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Multi-Level Analysis of Wheat Import Sensitivity in IGAD Countries: From Country-Level Elasticities to Regional Causal Dynamics

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ABSTRACT

This paper explores how wheat import volumes in Intergovernmental Authority on Development (IGAD) countries respond to global price changes, and whether these reactions vary across countries or over time. Wheat is a critical staple in the region, and its import dynamics are increasingly important as the bloc faces recurring shocks like drought, conflict, and global price spikes. Using a two-pronged approach, we first apply country-level autoregressive distributed lag (ARDL) models and find long-run cointegration across all IGAD members. Eritrea and Ethiopia show strong long-run negative price elasticities, pointing to substitution or price-sensitive behavior. South Sudan, Sudan, and Somalia display short-run positive responses, likely linked to urgent procurement or aid-related deliveries. Uganda shows limited responsiveness, while Djibouti—though also reactive in the short term—likely reflects its role as a re-export hub rather than fragility-driven volatility. Kenya shows both long-run sensitivity and short-run spikes, indicating a more complex market and policy mix. At the bloc level, panel Granger causality tests reveal a two-way relationship between global wheat prices and imports. Notably, imports also Granger-cause price shifts—an unexpected result suggesting that even uncoordinated regional import behavior may shape market expectations. This finding strengthens the case for more strategic procurement and regional storage mechanisms.

INTRODUCTION

Wheat is a vital component of the global food supply, particularly in regions with limited domestic production and high reliance on international markets (FAO, 2022a). The Intergovernmental Authority on Development (IGAD) region, comprising eight East African nations—Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, and Uganda—is one such area, characterized by significant fragility and food insecurity (IGAD, 2025). With a population exceeding 320 million (World Bank, 2025), most IGAD countries heavily depend on wheat imports to fulfill domestic demand, a reliance intensified by ongoing droughts, civil wars, economic challenges, and constrained agricultural capacity.

This pronounced fragility heightens its susceptibility to global wheat price fluctuations. Events such as the 2007–2008 food crisis, the 2022 price surge driven by the Russia–Ukraine conflict, and recent climate-induced production disruptions underscore the vulnerability of these fragile economies to external price shocks. Despite this structural exposure, the empirical literature has largely neglected the IGAD region, particularly regarding wheat import patterns and their sensitivity to global price trends.

This study fills the research gap by performing a multi-level analysis of wheat import sensitivity in IGAD member states. It examines how these countries, both individually and as a group, react to global wheat price volatility over time and explores whether their import behavior generates feedback effects that might shape market expectations. Understanding these dynamics is crucial for academic research and for guiding regional policy, particularly as IGAD nations pursue enhanced economic cooperation amid recurring supply chain challenges.

We frame the analysis around the following core research questions:

- How do IGAD countries differ in their responsiveness to global wheat price changes?
- Are these responses observed in the short run, the long run, or both?
- Does the bloc exhibit collective import behavior that contributes to or reacts to global price dynamics?
- What do these empirical patterns imply for regional procurement, storage strategies, and food security policy?

To investigate these issues, we employ a dual econometric approach. At the country level, we utilize autoregressive distributed lag (ARDL) models, as developed by Pesaran et al. (2001), to evaluate both short-run and long-run price elasticities of wheat imports. This method accounts for each country’s distinct institutional, economic, and climatic conditions, enabling a tailored analysis of import behavior. At the regional level, we apply panel Granger causality tests, as proposed by Juodis et al. (2021), to examine whether IGAD’s collective import volumes respond to global price fluctuations and, intriguingly, whether they also exert influence on those prices.

This study offers three key contributions to the literature. First, it brings the IGAD bloc into the discourse on wheat price volatility through a robust empirical approach, addressing a critical geographic and thematic gap. Second, it combines micro-level (country-specific) and macro-level (bloc-wide) econometric methods, providing a pioneering multi-scale framework for analyzing commodity import sensitivity. Third, it delivers actionable insights for policymakers: the finding that IGAD imports Granger-cause global price shifts, even without a coordinated procurement strategy, indicates the bloc’s latent market influence. Leveraging this through joint procurement mechanisms, shared storage infrastructure, and improved import planning could bolster food security and mitigate price vulnerability across the region.

Wheat Export (Supply), Import (Demand) and Price Cycle: General Mechanics

Wheat is a fundamental global commodity. It is not just like any tradable item, but a critical component of global food security. Its versatile nature makes it so important that disruptions in its export (supply) or major shifts in its price can have severe implications for countries that depend on it. This importance is notable in the global consumption trend. In just under a decade worldwide import (demand) rose from 161.9 million tons in 2014 to 211.3 million tons in 2023, an increase of over 30% as Shown in Figure 1.

