

## A NARDL Analysis of Asymmetric Price Transmission and Market Power in the Chilean Oil Market

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### Abstract

Vertical price transmission refers to how price changes at the producer level are passed along to retailers and ultimately to consumers. In agricultural markets, this process often exhibits significant asymmetry due to high volatility caused by factors such as weather conditions and market speculation. Typically, price increases are transmitted quickly to consumers, while price decreases are not, resulting in an imbalance that raises concerns about efficiency and transparency in the value chain. In Chile, the vegetable and sunflower oil market has experienced significant price increases, underscoring the importance of examining asymmetric price transmission in this sector. Such an analysis is essential for identifying market inefficiencies and informing policies aimed at promoting competition and curbing the market power of dominant retailers like Walmart and Cencosud, which hold substantial influence over the sector.

The study's findings indicate that the oil markets in Chile are inefficient, with prices between producers and retailers being cointegrated but exhibiting asymmetric transmission: price increases reach consumers more swiftly than decreases. This suggests that supermarkets exert considerable power in the market and highlights potential shortcomings in current economic policies. To gain a more comprehensive understanding of price transmission and market efficiency, future research should expand to include other essential products, such as dairy and cereals. This broader analysis would provide deeper insights into how price shocks are transmitted through the supply chain and inform the development of more effective policy measures.

**Keywords:** NARDL model, asymmetry, retail market power, Chilean food industry.

**JEL Classification:** C22; D43; L11; Q11.

## Introduction

Vertical price transmission is a critical concept used to assess how price increases and decreases are propagated within a supply chain, particularly the dynamics between producers and retailers. It is generally assumed that in a competitive market, price shocks are fully and instantaneously passed along the supply chain, ensuring efficiency and transparency.

Agricultural markets, however, present unique challenges due to their inherent volatility, driven by factors such as climate variability, storage conditions, and speculative behaviour, especially by those with purchasing power over primary products (Sharma, et al. 2025). This volatility is exacerbated by the fragmented nature of agricultural production. In practice, this often results in price increases being quickly and fully passed on to consumers (complete flexibility), whereas price decreases are less responsive, leading to downward price rigidity. This creates an asymmetry within the supply chain, which is crucial for examining the efficiency and information flow within the value chain.

The issue of price transmission has become increasingly significant for producers of basic agricultural goods, particularly in light of ongoing changes within the industry. In Chile, the number of domestic oilseed producers has drastically declined, as reported by the Office of Agricultural Studies and Policies (ODEPA). This has led to a significant increase in imports and a strong presence of private-label products from major supermarket chains. The Chilean retail market is dominated by four major retailers, Walmart, Cencosud, Unimarc, and Tottus (Falabella), which collectively control over 90% of the market, furthermore, according to Aguirre (2022), the HHI is estimated to have reached 3,352 points for the retail sector in 2020, effectively forming an oligopoly. This concentration of market power gives these retailers significant leverage over consumers, allowing them to dictate prices across various products.

This research focuses on the vegetable and sunflower oil markets in Chile, where recent volatility has led to sharp price increases. According to ODEPA (2024), consumers in Greater Santiago have experienced average price hikes of 131% for edible vegetable oil and 147% for sunflower oil. Investigating the asymmetric price transmission between retail and consumer prices in these markets is critical for several reasons.

First, asymmetric price transmission can lead to abuses of market power, where certain groups, whether consumers or producers, are disproportionately affected by price fluctuations. Analysing these asymmetries, policymakers can identify potential market failures and implement corrective measures to enhance price transparency and fairness. Second, asymmetric price transmission often signals underlying market inefficiencies, such as a lack of competition or the excessive market power of specific actors. Addressing these inefficiencies can foster a more competitive market, leading to better pricing mechanisms for both consumers and producers. Additionally, understanding these price transmission mechanisms is essential for shaping effective agricultural policies that align with the goals of the current government (Rahman, et al. 2022).

Moreover, comprehending price transmission across various markets within a country is crucial for policymakers, especially regarding free competition. Sectoral policymakers and competition authorities can use this knowledge to promote greater competition in agricultural markets, encouraging the entry of new firms, supporting domestic cultivation, and preventing the abuse of market power by dominant entities like supermarkets in Chile.

For instance, if producers receive lower prices while consumers pay higher prices, policy interventions such as subsidies or price controls may be necessary to support producers. Conversely, if consumers face high prices while producers receive inadequate compensation, measures to increase competition and improve market transparency might be warranted. In both cases, a nuanced understanding of price transmission can guide policymakers in crafting effective interventions that ensure a fair and efficient market for all stakeholders.

