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PRICE TRANSMISSION IN THE WHEAT MARKET IN ALGERIA: THRESHOLD COINTEGRATION APPROACH

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Abstract

This paper employs threshold cointegration technique that allows for asymmetric adjustment towards a long-run equilibrium relationship in order to examine the relationship between international and domestic prices of wheat in Algeria. The short-run adjustments are also examined with asymmetric error correction models. The analysis is based on annual series of international and domestic wheat prices. The time interval for the study runs from 1965 to 2021 using official data from national and international official organizations. The results indicate that the price transmission between the domestic and international price level of wheat is asymmetric, especially in the presence of structural breaks. The asymmetric error correction model with threshold cointegration provides strong evidence supporting asymmetric price behavior. Increases in the international price of wheat are transmitted more quickly to domestic prices than declines, which exhibit the increased vulnerability of the domestic market to be reconsidered.

Keywords: *Wheat sector, price transmission, error correction model, threshold cointegration, asymmetric adjustment, Algeria.*
JEL Codes: *Q13, Q17.*

1. Introduction

The rising prices of the main basic foodstuffs (milk, wheat, rice, palm oil, corn, soya, etc.) which started in 2008 provoked a series of social movements publicized under the term of the hunger riots in developing countries (Lerin *et al*., 2009; Bricas *et al*., 2010; Benz *et al*., 2010; Galtier, 2012; Le Mouël *et al*., 2017; Loyat & Pouch, 2018). Indeed, the prices of foodstuffs recorded increases ranging from 30% to 150% in 2007 and 2008 (Oxfam, 2008; Bricas *et al*., 2010). This crisis situation may be reproduced again in the years to come due to climate change, the reduction of world grain stocks, the volatility of exchange rates, the increase in demand, the promotion of biofuels and the financialization of agricultural futures markets (Gérard *et al*., 2008; Declerck & Portier, 2009; Galtier, 2012; Cheriet, 2013; Assefa *et al*., 2015; Ait Sidhoum & Serra, 2016). Given its economic, political and social importance, the

food price crisis has received considerable attention from researchers (Ait Sidhoum & Serra, 2016).

Price instability for cereals and other food products is a reality both on international markets and within countries (Gérard *et al*., 2008; Bonjean & Combes, 2010; Galtier, 2012). It has exhibited the fragility of food balances in certain southern and eastern Mediterranean countries (Cheriet, 2013). With this context, the international average price of durum wheat increased from 199.22 USD per ton during the period of 1979/2007 to 238.04 USD per ton during the period of 2009/2021, an increase of 19.49%. It peaked at 317.05 USD per ton during the 2008 crisis. In addition, during the same periods, the international price of common wheat experienced an upward trend, rising from 183.38 USD per ton (averaged on 1979/2007) to USD 225.28 per ton (averaged on 2009/2021), an increase of 22.85%. It peaked at 264.04 USD per ton during the 2008 crisis (Commodity Market Outlook, 2022). The increase in producer purchase prices for wheat decided by the Algerian government in 2008 is due to the international crisis in the prices of the main foodstuff products.

Algeria is particularly vulnerable to heightened volatility in international wheat markets (Chabane & Boussard, 2012; Bekkis *et al*. 2022). However, Algeria's foreign trade flows showed that imported food recorded 8,094.91 million USD in 2020 compared to 8,072.27 million USD in 2019, a slight increase of 0.28%. In terms of structure, cereals and milling products, and in particular imported wheat, represent 34.76% of total imported food (CNIS, 2022).

The average quantity of wheat imported by Algeria from 2018 to 2021 is around 7.22 million tons of grain for a cumulative total amount of 19.89 billion USD (OAIC, 2022). In terms of the structure of imported wheat, it is common wheat which shows an average annual import of more than 6 million tons. Imports of common wheat are regularly higher due to the evolution of consumption and the low production on the domestic market. This weight of cereals in the trade balance is becoming difficult for the government to bear. In addition, food price volatility is particularly pronounced in developing countries, especially for cereals, because they are highly dependent on wheat imports and the short-term demand for wheat is relatively inelastic in developing countries. In fact, cereals represent an important part of household expenditure. Cereal products occupy the first place in the food budget of Algerian households, i.e. 17.5% of total food expenditure; also, the budget share of cereal products is about 20% in rural areas against 16.3% in urban areas (ONS, 2011). It should be noted that plant-origin products represent on average 90% of the caloric intake of the inhabitants of the North Africa and Middle East region (Le Mouël *et al*., 2017; Bouzid & Bedrani, 2018). Among plant-based products, cereals continue to play a central role in food availability in the North Africa and Middle East region. As such, any increase in the price of cereals is likely to cause food security problems and urban riots.

Faced with this fluctuating food price situation, several countries have wondered about the public policy instruments to be deployed to secure their food supplies. In this respect, Galtier (2012) emphasizes that cereal price stabilization policies must therefore be supported in a dynamic perspective via the support and subsidy reform of the main consumer food products.

This study aims to fill a gap in the existing literature, by providing a better understanding of the effects of rising prices of key foodstuffs, notably wheat. Several studies have investigated the relationship between international price shocks and the price response in different domestic markets within a country given the issues of data availability in developing countries (Badolo, 2011). The presence of asymmetry in the transmission of prices between markets is generally considered as a demonstration of failures of these markets (Meyer & von Cramon-Taubadel, 2004).