Export (supply) volumes followed a similar trend, with periodic downturns caused by demand shocks and supply disruptions as shown in Figure 2.

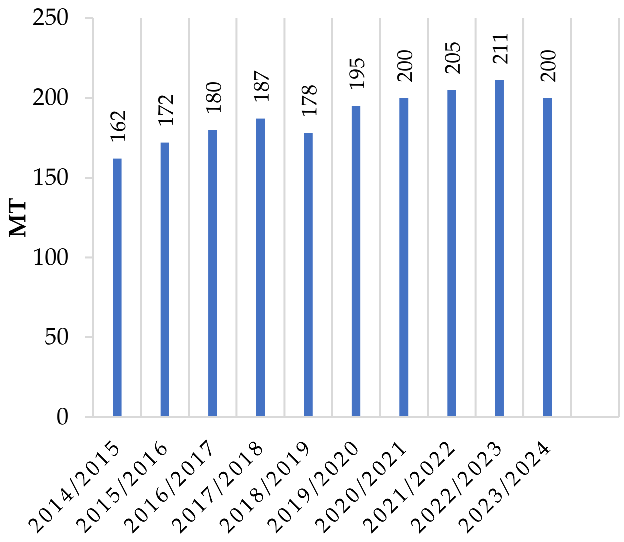

Figure 1. Global wheat demand (import) volume (Source: Statista, 2024a)

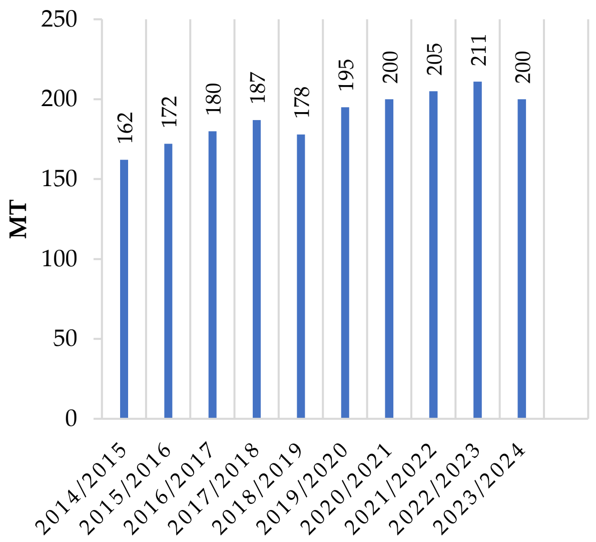

Figure 2. Global wheat supply (export) volume (Source: Statista, 2024b)

Global wheat price dynamics are shaped by interacting supply and demand factors. On the supply side, weather extremes, input costs, geopolitical tensions, and chokepoints like the Suez Canal create sudden shocks. On the demand side, wheat's staple status and government-driven procurement make adjustments slow. These structural pressures explain the sharp price swings observed in global markets.

Volatility Transmission: From Global Prices to Domestic Availability and Affordability

When global wheat prices spike, importing countries all face the same basic challenge: securing enough supply at an affordable cost. But they do not all cope equally. The transmission channel works through both affordability and availability.

Affordability refers to whether countries can pay for imports when prices rise. Many wheat-importing countries rely on foreign exchange reserves to finance these purchases. When global prices rise sharply, these countries must find additional foreign currency. This is especially hard for countries with floating exchange rates that tend to depreciate during crises. As their currencies weaken, the cost of wheat imports rises even more in local terms (IMF, 2022).

Availability is the other side of the problem. Even if a country can pay the higher price, there may simply not be enough wheat on the market to buy. Export bans, shipping disruptions, and competitive bidding from richer countries can limit physical supply. This dynamic was noticeable during the 2007–2008 and 2022 crises, when some exporters restricted shipments to protect local consumers, leaving importers scrambling to find supplies at any price.

Countries are not affecting equally and thus have different coping capacity.

- High-income, stable countries often have strong currencies and big reserves. They can navigate challenges fairly easily and even build up stocks during crises.
- Middle-income countries might use subsidies or tariff cuts to keep prices stable but often face budget constraints.
- Low-income and fragile states have limited fiscal capacity. They may be forced to reduce other essential imports to pay and prioritize this commodity or turn to donors and international agencies for emergency assistance (Headey & Fan, 2008).