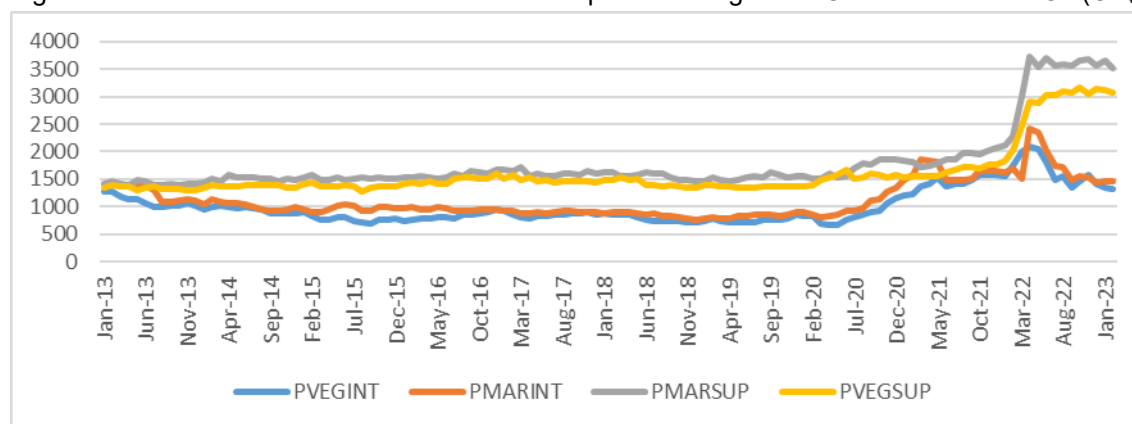
### Chilean Market

The edible oil market in Chile plays an important role in the country's economy, and understanding asymmetric price transmission within this sector is vital for both consumers and potential producers. Asymmetric price transmission can lead to significant economic consequences, particularly for domestic consumers who may face higher prices, and for producers who might encounter challenges in the market. By analysing these asymmetries, policymakers and industry stakeholders can gain insights into the effects of current pricing practices and implement strategies to mitigate any negative impacts. In essence, understanding price transmission in Chile's edible oil market is key to ensuring fair market prices, promoting producer efficiency, guiding policy decisions, and understanding the broader economic implications for both consumers and producers.

To provide context for this analysis, the following graph illustrates the evolution of vegetable and sunflower oil prices in Buenos Aires, Argentina, a reference market for Chile. A substantial portion of these oils is imported directly from Argentina, making their price trends in Buenos Aires particularly relevant to Chilean consumers and producers. The final retail prices in Chile, especially within the Metropolitan Region, are significantly influenced by these international price trends. In addition to international price behaviour, the Chilean economy's exposure to exchange rate volatility, stemming from its high degree of trade openness, must be considered. This factor directly affects producer-level commodity prices and is not accounted for in the present paper.

The graph depicts the evolution of the price of vegetable oil on the international market (PVEGINT) and at the supermarket level within the Metropolitan Region (PVEGSUP), as well as the international price of sunflower oil (PMARINT) and its corresponding supermarket price in the Metropolitan Region (PMARSUP) over the period from January 2013 to February 2023. This visual representation will help to better understand the relationship between international and domestic prices and the potential asymmetries in price transmission within Chilean market.

Figure 1: Evolution of domestic and international prices of Vegetable Oil and Sunflower Oil (Ch\$/Lt)



Source: [www.odepa.cl](http://www.odepa.cl) (2024)

This paper is organized as follows: First, a review of the most recent literature is provided to establish a theoretical foundation for understanding the price transmission mechanism and to summarize relevant empirical studies. Second, the methodology used in the analysis is detailed, including the research design and data analysis techniques employed. Third, the results are presented, analysed, and discussed, with a comparison to findings from previous studies. Finally, the paper concludes with a discussion of the implications for policymakers and suggests potential areas for future research.

## 1. Literature Review

When analysing price transmission in agricultural markets, these markets can be differentiated by time, form, and space, as well as by combinations of these factors. Transactions and storage costs, along with production and marketing considerations, define the boundaries of these markets.

Reziti (2014) conducted a significant study on the retail price transmission mechanism in the Greek milk market, using monthly time series data from January 1998 to June 2014. The study identified substantial changes in the market, largely due to increasing concentration within the pasteurized fresh milk industry, a trend like what has been observed in the Chilean edible oil industry. The Greek milk supply chain was characterized by a fragmented raw milk production sector alongside a highly concentrated dairy processing sector. Using an error correction model, Reziti tested for asymmetric behaviour in the price transmission process and found that the transmission between producer and consumer milk prices in Greece was asymmetric in both the short and long term, indicating that retailers exert significant market power over producers.