The choice of the wheat sector responds to different reasons. First, wheat is currently the leading cereal traded worldwide, ahead of rice and corn. World cereal trade is expected to reach 542 million tons by 2030, according to OECD and FAO projections 2021-2030. In addition, the share of wheat in international trade should increase to 25% by 2030, compared to

9% for rice and 17% for other coarse grains (OECD/FAO, 2021). Second, Algeria is considered a net importer of wheat with an annual average import of 7.5 million tons. It ranks fourth in the world behind Egypt (12.4 million tons), Indonesia (10.8 million tons) and Turkey (8.9 million tons) (FAO, 2022). Indeed, it shows an average dependency rate on cereal imports over 3 years during the period from 2017 to 2019 of 70.1% (FAO, 2022). Thirdly, despite this structural dependence on wheat, Algeria as itself manages to produce significant quantities of durum wheat, i.e. an annual average of 2.5 million tons, but it remains a very insufficient quantity. Indeed, the study by Bekkis *et al*. (2022) on the challenges faced by the wheat sector in Algeria by 2040 showed a growing inability to meet local demand for durum wheat, a total disappearance of local production of common wheat and a more exaggerated recourse to import wheat which only increases the food bill.

The rest of the study is organized as follows: section 2 presents the facts and current issues of wheat imports sector in Algeria, section 3 specifies the methodology pursued in this study, section 4 explores and discusses the results, and finally section 5 concludes.

2. Import Wheat Sector in Algeria: Facts and Issues

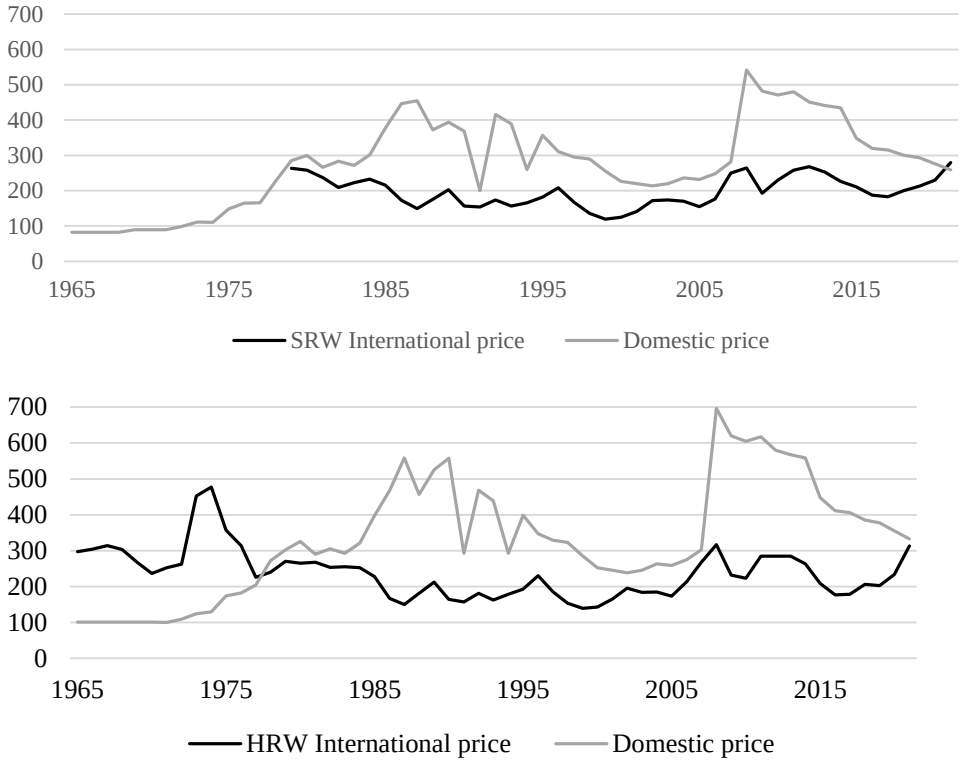
As a main public office, the OAIC[1] was the national operator entrusted with a public service mission in terms of organization of the cereals market, supply, regulation, price stabilization and support to production. The OAIC behaved like a veritable public purchasing center that managed all the agreements made between Algeria and the exporting countries to supply the domestic market. However, the OAIC developed a policy of bilateral commercial agreements with the public organizations of the supplier countries (Bencharif *et al*., 1996; Baba-Khelil, 1998; Talamali, 2000; OAIC, 2022).

