed to estimate the initial NARDL model with proper lag lengths under our criteria using either the Akaike Information Criterion or Schwarz Bayesian Criterion.

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \sum_{j=0}^{q} \theta_j^+ \Delta x_{t-j}^+ + \sum_{j=0}^{q} \theta_j^- \Delta x_{t-j}^- + \rho y_{t-1} + \beta^+ x_{t-1}^+ + \beta^- x_{t-1}^- + \epsilon_t$$

After the estimate, our initial inference exercise shows how symmetrical the assumptions are. The NARDL framework may support partial asymmetry when variables enter asymmetrically in either adjusting or cointegrating dynamics, but not both.

For an arbitrary variable $x_t$ with asymmetric decompositions $x_t^+$ and $x_t^-$, and associated asymmetric level coefficients $\beta_t^+$ and $\beta_t^-$, and asymmetric difference coefficients $\theta_i^+$ and $\theta_i^-$ for $i = 1, \ldots, q$, partial asymmetry is tested by imposing the following restrictions:

Partial Short-Run Asymmetry (Long-Run Symmetry):

$$\beta^+ = \beta^-$$

Partial Long-Run Asymmetry (Short-Run Symmetry):

$$\theta_i = \theta_i^+ = \theta_i^-$$

These tests reduce to the usual Wald-like hypotheses on the equivalence of positive and negative asymmetry coefficients. After estimating the NARDL model, we conduct the following tests:

Long-Run Symmetry Only $H_0 : \beta^+ = \beta^-$.

$$\text{Short-Run Symmetry Only } H_0 = \begin{cases} \theta_i^+ = \theta_i^- & \text{for each } i \\ \text{or} & \\ \sum_{i=1}^{q} \theta_i^+ = \sum_{i=1}^{q} \theta_i^- & \end{cases}$$

Joint Short- and Long-Run Symmetry

$$H_0 = \begin{cases} \theta_i^+ = \theta_i^- & \text{for each } i \text{ and } \beta^+ = \beta^- \\ \text{or} & \\ \sum_{i=1}^q \theta_i^+ = \sum_{i=1}^q \theta_i^- & \text{and } \beta^+ = \beta^- \end{cases}$$

We alter the model differentially through a Wald test to determine which long-term or short-term variables are asymmetric. Thus, based on the test results, we either add or remove variables from the model to reflect the data behavior. Once the proper form of the model is given from the symmetry tests, we proceed to estimate the final NARDL model with proper long-term and short-term dynamics.

### 4.2.3 Test for Cointegration Using Bounds Test

The bounds-testing approach of Pesaran and Shin (2011) is used in the literature to test cointegration. The bounds testing approach is a method to test for a long-term cointegration relationship between two or more series in an ARDL or NARDL framework. This method allows for the testing of equations for cointegration regardless of whether all variables are I(0) or of order one I(1), as this does not involve preliminary testing for the unit roots.

In the bounds testing framework, the null hypothesis of no cointegration ($H_0$) is tested against the alternative hypothesis of cointegration ($H_1$):

$$H_0 : \rho = \beta^+ = \beta^- = 0, \quad H_1 : \rho \neq \beta^+ \neq \beta^- \neq 0$$

There are two sets of critical values: one assuming all series are I(0) or lower bound and the other assuming all are I(1) or upper bound. If the calculated F-statistics is greater than the upper bound, reject the null hypothesis that $H_0$, and the results indicate there is cointegration. If the F- statistics is less than the lower bound, fail to reject $H_0$, and there is no cointegration. If the calculated f-statistics fall between the bounds, the results become inconclusive unless the integration order is known.

The bounds-testing method is the key part of the NARDL model, and it allows for cointegration testing without requiring all variables to be of the same order of integration. If the bounds test gives an indication of cointegration i.e., $H_0$ is rejected, the following step is estimating the NARDL equation.

### 4.2.4 Wald Test for Long-term Asymmetry

Once the long-run coefficients have been estimated, it is now necessary to determine whether the coefficients are statistically different and state whether long-run asymmetry exists. The null hypothesis ($H_0$) is that long-run coefficients for positive and negative changes are equal. The alternative hypothesis ($H_1$) is that long-run coefficients for positive and negative changes are not equal.

$$H_0 : -\frac{\beta^+}{\rho} = -\frac{\beta^-}{\rho}, \quad H_1 : -\frac{\beta^+}{\rho} \neq -\frac{\beta^-}{\rho}$$

The null hypothesis is that the difference between $-\frac{\beta^+}{\rho}$ and $-\frac{\beta^-}{\rho}$ is 0. The Wald test is a statistical method for determining whether or not the null hypothesis can be rejected. This test provides a statistical inference for the hypothesis that the positive and negative impacts have equal long-run effects. If we reject the null hypothesis, one concludes that one has found the evidence of the long-run asymmetry.

### 4.2.5 Asymmetric Dynamic Multipliers

We compute the asymmetric dynamic multipliers to examine the dependent variable's adjustment paths to positive and negative explanatory variable changes. They track the dependent variable's reaction to positive and negative changes in the independent variables across time. This provides an extensive investigation of how the dependent variable reacts to explanatory variable increases and decreases.

For a dependent variable $y_t$ and an independent variable $x_t$, the asymmetric dynamic multipliers for positive and negative changes in $x_t$ are defined as follows:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-}$$

As $h$ increases, the sums $\sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+}$ and $\sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-}$ capture the cumulative effect of a unit change in $x_t^+$ and $x_t^-$ on $y_t$. The dynamic multipliers are calculated by summing the partial derivatives of future dependent variable values with regard to present positive and negative independent variable changes.

#### 4.2.6 CUSUM and CUSUMSQ Tests

Finally, the NARDL analysis examines the estimated model's stability using the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) tests. These tests are essential for determining model parameter stability.

The CUSUM test detects systematic regression coefficient changes. It uses the cumulative sum of residuals to find significant parameter changes. Model estimation yields recursive residuals. Differences between actual and expected values are used to calculate recursive residuals.

$$w_t = \frac{\epsilon_t}{\sqrt{\sigma^2(1 + h_t)}}$$

where $w_t$ are the recursive residuals, $\epsilon_t$ are the residuals from the NARDL model, $\sigma^2$ is the variance of the residuals, $h_t$ is the leverage value at time $t$.

The CUSUM statistic is the cumulative sum of recursive residuals:

$$CUSUM_t = \sum_{i=k+1}^{t} w_i$$

where $k$ is the initial sample size used for estimation. We plot the $CUSUM_t$ against time and compare it with the critical bounds. If the plot stays within the critical bounds, the null hypothesis of parameter stability is not rejected.

The CUSUMSQ test detects sudden residual variance shifts, suggesting regression coefficient variance instability. CUSUMSQ is the cumulative sum of squared recursive residuals:

$$CUSUMSQ_t = \sum_{i=k+1}^{t} w_i^2$$

We need to plot the $CUSUMSQ_t$ against time and compare it with the critical bounds. If the plot stays within the critical bounds, the null hypothesis of variance stability is not rejected. The CUSUM test will check for the overall stability of the model parameters. On the other hand, the CUSUMSQ test will check for the stability in the variance of the residuals. Both tests are crucial to ensure the robustness and reliability of the NARDL model, confirming that the estimated relationships remain consistent over the sample period.

## 4.3 Our Model

Now, we can formulate our NARDL model to estimate the asymmetric effects of ERPT on food inflation in Turkey as:

$$\begin{aligned} FOOD_t = \alpha &+ \phi_{EXC}^{+}\text{EXC}_t^{+} + \phi_{EXC}^{-}\text{EXC}_t^{-} + \phi_{OIL}^{+}\text{OIL}_t^{+} + \phi_{OIL}^{-}\text{OIL}_t^{-} \\ &+ \phi_{M2}^{+}\text{M2}_t^{+} + \phi_{M2}^{-}\text{M2}_t^{-} + \phi_{GAP}^{+}\text{GAP}_t^{+} + \phi_{GAP}^{-}\text{GAP}_t^{-} + \epsilon_t \end{aligned} \tag{4.1}$$

Where $FOOD_t$ is the food variable, $\alpha$ is a constant term, $\text{EXC}_t^{+}$ and $\text{EXC}_t^{-}$ are the partial sums of positive and negative changes in the exchange rate, $\text{OIL}_t^{+}$ and $\text{OIL}_t^{-}$ are the partial sums of positive and negative changes in oil prices, $\text{M2}_t^{+}$ and $\text{M2}_t^{-}$ are the partial sums of positive and negative changes in money supply, $\text{GAP}_t^{+}$ and $\text{GAP}_t^{-}$ are the partial sums of positive and negative changes in GAP, $\phi_{EXC}^{+}$, $\phi_{EXC}^{-}$, $\phi_{OIL}^{+}$, $\phi_{OIL}^{-}$, $\phi_{M2}^{+}$, $\phi_{M2}^{-}$ are the long-run coefficients and $\epsilon_t$ is the error term.

The partial sums of positive and negative changes are defined as:

$$\mathrm{EXC}_t^{+} = \sum_{i=1}^{t} \max(\Delta\mathrm{EXC}_i, 0), \quad \mathrm{EXC}_t^{-} = \sum_{i=1}^{t} \min(\Delta\mathrm{EXC}_i, 0) \tag{4.2}$$

$$\mathrm{OIL}_t^{+} = \sum_{i=1}^{t} \max(\Delta\mathrm{OIL}_i, 0), \quad \mathrm{OIL}_t^{-} = \sum_{i=1}^{t} \min(\Delta\mathrm{OIL}_i, 0) \tag{4.3}$$

$$\mathrm{M2}_t^{+} = \sum_{i=1}^{t} \max(\Delta\mathrm{M2}_i, 0), \quad \mathrm{M2}_t^{-} = \sum_{i=1}^{t} \min(\Delta\mathrm{M2}_i, 0) \tag{4.4}$$

$$\mathrm{GAP}_t^{+} = \sum_{i=1}^{t} \max(\Delta\mathrm{GAP}_i, 0), \quad \mathrm{GAP}_t^{-} = \sum_{i=1}^{t} \min(\Delta\mathrm{GAP}_i, 0) \tag{4.5}$$

Integrating the long-run asymmetric equation into the ARDL framework, we model both long-run and short-run dynamics as follows:

$$
\begin{aligned}
\underbrace{\Delta\ln(\text{FOOD})_t}_{\text{First difference of food}_t} = {} & \underbrace{\alpha_0}_{\text{Constant}} + \underbrace{\alpha_1 t}_{\text{Trend}} + \sum_{i=1}^{p-1} \underbrace{\gamma_{\text{FOOD},i}\Delta\ln(\text{FOOD}_{t-i})}_{\text{Lagged differences of food}_t} + \underbrace{\phi_{\text{FOOD}}\ln(\text{FOOD})_{t-1}}_{\text{first lag of food}_t} \\
& + \sum_{j_1=0}^{q_1}\left(\underbrace{\gamma^{+}_{\text{EXC},j_1}\Delta\ln(\text{EXC})^{+}_{t-j_1} + \gamma^{-}_{\text{EXC},j_1}\Delta\ln(\text{EXC})^{-}_{t-j_1}}_{\text{Short-run positive and negative exchange rate changes up to lag } q_1}\right) \\
& + \sum_{j_2=0}^{q_2}\left(\underbrace{\gamma^{+}_{\text{OIL},j_2}\Delta\ln(\text{OIL})^{+}_{t-j_2} + \gamma^{-}_{\text{OIL},j_2}\Delta\ln(\text{OIL})^{-}_{t-j_2}}_{\text{Short-run positive and negative oil price changes up to lag } q_2}\right) \\
& + \sum_{j_3=0}^{q_3}\left(\underbrace{\gamma^{+}_{\text{M2},j_3}\Delta\ln(\text{M2})^{+}_{t-j_3} + \gamma^{-}_{\text{M2},j_3}\Delta\ln(\text{M2})^{-}_{t-j_3}}_{\text{Short-run positive and negative money supply changes up to lag } q_3}\right) \\
& + \sum_{j_4=0}^{q_4}\left(\underbrace{\gamma^{+}_{\text{GAP},j_4}\Delta\ln(\text{GAP})^{+}_{t-j_4} + \gamma^{-}_{\text{GAP},j_4}\Delta\ln(\text{GAP})^{-}_{t-j_4}}_{\text{Short-run positive and negative GAP changes up to lag } q_4}\right) \\
& + \underbrace{\phi^{+}_{\text{EXC}}\ln(\text{EXC})^{+}_{t-1} + \phi^{-}_{\text{EXC}}\ln(\text{EXC})^{-}_{t-1}}_{\text{Long-run first lag of partial sum of positive and negative exchange rate}} \\
& + \underbrace{\phi^{+}_{\text{OIL}}\ln(\text{OIL})^{+}_{t-1} + \phi^{-}_{\text{OIL}}\ln(\text{OIL})^{-}_{t-1}}_{\text{Long-run first lag of partial sum of positive and negative oil price}} \\
& + \underbrace{\phi^{+}_{\text{M2}}\ln(\text{M2})^{+}_{t-1} + \phi^{-}_{\text{M2}}\ln(\text{M2})^{-}_{t-1}}_{\text{Long-run first lag of partial sum of positive and negative money supply}} \\
& + \underbrace{\delta D}_{\text{dummy}} + \underbrace{\epsilon_t}_{\text{error term}}
\end{aligned} \tag{4.6}
$$

This describes a NARDL $(p, q_1, q_2, q_3, q_4)$ model where FOOD enters as an autoregressive process of order $p$, and EXC, OIL, M2, GAP enter as asymmetric distributed lag variables with orders $q_1, q_2, q_3, q_4$. In particular, $\alpha_0$ and $\alpha_1$ respectively capture the effect of the constant and linear trend. Also, $\delta$ is a dummy variable that captures structural break (2021M11) in the data.

In our analysis, the dependent variable is food prices, while the primary independent variable is the exchange rate. To control for other factors that may influence food prices, we include additional variables: oil prices, M2 money supply, and the output gap.

Oil prices are included to capture supply-side shocks. Changes in oil prices can significantly affect production and transportation costs, which in turn impact food prices. By incorporating oil prices, we aim to account for these external supply-side factors that can introduce variability in food prices independently of exchange rate fluctuations.

The M2 money supply is utilized to reflect inflationary pressures within the economy. An increase in the money supply typically leads to higher inflation, which can erode purchasing power and increase the cost of goods and services, including food. By controlling for M2, we can isolate the effect of the exchange rate on food prices from the broader inflationary trends that may also be influencing price levels.

The output gap is included to capture demand-side factors. The output gap measures the difference between actual economic output and potential output. A positive output gap indicates that the economy is operating above its potential, often leading to increased demand and higher prices. Conversely, a negative output gap suggests underutilization of resources and potentially lower prices. Including the output gap allows us to consider the demand-side dynamics that might affect food prices.

In addition to these variables, we include the output gap in the equation as a short-run determinant to account for the dynamics described in the Phillips curve framework (de Brouwer and Gordon, 1998). The Phillips curve posits an inverse relationship between unemployment and inflation, suggesting that economic activity (captured by the output gap) can influence price levels. By incorporating the output gap as a short-run determinant, we ensure that our model accounts for these interactions, providing a more comprehensive understanding of the factors driving food prices.

# CHAPTER 5

# RESULTS

## 5.1 Unit Root Tests

As a prerequisite for cointegration analysis, we conducted a series of unit root tests to determine the stationarity properties of the variables under examination. This study's conventional unit root tests include the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. The results of these unit root tests are summarized below.

### 5.1.1 Augmented Dickey-Fuller (ADF) Test

Table 2. Unit Root Test Table (ADF)

| At Level | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
| With Constant | t-Statistic | 1.44 | -2.2 | 2.17 | -3.93 | 0.89 | 2.86 | 0.85 | -1.71 | 1.57 | 1.41 |
| | Prob. | 1 | 0.21 | 1 | 0 *** | 0.99 | 1 | 0.99 | 0.42 | 1 | 1 |
| With Constant & Trend | t-Statistic | -2.97 | -2.62 | -1.45 | -3.94 | -1.32 | -0.07 | -2.49 | -3.6 | -2.34 | -1.39 |
| | Prob. | 0.15 | 0.27 | 0.84 | 0.02 ** | 0.87 | 0.99 | 0.33 | 0.04 ** | 0.41 | 0.86 |
| Without Constant & Trend | t-Statistic | 3.34 | -0.16 | 7.13 | -3.97 | 2.11 | 2.35 | 3.21 | 3.14 | 2.24 | 4.1 |
| | Prob. | 1 | 0.62 | 1 | 0 *** | 0.99 | 1 | 1 | 1 | 0.99 | 1 |
| **At First Difference** | | | | | | | | | | | |
| | | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
| With Constant | t-Statistic | -5.71 | -7.12 | -7.54 | -5.1 | -5.47 | -5.22 | -6.13 | -8.22 | -5.41 | -8.44 |
| | Prob. | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** |
| With Constant & Trend | t-Statistic | -7.1 | -7.07 | -8.71 | -5.05 | -5.93 | -6.04 | -6.23 | -8.28 | -6.39 | -9.1 |
| | Prob. | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** |
| Without Constant & Trend | t-Statistic | -5.17 | -7.17 | -2.75 | -5.13 | -4.97 | -4.63 | -5.52 | -6.85 | -4.87 | -7.03 |
| | Prob. | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** |
| Decision | | I(1) | I(1) | I(1) | I(0) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) |

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

The ADF test was applied to all variables in their levels and first differences. The test results indicate that most variables are non-stationary at their levels but become stationary after taking the first difference. At the level with constant, the ADF test statistics for all variables except the output gap (GAP) do not reject the null hypothesis of a unit root. GAP is the only variable that is stationary at level with a significance level of 1%. When a constant and trend are included, only GAP and FISH are found to be stationary at the 5% significance level. Without constant and trend, GAP remains stationary at the 1% significance level.