Similarly, Ricci et al. (2019) explored vertical price transmission in two prominent Italian wheat supply chains: the pasta and bread chains, both of which have experienced significant market fluctuations in recent years. The study divided these chains into upstream (farm-to-wholesaler) and downstream (wholesaler-to-retailer) segments and applied a cointegration methodology that accounts for potentially unknown structural breaks. By analysing price transmission elasticities across different sub-periods identified by break dates, the authors found evidence of asymmetric price transmission. In the pasta chain, farmers are price takers, while in the bread chain, price transmission is influenced by the market structure and the coexistence of small and large retailers.

Rose et al. (2019) focused on the broiler market chains in the UK and US, testing for asymmetry in price transmission as a measure of market efficiency. The study emphasized that price transmission has gained increased attention, particularly considering significant price spikes and their impact on agricultural markets, such as during the food crises of 2007 and 2008. Standard economic theory posits that markets should exhibit perfect price transmission, where any price change is fully and immediately passed along the supply chain. However, Rose et al. found no long-term asymmetry in the broiler value chains, suggesting that these markets are efficient.

Bittmann & Loy (2021) examined the formation of value chains, a central issue in the development of global trade, with a focus on price relationships and both vertical and horizontal price transmission. Their research investigated the causal structures in international dairy markets and their connections to domestic wholesale and retail prices in Germany, based on the law of one price, which asserts that identical goods should have the same price across different markets. Using panel data models and time series analyses of non-stationary

variables, the study revealed that international prices lead wholesale prices in Germany, which are then passed on to farmers and retailers.

The study highlighted that retail prices of private label products closely track the price movements of dairy products in global markets, while branded products show deviations from these trends. At the producer level, raw milk is a homogeneous product, resulting in a strong correlation between raw milk prices and international markets for skimmed milk powder and butter. However, at the retail level, where thousands of different products and brands are available, the complexity of price relationships increases significantly towards the end of the value chain, allowing firms to either pass on specific costs or generate additional profits.

The research by Omrani et al. (2017) highlights the significant impact of asymmetric price transmission on the welfare of both producers and consumers, ultimately reducing market efficiency by increasing the marketing margin. Their study focuses on measuring the market power of meat suppliers in the retail market using a mixed model, while also analysing the price transmission dynamics between wholesale and retail meat markets through a two-regime model. Utilizing quarterly data from 1994 to 2013, their findings indicate that retail suppliers can exert market power by imposing higher prices, albeit only for a short duration within a year. This market power, however, is minimal, with a welfare impact of just 0.34%. In the second regime, where the probability of occurrence is higher, wholesale price increases are transmitted to the retail level with a higher long-term coefficient, a critical insight for policy formulation.

Furthermore, the study reveals asymmetric price transmission across the medium, short, and long terms, with the degree of asymmetry varying between the two regimes. The likelihood of these regimes suggests that, in most cases, price transmission from the wholesale to retail level is more pronounced.

Similarly, Liu et al. (2022) investigate the aquaculture product market, where vertical price transmission efficiency is consistently evident. Their study examines the main freshwater fish market in China, focusing on the relationship between asymmetric price transmission and market power. By employing a nonlinear autoregressive distributed lag model, they capture the short- and long-term asymmetric effects of wholesale-to-retail price transmission. Additionally, they utilize an asymmetric autoregressive conditional heteroscedasticity model to assess the differences in market power between wholesalers and retailers.

The findings confirm the presence of non-linear cointegration between wholesale and retail prices in this market, with significant asymmetric effects in both the speed and degree of price transmission. The study demonstrates that wholesalers exert substantial control over pricing, resulting in asymmetric vertical price transmission. This underscores the necessity for improving market development and integration in the Chinese aquatic products sector. Also, keep in mind that this overview not only familiarises the reader with the foundational theories and concepts but also situates the current study within the broader scholarly discourse. Presenting a wide review of what is already known, the literature review identifies gaps or areas where further research is needed. This critical assessment helps justify the significance of the current study by highlighting unanswered questions or limitations in previous research that the current study aims to address.

Waiswa & Yavuz (2023) analyse price transmission dynamics and market integration across domestic markets for Uganda's primary staple foods using a NARDL model. Among the key findings, the causal order between wholesale and retail commodity prices flows unidirectionally forward, from the wholesale to the retail level across all markets. Furthermore,

wholesale and retail prices for Uganda's staples are interconnected in all markets, and spatially separated markets are also well integrated.