However, the period of the 1990s was marked by the opening of the cereal import market, private Algerian operators can also intervene on the cereal and pulse import markets and the OAIC would no longer be the only public operator.[2] During the same period, the financial ease of Algeria experienced a gradual decline. In this unfavorable context, purchases from Algeria during this period were increasingly oriented towards countries that grant advantageous payment terms such as the United States through GSM[3] programs (GSM 102: 1 to 3 years, GSM 103: 1 to 7 years) which are carried out within the framework of the BICEP[4] or BICEP/EEP[5] sales procedures and which are accompanied by facilities and bonuses. Deliveries of American wheat during the 1990s to Algeria were around 45% of the total imported quantities of wheat. For Canada, wheat sales are made through government credit lines. The share of imports from Canada is over 27%. Moreover, for the countries of the European continent and in particular France, sales of European wheat to Algeria are made through COFACE[6] credits. The share of imports from the European continent is over 30% (Bencharif *et al*., 1996; Baba-Khelil, 1998). The practice of purchases on lines of supplier credit has become common and it now constitutes a normal approach in the behavior of a large public operator such as the OAIC (Bencharif *et al*., 1996).

To deal with the important aspect of imports and regulation of the domestic market, the OAIC is still the beneficiary of the immense amounts granted by the Algerian Public Treasury to support the prices paid in the wheat sector in Algeria, to producers, processors and consumers. With this context, it is still in a difficult financial situation. Indeed, the support granted to the wheat sector has increased from 30 billion DZD in the early 1990s to more than 200 billion DZD in 2021, an increase of 566%. It should be noted that the private operators who intervene in the wheat import market recorded a considerable decline during the food price crisis from 2007 to 2008, falling from 55% in 2005 to 18% in 2007 and 0.2% in 2008 (Hamadache, 2015).

In terms of wheat prices, Figure 1 displays the evolution of international and domestic prices of wheat (in US$ per metric ton) from 1965 to 2021. From 1965 to 2000, the evolution of domestic prices are above international prices except for the post-independence decade,

where domestic prices are below international prices. This can be explained by strong public intervention in the administration of producer prices. This period is characterized by the implementation of the Agricultural Structural Adjustment Program (PASA) which embodied a drastic reform of agrarian structures. This difficult socio-economic situation experienced by the country is explained by the decline in resources after the fall in oil prices in 1986. In this unfavorable context, the government maintained considerable support only for wheat sector.



Source: World Bank Data and MADR, 2022.

Figure 1. Evolution of International and Domestic Wheat Prices in Algeria (1965-2021)

The period from 2000 to today, it has indeed been characterized by two trends: The first from 2000 to 2008, domestic prices are still above international prices but they are getting closer to each other. The second from 2008 to the present day, the domestic prices of wheat are gradually moving away from international prices and this can be explained by the upward increase in the purchase price of wheat production decided by the Algerian government in 2008 following the international crisis in the prices of the main basic foodstuffs. Also, the government through the Council of Ministers of January 16, 2022 revised, once again upwards, the production prices of cereals to settle at $425.23/ton the purchase price of durum wheat and at $248.05/ton the purchase price of common wheat if taking a parity of $141.1/AD until August 2022. The evolution of the wheat production price is regularly readjusted by the government in line with inflation. In addition, customs tax imposed by the government allow national prices to be well above world prices.

Currently, at the level of the OAIC, the examination of any consultation of an international market is carried out through a regulatory committee. Subsequently, all suppliers wishing to contract a supply deal must present a file authenticated by the Algerian consular authorities in the country where the applicant company is registered in the commercial register. Purchasing is then carried out by the *ad hoc* inter-ministerial purchasing commission established by Presidential Decree no. 15-247.[7] With this context, all OAIC purchases are forward purchases and optional origins, in accordance with the specifications reported by the specifications relating to each product and they are made in CFR[8] and not in FOB.[9] The cost of transporting durum wheat is very expensive because almost all of the quantities purchased come from the North and South American continents both on the Atlantic and Pacific coasts, i.e. longer maritime rotations, average of 20 days and therefore more expensive. Currently, 70% of the quantities of durum wheat purchased come from Canada. While the cost of transporting common wheat is less expensive due to the fact that 60% of the quantities purchased come from the European Union with an average maritime rotation of 7 days of navigation, of which 50% comes from France with a maritime rotation of a period of 5 to 6 days. It should also be noted that the specifications of the OAIC have undergone modifications from 2020 on certain technical conditions and standards required in order to diversify the origins of wheat and ensure competitiveness for the benefit of the OAIC between providers. Indeed, the technical modifications made concern the rate of pinned grains, instead of being previously fixed at 0.1%, it can be increased to 0.5%. With these new specifications, the purchases of the OAIC will no longer be oriented towards a specific origin, but will give access to more origins meeting the technical provisions listed in the new specifications, which will allow the OAIC to have a wider diversification of suppliers around the world and therefore at competitive prices.

World cereal production (all species combined) recorded in 2020/2021 is 2,796 million tons over an area of 723 million ha, i.e. an average yield of 3.86 tons/ha, thus representing 52% of arable land and 14% of the world's agricultural area (USDA, 2022). Wheat, which is one of the first plants to have been cultivated more than 10,000 years ago, remains the main cereal in temperate climates (Madignier, 2011; Denieulle, 2019; Abis, 2015; Cruz *et al*., 2019). Indeed, the world production of wheat was estimated during the 1880s at 50 million tons (Abis, 2015). With agronomic and machinery progress, the areas and production of wheat have experienced a highly significant increase. Currently, world wheat production varies between 730.9 million tons to 774.7 million tons over an area that fluctuates between 215 to 220 million hectares (USDA, 2021; IGC, 2022). Wheat is unquestionably the most traded agricultural commodity globally (Abécassis *et al*., 2009; Bencharif *et al*., 2010; Madignier, 2011; Charmet *et al*., 2017).