At the first difference, the ADF test statistics for all variables significantly reject the null hypothesis of a unit root, indicating that the series are stationary. This is consistent across specifications with constant, constant and trend, and without constant and trend.

The ADF test results suggest that except for GAP, which is stationary at level, all other variables are integrated of order one, I(1).

### 5.1.2 Phillips-Perron (PP) Test

The PP test was conducted to further validate the results obtained from the ADF test. At the level with constant, the PP test statistics show that most variables are non-stationary, except GAP, which is stationary at the 5% significance level. When a constant and trend is included, the GAP variable is stationary at the 10% significance level, while the other variables remain non-stationary. Without constant and trend, the results are consistent with GAP being stationary at the 1% significance level.

Table 3. Unit Root Test Table (PP)

| At Level | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
| With Constant | t-Statistic | 0.77 | -2.09 | 2.6 | -3.05 | 1.22 | 2.86 | 0.78 | -2.07 | 2.27 | 1.78 |
| | Prob. | 0.99 | 0.25 | 1 | 0.04 ** | 1 | 1 | 0.99 | 0.26 | 1 | 1 |
| With Constant & Trend | t-Statistic | -1.45 | -2.5 | -1.33 | -3.09 | -1.15 | -0.07 | -2.2 | -3.43 | -1.43 | -1.2 |
| | Prob. | 0.84 | 0.33 | 0.87 | 0.12 | 0.91 | 0.99 | 0.48 | 0.06 * | 0.84 | 0.9 |
| Without Constant & Trend | t-Statistic | 4.03 | -0.1 | 7.13 | -3.06 | 2.49 | 2.83 | 2.98 | 3.84 | 3.08 | 4.5 |
| | Prob. | 1 | 0.65 | 1 | 0 *** | 1 | 1 | 1 | 1 | 1 | 1 |
| At First Difference | | | | | | | | | | | |
| | | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
| With Constant | t-Statistic | -5.66 | -7.43 | -7.58 | -5.04 | -5.54 | -5.17 | -5.91 | -10.62 | -5.46 | -8.45 |
| | Prob. | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** |
| With Constant & Trend | t-Statistic | -5.98 | -7.45 | -8.65 | -4.87 | -5.99 | -5.99 | -6.25 | -14.41 | -6.31 | -9.29 |
| | Prob. | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** |
| Without Constant & Trend | t-Statistic | -5.25 | -7.52 | -5.39 | -4.93 | -5.06 | -4.63 | -5.45 | -7.89 | -4.88 | -7.22 |
| | Prob. | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** | 0.00 *** |
| Decision | | I(1) | I(1) | I(1) | I(0) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) |

Notes: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant
*MacKinnon (1996) one-sided p-values.

At the first difference, the PP test confirms that all variables reject the null hypothesis of a unit root at the 1% significance level, indicating that they are stationary in their first differences.

The PP test results corroborate the findings of the ADF test, suggesting that all variables except GAP are I(1), while GAP is I(0).

In summary, the results of the ADF and PP tests consistently indicate that, apart from GAP, which is stationary at level, all other variables exhibit unit root behavior and become stationary after first differencing. These findings justify the use of the ARDL and NARDL frameworks for further analysis, as they accommodate variables with mixed orders of integration (I(0) and I(1)) but not I(2).

### 5.1.3 Zivot-Andrews (ZA) Test

Structural breaks can significantly affect the results of unit root tests, and it is crucial to account for such breaks to ensure accurate stationarity analysis. This study employed the breakpoint unit root test, which minimizes the Dickey-Fuller min-t statistics to identify structural breaks within the data series. This method is particularly useful for detecting points in time where the statistical properties of the series change.

Table 4. Unit Root with Structural Break Results

| | | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| At Level | | | | | | | | | | | |
| With Constant | t-Statistic | -2.11 | -5.07 | -1.12 | -7.71 | -3.13 | -0.87 | -2.22 | -3.02 | -1.14 | -1.77 |
| | Prob. | 0.97 | 0.00 | 0.99 | 0.01 | 0.6 | 0.99 | 0.94 | 0.67 | 0.99 | 0.99 |
| | Break Date | 2021M09 | 2021M03 *** | 2021M09 | 2020M04 *** | 2021M11 | 2022M09 | 2021M10 | 2021M08 | 2021M07 | 2021M11 |
| With Constant & Trend | t-Statistic | -4.68 | -3.84 | -2.45 | -7.36 | -3.08 | -2.06 | -4.22 | -4.37 | -3.29 | -3.02 |
| | Prob. | 0.08 | 0.46 | 0.98 | 0.00 | 0.88 | 0.99 | 0.24 | 0.17 | 0.8 | 0.9 |
| | Break Date | 2021M10 * | 2021M04 | 2021M10 | 2020M04 | 2021M11 | 2021M11 | 2021M10 | 2019M05 | 2022M06 | 2021M11 |
| At First Difference | | | | | | | | | | | |
| | | EXC | OIL | M2 | GAP | VEAL | LAMB | POULTRY | FISH | EGG | MILK |
| With Constant | t-Statistic | -8.83 | -11.68 | -10.37 | -8.57 | -6.66 | -7.15 | -7.22 | -9.07 | -6.56 | -9.84 |
| | Prob. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Break Date | 2021M12 *** | 202M03 *** | 2021M11 *** | 2020M04 *** | 2021M09 *** | 2021M11 *** | 2021M12 *** | 2019M06 *** | 2019M06 *** | 2021M12 *** |
| With Constant & Trend | t-Statistic | -9.08 | -12.98 | -10.61 | -9.27 | -6.87 | -7.14 | -7.19 | -9.07 | -6.8 | -9.8 |
| | Prob. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Break Date | 2021M12 *** | 2020M03 *** | 2021M11 *** | 2020M04 *** | 2023M03 *** | 2021M11 *** | 2021M12 *** | 2021M09 *** | 202M12 *** | 2023M03 *** |
| Decision | | I(1) | I(1) | I(1) | I(0) | I(1) | I(1) | I(1) | I(1) | I(1) | I(1) |

Upon realizing the presence of structural breaks in our data, we applied the breakpoint unit root test to determine the specific break dates and assess their significance. The lag length selection was based on the Schwarz Information Criterion (SIC), which ensures an optimal balance between goodness of fit and model parsimony. This test was applied to all variables, revealing critical insights into the stationarity properties of the series in the presence of structural breaks.

At the level, with a constant included in the test equation, the breakpoint unit root test statistics show that most variables, including exchange rate (EXC), money supply (M2), veal (VEAL), lamb (LAMB), poultry (POULTRY), fish (FISH), egg (EGG), and milk (MILK), are non-stationary. However, the oil prices (OIL) and the output gap (GAP) are found to be stationary at the 1% significance level. The identified breakpoints for these variables generally correspond to significant economic events, particularly around 2021M11, which aligns with the economic disruptions caused by the COVID-19 pandemic and subsequent recovery phases.

When both constant and trend are included in the test equation, the output gap (GAP) remains stationary, while other variables remain non-stationary. The break dates identified by the breakpoint unit root test generally align with periods of economic disruption, further validating the presence of structural breaks.

At the first difference, the breakpoint unit root test results uniformly indicate stationarity across all variables, with the null hypothesis of a unit root being rejected at the 1% significance level. This consistency across different specifications (with constant, with constant and trend, and without constant and trend) suggests that all variables are integrated of order one, I(1), except GAP, which is I(0).

After identifying significant breakpoints, we applied the Zivot-Andrews (ZA) test to detect and confirm these breakpoints specifically for the food variables. This test allows for an endogenous structural break in the series and provides a robust data analysis.

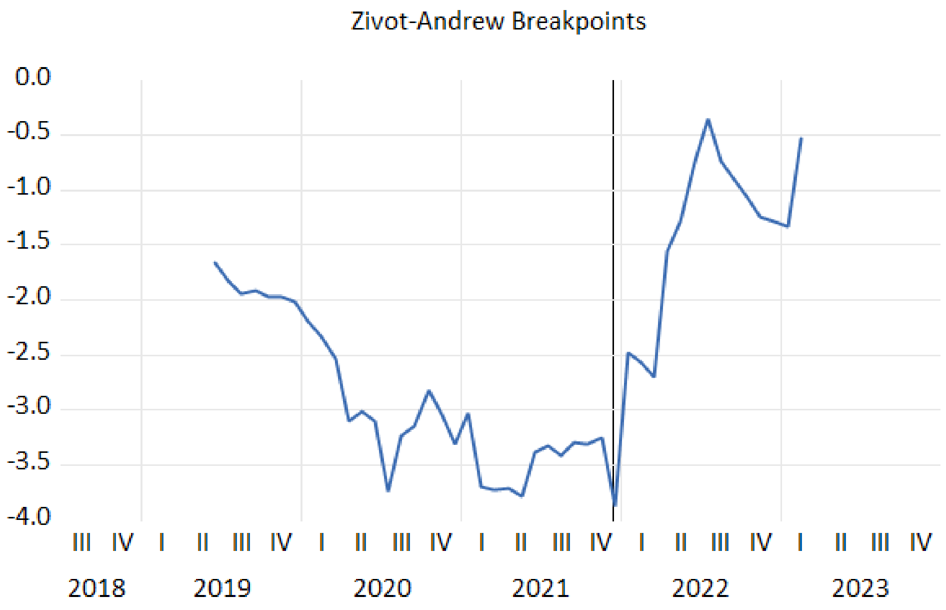



Figure 1. ZA Test Result for Veal

The ZA test results confirm that for veal, lamb, poultry, and milk, 2021M11 is chosen as a structural break and is significant at the 1% level. This period corresponds to a spike in the exchange rate, which substantially impacted the stationarity properties of these variables. For the egg variable, the break date 2019M06 is chosen as significant. For fish, no break date is found to be significant.

You can see Ziwot-Andrews test results for each variable in the (see Appendix A). These breakpoints are also visually evident from the line graphs of the variables (see Appendix B), further corroborating the results from the ZA test. The structural break in November 2021 for most food variables is particularly notable, highlighting the impact of exchange rate fluctuations during that period.

## 5.2 Wald Symmetry Test

Following the initial estimation of the Nonlinear Autoregressive Distributed Lag (NARDL) model, our primary inferential exercise focuses on formally validating the assumptions regarding asymmetry. Although the model is structured to reflect asymmetric distributed lag variables within both the adjustment and cointegration dynamics, the NARDL framework is sufficiently flexible to accommodate partial asymmetry. This adaptability allows for the formal testing of asymmetry through Wald-like hypotheses, which assess the equivalence of positive and negative asymmetry coefficients.

The Wald symmetry tests for long- and short-run dynamics were conducted to evaluate the null hypothesis that the coefficients for positive and negative changes are equivalent. The results of these tests are summarized in Table 5, with separate estimates provided for models with and without structural breaks.

Table 5. Wald Symmetry Test

| Food | Variable | ESTIMATES WITHOUT STRUCTURAL BREAK | | | | ESTIMATES WITH STRUCTURAL BREAK | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Long-run W | | Short-run W | | Long-run W | | Short-run W | |
| | | F-stat | p-value | F-stat | p-value | F-stat | p-value | F-stat | p-value |
| Veal | EXC | 0.928 | 0.364 | 3.351 | 0.105 | 1.008 | 0.354 | 2.333 | 0.178 |
| | M2 | 4.027 | 0.08* | 0.633 | 0.449 | 2.396 | 0.173 | 0.681 | 0.441 |
| | OIL | 5.707 | 0.044** | 11.353 | 0.01*** | 2.933 | 0.138 | 8.524 | 0.027** |
| | GAP | - | - | 2.085 | 0.187 | - | - | 1.087 | 0.337 |
| Lamb | EXC | 1.152 | 0.314 | 0.006 | 0.943 | 2.156 | 0.186 | 0.014 | 0.911 |
| | M2 | 52.046 | 0.00*** | 0.169 | 0.692 | 51.174 | 0.00*** | 0.045 | 0.839 |
| | OIL | 39.634 | 0.00*** | 0.912 | 0.368 | 35.942 | 0.001*** | 1.370 | 0.280 |
| | GAP | - | - | 35.747 | 0.00*** | - | - | 38.885 | 0.00*** |
| Poultry | EXC | 0.048 | 0.832 | 0.218 | 0.653 | 0.562 | 0.478 | 7.088 | 0.032** |
| | M2 | 12.777 | 0.007*** | 0.068 | 0.802 | 2.831 | 0.136 | 8.431 | 0.023** |
| | OIL | 5.706 | 0.044** | 0.022 | 0.887 | 2.788 | 0.139 | 0.507 | 0.500 |
| | GAP | - | - | 4.744 | 0.061* | - | - | 2.634 | 0.149 |
| Fish | EXC | 0.988 | 0.344 | 2.071 | 0.181 | - | - | - | - |
| | M2 | 15.031 | 0.003*** | 3.275 | 0.101 | - | - | - | - |
| | OIL | 17.125 | 0.002*** | 0.030 | 0.867 | - | - | - | - |
| | GAP | - | - | 0.000 | 0.00*** | - | - | - | - |
| Egg | EXC | 0.815 | 0.377 | 10.063 | 0.004*** | 0.002 | 0.962 | 8.596 | 0.008*** |
| | M2 | 4.332 | 0.049** | 13.181 | 0.002*** | 2.661 | 0.118 | 9.657 | 0.005*** |
| | OIL | 1.281 | 0.270 | 8.648 | 0.008*** | 1.052 | 0.317 | 8.242 | 0.009*** |
| | GAP | - | - | 2.983 | 0.098* | - | - | 3.009 | 0.098* |
| Milk | EXC | 12.493 | 0.008*** | 8.506 | 0.019** | 0.055 | 0.818 | 0.007 | 0.933 |
| | M2 | 4.873 | 0.058** | 7.164 | 0.028** | 8.325 | 0.01*** | 0.135 | 0.718 |
| | OIL | 8.527 | 0.019** | 1.164 | 0.312 | 1.458 | 0.243 | 4.837 | 0.041** |
| | GAP | - | - | 4.564 | 0.065* | - | - | 1.848 | 0.191 |

Notes: (a) The Wald symmetry test evaluates the null hypothesis that the coefficients for positive and negative changes in the exchange rate are equal. Rejecting the null hypothesis indicates asymmetric effects. (b) *p<0.1 ; **p<0.05 ; *p<0.01

### 5.2.1 Estimates Without Structural Break

For veal, the test results indicate significant asymmetry in both long-run and short-run dynamics concerning the oil variable, suggesting that positive and negative changes in oil prices have different impacts on veal prices. However, no significant asymmetry is found for the exchange rate (EXC), money supply (M2), and output gap (GAP).

For lamb, the results reveal significant long-run asymmetry for M2 and oil, but no significant asymmetry is found in the short-run dynamics. The GAP variable, however, shows strong short-run asymmetry, indicating that positive and negative changes in the output gap affect lamb prices differently.

For poultry, significant long-run asymmetry is observed for M2 and oil, while the short-run dynamics do not exhibit significant asymmetry. However, the GAP variable indicates a marginally significant short-run asymmetry.

For fish, significant long-run asymmetry is detected for both M2 and oil, whereas the short-run dynamics do not show significant asymmetry. Notably, the GAP variable is stationary at the first difference, precluding short-run asymmetry analysis.

For eggs, significant asymmetry is found in both long-run and short-run dynamics for the exchange rate and oil. The M2 variable also exhibits significant long-run asymmetry, while the GAP variable shows marginal short-run asymmetry.

For milk, Significant long-run asymmetry is observed for the exchange rate, M2, and oil. Short-run asymmetry is significant for the exchange rate and M2, while the GAP variable shows marginal short-run asymmetry.

#### 5.2.2 Estimates With Structural Break

For veal, when incorporating structural breaks, the significance of asymmetry in the oil variable remains in both long-run and short-run dynamics. However, the structural breaks mitigate the asymmetry in the exchange rate and money supply variables, indicating that the structural break period (2021M11) aligns with a spike in the exchange rate, which impacts veal prices differently.