Rudinskaya & Boskova (2021) investigated whether price distribution within the Czech dairy chain was fair and whether farmers progressed toward a collective approach to strengthen their position in the supply chain. Utilizing pre-cointegration and cointegration approaches, they tested for asymmetry in the transmission of farm-gate milk prices throughout the supply chain. Additionally, they measured the evolution of market concentration using the Herfindahl-Hirschman Index and discussed the context of these figures with representatives from producer organizations. Their results demonstrated the existence of asymmetric price transmissions. In response, farmers consolidated and concentrated on their milk sales. This concentration should not be understood as an end, but rather as a means toward further strategic objectives.

Finally, the work of Theofanous & Tremma (2024) examines price relationships among the three major EU olive oil markets: Spain, Italy, and Greece. They utilize both linear and non-linear econometric techniques to explore short- and long-run relationships, examining market integration as well as price transmission patterns. The study employs monthly wholesale price data for virgin olive oil across the three countries, covering the period from January 2000 to April 2022. Results from non-linear causality tests suggest that Spain acts as the central market. Furthermore, stable long-run relationships are revealed through the Momentum Threshold Cointegration (M-TAR) model, with the strongest relationship identified between Italy and Greece. Regarding the price transmission pattern, it is found to be asymmetric for the Spain–Greece and Spain–Italy pairs; conversely, symmetry is confirmed for the Italy–Greece pair, where the Law of One Price (LOP) holds in its strong version. This suggests that while the markets are integrated, the EU olive oil market is characterized by inefficiencies that indicate the need for further reforms

## 2. Research Methodology

This research aims to identify the presence of price asymmetry in the vegetable oil and sunflower oil markets in Chile. According to our literature review, while there are studies examining price asymmetry in various supply chains, none specifically address the oil market in Chile. The key questions we seek to answer are: Is there a long-term relationship between international oil prices and retail prices in Chile? And is there evidence of asymmetry in the price transmission within the Chilean oil market?

To conduct this analysis, we utilize monthly price data for sunflower oil and vegetable oil. The retail prices used in this study are based on international market prices in Buenos Aires, which serve as a proxy for producer prices at the retail level. This approach is justified by the structure of the Chilean market, where these types of oil are not produced domestically, resulting in the need to import all the oil consumed in the country. For consumer prices, we consider the average prices in supermarkets within the Metropolitan Region, given the significance of this market in the Chilean economy.

The data series spans from Jan 2013 to Feb 2023, providing 122 observations in total. The source of the data is the Office of Agricultural Studies and Policy (ODEPA, 2024), a government agency under the Ministry of Agriculture. For the purposes of this modelling, factors such as marketing, transportation, and other elements that might cause price variations at the wholesale and retail levels are excluded. Various econometric techniques are commonly employed to examine asymmetric price transmission.

Johansen cointegration is a technique used to test for the existence of a long-term equilibrium relationship between two or more non-stationary variables. This relationship occurs when the variables are linearly dependent over the long term. In the context of asymmetric price transmission, Johansen cointegration can be applied to determine whether consumer and producer prices are cointegrated, indicating a long-term equilibrium relationship. If cointegration is present, any deviations from this equilibrium are considered temporary, with prices eventually reverting to their long-run equilibrium (Johansen, 1988).

The Johansen Cointegration test estimates the number of cointegration vectors, which are linear combinations of the variables that point to a long-term equilibrium relationship. These vectors can also be used to estimate the error correction mechanism, which captures the short-run dynamics that adjust towards this equilibrium. Asymmetric price transmission may be indicated if the error correction coefficients for different price changes follow divergent paths. For example, if producer prices adjust more quickly to increases in consumer prices than to decreases, this would suggest the presence of asymmetric price transmission (Johansen & Juselius, 1990),

Error correction Models (ECMs) are used to analyse the dynamics of time series data, particularly when dealing with non-stationary variables whose mean and variance change over time. In this study, ECMs will be used to estimate both the long-run equilibrium relationship between consumer and producer prices and the short-run dynamics of their adjustment towards equilibrium. This method allows us to assess both the long-term and short-term relationships between these prices and identify any evidence of asymmetric price transmission. The long-term relationship represents the equilibrium between the prices, while the short-term dynamics capture the adjustment process following price shocks.

Granger causality tests are employed to determine whether past values of one variable provide useful information for predicting another variable, beyond what can be predicted by the past values of the second variable alone. In the context of asymmetric price transmission, Granger causality tests can be used to assess whether changes in consumer prices lead to changes in producer prices, or vice versa. A significant causal relationship in one direction but not the other would indicate the presence of asymmetric price transmission.