The wheat market is dominated by an oligopoly of supplying countries which account for more than 90% of wheat trade. From this perspective, the major world exporters of wheat are generally industrialized countries such as the United States, the European Union (mainly France, Germany and the United Kingdom), Canada, Argentina, Australia, Russia and Ukraine. While wheat importing countries are often developing countries. The most important are North African countries such as Egypt and Algeria, the Middle East such as Iraq, some Southeast Asian countries (Indonesia, Japan), and some Latin American countries, such as Brazil and Mexico. However, some countries or groups of countries such as the European Union and the United States, which are major exporters, are also importers, especially of durum wheat (high protein content, i.e. $\geq$ 14.5% of dry matter) from the United States or Canada (Abecassis *et al*., 2009; USDA, 2021). Charmet *et al*. (2017) emphasizes the importance of the protein content criterion, which is binding on all market players: traders, collection organizations and, ultimately, farmers as the main criterion for market access. On this point, it should be noted that the quality of French wheat in terms of protein content occupies the last position compared to major exporting countries such as Russia, Ukraine or Argentina (L'Helgouac'h

& Leygue, 2010; Charmet *et al*., 2017). As such, in December 2013, the French cereal inter-profession adopted a "Tender Wheat Protein" plan, in order to meet market needs with good quality protein reserves and high yields.

The grain trade is dominated by five firms, or rather five international groups: Cargill, Continental, Louis Dreyfus, Bunge, and André. They all developed in Europe except Cargill of purely American origin, which later came to international affairs. All companies have become largely transnational: Cargill controls 140 companies in 36 countries (Morgan, 1980; Abis, 2015). As such, the purchase and sale of cereals and other raw materials is carried out via futures contracts and options contracts on the stock exchanges. There are several places in the world: MGEX in Minneapolis and Minnesota, CBOT in Chicago and Illinois and KCBT in Kansas City and Missouri. Outside the United States, Euronext in Europe. Futures trading allows traders to buy and sell the right to a quantity of grain of a given quality, delivered at a specific time in the future (Mcfall & Fowler, 2009; Declerck & Portier, 2009 ; Ghazi, 2011). Mcfall & Fowler and even Declerck & Portier (2009) point out that the prices displayed on the futures market are not prices practiced in reality. To this FOB forward price is added a FOB premium also called "base" and which represents the various costs added for the preservation of quality (fumigation, storage, pest control) and the mandatory costs related to the movement grain from the field to the final point of sale. Other premiums are also added, thus modifying the real structure of wheat prices. These are American bonuses and European refunds aimed at obtaining privileged agreements with importing partners.

If only one out of six hectares of cereals takes part in international trade, a bad harvest or a geopolitical conflict in one of the planet's granaries has immediate consequences on the markets. With this context, the Russian-Ukrainian conflict, which began in March 2022, abruptly interrupted all wheat exports from Ukraine and a large part of those from Russia which transit through the Black Sea, which caused the surge prices of wheat and other staple foods in agricultural markets. In such a context, a major wheat exporter like India has banned the export of wheat since May 2022, favoring its domestic market. The reproduction of this sort of action can only accentuate the international tension in wheat market prices. It remains to know the repercussions of the vicissitudes of this international market on the wheat sector in Algeria.

3. Research Methodology

3.1 Data Sources

The annual data used for this study come from two different sources: The annual world prices of durum wheat (Wheat US HRW) and common wheat (Wheat US SRW) expressed in USD/metric ton are taken from the Commodity Markets Outlook of the World Bank for the period from 1965 to 2021. The international price of wheat refers at FOB Grade 2 Red Winter Wheat Price U.S. Ports. For the Algerian wheat market, the data provided from the agricultural statistical yearbooks of the Ministry of Agriculture and Rural Development (MADR, 2021) for durum and common wheat. The data extends from 1965 to 2021 for which data were available.

3.2 Modeling Procedure

In order to empirically analyze the relationship between the price series of durum and common wheat and its price in the international market, the standard approach of Engle-Granger (1987) is used because of the possible non-stationarity of the data. However, the long-term equilibrium relationship between the two prices must be estimated by the following equation:

$$P_t^{IN} = \beta_0 + \beta_1 P_t^D + \epsilon_t \quad (1)$$

where P_t^{IN} represents the international price of the cereal, and P_t^D represents the domestic prices. The error term is represented by ϵ_t which can be serially correlated. The random error term captures the effect of unobservable variables such as transaction costs, public intervention mechanisms which may constitute an implicit import tax and which subsequently influence the speed of adjustment of domestic prices to international price shocks. If ϵ_t is stationary, the two prices P_t^{IN} and P_t^D are conintegrated, which implies that they are linked by a long-term stable equilibrium relation.

The coefficient β_0 is an arbitrary constant that takes into account transfer costs and quality differences, and β_1 represents the transmission elasticity of long-term prices. It measures the proportion of variations of P_t^{IN} and P_t^D. Several factors influence the degree to which world price fluctuations are transmitted to domestic markets, such as the trade policies applied to imports. A fixed import tax can reduce the long-run transmission elasticity.