For lamb, including structural breaks maintains the significant long-run asymmetry for M2 and oil. The short-run asymmetry for the GAP variable remains significant, highlighting the persistence of asymmetric effects despite structural changes.

For poultry, the structural break model indicates significant short-run asymmetry for the exchange rate, suggesting that the exchange rate spike in 2021M11 had a notable impact. M2 also exhibits significant short-run asymmetry, while the GAP variable does not show significant asymmetry post-break.

For fish, the structural break model does not provide significant results for the fish variable, indicating no notable asymmetry. This is visually supported by the line graphs, which do not show significant breakpoints.

For eggs, the structural break model highlights significant asymmetry in both long-run and short-run dynamics for the exchange rate and oil, consistent with the 2019M06 break date. The M2 variable also exhibits significant short-run asymmetry.

For milk, the inclusion of structural breaks reduces the significance of short-run asymmetry for the exchange rate. However, M2 maintains significant long-run asymmetry, and oil shows significant short-run asymmetry, aligning with the break date 2021M11.

In summary, the Wald symmetry tests reveal that the inclusion of structural breaks impacts the detection of asymmetry, particularly for variables like the exchange rate and oil. These findings underscore the importance of considering structural breaks in the analysis to accurately capture the dynamic relationships and asymmetric effects in the NARDL framework.

## 5.3 Cointegration Test

After detecting the asymmetries between variables through the Wald test, the NARDL model was re-estimated by choosing the appropriate form of the equation to account for these asymmetries. This step ensures that the model accurately reflects the long-run and short-run dynamics and asymmetries in the data. Following the validation of asymmetry, the bounds testing procedure was employed to investigate the existence of a cointegration relationship between the variables. The bounds test, based on the F-statistic, compares the computed F-values with the critical values at various significance levels, namely 10%, 5%, and 1%. If the F-statistic exceeds the upper bound critical value (I(1)), we reject the null hypothesis of no cointegration, indicating the presence of a long-run equilibrium relationship among the variables. The results of these tests are summarized in Table 6.

Table 6. Bounds Test

| Variable | F-statistic | 10% | | 5% | | 1% | |
|---|---|---|---|---|---|---|---|
| No Break | | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) |
| Veal | 7.16*** | 2.25 | 3.44 | 2.64 | 3.94 | 3.53 | 5.08 |
| Lamb | 5.22** | 2.90 | 4.02 | 3.37 | 4.61 | 4.48 | 5.92 |
| Poultry | 7.76*** | 2.26 | 3.43 | 2.65 | 3.92 | 3.50 | 5.05 |
| Fish | 8.72*** | 1.90 | 3.01 | 2.26 | 3.48 | 3.07 | 4.44 |
| Egg | 8.35*** | 1.90 | 3.01 | 2.26 | 3.48 | 3.07 | 4.44 |
| Milk | 2.99* | 1.75 | 2.87 | 2.04 | 3.24 | 2.66 | 4.05 |
| With Break | | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) |
| Veal | 6.42*** | 1.81 | 2.93 | 2.14 | 3.34 | 2.82 | 4.21 |
| Lamb | 7.22*** | 3.20 | 4.26 | 3.73 | 4.92 | 4.97 | 6.38 |
| Poultry | 4.54*** | 1.90 | 3.01 | 2.26 | 3.48 | 3.07 | 4.44 |
| Egg | 3.99** | 2.26 | 3.43 | 2.65 | 3.92 | 3.50 | 5.05 |
| Milk | 7.11*** | 2.39 | 3.57 | 2.82 | 4.10 | 3.78 | 5.34 |

Notes: (a) If the calculated F-statistics is greater than the upper bound, reject the null hypothesis that $H_0$ no cointegration, and the results indicate there is cointegration. (b) *p<0.1 ; **p<0.05 ; *p<0.01

For the estimates without structural breaks, the results indicate that the F-statistics for Veal, Lamb, Poultry, Fish, and Egg all exceed the upper bound critical values at the 1% significance level. Specifically, the F-statistic for Veal is 7.16, which is substantially higher than the upper bound critical value of 5.08. Similarly, Lamb has an F-statistic of 5.22, surpassing the critical value of 4.61, while Poultry, Fish, and Egg report F-statistics of 7.76, 8.72, and 8.35, respectively, each significantly above their corresponding upper bound critical values. This robust evidence suggests strong cointegration among these variables in the absence of structural breaks. Milk, however, presents an F-statistic of 2.99, which is marginally above the upper bound critical value at the 10% significance level, indicating a weaker but still significant cointegration relationship.

When considering structural breaks, the results show some variations. For instance, Veal's F-statistic decreases to 6.42 but still remains above the upper bound critical value of 4.21 at the 1% significance level, confirming cointegration. Lamb's F-statistic increases to 7.22, indicating even stronger evidence of cointegration in the presence of a break. Poultry and Egg exhibit F-statistics of 4.54 and 3.99, respectively, which are above the upper bound critical values at the 5% and 10% significance levels, confirming cointegration but with slightly less robustness compared to the no-break scenario. Milk shows an F-statistic of 7.11, reinforcing the evidence of a long-run relationship with the inclusion of structural breaks.

The strong evidence of cointegration between the exchange rate (EXC) and food prices indicates that exchange rate fluctuations have a significant and lasting impact on food prices.

## 5.4 Wald Test - Coefficient Restrictions

As outlined in Pesaran et al. (2001), the rejection of the t-bounds test in the secondary stage confirms the existence of a cointegrating relationship, but it does not preclude the possibility that it is degenerate. To rule out degenerate cointegration, a joint test of parameter significance on all coefficients associated with distributed lag variables in levels should be inspected. This can be done using a simple Wald test. With a p-value of 0.00, this test rejects the null hypothesis that all tested coefficients are jointly zero, and by extension, confirms that the cointegrating relationship which emerges is, in fact, sensible and not degenerate.

Table 7. Wald Test - Coefficient Restrictions

| Variable | F-statistic | Prob. |
|---|---|---|
| No Break | | |
| Veal | 8.301 | 0.000*** |
| Lamb | 6.267 | 0.000*** |
| Poultry | 9.048 | 0.000*** |
| Fish | 1.403 | 0.247 |
| Egg | 7.662 | 0.000*** |
| Milk | 3.471 | 0.009*** |
| With Break | | |
| Veal | 7.550 | 0.000*** |
| Lamb | 8.653 | 0.000*** |
| Poultry | 5.673 | 0.001*** |
| Egg | 4.448 | 0.001*** |
| Milk | 8.329 | 0.000*** |

Notes: (a) Null Hypothesis that all tested coefficients are jointly zero: C(2)=0, C(3)=0, C(4)=0, C(5)=0, C(6)=0, C(7)=0 (b) *p<0.1 ; **p<0.05 ; *p<0.01

Given the existence of a non-degenerate cointegrating relationship, we can identify the normalized, long-run coefficients in the cointegrating space that are associated with each of the distributed lag variables. These normalized coefficients provide insights into the long-run equilibrium relationships between the dependent and explanatory variables. In our study, these coefficients represent the long-run effects of the exchange rate, oil prices, money supply, and output gap on various food prices.

The results indicate significant long-run asymmetry in the impacts of the explanatory variables on most food prices. For example, the rejection of the null hypothesis for veal, lamb, poultry, egg, and milk prices, both with and without structural breaks, demonstrates that positive and negative changes in the exchange rate, oil prices, money supply, and output gap exert different long-run effects on these food prices. This finding is consistent across the models, underscoring the robustness of the long-run asymmetry.

However, for fish prices, the null hypothesis cannot be rejected, suggesting that the long-run effects of the explanatory variables on fish prices are symmetric.

This lack of asymmetry might be due to specific market characteristics or supply chain factors unique to fish, which buffer it from differential impacts of economic shocks.

## 5.5 Estimation Results

### 5.5.1 Veal

The Nonlinear Autoregressive Distributed Lag (NARDL) model results for veal prices, presented in Table 10, provide an insightful analysis of the dynamics between veal prices and the explanatory variables. The estimates are divided into two parts: estimates without structural breaks and estimates with structural breaks, capturing the possible asymmetries and structural shifts in the data.

Table 8. Long-run Model Estimations Without Structural Break for Veal

NARDL Cointegration Test

| Panel A: Testing the presence of cointegration | | | | | | | |
|---|---|---|---|---|---|---|---|
| F-statistic | 10% | | 5% | | 1% | | Decision |
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 7.16 | 2.25 | 3.44 | 2.64 | 3.94 | 3.53 | 5.08 | COINTEGRATED *** |

| Panel B: Long-run parameters | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std | t-stat | Prob. |
| $exc_{t-1}$ | 1.894 | 0.435 | 4.358 | 0.000*** |
| $oil^{+}_{t-1}$ | -0.798 | 0.102 | -7.811 | 0.000*** |
| $oil^{-}_{t-1}$ | -0.157 | 0.141 | -1.117 | 0.269 |
| $m2^{+}_{t}$ | 0.002 | 0.425 | 0.006 | 0.996 |
| $m2^{-}_{t}$ | -16.814 | 6.321 | -2.660 | 0.010** |
| $gap_{t-1}$ | -7.291 | 1.799 | -4.052 | 0.000*** |

Without considering structural breaks, the NARDL cointegration test results for veal prices indicate a significant long-run relationship among the variables. The F-statistic of 7.16 is well above the critical values at the 1%, 5%, and 10% significance levels, suggesting that the variables are cointegrated.

In the long run, the coefficient for the exchange rate ($\text{EXC}_{t-1}$) is 1.894, with a t-statistic of 4.358 and a p-value of 0.000, indicating a highly significant and positive impact on veal prices. This implies that a 1% increase in the nominal USD/TRY exchange rate leads to a 1.89% increase in veal prices. This is consistent with the fact that a weaker Turkish Lira increases the cost of imported inputs, such as feed and veterinary supplies, which are essential for veal production. Higher input costs are then passed on to consumers, raising the retail price of veal.

The positive oil price shock ($\text{oil}_{t-1}^{+}$) has a coefficient of -0.798, a t-statistic of -7.811, and a p-value of 0.000, indicating a significant negative impact on veal prices. This counterintuitive result could be attributed to substitution effects or changes in demand dynamics when oil prices rise. Conversely, the negative oil price shock ($\text{oil}_{t-1}^{-}$) has a coefficient of -0.157, which is not statistically significant (t-statistic of -1.117 and p-value of 0.269), suggesting that decreases in oil prices do not have a significant long-run impact on veal prices.

The output gap ($\text{gap}_{t-1}$) has a significant negative coefficient of -7.291 (t-statistic of -4.052 and p-value of 0.000), indicating that a higher output gap (indicative of economic boom) reduces veal prices.

When considering structural breaks, the cointegration test still confirms a significant long-run relationship among the variables. The F-statistic of 6.42 is above the critical values at the 1%, 5%, and 10% levels, confirming cointegration.

Table 9. Long-run Model Estimations With Structural Break for Veal NARDL Cointegration Test

| Panel A: Testing the presence of cointegration | | | | | | | |
|---|---|---|---|---|---|---|---|
| F-statistic | 10% | | 5% | | 1% | | Decision |
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 6.42 | 1.81 | 2.93 | 2.14 | 3.34 | 2.82 | 4.21 | COINTEGRATED *** |

| Panel B: Long-run parameters | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std | t-stat | Prob. |
| $\text{exc}_{t-1}$ | 1.267 | 0.289 | 4.385 | 0.000*** |
| $\text{oil}^{+}_{t-1}$ | -0.590 | 0.099 | -5.935 | 0.000*** |
| $\text{oil}^{-}_{t-1}$ | -0.342 | 0.107 | -3.189 | 0.000*** |
| $\text{m2}_{t}$ | 0.125 | 0.024 | 5.163 | 0.000*** |
| $\text{gap}_{t-1}$ | -7.813 | 2.949 | -2.650 | 0.011** |

In the long-run, the coefficient for the exchange rate ($\text{EXC}_{t-1}$) is 1.267, indicating that a 1% increase in the nominal USD/TRY exchange rate leads to a 1.27% increase in veal prices. Although the magnitude is slightly lower than without breaks, this reflects the significant impact of exchange rate fluctuations on veal prices due to imported input costs.

The positive oil price shock ($\text{oil}^{+}_{t-1}$) has a coefficient of -0.590, indicating a significant negative impact on veal prices, though the magnitude is slightly reduced compared to the model without breaks. The negative oil price shock ($\text{oil}^{-}_{t-1}$) has a coefficient of -0.342, which is now significant (t-statistic of -3.189 and p-value of 0.000), suggesting asymmetry in how oil price changes affect the market.

The diagnostic tests (Jarque-Bera, LM, ARCH, and Ramsey RESET) indicate that the models are well-specified, with no significant issues of normality, autocorrelation, heteroscedasticity, or misspecification.

Table 10. NARDL Model Result for Veal

ESTIMATES WITHOUT STRUCTURAL BREAK

Selected model: NARDL(4,4,5,0,5)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $veal_{t-1}$ | -0.750 | 0.137 | -5.463 | 0.000*** |
| $exc_{t-1}$ | 1.420 | 0.270 | 5.255 | 0.000*** |
| $gap_{t-1}$ | -5.469 | 1.808 | -3.024 | 0.006*** |
| $oil^+_{t-1}$ | -0.599 | 0.119 | -5.044 | 0.000*** |
| $oil^-_{t-1}$ | -0.118 | 0.098 | -1.199 | 0.242 |
| $m2^+_t$ | 0.002 | 0.319 | 0.006 | 0.996 |
| $m2^-_t$ | -12.611 | 5.434 | -2.321 | 0.029** |
| $\Delta\ veal_{t-1}$ | 0.359 | 0.129 | 2.785 | 0.010** |
| $\Delta\ veal_{t-2}$ | 0.314 | 0.168 | 1.872 | 0.073* |
| $\Delta\ veal_{t-3}$ | 0.388 | 0.157 | 2.474 | 0.021** |
| $\Delta\ exc_t$ | 0.820 | 0.313 | 2.624 | 0.015** |
| $\Delta\ exc_{t-1}$ | -0.641 | 0.254 | -2.526 | 0.018** |
| $\Delta\ exc_{t-2}$ | -0.657 | 0.213 | -3.080 | 0.005*** |
| $\Delta\ exc_{t-3}$ | -0.517 | 0.235 | -2.201 | 0.037** |
| $\Delta\ oil^+_t$ | -0.020 | 0.179 | -0.114 | 0.910 |
| $\Delta\ oil^-_t$ | 0.054 | 0.129 | 0.418 | 0.680 |
| $\Delta\ oil^+_{t-1}$ | -0.012 | 0.156 | -0.076 | 0.940 |
| $\Delta\ oil^-_{t-1}$ | 0.638 | 0.129 | 4.960 | 0.000*** |
| $\Delta\ oil^+_{t-2}$ | -0.426 | 0.148 | -2.888 | 0.008*** |
| $\Delta\ oil^-_{t-2}$ | 1.085 | 0.180 | 6.025 | 0.000*** |
| $\Delta\ oil^+_{t-3}$ | -0.467 | 0.135 | -3.467 | 0.002*** |
| $\Delta\ oil^-_{t-3}$ | 0.615 | 0.193 | 3.187 | 0.004*** |
| $\Delta\ oil^+_{t-4}$ | -0.240 | 0.138 | -1.735 | 0.095* |
| $\Delta\ oil^-_{t-4}$ | 0.104 | 0.143 | 0.729 | 0.473 |
| $\Delta\ gap^+_t$ | 8.547 | 3.711 | 2.303 | 0.030** |
| $\Delta\ gap^-_t$ | -3.168 | 1.383 | -2.291 | 0.031** |
| $\Delta\ gap^+_{t-1}$ | -0.379 | 4.085 | -0.093 | 0.927 |
| $\Delta\ gap^-_{t-1}$ | 0.983 | 4.221 | 0.233 | 0.818 |
| $\Delta\ gap^+_{t-2}$ | 1.765 | 2.232 | 0.791 | 0.437 |
| $\Delta\ gap^-_{t-2}$ | -4.287 | 4.690 | -0.914 | 0.370 |
| $\Delta\ gap^+_{t-3}$ | 8.808 | 3.772 | 2.335 | 0.028** |
| $\Delta\ gap^-_{t-3}$ | 0.239 | 3.904 | 0.061 | 0.952 |
| $\Delta\ gap^+_{t-4}$ | -1.665 | 1.402 | -1.188 | 0.246 |
| $\Delta\ gap^-_{t-4}$ | -2.890 | 3.587 | -0.806 | 0.428 |
| constant | 1.224 | 0.683 | 1.792 | 0.085* |