In this study, we will apply these econometric models to analyse the data and identify the relationship between prices in the Chilean oil market. This approach will allow us to determine whether there is asymmetry in the transmission of prices from the international market to the retail level in Chile, providing insights into the efficiency and dynamics of this market.

It is important to recognize that the design and econometric tests employed in these studies can be subject to debate, as various alternative methods exist for testing these hypotheses. The Augmented Dickey-Fuller (ADF) Unit Root test, while commonly used to determine whether a data set is stationary, has limitations, particularly its inability to account for structural breaks. This limitation can potentially lead to spurious results. Additionally, the KPSS (Kwiatkowski-Phillips-Schmidt-Shin) test offers an alternative approach by assessing the stationarity of a time series around a deterministic trend. Unlike the ADF or Phillips-Perron tests, the KPSS test considers the null hypothesis that the series is stationary around a trend, with the alternative being that the series possesses a unit root.

The Granger causality test, although valuable, also has its limitations. One of its key drawbacks is that it may infer a causal relationship across all cross sections, even if the relationship exists in only a single cross section. Despite this, the Granger causality test offers

significant advantages over other methods, including its capability to handle many observations simultaneously, making it a powerful tool in time series analysis. Follow with a detailed description of the experimental procedures, ensuring to include step-by-step instructions, conditions, and any modifications from standard protocols. Next, describe the data collection methods, specifying the instruments and techniques used for measurement, along with calibration details and accuracy. Outline the statistical methods employed for data analysis, including the software used and criteria for significance. If the study involves human or animal subjects, include statements about ethical approvals, informed consent, and confidentiality measures. Finally, ensure that enough detail is provided for reproducibility, and cite any established methods or protocols referenced in the study.

### 3. Research Results

This section presents the results of the econometric tests conducted using STATA software, as outlined in the methodology. To ensure the validity and accuracy of subsequent statistical analyses, it is essential to first determine whether the variables in question are stationary. The variables under investigation include LPVEGINT and LPMARINT (the international retail prices of vegetable oil and sunflower oil, respectively) as well as LPVEGSUP and LPMARSUP (the retail prices of vegetable oil and sunflower oil at the consumer level in Chile). The stationarity of these variables is tested using the Augmented Dickey-Fuller (ADF) test.

The ADF test is designed to detect the presence of a unit root in a time series, which indicates non-stationarity. The test is first applied to the level time series to assess whether trends or seasonality impact the data. In this context, the null hypothesis of the ADF test posits that the series is non-stationary (i.e., it contains a unit root), while the alternative hypothesis suggests that the series is stationary.

For the null hypothesis to be rejected, the ADF test statistic must be more negative than the critical value at a given significance level, or the p-value must be less than the 5% significance threshold. As shown in Table 1, the ADF test results indicate that the test statistics for LPVEGINT, LPMARINT, LPVEGSUP, and LPMARSUP are not more negative than their respective critical values. Additionally, the p-values do not fall below the 5% significance level. Therefore, the null hypothesis of non-stationarity cannot be rejected, implying that the data series are non-stationary at their level form.

These results suggest that further transformation, such as differencing, may be required to achieve stationarity before proceeding with additional econometric analyses.

Table 1: ADF Unit Root Test January 2013 – December 2022

Variables	t(ADF)	p-Value	Critic Value (5%)
lpvegint	-1.063	0.7296	-2.889
lpvegsup	1.495	0.9975	-2.889
Dlpvegint	-8.690	0.000	-2.889
Dlpvegsup	-9.525	0.000	-2.889
lpmarint	-1.373	0.5953	-2.889
lpmarsup	1.038	0.9947	-2.889
Dlpmarint	-10.413	0.000	-2.889
Dlpmarsup	-9.253	0.000	-2.889

Source: Authors' own elaboration

Given that the data series is non-stationary in its level form, we proceed by testing the stationarity of the series using its first difference. Differencing the data helps stabilize the series by removing any trends or variations in the level time series, thereby eliminating any underlying trend. The null and alternative hypotheses for the Augmented Dickey-Fuller (ADF) test remain unchanged from the previous level time series analysis.

As presented in Table 1, when we apply the ADF test to the first differences of the variables,  $\Delta LPVEGINT$ ,  $\Delta LPMARINT$ ,  $\Delta LPVEGSUP$ , and  $\Delta LPMARSUP$ , the results show that the ADF t-statistics are more negative than the corresponding critical values, and the p-values are less than the 5% significance level. Therefore, we reject the null hypothesis of non-stationarity and accept the alternative hypothesis that the data series are stationary in their first differences.