The Engle-Granger approach illustrates that cointegration exists if $\epsilon_t \backsim \boldsymbol{I}(0)$, the residuals of this equation are used to estimate the following relationship:

$$\Delta\epsilon_t = \rho\epsilon_{t-1} + \varepsilon_t \quad (2)$$

Rejection of the null hypothesis of no cointegration (i.e., $\rho \neq 0$) implies that the residuals of the long-term equilibrium equation are stationary. The empirical literature on agricultural commodity analysis has argued that if the price transmission is asymmetric, then the standard tests of cointegration and its extensions would be ill-designed and, therefore, it is considered that another error correction specification would be more adequate, it is called the autoregressive threshold model (TAR). So when we incorporate this specification into the previous equation (2), we get:

$$\Delta\epsilon_t = I\rho_1\epsilon_{t-1} + (1-I)\rho_2\epsilon_{t-1} + \varepsilon_t \quad (3)$$

ϵ_t is the residual of relation [1], such that ϵ_t is independent of ε_t. I is an indicator variable such that:

$$I = \begin{cases} 1 & \text{if } \epsilon_{t-1} \geq \tau \\ 0 & \text{if } \epsilon_{t-1} < \tau \end{cases}$$

where τ is the endogenously estimated threshold. This specification allows for asymmetric adjustment, where ρ_1 and ρ_2 represent the speed of the adjustment coefficients. Since the long-term equilibrium is given by $\Delta\epsilon_t = \tau$, if $\rho_1 = \rho_2$, then the adjustment is said to be symmetric; and if the fit is not symmetric, asymmetry may occur in the series. If $\rho_1 \neq \rho_2$ and $\Delta\epsilon_t$ is higher (or lower) than its long-term equilibrium, the adjustment will be given by ρ_1 (or ρ_2). In this case, the threshold is of crucial importance, because it implies that the movement towards long-term equilibrium does not take place at all times but only when the deviation from equilibrium exceeds this threshold.

An alternative is suggested such that the threshold depends on the previous period changes in ϵ_{t-1} and the ϵ_t series exhibit more momentum in one of the directions which is called the momentum threshold autoregressive (M-TAR) model. . In this case, the indicator variable is defined using lagged changes of $\Delta\epsilon_t$, i.e.

$$I = \begin{cases} 1 & \text{if } \Delta\epsilon_{t-1} \geq \tau \\ 0 & \text{if } \Delta\epsilon_{t-1} < \tau \end{cases}$$

The Engle-Granger theorem (1987) states that an error correction model can be estimated where all the variables are cointegrated with the assumption that the adjustment process due to the disequilibrium between the variables is symmetric. To analyze the asymmetric transmission of prices, Enders & Siklos (2001) propose an extension of the test strategy of Engle & Granger (1987) based on two approaches two models: thresholds autoregressive model (TAR) and momentum thresholds autoregressive model (M-TAR). However, the TAR model can capture deep asymmetric movements in a series, while the M-TAR model is particularly useful in capturing the possibility of abrupt or deep asymmetric movements in a series (Enders & Granger, 1998).

The M-TAR model used allows a variable to display different degrees of autoregressive decay depending on whether it is increasing or decreasing. This contrasts with the tests of Engle & Granger (1987) and Johansen (1996) which implicitly assume a linear adjustment mechanism. The nature of the asymmetry in an M-TAR type modeling differs fundamentally from the Houck (1977) approach and even from the asymmetric ECM approach. Indeed, the M-TAR model has been applied by some authors, such as Harper & Goodwin (1999), Hassan & Simioni (2001), Goodwil & Piggott (2001), Abdulai (2002), Adingra & Dedewanou (2016), Osseyi (2017) and Tuncay & Ozgur (2021) in different contexts in agriculture, as it is applied elsewhere (consumption of different products, prices at the loading rack of refineries and even in the financial field). Particularly for wheat market, this empirical model was applied frequently in many countries, e.g. Mainardi (2001), Balcombe *et al.* (2007), Brümmer *et al*. (2009), Ghoshray & Ghosh (2011), Hassanzoy *et al*. (2017), Cinar (2018), Alam & Jha (2020).

In addition, Granger & Lee (1989) found that US sales, production, and inventory exhibit asymmetric error correction toward a long-run multiple cointegrating relationship. They decompose the error correction terms (ECT) and the first differences on the variables into positive and negative components (equation 4). In this way, it is possible to know whether positive and negative price differences have asymmetric effects on the dynamic behavior of prices. The consistency of these specifications and assumptions made it possible to build the following error correction model:

$$\Delta P_t^{IN} = \beta + \alpha^{+}\Delta P_t^{IN+} + \alpha^{-}\Delta P_t^{IN-} + \delta^{+}\Delta P_t^{D+} + \delta^{-}\Delta P_t^{D-} + \lambda^{+}EC_t^{+} + \lambda^{-}EC_t^{-} + \omega_t \quad (4)$$

This method, first used for price transmission by von Cramon-Taubadel & Fahlbusch (Mayer & von Cramon-Taubadel, 2004). A more general specification of ECM was used by von Cramon-Taubadel & Loy in 1999 (Mayer & von Cramon-Taubadel, 2004), in which the error correction term and exogenous price changes are segmented.