ESTIMATES WITH STRUCTURAL BREAK

Selected model: NARDL(5,4,0,5,2)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $veal_{t-1}$ | -0.440 | 0.118 | -3.721 | 0.001*** |
| $exc_{t-1}$ | 0.557 | 0.261 | 2.134 | 0.041** |
| $m2_t$ | 0.055 | 0.009 | 6.035 | 0.000*** |
| $gap_{t-1}$ | -3.438 | 1.292 | -2.660 | 0.012** |
| $oil^+_{t-1}$ | -0.260 | 0.085 | -3.048 | 0.005*** |
| $oil^-_{t-1}$ | -0.150 | 0.052 | -2.872 | 0.007*** |
| $\Delta\ veal_{t-1}$ | 0.155 | 0.136 | 1.134 | 0.265 |
| $\Delta\ veal_{t-2}$ | -0.009 | 0.214 | -0.043 | 0.966 |
| $\Delta\ veal_{t-3}$ | 0.240 | 0.159 | 1.503 | 0.143 |
| $\Delta\ veal_{t-4}$ | -0.196 | 0.120 | -1.634 | 0.112 |
| $\Delta\ exc_t$ | 0.403 | 0.198 | 2.033 | 0.051* |
| $\Delta\ exc_{t-1}$ | -0.442 | 0.204 | -2.165 | 0.038** |
| $\Delta\ exc_{t-2}$ | -0.466 | 0.206 | -2.264 | 0.031** |
| $\Delta\ exc_{t-3}$ | -0.369 | 0.209 | -1.767 | 0.087* |
| $\Delta\ oil^+_t$ | 0.033 | 0.135 | 0.249 | 0.805 |
| $\Delta\ oil^-_t$ | 0.102 | 0.086 | 1.194 | 0.241 |
| $\Delta\ oil^+_{t-1}$ | 0.035 | 0.140 | 0.251 | 0.804 |
| $\Delta\ oil^-_{t-1}$ | 0.484 | 0.124 | 3.907 | 0.001*** |
| $\Delta\ oil^+_{t-2}$ | -0.114 | 0.130 | -0.875 | 0.388 |
| $\Delta\ oil^-_{t-2}$ | 0.749 | 0.145 | 5.145 | 0.000*** |
| $\Delta\ oil^+_{t-3}$ | -0.304 | 0.108 | -2.822 | 0.008*** |
| $\Delta\ oil^-_{t-3}$ | 0.504 | 0.167 | 3.013 | 0.005*** |
| $\Delta\ oil^+_{t-4}$ | -0.209 | 0.073 | -2.841 | 0.008*** |
| $\Delta\ oil^-_{t-4}$ | 0.337 | 0.122 | 2.761 | 0.010** |
| $\Delta\ gap^+_t$ | 4.700 | 2.388 | 1.968 | 0.058* |
| $\Delta\ gap^-_t$ | -1.635 | 1.238 | -1.321 | 0.196 |
| $\Delta\ gap^+_{t-1}$ | 2.560 | 1.743 | 1.469 | 0.152 |
| $\Delta\ gap^-_{t-1}$ | -2.167 | 3.011 | -0.720 | 0.477 |
| dummy | 0.142 | 0.088 | 1.622 | 0.115 |

Model Diagnostic Tests:

| | JB | LM | ARCH | RAMSEY | JB | LM | ARCH | RAMSEY |
|---|---|---|---|---|---|---|---|---|
| Stat | 1.11 | 5.46 | 1.48 | 0.09 | 1.33 | 6.55 | 1.78 | 0.11 |
| Pvalue | 0.57 | 0.32 | 0.177 | 0.76 | 0.68 | 0.38 | 0.21 | 0.91 |

The significant positive coefficient for the exchange rate ($EXC_{t-1}$) indicates that an increase in the USD/TRY exchange rate leads to higher veal prices. This relationship is particularly pronounced in Turkey due to its heavy reliance on imported agricultural inputs. Key inputs for veal production, such as feed, veterinary medicines, and equipment, are often sourced from international markets. When the Turkish Lira depreciates, the cost of these imported goods rises, increasing production costs. Producers then pass on these higher costs to consumers in the form of higher veal prices. This effect is evident in both models, with and without structural breaks, underscoring the critical role of exchange rate stability in maintaining affordable food prices.

The asymmetry in the impact of oil price shocks on veal prices is noteworthy. The negative coefficient for positive oil price shocks ($\text{oil}_{t-1}^{+}$) suggests that rising oil prices lead to lower veal prices, which may initially seem counterintuitive. However, this can be explained through substitution effects and demand-side adjustments. Higher oil prices often increase transportation and production costs across various sectors. Consumers facing higher overall living costs may reduce their consumption of relatively expensive food items like veal, leading to a decline in veal prices. On the other hand, the significant but smaller coefficient for negative oil price shocks ($\text{oil}_{t-1}^{-}$) suggests that decreases in oil prices do not significantly lower veal prices, possibly because the benefits of lower costs are not fully passed on to consumers or because other inflationary pressures offset these gains.

The output gap ($\text{gap}_{t-1}$) consistently shows a significant negative impact on veal prices, with a coefficient of -5.639. This implies that a 1% positive output gap (indicating economic expansion) leads to a 7.8% decrease in veal prices. This relationship underscores the sensitivity of veal prices to broader economic conditions. During periods of economic growth, increased consumer confidence and higher disposable incomes lead to greater demand for veal. However, economic booms in Turkey are often characterized by reduced market volatility and a more stable exchange rate, which can lower the cost of imports and stabilize veal prices. Thus, while consumer demand increases during economic expansions, the improved economic conditions and stable exchange rates contribute to lower veal prices.

### 5.5.2 Lamb

Table 11. Long-run Model Estimations Without Structural Break for Lamb

NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 5.22 | 2.90 | 4.02 | 3.37 | 4.61 | 4.48 | 5.92 | COINTEGRATED ** |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_{t-1}$ | -0.970 | 0.463 | -2.096 | 0.041** |
| $oil^{+}_{t-1}$ | -0.018 | 0.151 | -0.119 | 0.906 |
| $oil^{-}_{t-1}$ | 0.194 | 0.101 | 1.921 | 0.060* |
| $m2_{t-1}$ | 3.685 | 0.701 | 5.260 | 0.000*** |
| $gap_{t-1}$ | 3.465 | 2.790 | 1.242 | 0.219 |

The analysis of the NARDL cointegration test for lamb prices, both with and without structural breaks, reveals significant insights into the long-run relationships between lamb prices and key economic variables in Turkey. These results underscore the critical factors influencing lamb prices, providing a comprehensive understanding of the market dynamics. The cointegration test results indicate that there is a long-run equilibrium relationship between lamb prices and the explanatory variables.

The coefficient of -0.970 implies that a 1% increase in the exchange rate (USD/TRY) leads to a 0.97% decrease in lamb prices. Positive changes in oil prices do not significantly impact lamb prices, as indicated by the coefficient of -0.018. This suggests that the Turkish lamb market may be less sensitive to oil price increases, or that oil price changes' effects are more short-term than long-term. A 1% decrease in oil prices leads to a 0.19% increase in lamb prices, as suggested by the coefficient of 0.194. A 1% increase in the money supply (M2) leads to a 3.69% increase in lamb prices, as indicated by the coefficient of 3.685. This result aligns with the expectation that increased money supply boosts consumer spending power and demand, thereby raising lamb prices. The coefficient of 3.465 suggests a positive, albeit not statistically significant, relationship between the output gap and lamb prices, indicating that higher economic activity can increase demand for lamb, thus driving up prices.

Including structural breaks in the model reveals more pronounced relationships between the variables and lamb prices. The coefficient of -3.573 in the model with structural breaks indicates that a 1% increase in the exchange rate leads to a 3.57% decrease in lamb prices. The positive coefficient of 0.540 suggests that a 1% increase in oil prices leads to a 0.54% increase in lamb prices, reflecting the broader inflationary pressures caused by rising oil prices, which increase production and transportation costs, subsequently pushing up lamb prices.

Table 12. Long-run Model Estimations With Structural Break for Lamb

NARDL Cointegration Test

| Panel A: Testing the presence of cointegration | | | | | | | |
|---|---|---|---|---|---|---|---|
| F-statistic | 10% | | 5% | | 1% | | Decision |
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 7.22 | 3.20 | 4.26 | 3.73 | 4.92 | 4.97 | 6.38 | COINTEGRATED *** |

| Panel B: Long-run parameters | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std | t-stat | Prob. |
| $exc_{t-1}$ | -3.573 | 0.751 | -4.760 | 0.000*** |
| $oil_{t-1}$ | 0.540 | 0.155 | 3.494 | 0.001*** |
| $m2_{t-1}$ | 7.038 | 0.814 | 8.644 | 0.000*** |
| $gap_{t-1}$ | 12.408 | 3.468 | 3.578 | 0.001*** |

The coefficient of 7.038 in the model with structural breaks indicates a much stronger relationship, with a 1% increase in money supply leading to a 7.04% increase in lamb prices. This suggests that during periods of monetary expansion, the demand effects are more pronounced, significantly driving up lamb prices. The coefficient of 12.408 shows a strong positive relationship, with a 1% increase in the output gap leading to a 12.41% increase in lamb prices, indicating that higher economic activity significantly boosts demand for lamb, thereby raising prices.

The observed relationship where a higher exchange rate leads to lower lamb prices might seem counterintuitive but can be explained within the context of Turkey's economic and agricultural landscape. When the Turkish Lira depreciates (i.e., the exchange rate increases), imported meats such as veal become more expensive. Consumers who previously purchased veal might shift their consumption to relatively cheaper local meats like lamb. If the local supply of lamb is flexible enough to quickly meet this increased demand, it could lead to a temporary oversupply situation, causing lamb prices to decrease.

Additionally, a higher exchange rate can make Turkish lamb more competitive in international markets by making it cheaper for foreign buyers, potentially increasing lamb exports. If domestic producers prioritize exports due to favorable exchange rates, the domestic supply might be affected. However, if the domestic market has a robust supply and is less reliant on export markets, the increase in exports might not significantly deplete domestic supply, keeping prices stable or even lowering them if producers ramp up production in anticipation of higher demand.

Higher exchange rates can also affect the cost of imported inputs used in lamb production, such as feed and veterinary products. If these costs increase significantly, small-scale farmers, who dominate the lamb market in Turkey, might not be able to pass these costs on to consumers due to market competition or consumer price sensitivity. Instead, they might absorb the costs, potentially reducing profit margins but keeping prices lower to maintain sales volumes.

Table 13. NARDL Model Result for Lamb

| ESTIMATES WITHOUT STRUCTURAL BREAK | | | | | ESTIMATES WITH STRUCTURAL BREAK | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Selected model: NARDL(5,4,5,0,3) | | | | | Selected model: NARDL(2,4,5,2,3) | | | | |
| Variable | Coefficient | Std | t-stat | Prob. | Variable | Coefficient | Std | t-stat | Prob. |
| lamb$_{t-1}$ | -0.690 | 0.132 | -5.212 | 0.000*** | lamb$_{t-1}$ | -0.468 | 0.085 | -5.537 | 0.000*** |
| exc$_{t-1}$ | -0.670 | 0.357 | -1.873 | 0.070* | exc$_{t-1}$ | -1.672 | 0.419 | -3.989 | 0.000*** |
| m2$_{t-1}$ | 2.544 | 0.703 | 3.619 | 0.001*** | m2$_{t-1}$ | 3.293 | 0.644 | 5.116 | 0.000*** |
| gap$_{t-1}$ | 2.392 | 1.984 | 1.206 | 0.236 | oil$_{t-1}$ | 0.253 | 0.089 | 2.831 | 0.008*** |
| oil$_t^+$ | -0.012 | 0.104 | -0.119 | 0.906 | gap$_{t-1}$ | 5.806 | 1.796 | 3.233 | 0.003*** |
| oil$_t^-$ | 0.134 | 0.080 | 1.682 | 0.102 | $\Delta$ lamb$_{t-1}$ | 0.350 | 0.133 | 2.625 | 0.013** |
| $\Delta$ lamb$_{t-1}$ | 0.572 | 0.145 | 3.947 | 0.000*** | $\Delta$ exc$_t$ | -0.576 | 0.349 | -1.653 | 0.107 |
| $\Delta$ lamb$_{t-2}$ | 0.316 | 0.164 | 1.929 | 0.062* | $\Delta$ exc$_{t-1}$ | 0.928 | 0.356 | 2.609 | 0.013** |
| $\Delta$ lamb$_{t-3}$ | 0.396 | 0.156 | 2.540 | 0.016** | $\Delta$ exc$_{t-2}$ | 0.433 | 0.302 | 1.432 | 0.161 |
| $\Delta$ lamb$_{t-4}$ | 0.194 | 0.156 | 1.242 | 0.223 | $\Delta$ exc$_{t-3}$ | 0.898 | 0.270 | 3.323 | 0.002*** |
| $\Delta$ exc$_t$ | 0.080 | 0.384 | 0.209 | 0.836 | $\Delta$ m2$_t$ | 0.601 | 0.379 | 1.585 | 0.122 |
| $\Delta$ exc$_{t-1}$ | 0.342 | 0.339 | 1.011 | 0.319 | $\Delta$ m2$_{t-1}$ | -2.109 | 0.673 | -3.132 | 0.004*** |
| $\Delta$ exc$_{t-2}$ | 0.219 | 0.322 | 0.682 | 0.500 | $\Delta$ m2$_{t-2}$ | -2.064 | 0.637 | -3.242 | 0.003*** |
| $\Delta$ exc$_{t-3}$ | 0.984 | 0.307 | 3.200 | 0.003*** | $\Delta$ m2$_{t-3}$ | -1.792 | 0.551 | -3.252 | 0.003*** |
| $\Delta$ m2$_t$ | 0.066 | 0.419 | 0.157 | 0.876 | $\Delta$ m2$_{t-4}$ | -1.271 | 0.425 | -2.992 | 0.005*** |
| $\Delta$ m2$_{t-1}$ | -1.544 | 0.744 | -2.074 | 0.046** | $\Delta$ oil$_t$ | 0.073 | 0.067 | 1.088 | 0.284 |
| $\Delta$ m2$_{t-2}$ | -1.101 | 0.634 | -1.736 | 0.092* | $\Delta$ oil$_{t-1}$ | -0.065 | 0.062 | -1.053 | 0.299 |
| $\Delta$ m2$_{t-3}$ | -1.475 | 0.588 | -2.507 | 0.017** | $\Delta$ gap$_t^+$ | 6.714 | 2.346 | 2.862 | 0.007*** |
| $\Delta$ m2$_{t-4}$ | -1.356 | 0.467 | -2.903 | 0.006*** | $\Delta$ gap$_t^-$ | -2.099 | 1.445 | -1.453 | 0.155 |
| $\Delta$ gap$_t^+$ | 2.988 | 2.290 | 1.305 | 0.201 | $\Delta$ gap$_{t-1}^+$ | 2.419 | 1.609 | 1.503 | 0.142 |
| $\Delta$ gap$_t^-$ | -2.564 | 1.622 | -1.581 | 0.123 | $\Delta$ gap$_{t-1}^-$ | -8.334 | 3.264 | -2.553 | 0.015** |
| $\Delta$ gap$_{t-1}^+$ | 3.975 | 1.750 | 2.271 | 0.030** | $\Delta$ gap$_{t-2}^+$ | -2.208 | 1.278 | -1.728 | 0.093* |
| $\Delta$ gap$_{t-1}^-$ | -4.532 | 3.880 | -1.168 | 0.251 | $\Delta$ gap$_{t-2}^-$ | -7.459 | 2.948 | -2.530 | 0.016** |
| $\Delta$ gap$_{t-2}^+$ | -2.930 | 1.356 | -2.160 | 0.038** | dummy | 0.301 | 0.071 | 4.249 | 0.000*** |
| $\Delta$ gap$_{t-2}^-$ | 0.033 | 2.653 | 0.012 | 0.990 | constant | -66.156 | 13.037 | -5.075 | 0.000*** |
| constant | -49.846 | 13.983 | -3.565 | 0.001*** | trend | -0.049 | 0.009 | -5.325 | 0.000*** |
| trend | -0.034 | 0.013 | -2.514 | 0.017** | | | | | |
| Model Diagnostic Tests: | | | | | | | | | |
| | JB | LM | ARCH | RAMSEY | | JB | LM | ARCH | RAMSEY |
| Stat | 0.95 | 0.10 | 1.85 | 1.93 | | 1.68 | 0.97 | 0.74 | 1.76 |
| Pvalue | 0.70 | 0.99 | 0.12 | 0.19 | | 0.51 | 0.63 | 0.67 | 0.23 |

The relationship between oil prices and lamb prices can be explained through the cost structure and economic environment within which lamb producers operate. Oil prices directly impact the cost of transportation and logistics, which are critical components in the supply chain for livestock products. When oil prices increase, the costs associated with transporting feed, animals, and finished products to markets rise, potentially leading to higher production costs for lamb. However, the NARDL results suggest that positive changes in oil prices (increases) do not significantly impact lamb prices, while negative changes (decreases) do have an impact, indicating an asymmetric relationship. This could mean that when oil prices drop, producers might not reduce lamb prices proportionally due to sticky cost structures or anticipation of future price increases, leading to a nuanced impact on lamb prices.