Since all the price series are integrated of order one (i.e., they become stationary after differencing once), further analyses will be conducted using the first-differenced variables. This approach ensures the validity of the tests and prevents any seasonality from affecting the results.

To confirm these findings, the Phillips-Perron (PP) test was also conducted (Table 2), yielding results consistent with those of the ADF test. The PP test similarly indicates that  $\Delta LPVEGINT$ ,  $\Delta LPMARINT$ ,  $\Delta LPVEGSUP$ , and  $\Delta LPMARSUP$  are integrated of order one. Consequently, all subsequent tests and analyses will be performed using the first differences of these variables to maintain the validity and robustness of the results and to mitigate the influence of seasonality on the data series.

Table 2: Phillip Perron Unit Root Test January 2013 – December 2022

Variables	PP	p-Value	Critic Value (5%)
lpvegint	-3.384	0.6432	-13.742
lpvegsup	2.187	0.9945	-13.742
Dlpvegint	-89.872	0.000	-13.742
Dlpvegsup	-117.403	0.000	-13.742
lpmarint	-4.124	0.5717	-13.742
lpmarsup	1.457	0.989	-13.742
Dlpmarint	-111.656	0.000	-13.742
Dlpmarsup	-107.518	0.000	-13.742

Source: Authors' own elaboration

Table 3: KPSS Unit Root Test January 2013 – December 2022

Variables	PP	Critic Value (5%)
lpvegint	2.19	0.146
lpvegsup	1.68	0.146
Dlpvegint	0.095	0.146
Dlpvegsup	0.140	0.146
lpmarint	2.27	0.146
lpmarsup	1,75	0.146
Dlpmarint	0.062	0.146
Dlpmarsup	0.095	0.146

Source: Authors' own elaboration

To determine the order of integration of the variables, stationarity was first examined using the Augmented Dickey–Fuller (ADF) test developed by Dickey & Fuller (1979), together with the Phillips–Perron (PP) test (Phillips & Perron, 1988) and the Kwiatkowski – Phillips-Schmidt–Shin (KPSS) test. Employing these complementary unit root tests provides a more robust assessment of the stochastic properties of the series and ensures the validity of the subsequent cointegration and NARDL analyses.

The Phillips-Perron (PP) test has been demonstrated to provide more reliable results compared to the Augmented Dickey-Fuller (ADF) test, particularly in detecting the presence of a unit root when it exists. One significant advantage of the PP test is its robustness to outliers and structural breaks within the data, factors that can often lead to misleading results when using the ADF test.

In contrast, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test operates under a different null hypothesis: it assumes that the data series is stationary, whereas the ADF test assumes the presence of a unit root (non-stationarity) as the null hypothesis. This difference makes the KPSS test particularly valuable for assessing the stationarity of a series. Moreover, the KPSS test is well-suited for detecting the presence of a trend in the data, which is not explicitly accounted for in the ADF test. Combining the strengths of the PP and KPSS tests, analysts can achieve a more comprehensive understanding of the stationarity properties of the data, ensuring that the results are robust to outliers, structural breaks, and underlying trends.

The dataset was analysed twice using the Johansen cointegration test: once without dummy variables and once with them. The Johansen cointegration test involves two key tests: the trace test and the maximum eigenvalue test.

In the trace test, the null hypothesis is that the number of cointegration relationships, denoted by  $r=0$  (i.e., no cointegration exists between the variables). The alternative hypothesis is that there is at least one cointegration relationship. The test then proceeds to evaluate whether  $r=1$ , where the null hypothesis is that there is exactly one cointegration relationship, with the alternative being that there is more than one. For the null hypothesis to be accepted at each step, the trace statistic must be greater than the critical value at the 5% significance level.

The maximum eigenvalue test follows a similar approach, testing the null hypothesis that there are exactly  $r$  cointegration relationships against the alternative that there are  $r+1$  relationships. Again, the maximum eigenvalue statistic must exceed the critical value at the 5% significance level for the null hypothesis to be accepted.

To account for potential structural breaks in the data, the cointegration test was also conducted with the inclusion of a dummy variable. This approach helps to identify whether cointegration is present when considering a specific breakpoint in the data. The null hypothesis in this context remains the same,  $r = 0$ , indicating no cointegration, while the alternative hypothesis posits the existence of a cointegration relationship. The results with and without the dummy variable are summarized in Table 4 and Table 5. Incorporating a dummy variable to capture structural breaks, the analysis ensures that the cointegration relationship is robust, even in the presence of potential shifts or changes in the underlying data series. This comprehensive approach allows for a more accurate assessment of the long-term equilibrium relationships between the variables in the dataset.