The two lagged prices are divided into two components: positive and negative, as indicated by the superscripts. The error correction terms are constructed from the threshold cointegration regressions in the previous equations. The adjustment speed asymmetry is checked by defining the positive or negative disequilibria terms using λ^{+} and λ^{-}. We use α^{+}, α^{-}, δ^{+}, δ^{-} to capture short-run asymmetries. This empirical model through equation (4) will be reproduced twice for the wheat value chain in Algeria. The first for international and domestic durum wheat prices, the second for international and domestic common wheat prices.

4. Results and Discussion

In this section, we explore and discuss the asymmetric speed of price adjustment in the Algerian wheat sector. To analyze price asymmetry in the two wheat sectors, we use the logarithms of average annual prices of durum and common wheat. We first analyze the cointegration of the studied series.

Table 1 represents the results of the unit root tests (through the ADF test) and the cointegration of wheat prices. According to the results of the ADF test, it turns out that, for the two periods chosen, the variables do not present unit roots. The results are very significant for the regression cases with drift and trend also for their first differences. On the other hand, the cointegration test confirms the existence of cointegration relationships between international prices and domestic prices of durum wheat and common wheat for the two periods (1965 to 1999) and (2000 to 2021).

We estimate the long-term relationship between the two international and domestic prices of durum wheat and common wheat by following the Engle-Granger (1987) approach as specified. The results of the regressions are presented in Table 2. In Table 3, the residuals are used to perform a unit root test with the specification as TAR, Consistent TAR, M-TAR, and Consistent M-TAR models. We use the thresholds, $\tau = 0$ for TAR, $\tau = 0.936$ for coherent TAR, $\tau = 0$ for M-TAR and $\tau = -0.029$ for coherent M-TAR. To estimate threshold values for consistent TAR and M-TAR, we follow the methodology introduced by Chan (1993). We chose 2 lags based on Akaike's Criterion (AIC) statistics and also found that different lag specifications in the models have little impact on the final threshold values selected.

Table 1. Results of Tests for Unit Roots and Cointegration of International and Domestic Prices of Durum Wheat and Common Wheat

ADF Tests for Unit Roots							
		1965-1999			2000-2021		
		Level with only drift	with drift and trend	First difference	Level with only drift	with drift and trend	First difference
Durum Wheat	P^{in}	-0.135 (-1.332)	-0.568 (-3.797)**	-0.847 (-4.762)***	-0.258 (-1.626)	-0.323 (-2.014)	-0.785 (-2.091)*
	P^{d}	0.031 (0.418)	-0.564 (-3.716)**	-1.911 (-1.624)	-0.151 (-1.539)	-0.625 (-3.235)**	-0.408 (-1.064)
Common Wheat	P^{in}	-0.332 (-1.742)	-0.855 (-3.47)***	-0.902 (-3.819)***	-0.303 (-2.204)	-2.727 (-2.156)	-1.193 (-1.895)
	P^{d}	1.295 (0.352)	-8.809 (-1.560)	-1.39 (-6.361)***	-0.690 (-1.413)	-1.222 (-1.353)	-1.435 (-7.39)***
Cointegration Tests							
	Rank	Eigenvalue	Trace	p-value	Lmax	p-value	
Durum Wheat	0	0.244	9.685	0.311	9.542	0.249	
	1	0.004	0.142	0.705	0.142	0.705	
Common Wheat	0	0.143	9.094	0.363	6.492	0.558	
	1	0.060	2.601	0.106	2.601	0.106	

Table 2. Results of Regressions of the Long-term Equilibrium Relationship of Cereals

	Durum Wheat		Common Wheat	
	1965-1999	2000-2021	1965-1999	2000-2021
β_0	8.652 (16.2)***	1.847 (1.29)	7.328 (10.3)***	−0.868 (−0.45)
β_1	−0.150 (−6.01)***	0.142 (2.48)**	−0.100 (−2.99)***	0.261 (3.22)***
$\hat{R}^2$	0.508	0.198	0.284	0.308
F-test	36.1***	6.19**	8.94***	10.37***
D.W.	0.919	0.842	1.032	1.430

Note: Values in parentheses represent t-ratios. The asterisks for the level of statistical significance: *** for 0.1%, ** for 1%, * for 10%.

The *t*-statistic for the coefficient of μ_{t-1} is equal to −2.719. Thus, the cointegration test confirms that the two price series are cointegrated at the 1% level. Nonlinear cointegration analysis is performed using threshold autoregression models. The estimated residuals of TAR, Consistent TAR, M-TAR and Consistent M-TAR models are presented in Table 3. The values of TAR, Consistent TAR and Consistent M-TAR models are significant at the 1% level, M-TAR is significant at the 5% level and the results indicate that two series are cointegrated. The null hypothesis according to which the adjustment coefficients are equal ($\rho_1 = \rho_2$) is also rejected for the TAR, coherent TAR and M-TAR coherent models. The equality of adjustment coefficients is not rejected only in the M-TAR model. By performing a model selection test by Akaike's criterion, we conclude that the consistent model TAR is appropriate to be selected. Therefore, the results of the model estimation suggest that the consistent TAR model detects asymmetry better than the other models.