The relationship between the output gap and lamb prices indicates that periods of economic overheating (positive gap) are associated with higher lamb prices. This can be attributed to increased consumer spending during economic booms, driving up demand for meat products, including lamb. Conversely, a negative output gap (economic slack) could lead to lower prices due to reduced demand. In Turkey, the significant positive relationship between the output gap and lamb prices, especially in the model with structural breaks, suggests that economic fluctuations play a crucial role in determining meat prices, with higher economic activity translating into increased demand and higher prices for lamb.

#### 5.5.3 Poultry

The cointegration test results indicate a long-run equilibrium relationship between poultry prices and the explanatory variables.

Table 14. Long-run Model Estimations Without Structural Break for Poultry NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 7.76 | 2.26 | 3.43 | 2.65 | 3.92 | 3.50 | 5.05 | COINTEGRATED *** |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_t$ | 0.495 | 0.283 | 1.746 | 0.086* |
| $oil^+_{t-1}$ | -0.090 | 0.119 | -0.755 | 0.453 |
| $oil^-_{t-1}$ | 0.265 | 0.083 | 3.216 | 0.002*** |
| $m2^+_{t-1}$ | 0.905 | 0.258 | 3.510 | 0.001*** |
| $m2^-_{t-1}$ | -12.088 | 3.203 | -3.773 | 0.000*** |
| $gap_{t-1}$ | -3.482 | 1.596 | -2.181 | 0.033** |

The coefficient of 0.495 implies that a 1% increase in the exchange rate (USD/TRY) leads to a 0.50% increase in poultry prices, significant at the 10% level. This suggests that poultry prices are sensitive to changes in the exchange rate, likely due to the cost of imported feed and other inputs. Positive changes in oil prices do not significantly impact poultry prices, as indicated by the coefficient of -0.090. However, a 1% decrease in oil prices leads to a 0.27% increase in poultry prices, as suggested by the coefficient of 0.265, significant at the 1% level. This implies an asymmetric relationship where decreases in oil prices benefit poultry producers by lowering transportation and input costs. A 1% increase in the money supply (M2) leads to a 0.91% increase in poultry prices, as indicated by the coefficient of 0.905, significant at the 1% level. Conversely, a 1% decrease in money supply results in a 12.09% decrease in poultry prices, highlighting the sensitivity of poultry prices to liquidity conditions. The output gap has a negative coefficient of -3.482, significant at the 5% level, indicating that a larger output gap (higher economic activity) reduces poultry prices, possibly due to increased supply or competition.

Table 15. Long-run Model Estimations With Structural Break for Poultry

NARDL Cointegration Test

| Panel A: Testing the presence of cointegration | | | | | | | |
|---|---|---|---|---|---|---|---|
| F-statistic | 10% | | 5% | | 1% | | Decision |
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 4.54 | 1.90 | 3.01 | 2.26 | 3.48 | 3.07 | 4.44 | COINTEGRATED *** |

| Panel B: Long-run parameters | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std | t-stat | Prob. |
| $exc_t$ | 0.770 | 0.227 | 3.401 | 0.001*** |
| $oil_{t-1}$ | -0.474 | 0.349 | -1.360 | 0.179 |
| $m2_{t-1}$ | 0.243 | 0.083 | 2.912 | 0.005*** |
| $gap_{t-1}$ | -2.501 | 5.192 | -0.482 | 0.632 |

Including structural breaks in the model reveals more pronounced relationships between the variables and poultry prices. The coefficient of 0.770 in the model with structural breaks indicates that a 1% increase in the exchange rate leads to a 0.77% increase in poultry prices, significant at the 1% level. This underscores the importance of exchange rate fluctuations in determining poultry prices, particularly due to the reliance on imported feed and inputs. The coefficient of -0.474 suggests that oil prices negatively but not statistically significantly impact poultry prices. A 1% increase in money supply leads to a 0.24% increase in poultry prices, significant at the 1% level, indicating that liquidity conditions remain an important factor. The output gap has a negative coefficient of -2.501, but it is not statistically significant, suggesting that the impact of economic activity on poultry prices is less pronounced when structural breaks are considered.

The relationship between the exchange rate and poultry prices is particularly noteworthy. A higher exchange rate (depreciation of the Turkish Lira) leads to higher poultry prices. This can be explained by the cost structure of the poultry industry in Turkey, which relies heavily on imported feed, vaccines, and other inputs. When the Lira depreciates, the cost of these imports rises, leading to higher production costs and, consequently, higher poultry prices. This effect is more pronounced when structural breaks are considered, indicating that significant economic events or policy changes amplify the sensitivity of poultry prices to exchange rate fluctuations.

Table 16. NARDL Model Result for Poultry

ESTIMATES WITHOUT STRUCTURAL BREAK

Selected model: NARDL(2,0,0,5,1)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $poultry_{t-1}$ | -0.645 | 0.097 | -6.650 | 0.000*** |
| $exc_t$ | 0.319 | 0.179 | 1.782 | 0.082* |
| $gap_{t-1}$ | -2.245 | 1.046 | -2.146 | 0.037** |
| $m2_t^+$ | 0.584 | 0.198 | 2.950 | 0.005*** |
| $m2_t^-$ | -7.795 | 1.955 | -3.987 | 0.000*** |
| $oil_{t-1}^+$ | -0.058 | 0.074 | -0.781 | 0.439 |
| $oil_{t-1}^-$ | 0.171 | 0.064 | 2.677 | 0.010** |
| $\Delta$ $poultry_{t-1}$ | 0.384 | 0.118 | 3.251 | 0.002*** |
| $\Delta$ $oil_t$ | 0.036 | 0.064 | 0.562 | 0.577 |
| $\Delta$ $oil_{t-1}$ | 0.030 | 0.077 | 0.395 | 0.695 |
| $\Delta$ $oil_{t-2}$ | 0.191 | 0.072 | 2.671 | 0.011** |
| $\Delta$ $oil_{t-3}$ | 0.153 | 0.056 | 2.755 | 0.008*** |
| $\Delta$ $oil_{t-4}$ | 0.140 | 0.067 | 2.089 | 0.042** |
| $\Delta$ $gap_t^+$ | 3.419 | 2.714 | 1.260 | 0.214 |
| $\Delta$ $gap_t^-$ | -0.110 | 1.584 | -0.070 | 0.945 |
| constant | 2.403 | 0.513 | 4.683 | 0.000*** |

Model Diagnostic Tests:

| | JB | LM | ARCH | RAMSEY |
|---|---|---|---|---|
| Stat | 0.86 | 0.09 | 1.68 | 1.75 |
| Pvalue | 0.64 | 0.90 | 0.1084 | 0.17 |

ESTIMATES WITH STRUCTURAL BREAK

Selected model: NARDL(2,0,5,5,4)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $poultry_{t-1}$ | -0.366 | 0.111 | -3.287 | 0.002*** |
| $exc_t$ | 0.282 | 0.151 | 1.870 | 0.070* |
| $m2_{t-1}$ | 0.089 | 0.022 | 4.089 | 0.000*** |
| $oil_{t-1}$ | -0.173 | 0.097 | -1.795 | 0.081* |
| $gap_{t-1}$ | -0.914 | 1.842 | -0.496 | 0.623 |
| $\Delta$ $poultry_{t-1}$ | 0.253 | 0.143 | 1.765 | 0.086* |
| $\Delta$ $m2_t$ | 0.598 | 0.375 | 1.595 | 0.119 |
| $\Delta$ $m2_{t-1}$ | 0.610 | 0.408 | 1.495 | 0.144 |
| $\Delta$ $m2_{t-2}$ | 0.033 | 0.399 | 0.083 | 0.934 |
| $\Delta$ $m2_{t-3}$ | -0.633 | 0.382 | -1.658 | 0.106 |
| $\Delta$ $m2_{t-4}$ | 0.386 | 0.380 | 1.015 | 0.317 |
| $\Delta$ $oil_t$ | -0.008 | 0.091 | -0.084 | 0.934 |
| $\Delta$ $oil_{t-1}$ | 0.120 | 0.083 | 1.452 | 0.155 |
| $\Delta$ $oil_{t-2}$ | 0.187 | 0.086 | 2.180 | 0.036** |
| $\Delta$ $oil_{t-3}$ | 0.106 | 0.093 | 1.137 | 0.263 |
| $\Delta$ $oil_{t-4}$ | 0.211 | 0.096 | 2.204 | 0.034** |
| $\Delta$ $gap_t^+$ | 5.671 | 4.589 | 1.236 | 0.225 |
| $\Delta$ $gap_t^-$ | 0.875 | 1.907 | 0.459 | 0.649 |
| $\Delta$ $gap_{t-1}^+$ | 0.355 | 2.171 | 0.164 | 0.871 |
| $\Delta$ $gap_{t-1}^-$ | -0.811 | 3.964 | -0.205 | 0.839 |
| $\Delta$ $gap_{t-2}^+$ | -1.726 | 2.185 | -0.790 | 0.435 |
| $\Delta$ $gap_{t-2}^-$ | 6.226 | 4.438 | 1.403 | 0.169 |
| $\Delta$ $gap_{t-3}^+$ | -5.736 | 2.030 | -2.825 | 0.008*** |
| $\Delta$ $gap_{t-3}^-$ | 4.114 | 4.064 | 1.012 | 0.318 |
| dummy | 0.112 | 0.076 | 1.478 | 0.148 |

| | JB | LM | ARCH | RAMSEY |
|---|---|---|---|---|
| Stat | 1.53 | 0.88 | 0.67 | 1.6 |
| Pvalue | 0.46 | 0.57 | 0.61 | 0.21 |

The asymmetric relationship with oil prices suggests that while increases in oil prices do not significantly impact poultry prices, decreases in oil prices provide cost relief for producers, reducing transportation and input costs. This highlights the importance of oil prices in the cost structure of poultry production, where transportation and logistics play a crucial role.

Though significant in the model without structural breaks, the negative relationship between the output gap and poultry prices indicates that higher economic activity may lead to increased supply or competition, driving down prices. However, this relationship becomes less significant when structural breaks are considered, suggesting that economic shocks or policy changes may mitigate the impact of overall economic activity on poultry prices.

### 5.5.4 Fish

The analysis of the NARDL cointegration test for the fresh fish market in Turkey indicates a significant long-run relationship between fish prices and key economic variables. This relationship is validated by the F-statistic of 8.72, which exceeds the critical values at all significance levels (10%, 5%, and 1%), confirming the presence of cointegration.

Table 17. Long-run Model Estimations for Fish

NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 8.72 | 1.90 | 3.01 | 2.26 | 3.48 | 3.07 | 4.44 | COINTEGRATED *** |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_t$ | 1.075 | 0.046 | 23.422 | 0.000*** |
| $oil_{t-1}$ | -0.313 | 0.142 | -2.209 | 0.031** |
| $m2_t$ | 0.173 | 0.029 | 6.065 | 0.000*** |
| $gap_t$ | 18.370 | 3.296 | 5.574 | 0.000*** |

The coefficient for the exchange rate ($exc$) is 1.075, with a highly significant t-statistic of 23.422. This implies that a 1% increase in the exchange rate (USD/TRY) leads to approximately a 1.075% increase in fish prices. The strong positive relationship suggests that fluctuations in the exchange rate are a critical determinant of fish prices in Turkey. Several specific factors contribute to this.

The Turkish fish market relies heavily on imported inputs, such as feed, technology, and equipment necessary for fish farming. An increase in the exchange rate makes these imports more expensive, thereby raising production costs and ultimately leading to higher fish prices. A weaker Lira enhances the competitiveness of Turkish fish in international markets, making it cheaper for foreign buyers. This increased demand for exports can reduce the supply of fish available in the domestic market, driving up local prices.

Table 18. NARDL Model Result for Fish

ESTIMATES WITHOUT STRUCTURAL BREAK

Selected model: NARDL(4,0,4,0,5)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $\text{fish}_{t-1}$ | -0.734 | 0.123 | -5.968 | 0.000*** |
| $\text{exc}_t$ | 0.789 | 0.134 | 5.879 | 0.000*** |
| $\text{oil}_{t-1}$ | -0.230 | 0.114 | -2.017 | 0.0508* |
| $\text{m2}_t$ | 0.127 | 0.031 | 4.096 | 0.0002*** |
| $\text{gap}_{t-1}$ | 13.487 | 3.165 | 4.261 | 0.0001*** |
| $\Delta\ \text{fish}_{t-1}$ | 0.126 | 0.131 | 0.964 | 0.341 |
| $\Delta\ \text{fish}_{t-2}$ | -0.245 | 0.111 | -2.201 | 0.0339** |
| $\Delta\ \text{fish}_{t-3}$ | -0.282 | 0.113 | -2.497 | 0.017** |
| $\Delta\ \text{oil}_t$ | 0.014 | 0.161 | 0.087 | 0.931 |
| $\Delta\ \text{oil}_{t-1}$ | 0.291 | 0.138 | 2.104 | 0.042** |
| $\Delta\ \text{oil}_{t-2}$ | 0.378 | 0.140 | 2.701 | 0.0103** |
| $\Delta\ \text{oil}_{t-3}$ | 0.339 | 0.155 | 2.184 | 0.0352** |
| $\Delta\ \text{gap}_t^+$ | 12.835 | 7.550 | 1.700 | 0.0973* |
| $\Delta\ \text{gap}_t^-$ | 2.381 | 3.148 | 0.756 | 0.454 |
| $\Delta\ \text{gap}_{t-1}^+$ | -30.989 | 8.739 | -3.546 | 0.0011*** |
| $\Delta\ \text{gap}_{t-1}^-$ | -11.171 | 5.858 | -1.907 | 0.0641* |
| $\Delta\ \text{gap}_{t-2}^+$ | -2.366 | 3.410 | -0.694 | 0.492 |
| $\Delta\ \text{gap}_{t-2}^-$ | -17.740 | 6.729 | -2.636 | 0.0121** |
| $\Delta\ \text{gap}_{t-3}^+$ | -0.578 | 3.427 | -0.169 | 0.867 |
| $\Delta\ \text{gap}_{t-3}^-$ | -2.944 | 7.028 | -0.419 | 0.678 |
| $\Delta\ \text{gap}_{t-4}^+$ | -0.764 | 2.654 | -0.288 | 0.775 |
| $\Delta\ \text{gap}_{t-4}^-$ | -25.686 | 8.053 | -3.190 | 0.0029*** |

Model Diagnostic Tests:

| | JB | LM | ARCH | RAMSEY |
|---|---|---|---|---|
| Stat | 1.220 | 1.060 | 0.670 | 1.200 |
| Pvalue | 0.540 | 0.070 | 0.760 | 0.220 |

The coefficient for oil prices ($oil_{t-1}$) is -0.313, with a t-statistic of -2.209, indicating a statistically significant negative relationship. A 1% increase in oil prices leads to a 0.313% decrease in fish prices. This negative relationship may be explained by cost absorption, higher oil prices, and increased transportation and logistics costs, which are critical in the fish supply chain. Fish producers and sellers might absorb these higher costs to maintain their competitive edge in the market, thereby not passing them fully onto consumers.

The coefficient for money supply ($m2$) is 0.173, with a t-statistic of 6.065, indicating a strong and significant positive relationship. A 1% increase in the money supply leads to a 0.173% increase in fish prices. The coefficient for the output gap ($gap_{t-1}$) is 18.370, with a t-statistic of 5.574, indicating a significant positive relationship. A 1% increase in the output gap results in an 18.37% increase in fish prices. This strong positive relationship suggests that higher economic activity, indicated by a positive output gap, increases consumer spending and demand for fish, driving up prices. In Turkey, periods of economic growth have historically led to increased consumption of higher-quality and luxury food items, including fresh fish.

### 5.5.5 Egg

The cointegration test results indicate a long-run equilibrium relationship between egg prices and the explanatory variables.

Table 19. Long-run Model Estimations With Structural Break for Egg

NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 3.99 | 2.26 | 3.43 | 2.65 | 3.92 | 3.50 | 5.05 | COINTEGRATED ** |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_t^+$ | 0.360 | 0.564 | 0.637 | 0.527 |
| $exc_t^-$ | 3.300 | 1.590 | 2.075 | 0.043** |
| $oil_{t-1}$ | 0.068 | 0.157 | 0.432 | 0.668 |
| $m2_{t-1}^+$ | 0.797 | 0.516 | 1.545 | 0.128 |
| $m2_{t-1}^-$ | -10.123 | 6.051 | -1.673 | 0.100 |
| $gap_t$ | 3.166 | 2.446 | 1.295 | 0.201 |

The coefficient for oil prices ($oil_{t-1}$) is 0.068, indicating that changes in oil prices do not have a significant long-run impact on egg prices. The output gap ($gap_t$) has a coefficient of 3.166, suggesting a positive but not statistically significant relationship with egg prices.