Table 4. Johansen Cointegration Test: Vegetable Oil

Rank	Parms	LL	Eigenvalue	Tracee Statistic	5% Critical Value
0	6	366.70597		71.3048	15.41
1	9	386.64995	0.28480	31.4168	3.76
2	10	402.35837	0.23203		

Source: Authors' own elaboration

Table 5. Johansen Cointegration Test: Sunflower Oil

Rank	Parms	LL	Eigenvalue	Tracee Statistic	5% Critical Value
0	6	326.71697		83.2287	15.41
1	9	352.12508	0.34755	32.41257	3.76
2	10	368.33134	0.23843		

Source: Authors' own elaboration

The error correction model (ECM) is used to determine the speed at which cointegrated variables return to equilibrium after a price shock occurs in the independent variable (in this case, the international price). The speed of adjustment is estimated using the error correction term (ECT), which measures how quickly deviations from the long-term equilibrium are corrected.

For the cointegration to be valid, the error correction term must be negative and statistically significant, as indicated by the t-statistic. This ensures that the model properly captures the adjustment process back to equilibrium. In this analysis, structural changes are not considered to focus on the core relationship between the variables.

As shown in Table 6 and Table 7, the estimated Error Correction Term (ECT) is negative for both vegetable oil and sunflower oil markets, indicating convergence toward the long-run equilibrium following a price shock. However, the coefficients are not statistically significant at conventional significance levels, suggesting that the speed of adjustment should be interpreted with caution. Although the estimated adjustment rates imply that approximately 31% (vegetable oil) and 26% (sunflower oil) of deviations from the long-run equilibrium are corrected each month, the lack of statistical significance indicates that these estimates do not provide strong empirical evidence of a stable short-run adjustment process.

Table 6. Error Correction Model Results: Vegetable Oil Market

Error Correction Term	Coefficient
ECT (-1)	-0.3127019 (-1.11)

Note: (-) ECT coefficient indicates convergence toward equilibrium but lacks statistical significance.

Table 7. Error Correction Model Results: Sunflower Oil Market

Error Correction	Coefficienr
ECT (-1)	-0.2583039 (-0.96)

Note: The negative coefficient indicates convergence toward the long-run equilibrium; however, it is not statistically significant at conventional significance levels.

Source: Authors' own elaboration

As identified through the Johansen cointegration test, a long-term relationship exists between international prices and consumer prices set by large supermarkets. The next step is to determine whether a short-term relationship also exists, which will be examined using Granger Causality tests.

The Granger Causality test assesses whether past values of one variable help predict future values of another, thereby indicating a short-term causal relationship. The null hypothesis in this context is that the independent variable (international prices) does not Granger-cause the dependent variable (consumer prices). This hypothesis is tested using the Chi-squared (Chi2) statistic, derived from the Wald test.

To reject the null hypothesis, the Chi2 statistic must exceed the critical value at the chosen significance level. As presented in Table 8, the results show that the null hypothesis is rejected in both cases, with the Chi2 statistics being significant at the 1% level. This indicates that there is a statistically significant short-term relationship between international prices and consumer prices, suggesting that changes in international prices do indeed Granger-cause changes in consumer prices at the retail level.

Table 8: Granger Causality Test January 2013 – December 2022

Error Correction	lpmarsup
lpvegint does not Granger-causality to lpvegsup	1.9859
lpvegsup does not Granger-causality to lpvegint	8.8141*
lpmarint does not Granger-causality to lpmarsup	21.213*
lpmarsup does not Granger-causality to lpmarint	5.279*

Source: Authors' own elaboration

In this case, the analysis indicates that the international price of vegetable oil does not exhibit Granger causality on the retail price of vegetable oil. Therefore, the null hypothesis cannot be rejected, as the test statistic is lower than the critical value. Similarly, the second hypothesis, that the retail price of vegetable oil influences the international price, also cannot be supported, as the test statistic exceeds the critical value. This outcome is consistent for both hypotheses concerning sunflower oil as well.

Consequently, the findings suggest that the international price does not have a direct causal effect on the domestic retail price of vegetable oil in the short term. However, the absence of Granger causality in both directions implies that the relationship between international and domestic prices may be more complex, potentially involving other factors or lagged effects that are not captured by the Granger causality test. Therefore, while the international price may influence domestic prices, this influence is not immediate or straightforward in the short term, according to the test results.