Table 3. Results of Threshold Cointegration Tests

		TAR	Consistent TAR	MTAR	Consistent MTAR
Durum Wheat	τ	0	0.936	0	−0,029
	ρ_1	−0.632 (−2.719)***	−0.511 (−1.225)*	−0.175 (−1.649)*	−0.1987 (−1.942)*
	ρ_2	−0.536 (−1.953)*	−0.744 (−3.905)***	−0.018 (−0.108)	−0.191 (−5.696)***
	AIC	−14.872	−4.086	−38.193	−47.582
	F	7.394***	1.082	2.720	3.770*
Common Wheat	τ	0	0.539	0	−0,064
	ρ_1	−0.405 (−0.018)	−0.298 (−21.52)***	−0.236 (−1.976)*	−0.249 (−1.983)*
	ρ_2	−0.185 (−2.303)**	−0.207 (−2.893)***	−0.432 (−1.656)	−0.146 (−2.993)***
	AIC	−8.220	−12.174	−44.556	−44.080
	F	2.389*	1.839	3.903*	3.931*

Note : Values in parentheses represent t-ratios. The asterisks for the level of statistical significance: *** for 0.1%, ** for 1%, * for 10%.

Thus, these results indicate an asymmetric adjustment and suggest that domestic prices and international prices are cointegrated in Algerian wheat sector. The values of the adjustment parameters (ρ_1 and ρ_2) have the correct signs and suggest convergence. But estimates also suggest that declines in international prices are eliminated faster than price increases. The positive deviations from the long-term equilibrium resulting from price increases or decreases are eliminated at the rate of 51 and 29 per year for durum wheat and common wheat respectively. Negative deviations from the long-term equilibrium resulting from price increases or decreases are eliminated at 74 and 21% per year for durum wheat and common wheat respectively. Therefore, there is a noticeably slower convergence for positive deviations (above the threshold) from the long-term equilibrium compared to negative deviations (below the threshold).

The demonstration of an asymmetric cointegration leads to the estimation of an ECM with an asymmetric long-term equilibrium. Long-term adjustments may vary based on prior period changes in long-term error terms. The cointegration model with consistent TAR adjustment justifies the estimation of the error correction model as specified in equation (4). We estimate the asymmetric error correction model with threshold cointegration and our results are presented in Table 4.

Table 4. Results of Asymmetric Error Correction Model with Threshold Cointegration

Coeff.	Durum Wheat		Common Wheat	
	1965-1999	2000-2021	1965-1999	2000-2021
β	−0.023 (−0.438)	0.104 (1.137)	0.056 (0.866)	−0.022 (−0.380)
α^+	0.160 (0.474)	0.515 (1.176)**	−0.817 (−1.520)	0.852 (2.594)**
α^-	0.656 (1.964)*	0.602 (1.331)**	1.250 (3.178)***	−0.159 (−0.388)
δ^+	0.024 (0.320)	−0.031 (−0.259)	−0.013 (−0.256)	−0.098 (0.827)
δ^-	−0.014 (−0.139)	−0.052 (−0.234)	−0.014 (−0.185)	0.063 (0.438)
λ^+	−0.302 (−1.185)*	−0.963 (−2.621)**	−0.413 (−1.415)*	−0.575 (−2.071)*
λ^-	−0.745 (−2.434)**	−0.064 (−0.145)	−0.995 (−2.96)**	−0.857 (−1.754)*
$\hat{R}^2$	0.203	0.240	0.446	0.390
F	2.406**	2.052*	3.558**	3.138**
D.W.	1.944***	1.975***	1.973***	1.514*

Note: Values in parentheses represent t-ratios. The asterisks for the level of statistical significance: *** for 0.1%, ** for 1%, * for 10%.

As shown in Table 4, the short-term coefficients α^+ and α^- suggest the presence of price asymmetries. This result suggests that a threshold specification of the long-term mechanism provides a more plausible representation of the relationship between international and domestic durum and common wheat prices. For the international price of durum wheat, the response to positive changes seems weak, i.e. 0.160 during the period from 1965 to 1999 against a strong response of 0.515 with a high level of significance during the period from 2000 to 2021. This means an elasticity at relatively strong short term for durum wheat imports during the period from 2000 to 2021 compared to the previous period. While in the negative sense, the short-term asymmetric coefficients recorded with a level of significance are almost similar, i.e. 0.656 for the period from 1965 to 1999 and 0.602 for the period from 2000 to 2021. As for the speed of adjustment to positive disequilibria rises to 96.3% with a high level of significance during the period from 2000 to 2021 while it is less low (6.4%) for negative disequilibria. While during the period from 1965 to 1999, we observed that the speed of adjustment to positive disequilibria is weak (30.2%) while it is strong in the negative sense (74.5%) with a high level of significance during the same period (1965/1999). The fact that durum wheat price adjustment speeds are higher than declines during the period from 2000 to 2021 compared to the previous period from 1965 to 1999, this would confirm the existence of an overbilling of the purchase of durum wheat. This situation is not to the advantage of the Algerian government, which still has to suffer from price increases on international markets.