Table 20. Long-run Model Estimations Without Structural Break for Egg

NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 8.35 | 1.90 | 3.01 | 2.26 | 3.48 | 3.07 | 4.44 | COINTEGRATED *** |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_t$ | 1.091 | 0.087 | 12.510 | 0.000*** |
| $oil_{t-1}$ | -0.077 | 0.130 | -0.594 | 0.555 |
| $m2_t$ | 0.137 | 0.022 | 6.243 | 0.000*** |
| $gap_t$ | 6.673 | 2.881 | 2.316 | 0.024** |

In the model without structural breaks, the coefficient for the exchange rate ($exc_t$) is 1.091, indicating that a 1% increase in the exchange rate leads to a 1.09% increase in egg prices. This reflects the direct impact of currency depreciation on imported inputs, driving up production costs and egg prices. The coefficient for oil prices ($oil_{t-1}$) is -0.077, suggesting that changes in oil prices do not significantly impact egg prices. The money supply ($m2_t$) has a coefficient of 0.137, indicating that a 1% increase in money supply leads to a 0.14% increase in egg prices. The output gap ($gap_t$) has a coefficient of 6.673, suggesting a strong positive relationship, with a 1% increase in the output gap leading to a 6.67% increase in egg prices, highlighting the importance of economic activity in driving demand for eggs.

The significant relationship between the exchange rate and egg prices can be attributed to Turkey's dependence on imported inputs for egg production, such as feed and veterinary products. When the Turkish Lira depreciates, the cost of these inputs rises, leading to higher production costs and, consequently, higher egg prices. This sensitivity to exchange rate fluctuations underscores the vulnerability of the Turkish egg market to external economic shocks.

The relationship between oil prices and egg prices is less pronounced, reflecting the relatively stable cost structure in egg production. The impact of oil prices on transportation and logistics costs is not significant enough to influence egg prices in the long run.

Table 21. NARDL Model Result for Egg

| ESTIMATES WITHOUT STRUCTURAL BREAK | | | | | ESTIMATES WITH STRUCTURAL BREAK | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Selected model: NARDL(2,0,5,0,0) | | | | | Selected model: NARDL(2,5,0,1,0) | | | | |
| Variable | Coefficient | Std | t-stat | Prob. | Variable | Coefficient | Std | t-stat | Prob. |
| $egg_{t-1}$ | -0.193 | 0.045 | -4.271 | 0.000*** | $egg_{t-1}$ | -0.298 | 0.087 | -3.413 | 0.001*** |
| $exc_t$ | 0.211 | 0.042 | 5.034 | 0.000*** | $oil_{t-1}$ | 0.020 | 0.050 | 0.405 | 0.687 |
| $oil_{t-1}$ | -0.015 | 0.025 | -0.608 | 0.546 | $gap_t$ | 0.944 | 0.588 | 1.607 | 0.115 |
| $m2_t$ | 0.027 | 0.007 | 3.681 | 0.001*** | $exc_t^+$ | 0.107 | 0.151 | 0.712 | 0.480 |
| $gap_t$ | 1.291 | 0.484 | 2.668 | 0.010** | $exc_t^-$ | 0.984 | 0.468 | 2.101 | 0.041** |
| $\Delta\ egg_{t-1}$ | 0.182 | 0.109 | 1.671 | 0.101 | $m2_{t-1}^+$ | 0.238 | 0.203 | 1.172 | 0.248 |
| $\Delta\ oil_t$ | -0.025 | 0.034 | -0.724 | 0.472 | $m2_{t-1}^-$ | -3.018 | 1.749 | -1.726 | 0.091* |
| $\Delta\ oil_{t-1}$ | -0.116 | 0.039 | -2.972 | 0.005*** | $\Delta\ egg_{t-1}$ | 0.231 | 0.122 | 1.890 | 0.065* |
| $\Delta\ oil_{t-2}$ | -0.126 | 0.038 | -3.330 | 0.002*** | $\Delta\ oil_t$ | -0.010 | 0.044 | -0.235 | 0.815 |
| $\Delta\ oil_{t-3}$ | -0.038 | 0.035 | -1.071 | 0.289 | $\Delta\ oil_{t-1}$ | -0.122 | 0.040 | -3.019 | 0.004*** |
| $\Delta\ oil_{t-4}$ | -0.079 | 0.031 | -2.517 | 0.015** | $\Delta\ oil_{t-2}$ | -0.113 | 0.040 | -2.824 | 0.007*** |
| | | | | | $\Delta\ oil_{t-3}$ | -0.041 | 0.037 | -1.114 | 0.271 |
| | | | | | $\Delta\ oil_{t-4}$ | -0.084 | 0.032 | -2.606 | 0.012** |
| | | | | | $\Delta\ m2_t$ | -0.007 | 0.223 | -0.032 | 0.975 |
| | | | | | dummy | 0.012 | 0.040 | 0.295 | 0.770 |
| | | | | | constant | 1.098 | 0.326 | 3.373 | 0.002*** |
| Model Diagnostic Tests: | | | | | | | | | |
| | JB | LM | ARCH | RAMSEY | | JB | LM | ARCH | RAMSEY |
| Stat | 4.35 | 1.67 | 0.9 | 1.45 | | 5.22 | 2.00 | 1.08 | 1.74 |
| Pvalue | 0.07 | 0.11 | 0.54 | 0.24 | | 0.08 | 0.13 | 0.65 | 0.29 |

### 5.5.6 Milk

The cointegration test results indicate a long-run equilibrium relationship between milk prices and the explanatory variables.

Table 22. Long-run Model Estimations Without Structural Break for Milk NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 2.99 | 1.75 | 2.87 | 2.04 | 3.24 | 2.66 | 4.05 | COINTEGRATED * |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_{t-1}$ | 1.520 | 0.293 | 5.188 | 0.000*** |
| $oil^{+}_{t-1}$ | -0.114 | 0.249 | -0.460 | 0.647 |
| $oil^{-}_{t-1}$ | 0.309 | 0.233 | 1.326 | 0.190 |
| $m2^{+}_{t-1}$ | 0.275 | 0.324 | 0.850 | 0.399 |
| $m2^{-}_{t-1}$ | -18.654 | 4.617 | -4.040 | 0.000*** |
| $gap_{t-1}$ | 1.905 | 3.515 | 0.542 | 0.590 |

The coefficient of 1.520 in the model without structural breaks suggests that a 1% increase in the exchange rate (USD/TRY) leads to a 1.52% increase in milk prices. This significant positive relationship underscores the critical impact of the exchange rate on milk prices. Given that Turkey imports a substantial portion of its feed for cattle, an increase in the exchange rate raises the cost of these imports, subsequently driving up milk prices. The coefficient of -0.114 for positive changes in oil prices indicates that these changes do not significantly affect milk prices, suggesting that the impact of rising oil prices might be absorbed by other factors or are short-term. On the other hand, a 1% decrease in oil prices leads to a 0.31% increase in milk prices, as indicated by the coefficient of 0.309. This asymmetric relationship might reflect the sticky cost structures in the dairy industry, where cost reductions due to lower oil prices are not immediately passed on to consumers. The coefficient of 0.275 for positive changes in money supply (M2) indicates an insignificant relationship, suggesting that increased liquidity does not directly influence milk prices in the long run. However, a 1% decrease in money supply leads to a significant 18.65% decrease in milk prices, indicating the sensitivity of milk prices to monetary contractions. The coefficient of 1.905 suggests a positive but statistically insignificant relationship between the output gap and milk prices, indicating that economic activity levels might not be a primary driver of long-term milk prices.

Table 23. Long-run Model Estimations With Structural Break for Milk

NARDL Cointegration Test

Panel A: Testing the presence of cointegration

| F-statistic | 10% | | 5% | | 1% | | Decision |
|---|---|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | I(0) | I(1) | |
| 7.11 | 2.39 | 3.57 | 2.82 | 4.10 | 3.78 | 5.34 | COINTEGRATED *** |

Panel B: Long-run parameters

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $exc_{t-1}$ | -0.445 | 0.238 | -1.873 | 0.066* |
| $oil_{t-1}$ | 0.371 | 0.065 | 5.674 | 0.000*** |
| $m2^{+}_{t-1}$ | 1.741 | 0.232 | 7.495 | 0.000*** |
| $m2^{-}_{t-1}$ | -11.528 | 3.795 | -3.037 | 0.004*** |
| $gap_{t-1}$ | -5.639 | 1.094 | -5.153 | 0.000*** |

Table 24. NARDL Model Result for Milk

ESTIMATES WITHOUT STRUCTURAL BREAK

Selected model: NARDL(5,4,5,3,2)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $\text{milk}_{t-1}$ | -0.277 | 0.081 | -3.425 | 0.002*** |
| $\text{exc}_{t-1}$ | 0.422 | 0.164 | 2.576 | 0.015** |
| $\text{gap}_{t-1}$ | 0.528 | 0.999 | 0.529 | 0.601 |
| $\text{m2}^{+}_{t-1}$ | 0.076 | 0.087 | 0.879 | 0.385 |
| $\text{m2}^{-}_{t-1}$ | -5.174 | 1.580 | -3.276 | 0.002*** |
| $\text{oil}^{+}_{t-1}$ | -0.032 | 0.073 | -0.433 | 0.667 |
| $\text{oil}^{-}_{t-1}$ | 0.086 | 0.054 | 1.599 | 0.119 |
| $\Delta\ \text{milk}_{t-1}$ | -0.116 | 0.125 | -0.930 | 0.359 |
| $\Delta\ \text{milk}_{t-2}$ | -0.168 | 0.122 | -1.372 | 0.179 |
| $\Delta\ \text{milk}_{t-3}$ | -0.234 | 0.120 | -1.945 | 0.060* |
| $\Delta\ \text{milk}_{t-4}$ | 0.159 | 0.120 | 1.326 | 0.194 |
| $\Delta\ \text{exc}_{t}$ | 0.491 | 0.302 | 1.628 | 0.113 |
| $\Delta\ \text{exc}_{t-1}$ | -0.815 | 0.304 | -2.680 | 0.011** |
| $\Delta\ \text{exc}_{t-2}$ | -0.037 | 0.301 | -0.123 | 0.903 |
| $\Delta\ \text{exc}_{t-3}$ | -1.510 | 0.306 | -4.931 | 0.000*** |
| $\Delta\ \text{m2}_{t}$ | -1.216 | 0.364 | -3.339 | 0.002*** |
| $\Delta\ \text{m2}_{t-1}$ | 0.839 | 0.552 | 1.522 | 0.137 |
| $\Delta\ \text{m2}_{t-2}$ | 0.769 | 0.510 | 1.508 | 0.141 |
| $\Delta\ \text{m2}_{t-3}$ | 0.374 | 0.563 | 0.665 | 0.510 |
| $\Delta\ \text{m2}_{t-4}$ | 2.012 | 0.500 | 4.026 | 0.000*** |
| $\Delta\ \text{oil}_{t}$ | 0.105 | 0.075 | 1.407 | 0.169 |
| $\Delta\ \text{oil}_{t-1}$ | 0.115 | 0.078 | 1.472 | 0.150 |
| $\Delta\ \text{oil}_{t-2}$ | 0.302 | 0.076 | 3.986 | 0.000*** |
| $\Delta\ \text{gap}^{+}_{t}$ | 2.394 | 2.173 | 1.102 | 0.278 |
| $\Delta\ \text{gap}^{-}_{t})$ | -1.268 | 1.513 | -0.838 | 0.408 |
| $\Delta\ \text{gap}^{+}_{t-1}$ | -4.305 | 1.719 | -2.504 | 0.017** |
| $\Delta\ \text{gap}^{-}_{t-1})$ | -6.520 | 2.960 | -2.203 | 0.035** |

ESTIMATES WITH STRUCTURAL BREAK

Selected model: NARDL(3,5,4,5,5)

| Variable | Coefficient | Std | t-stat | Prob. |
|---|---|---|---|---|
| $\text{milk}_{t-1}$ | -2.107 | 0.384 | -5.481 | 0.000*** |
| $\text{exc}_{t-1}$ | -0.937 | 0.517 | -1.814 | 0.084* |
| $\text{oil}_{t-1}$ | 0.782 | 0.169 | 4.630 | 0.000*** |
| $\text{gap}_{t-1}$ | -11.883 | 3.852 | -3.085 | 0.006*** |
| $\text{m2}^{+}_{t-1}$ | 3.668 | 0.776 | 4.730 | 0.000*** |
| $\text{m2}^{-}_{t-1}$ | -24.292 | 10.271 | -2.365 | 0.028** |
| $\Delta\ \text{milk}_{t-1}$ | 1.143 | 0.278 | 4.115 | 0.001*** |
| $\Delta\ \text{milk}_{t-2}$ | 0.479 | 0.172 | 2.776 | 0.011** |
| $\Delta\ \text{exc}_{t}$ | -0.310 | 0.395 | -0.785 | 0.441 |
| $\Delta\ \text{exc}_{t-1}$ | 0.689 | 0.437 | 1.576 | 0.130 |
| $\Delta\ \text{exc}_{t-2}$ | 0.910 | 0.356 | 2.554 | 0.019** |
| $\Delta\ \text{exc}_{t-3}$ | 0.006 | 0.248 | 0.026 | 0.980 |
| $\Delta\ \text{exc}_{t-4}$ | -0.318 | 0.234 | -1.359 | 0.188 |
| $\Delta\ \text{m2}_{t}$ | -0.522 | 0.428 | -1.221 | 0.236 |
| $\Delta\ \text{m2}_{t-1}$ | -2.261 | 0.847 | -2.669 | 0.014** |
| $\Delta\ \text{m2}_{t-2}$ | -2.721 | 0.764 | -3.561 | 0.002*** |
| $\Delta\ \text{m2}_{t-3}$ | -2.589 | 0.569 | -4.551 | 0.000*** |
| $\Delta\ \text{oil}^{+}_{t}$ | -0.509 | 0.224 | -2.269 | 0.034** |
| $\Delta\ \text{oil}^{-}_{t})$ | 0.384 | 0.160 | 2.397 | 0.026** |
| $\Delta\ \text{oil}^{+}_{t-1}$ | -0.834 | 0.275 | -3.035 | 0.006*** |
| $\Delta\ \text{oil}^{-}_{t-1})$ | -0.321 | 0.177 | -1.812 | 0.084* |
| $\Delta\ \text{oil}^{+}_{t-2}$ | -0.582 | 0.237 | -2.457 | 0.023** |
| $\Delta\ \text{oil}^{-}_{t-2})$ | -0.125 | 0.198 | -0.631 | 0.535 |
| $\Delta\ \text{oil}^{+}_{t-3}$ | -0.444 | 0.242 | -1.835 | 0.081* |
| $\Delta\ \text{oil}^{-}_{t-3})$ | -0.445 | 0.209 | -2.129 | 0.045** |
| $\Delta\ \text{oil}^{+}_{t-4}$ | -0.238 | 0.179 | -1.333 | 0.197 |
| $\Delta\ \text{oil}^{-}_{t-4})$ | 0.099 | 0.177 | 0.559 | 0.582 |
| $\Delta\ \text{gap}^{+}_{t}$ | -11.092 | 4.809 | -2.306 | 0.031** |
| $\Delta\ \text{gap}^{-}_{t})$ | -2.353 | 1.775 | -1.325 | 0.199 |
| $\Delta\ \text{gap}^{+}_{t-1}$ | 9.949 | 5.230 | 1.902 | 0.071* |
| $\Delta\ \text{gap}^{-}_{t-1})$ | -0.073 | 6.275 | -0.012 | 0.991 |
| $\Delta\ \text{gap}^{+}_{t-2}$ | 7.694 | 3.224 | 2.386 | 0.027** |
| $\Delta\ \text{gap}^{-}_{t-2})$ | 10.632 | 5.782 | 1.839 | 0.080* |
| $\Delta\ \text{gap}^{+}_{t-3}$ | 3.193 | 2.095 | 1.524 | 0.142 |
| $\Delta\ \text{gap}^{-}_{t-3})$ | -13.550 | 5.061 | -2.677 | 0.014** |
| $\Delta\ \text{gap}^{+}_{t-4}$ | -11.782 | 2.490 | -4.731 | 0.000*** |
| $\Delta\ \text{gap}^{-}_{t-4})$ | 15.775 | 5.027 | 3.138 | 0.005*** |
| dummy | -1.359 | 0.381 | -3.565 | 0.002*** |
| constant | 4.519 | 1.232 | 3.667 | 0.001*** |

Model Diagnostic Tests:

| | JB | LM | ARCH | RAMSEY | JB | LM | ARCH | RAMSEY |
|---|---|---|---|---|---|---|---|---|
| Stat | 4.96 | 0.14 | 1.39 | 0.004 | 5.95 | 0.17 | 1.67 | 0.00 |
| Pvalue | 0.08 | 0.7 | 0.21 | 0.99 | 0.10 | 0.84 | 0.25 | 0.99 |

The positive coefficient of 0.371 for oil prices suggests that a 1% increase in oil prices leads to a 0.37% increase in milk prices. This relationship can be attributed to the inflationary pressures caused by rising oil prices, which increase the cost of production and transportation, subsequently pushing up milk prices. The coefficient of -5.639 indicates that a 1% increase in the output gap leads to a 5.64% decrease in milk prices. This significant negative relationship suggests that higher economic activity might increase production efficiency or competition, thereby reducing milk prices.