#### 4. Discussion of Results

This section discusses the findings of the paper in relation to the research questions outlined in Section 3 (on the methodologies used) and previous studies on price transmission in other goods, such as those by Bakucs et al. (2012) and Weldesenbet (2013).

The results of the Augmented Dickey-Fuller (ADF) unit root test, applied to the first differences, indicate that the data set is stationary, with both the international and consumer price indices being integrated of the first order.

The Johansen cointegration test reveals a long-run cointegrated relationship between international and retail prices, which aligns with Falkowski's (2010) study on price transmission in Poland's fluid dairy sector and Acosta et al.'s (2014) research on vertical price transmission in Panama's milk market. These findings suggest a robust and stable long-term cointegration factor between international and wholesale prices, indicating that, despite short-term fluctuations, both prices tend to move together over time. This implies a structural relationship

that corrects any temporary deviations, reinforcing the hypothesis of a market equilibrium influenced by shared factors across both price levels. However, the Granger causality test results show a unidirectional causality relationship, where the producer price Granger-causes the retail price. Interestingly, the international price does not exhibit Granger causality with respect to the consumer price.

As a result, the causality direction is from the international price to the consumer price set by large supermarkets, consistent with Bakucs et al.'s (2012) findings on price transmission in Polish and Hungarian milk markets, where the producer was identified as the causal factor. It is important to note that the Polish dairy market is dominated by large-scale farming, which allows dairy producers to exert market power, a situation that contrasts with the Chilean market. In contrast, Weldesenbet's (2013) study on price transmission in the Slovak liquid milk market identified the retailer as the causal factor.

These results contribute to the broader understanding of price transmission dynamics, highlighting the different roles that producers and retailers can play in influencing market prices depending on the specific market structure and economic environment.

### Conclusion

The main finding of this research indicates that the vegetable and sunflower oil markets in Chile are inefficient. The Johansen cointegration tests revealed that the producer and retail price series are cointegrated, signifying a long-term relationship between these price series. However, the Granger causality test identified a unidirectional causality in the short term, where international prices (reflecting producer prices) influence retail prices. Despite the cointegration, threshold autoregressive tests indicated that long-term asymmetry is absent in the price series.

The error correction model (ECM) analysis showed that these markets return to equilibrium at a relatively slow rate of 31% and 25% per month following an international price shock. This slow adjustment may impact the intensity of competition, as the international price serves as a proxy for the cost at which supermarkets acquire the product. Consequently, supermarkets tend to pass on price increases to consumers more rapidly than they adjust for price decreases, suggesting an asymmetry in the way prices are transmitted in retail market.

These asymmetries imply that current economic policies may not be effectively ensuring a perfectly competitive market. The direction of causality, from large supermarkets (equivalent to the international price) to the consumer, suggests that these supermarkets are exercising their market power to shield themselves from international price fluctuations, potentially at the expense of consumers.

Understanding price transmission mechanisms across a country's various markets is essential for policymakers, particularly regarding antitrust matters. Therefore, it is crucial for agencies such as the National Economic Prosecutor's Office (FNE) to employ NARDL models for price monitoring, not only in agricultural markets but across other sensitive sectors of the economy. This would enable the implementation of policies aimed at fostering greater market competition, promoting the entry of new firms, incentivizing innovation, and preventing the abuse of market power by dominant firms, as is the case within the Chilean retail sector.

Future research in agricultural markets should aim to extend these findings by examining other sensitive products, such as dairy and cereals. This study lays the groundwork for a broader analysis of the country's supply chain, including producers, retailers, wholesalers, and consumers. It provides both theoretical and empirical support for evaluating how price shocks

is transmitted through different levels of the supply chain, offering valuable insights for policymakers and industry stakeholders.

#### Credit Authorship Contribution Statement

Escobar, E. contributed to the conceptualization, investigation, methodology, econometrics, supervision, and review and editing of the original draft writing. Valdes, I., was responsible for conceptualization, formal analysis, validation, and review and editing of the manuscript. Sauer, K, conducted the literature review, assisted in the investigation, contributed to data validation, and managed field coordination

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#### Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

#### Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

#### Ethical Approval Statement

This study is based exclusively on secondary data obtained from publicly available market price databases provided by the Office of Agricultural Studies and Policies (ODEPA), Chile. The research involves econometric analysis of aggregated time-series data and does not include human participants, animals, clinical data, surveys, interviews, or experiments. Consequently, ethical approval and informed consent were not required in accordance with applicable institutional and international research ethics guidelines.

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