For the international price of common wheat, the short-term response to positive changes seems very strong with a level of significance, i.e. 0.852 during the period from 2000 to 2021 against a negative response during the same period, i.e. −0.159. As for the period from 1965 to 1999, the response recorded in the positive direction is −0.817 while in the negative sense, the response recorded is 1.250 with a high level of significance. The analysis of the asymmetric

short-term dynamics shows that a 1% increase in the international price change of common wheat leads to an increase in the domestic price change of around 85% during the period from 2000 to 2021 against domestic price change of less than 82% during the previous period.

Regarding the speed of adjustment to positive disequilibria, it is higher (57.5%) during the period from 2000 to 2021 compared to the rate recorded (41.3%) during the period from 1965 to 199. The speed of adjustment to negative changes in common wheat recorded during the period from 1965 to 1999 is higher (99.5%) from the previous. As for the period from 2000 to 2021, the speed of adjustment to negative changes is also significantly high (85.7%). This can be explained by the fact that the deviations of common wheat prices are higher than the declines during the period from 2000 to 2021 compared to the previous period from 1965 to 1999, and this would also confirm the existence of overbilling the purchase of common wheat, accentuated by the depreciation of the value of the Algerian currency. Indeed, wheat imports were multiplied by 10 in Algeria between the years 1966-69 (698,500 tons) and 2000-2005 (6,796,000 tons), to reach about 8 million tons nowadays.

This situation is not to the advantage of the Algerian government, which has yet to suffer from the increases in the prices of durum wheat and common wheat on the international markets. The presence of negative asymmetry observed during the long period from 1965 to 2021 could have serious consequences on the government budget. Wheat, being a key foodstuff in Algeria, is anchored in household consumption habits, the fact that the prices of durum wheat and common wheat adjust more quickly to increases more than to decreases could increase the import bill.

5. Conclusion

The objective of this paper was to analyze the transmission of international price shocks to the domestic market price of wheat in Algeria. The main hypothesis tested is the existence of asymmetry in price transmission. This hypothesis assumes that prices on domestic markets respond more quickly to international price increases than to decreases.

This study uses price data series on wheat in Algeria over the period from 1965 to 2021 (56 years) from two different sources: the Commodity Markets Outlook of the World Bank and the agricultural statistical yearbooks of the Algerian Ministry of Agriculture and Rural Development. This study uses the threshold cointegration technique that allows an asymmetric adjustment towards a long-term equilibrium relationship to examine the relationship between international and domestic wheat prices in Algeria.

The asymmetric error correction model with threshold cointegration provides strong evidence supporting asymmetric price behavior. The results obtained can be summarized as follows: For the international price of durum wheat, the response to positive changes seems weak, i.e. 0.160 during the period from 1965 to 1999 against a strong response of 0.515. As for the speed of adjustment to positive disequilibria, it rises to 96.3%, while it is less low (6.4%) for negative disequilibria. For the international common wheat price, the short-term response to positive changes seems very strong, i.e. 0.852 during the period from 2000 to 2021 against a negative response during the same period, i.e. −0.159. Regarding the rate of adjustment to positive disequilibria, it is greater (57.5%) during the period from 2000 to 2021 compared to the speed recorded (41.3%) during the previous period from 1965 to 1999.

These results highlight that an overbilling of the purchase of wheat can exist especially during the period from 2000 to 2021 compared to the previous period (1965-1999). This could also be explained by the higher costs related to the cost of transport, port costs and customs costs and other costs on purchase. The additional costs related to demurrage and which increase the cost of purchasing imported wheat are mainly due to the lack of reception quays and, in other cases, to management problems and conflicts between the port authorities and the services of OAIC. responsible for receiving grain import vessels (Ammar, 2014).

Also, this study highlighted the mode of forward purchase with an optional origin which was exercised during the years from 2000 to 2021 compared to the previous period (1965/1999). This situation is not to the advantage of the Algerian government, which still has to suffer from the rises in the prices of durum wheat and common wheat on the international markets, insofar as there will be a more exaggerated recourse by 2040 to the option of importing wheat which only increases the food bill (Bekkis *et al*., 2022). Actions will have to be designed and carried out by the Algerian government in order to reduce these shortcomings through the improvement of the supply chain of the wheat import sector, to re-examine the current mechanisms of regulation, organization and coordination of the domestic market wheat.

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[1] Abbreviation for *Office Algérien Interprofessionnel des Céréales*. Created by ordinance on July 12, 1962.

[2] Currently, the Algerian government has decided to entrust the import mission, exclusively, to the OAIC (Council of Ministers of February 8, 2022).

[3] Credit Guarantee Program.

[4] Bonus Incentive Export Program.

[5] Enhancement Export Program.

[6] Abbreviation for *Compagnie Française d'Assurance pour le Commerce Extérieur*.

[7] Presidential Decree no.15-247 of September 16, 2015 regulating public procurement and public service delegations.

[8] Incoterm Cost and Freight means that the seller pays for the pre-transport of the product to the port of shipment, as well as the loading and the main maritime transport.

[9] Incoterm Free on Board means that the seller is responsible for the product only until it is loaded on board a vessel, in which case the buyer is responsible.