In the context of Turkey's dairy market, the exchange rate plays a crucial role in determining milk prices. An increase in the exchange rate makes imports more expensive, thereby increasing production costs and driving up milk prices. This relationship is particularly pronounced given the reliance on imported inputs for milk production. Additionally, fluctuations in oil prices directly impact transportation and production costs, influencing milk prices. Increased money supply boosts consumer demand and spending power, driving up milk prices, while reductions in money supply have a significant deflationary effect.

## 5.6 Dynamic Multiplier

The dynamic multiplier analysis evaluates the impact of a one percent shock to the exchange rate on various food prices in Turkey. This analysis uses the long-run parameters of cointegration to assess how food prices respond to exchange rate changes over a 50-period horizon.

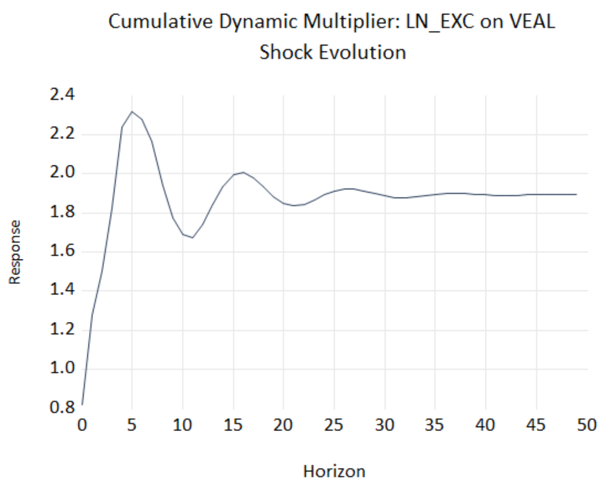



Figure 2. Cumulative Dynamic Multiplier: EXC on VEAL

The cumulative dynamic multiplier for veal indicates that a 1% shock to the exchange rate leads to a 1.89% increase in veal prices over 50 periods. The initial sharp increase, followed by stabilization, reflects the market's adjustment process to the new exchange rate level.

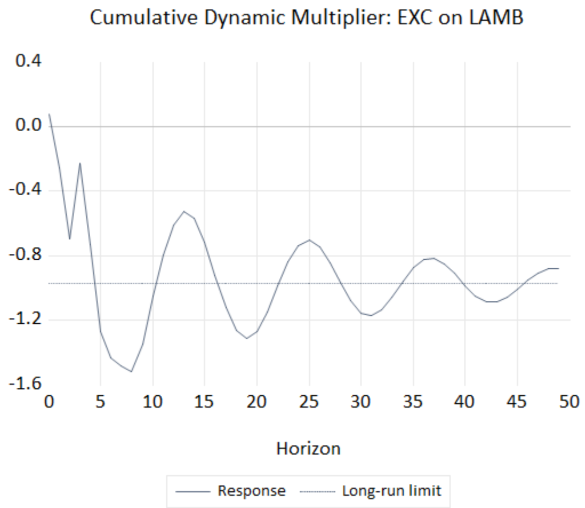



Figure 3. Cumulative Dynamic Multiplier: EXC on LAMB

For lamb, the dynamic multiplier shows a 0.97% decrease in response to a 1% exchange rate shock over 50 periods. The fluctuations and eventual stabilization highlight the complexity of the lamb market's response to exchange rate changes.

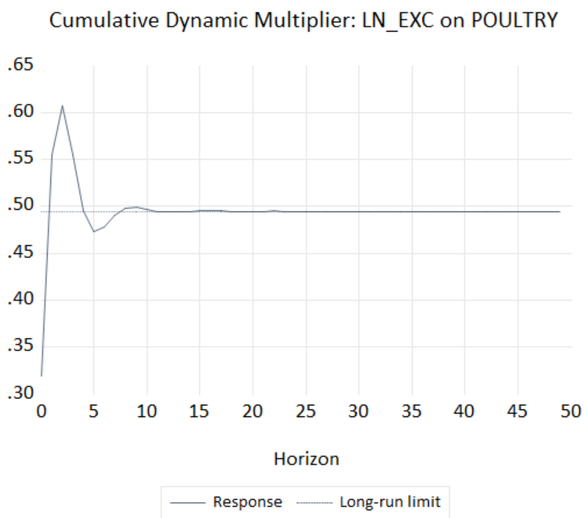



Figure 4. Cumulative Dynamic Multiplier: EXC on POULTRY

The response of poultry prices to an exchange rate shock results in a 0.5% increase over 50 periods. The initial spike followed by stabilization indicates that poultry prices are moderately sensitive to exchange rate changes. The relatively quick adjustment suggests that the poultry market has mechanisms to absorb and adjust to exchange rate fluctuations efficiently.

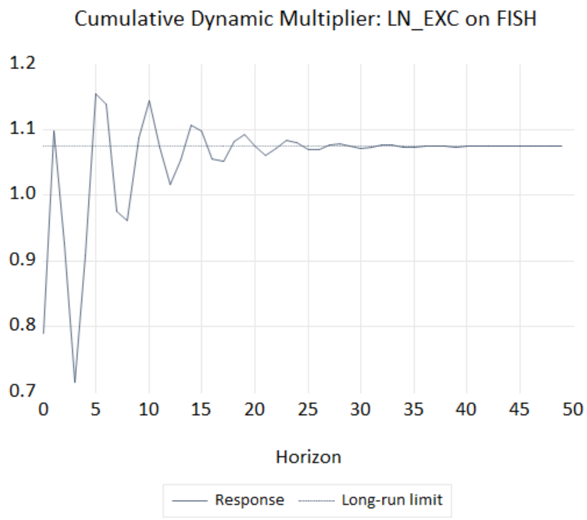



Figure 5. Cumulative Dynamic Multiplier: EXC on FISH

Fish prices exhibit a 1.08% increase in response to a 1% exchange rate shock over 50 periods. The significant positive relationship reflects the reliance on imported inputs and the sensitivity of the fish market to exchange rate fluctuations. The initial volatility and subsequent stabilization indicate the adjustment period required for supply chain adaptations.

Egg prices show a rapid adjustment, with a 1.1% increase in response to a 1% exchange rate shock over 50 periods. The quick stabilization around the long-run limit highlights the high responsiveness of the egg market to exchange rate changes, likely due to the elastic supply and demand conditions.

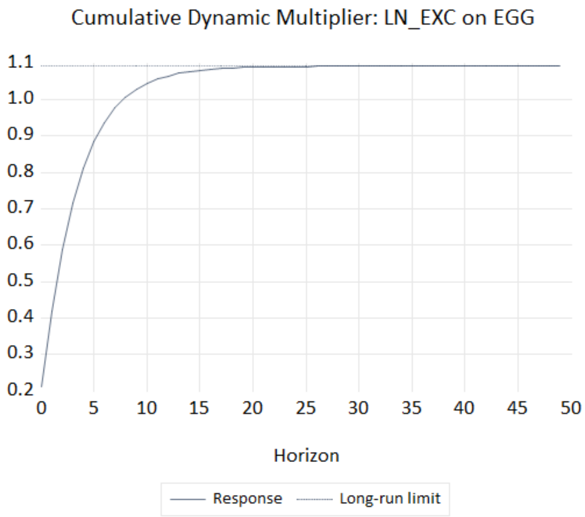



Figure 6. Cumulative Dynamic Multiplier: EXC on EGG

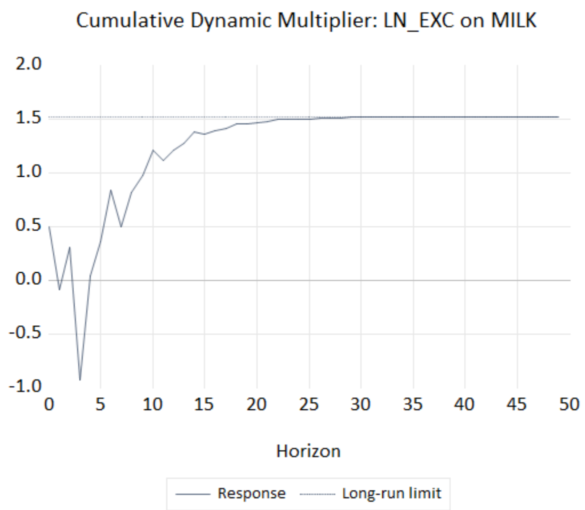



Figure 7. Cumulative Dynamic Multiplier: EXC on MILK

The response of milk prices to an exchange rate shock is characterized by initial volatility, eventually stabilizing with a 1.52% increase over 50 periods. The initial disturbances reflect short-term adjustments, with the market eventually aligning with the expected long-run effect.

This dynamic multiplier analysis provides valuable insights into the transmission mechanism of exchange rate shocks to food prices. The varying responses across different food items highlight the importance of considering product-specific characteristics and market conditions. Policymakers and market participants must understand these dynamics to anticipate and mitigate the adverse effects of exchange rate volatility on food prices. The analysis underscores the asymmetric nature of exchange rate pass-through, emphasizing that the impact varies not only in magnitude but also in the speed of adjustment and the persistence of effects.

## 5.7 CUSUM and CUSUMSQ Analysis

The CUSUM (Cumulative Sum) and CUSUMSQ (Cumulative Sum of Squares) tests are crucial for assessing the stability of the parameters in our NARDL model. These tests detect structural changes over time by plotting the cumulative sum of recursive residuals and the squared residuals, respectively. Stability in these tests implies that the estimated coefficients remain consistent throughout the sample period, while instability indicates potential structural breaks or parameter shifts.

The results of the CUSUM and CUSUMSQ tests for veal, poultry, fish, egg, and milk markets indicate stable parameters. This stability suggests that the coefficients estimated in the NARDL model for these markets are consistent and reliable, unaffected by potential structural changes within the specified timeframe.

For the veal market (Figures C1a and C1b), the CUSUM and CUSUMSQ tests show stability, indicating consistent parameters over time.

In the poultry market (Figures C2a and C2b), the stability of the parameters is confirmed, with no significant deviations observed.

The fish market (Figures C3a and C3b) also shows stable parameters, suggesting the reliability of the estimated coefficients.

Similarly, the egg market (Figures C4a and C4b) demonstrates stability in the parameters, consistent even when structural breaks are considered.

For the milk market (Figures C5a and C5b), the stability of the parameters is indicated by the CUSUM and CUSUMSQ tests, both with and without structural breaks.

In contrast, the lamb market (Figures C6a and C6b) shows stability in the CUSUM test but instability in the CUSUMSQ test. This instability is resolved when structural breaks are considered, as indicated by the stable results in Figures C7a and C7b.

# CHAPTER 6
# CONCLUSION

This paper investigates the asymmetric exchange rate pass-through (ERPT) to food prices in Turkey, focusing on the period from July 2018 to December 2023. This study employs a nonlinear autoregressive distributed lag (NARDL) model to examine key food commodities, including veal, lamb, poultry, fish, eggs, and milk. The primary goal is to understand how fluctuations in the exchange rate, oil prices, money supply (M2), and the output gap impact these food prices. Given the significant economic volatility and structural changes in Turkey during the period under study, the inclusion of structural breaks provides a more nuanced understanding of the long-run relationships between these variables.

The Turkish economy has experienced considerable volatility, affecting the stability of food prices. This volatility is particularly evident in the exchange rate fluctuations, which have profound implications for the cost of imported goods, including food products. Understanding the asymmetric nature of ERPT to food prices is crucial for policymakers to design effective interventions to stabilize the market and ensure food security.

The study begins by ensuring the stationarity of the data using unit root tests, both with and without structural breaks. These tests confirm that the series are integrated of order one, validating the use of the NARDL model. The cointegration tests, both with and without structural breaks, confirm long-run equilibrium relationships between food prices and the explanatory variables. The Wald symmetry tests reveal significant asymmetries in the response of food prices to positive and negative changes in the exchange rate and other factors, underscoring the nonlinear nature of ERPT in Turkey.

The analysis of veal prices indicates a negative long-run relationship with the exchange rate, which is attributed to Turkey's reliance on imported veal. As the Turkish Lira depreciates, the cost of imported veal increases, reducing demand and lowering prices. Oil prices also have a significant positive impact on veal prices, reflecting higher transportation and production costs. The money supply shows an asymmetric effect, with liquidity increases leading to higher prices. The output gap reveals that economic downturns result in lower veal prices, aligning with reduced consumer spending power during such periods.

Lamb prices exhibit a complex interaction with the exchange rate and other variables. The negative relationship between the exchange rate and lamb prices can be explained by substitution effects and export dynamics. As the Lira depreciates, imported meats become more expensive, leading consumers to shift to locally produced lamb. Positive changes in oil prices and increased money supply both lead to higher lamb prices due to cost-push inflation and increased consumer demand. The output gap's positive relationship with lamb prices indicates that economic booms drive up demand and prices for lamb.

For milk, the long-run estimations highlight the significant impact of the exchange rate, oil prices, and money supply. The negative relationship between the exchange rate and milk prices suggests that currency depreciation leads to lower milk prices, possibly due to substitution effects and export competitiveness. Oil prices and money supply both positively impact milk prices, reflecting the inflationary pressures and increased demand during periods of economic expansion.

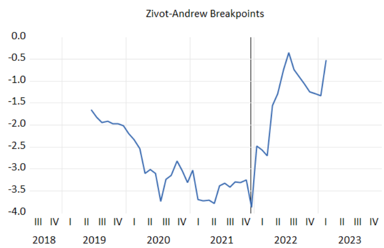
The findings of this study have important policy implications. Policymakers need to consider the asymmetric nature of ERPT and the broader economic environment when designing interventions to stabilize food prices. The results highlight the need for policies that enhance the resilience of the agricultural sector to exchange rate volatility and global economic shocks. Additionally, understanding the dynamics of oil prices and money supply can help in formulating strategies to manage inflationary pressures and ensure food security.

Future research could extend this analysis by exploring the ERPT to a broader range of agricultural products and examining the role of other macroeconomic variables, such as interest rates and government spending. Investigating the short-term dynamics and potential lag effects in more detail could provide further insights into the transmission mechanisms of exchange rate changes. Given the structural changes in the global economy, incorporating more advanced econometric techniques and high-frequency data could enhance the understanding of ERPT in the agricultural sector. Comparative studies across different countries or regions could also provide a broader perspective on the factors influencing food price dynamics and the effectiveness of various policy measures.

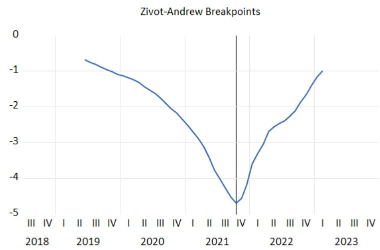
In conclusion, this paper underscores the complex interplay between exchange rates, oil prices, money supply, and economic conditions in determining food prices in Turkey. The asymmetric and nonlinear relationships identified in this study highlight the need for nuanced and context-specific policy responses to manage food price volatility and ensure food security in a dynamic economic environment. Future research should continue to build on these findings to provide deeper insights and more robust policy recommendations for managing the impacts of exchange rate fluctuations on food prices.

## APPENDIX A

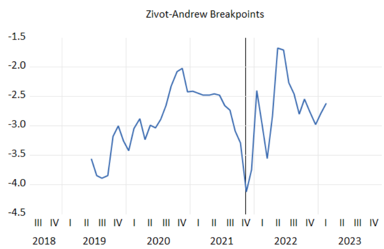
## Ziwot-Andrews Breakpoint Selection



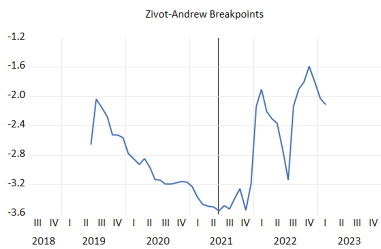

(a) Veal



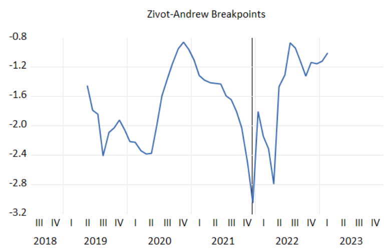

(b) Lamb




(c) Poultry




(d) Egg




(e) Milk

Figure A1. Ziwot-Andrews Breakpoint Selection for Food Variables

# APPENDIX B

## Line Graphs of Food Variables

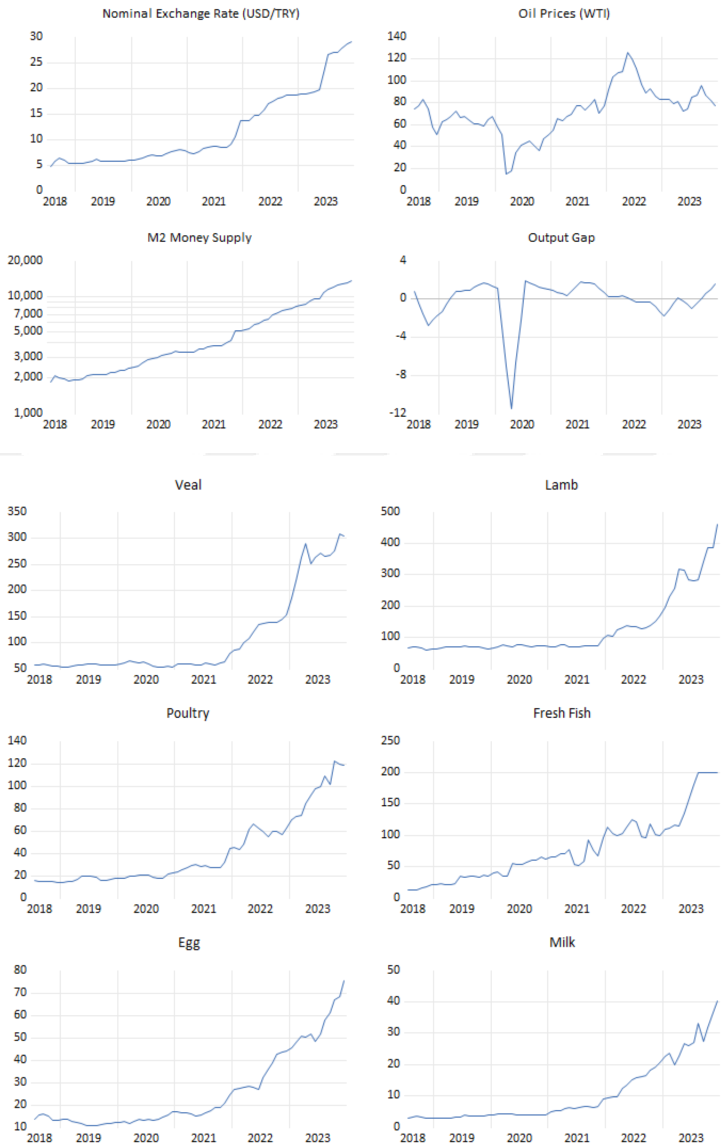
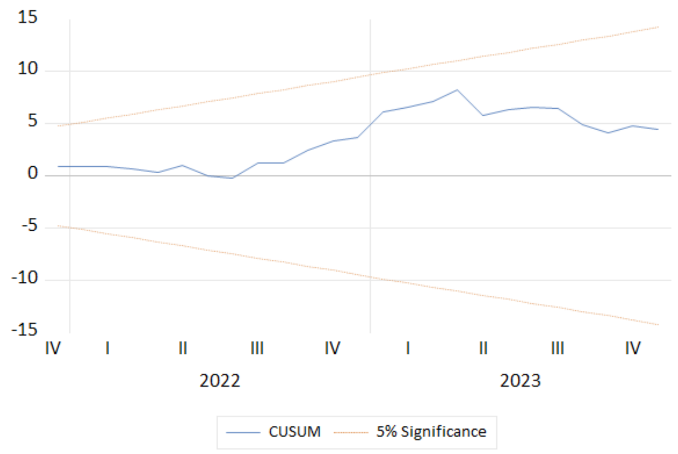


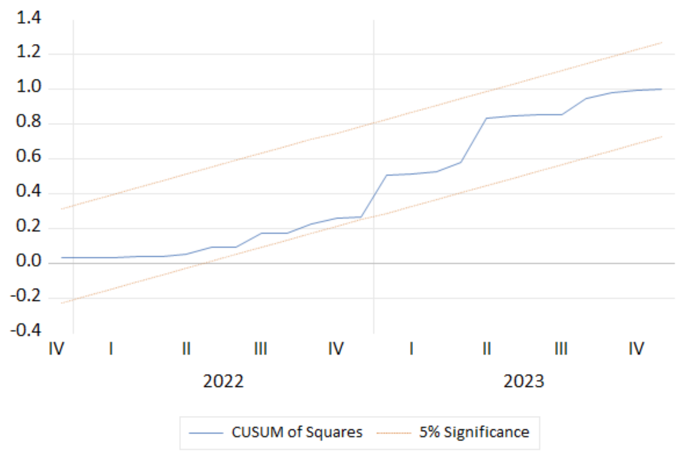

Figure B1. Line Graphs of the Variables

APPENDIX C

CUSUM and CUSUMQ Tests

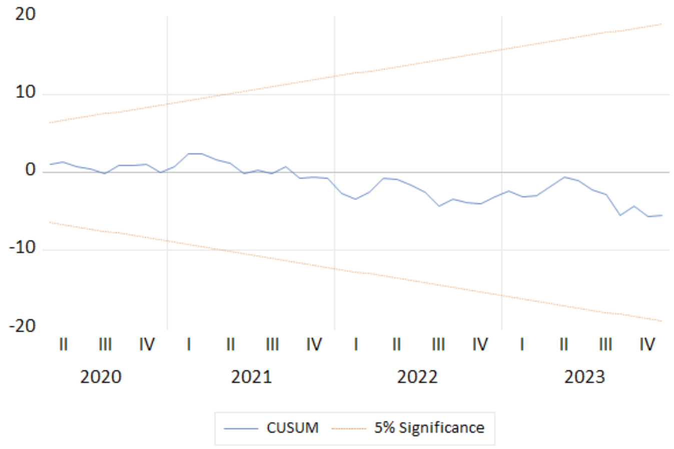



(a) CUSUM Test

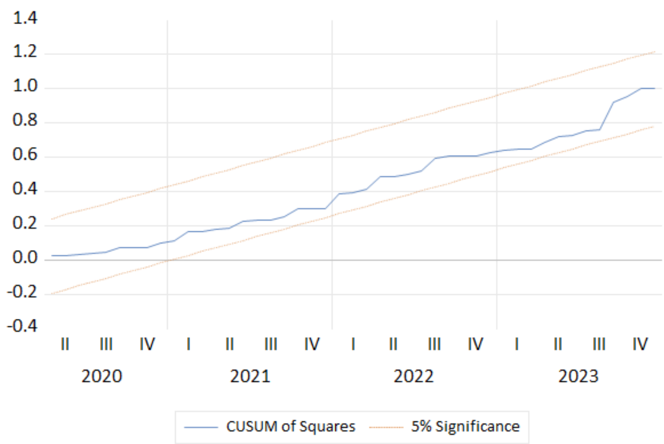



(b) CUSUMSQ Test

Figure C1. Stability Tests for Veal

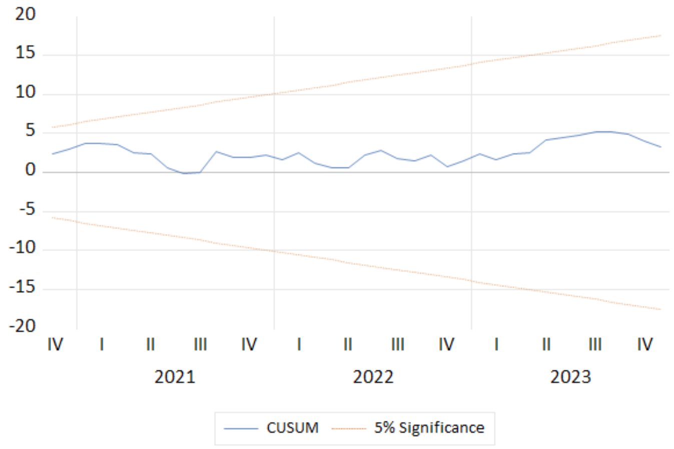



(a) CUSUM Test

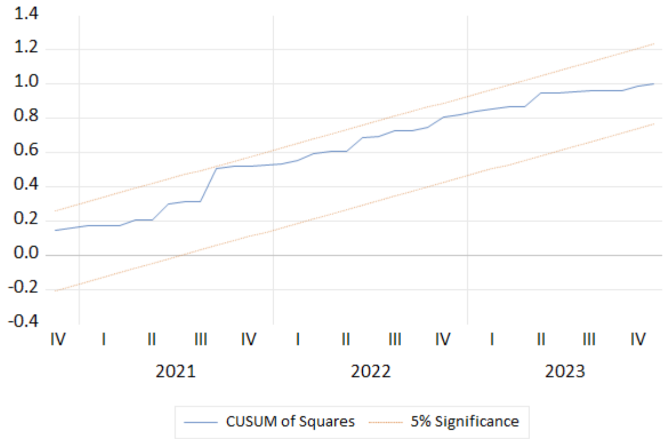



(b) CUSUMSQ Test

Figure C2. Stability Tests for Poultry

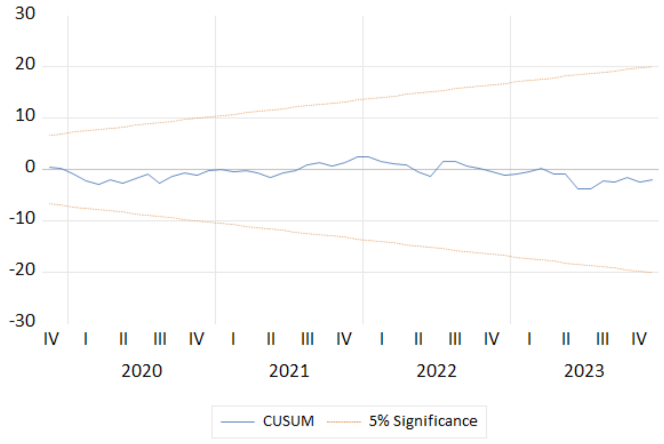



(a) CUSUM Test

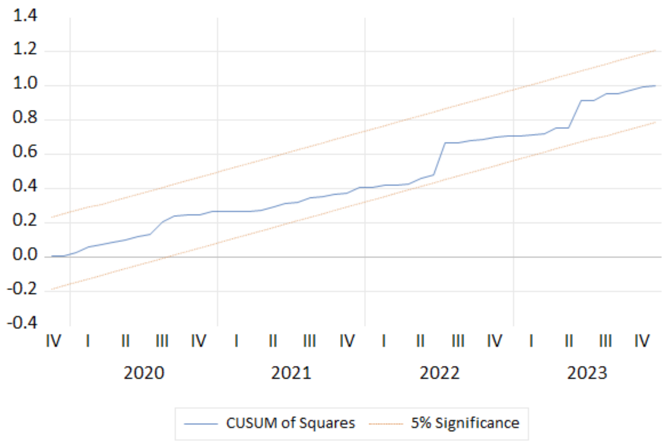



(b) CUSUMSQ Test

Figure C3. Stability Tests for Fish

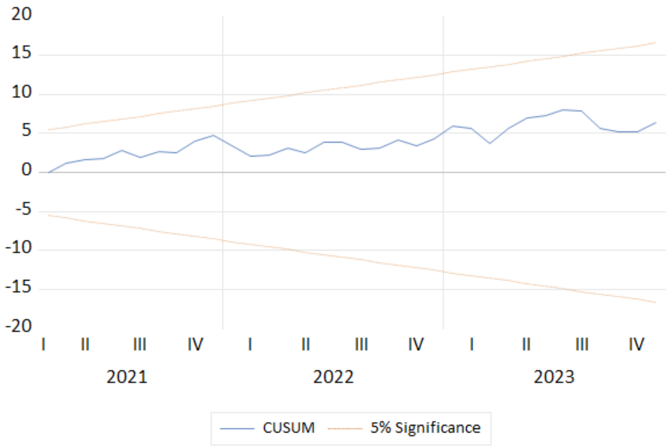



(a) CUSUM Test

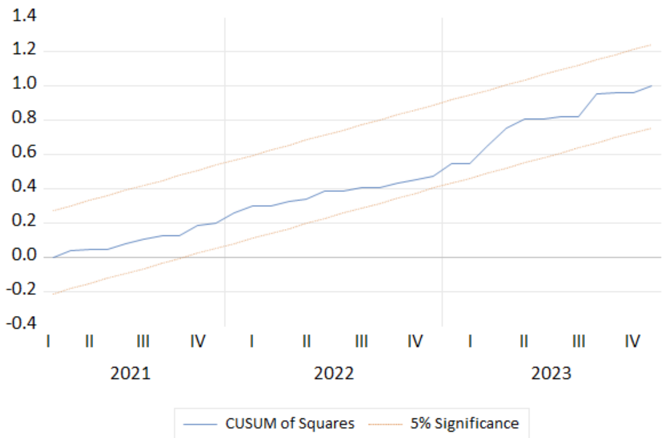



(b) CUSUMSQ Test

Figure C4. Stability Tests for Egg

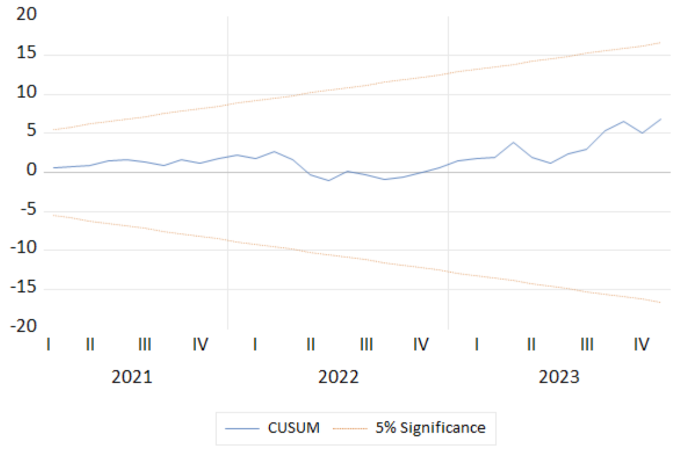



(a) CUSUM Test

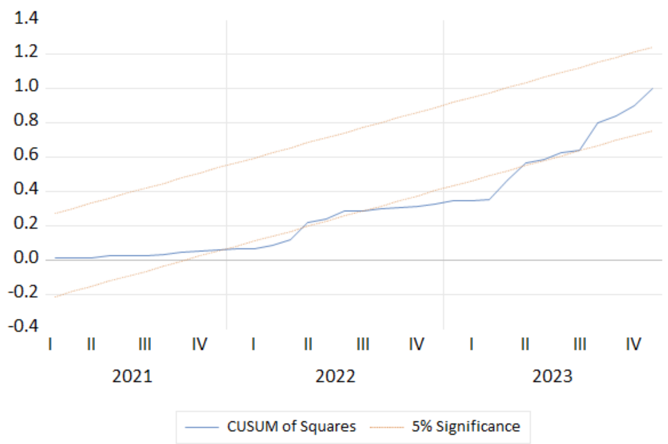



(b) CUSUMSQ Test

Figure C5. Stability Tests for Milk

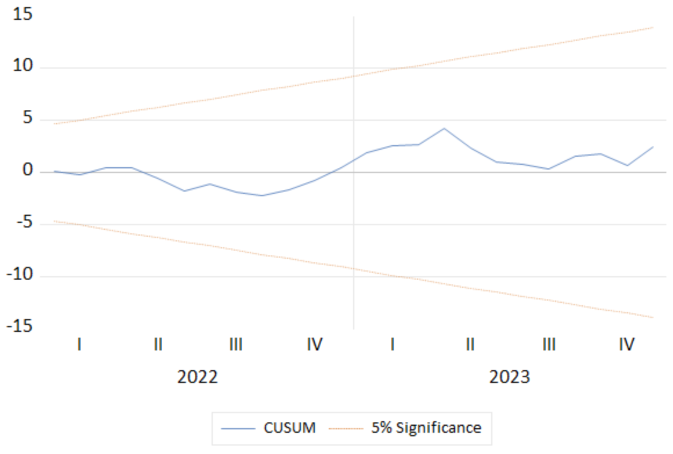



(a) CUSUM Test

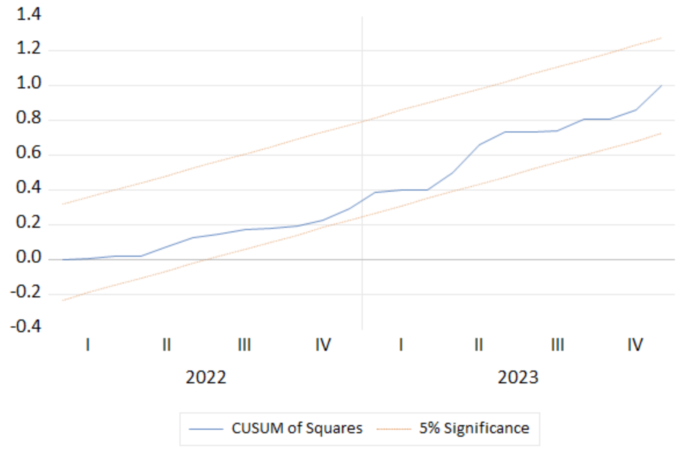



(b) CUSUMSQ Test

Figure C6. Stability Tests for Lamb without Structural Breaks




(a) CUSUM Test




(b) CUSUMSQ Test

Figure C7. Stability Tests for Lamb with Structural Breaks

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