Price Volatility in Import-Dependent Developing Countries and IGAD Bloc Particularity

The transmission mechanism applies to all import-dependent countries, regardless of region or income level, though capacity dramatically varies. However, the most exposed are the developing countries presenting the following factors:

- *Currency fragility*: Many developing countries have floating exchange rates and structurally weaker currencies. During global crises, investor confidence often drops, leading to currency depreciation. When this happens, the local cost of importing wheat rises even faster than the world price itself (IMF, 2022).
- *Limited fiscal space*: High-income countries can subsidize the commodity import or absorb higher costs without risking budget collapse. Developing countries often cannot. Subsidies strain public finances, and cuts elsewhere can lead to social tension.
- *High import dependence with little domestic substitution*: Many developing regions lack the climatic conditions or infrastructure to grow enough wheat locally. This dependency means they cannot quickly switch to other staples or local substitutes when prices rise.
- *Climate shocks* compound these problems. Many developing countries are in regions prone to drought, floods, and other extreme weather events. These reduce local food production just when imports become more expensive, deepening food insecurity (Wheeler & von Braun, 2013).
- Political instability is another factor. Conflicts, weak institutions, and poor governance can disrupt procurement, storage, and distribution. Even if wheat is imported successfully, getting it to consumers at stable prices can be difficult (World Bank, 2023).

The level of combination of these factors is a determinant element of the severity of the exposure to supply disruptions and price fluctuations. Given the structure of economic blocs in developing countries, the Intergovernmental Authority on Development (IGAD), in particular, stands out as a severely exposed bloc. It combines nearly all of these challenges in an extreme form, although there is a heterogeneity among country members.

- *Conflict and instability*: Somalia has experienced over 30 years of conflict. Sudan is currently going through a devastating civil war. South Sudan remains fragile since independence. Ethiopia had a devastating civil war from 2020 to 2022 that displaced millions (World Bank, 2023).
- *Protracted crises*: These conflicts are not one-off events but long-running, eroding institutions and social safety nets over decades.
- *Recurrent drought*: The Horn of Africa is among the world's most drought-prone regions. In recent years, multiple failed rainy seasons have caused massive food insecurity (FAO, 2022b).
- *Climate shocks*: Beyond drought, floods and locust invasions have further stressed food systems.
- *Currency fragility*: Except for Djibouti (which uses a USD-pegged currency), all IGAD countries have floating currencies that have depreciated significantly in recent years.
- *Weak fiscal capacity*: Limited ability to fund subsidies or strategic reserves.

This picture contrasts with other Regional Economics Communities (RECS) in the African continent or similar blocs elsewhere, where fragility exists but is usually not multi-dimensional or rarely comes all at once. Table 1 below illustrates the comparative fragility matrix pertaining to regional exposure to wheat import shocks.

IGAD Wheat Import Pattern and Trend

The Intergovernmental Authority on Development (IGAD) was established in 1996, as a successor to the Intergovernmental Authority on Drought and Development (IGADD), which was created in 1986 to address frequent droughts and food insecurity in the Horn of Africa. Today, IGAD includes eight countries: Djibouti, Eritrea, and Ethiopia, Kenya, and Somalia, South Sudan, Sudan, and Uganda— together home to more than 230 million people. Despite this shared platform, the region is marked by deep heterogeneity in terms of fragility to wheat import shocks as seen in Table 2.

Table 1. Comparative fragility matrix – regional blocs

Regional Bloc	Currency Fragility	Fiscal Space	Climate Shocks	Instability	Wheat Import Dependence	Overall Exposure
IGAD (East Africa)	High	Severely Limited	Very High (drought-prone)	Ongoing	High	Extremely High
ECOWAS (West Africa)	Mixed	Limited to Moderate	High	Fragile in Sahel Belt	High	High
SADC (Southern Africa)	Mixed	Moderate	High (Drought, floods)	Relatively Stable	Moderate	Moderate to High
AMU (North Africa)	Moderate to Strong	Better (Oil-driven)	Moderate to High	Transitioning regimes	Very high (Especially Egypt)	Moderate to High
SAARC (South Asia)	Moderate	Moderate	High (Floods, drought)	Nuclear Standoff Zone	Mixed (Net Importer overall)	Moderate
CARICOM (Caribbean)	High	Limited	High (Hurricane prone)	Generally Stable	Very High (Small Markets)	High

Note: Source: Author Compilation (Using information from World Bank, IMF, UNCTAD, FAO, EM-DAT, Fragile State Index, Uppsala Conflict Data Program).

Table 2. Comparative fragility matrix – IGAD member countries

Country	Currency Fragility	Limited Fiscal Space	Import Dependency With Little Substitution	Exposure To Climate Shocks	Instability	Overall Exposure
South Sudan	High	High	High	High	High	Extremely High
Somalia	High	High	High	High	High	Extremely High
Eritrea	High	High	Moderate	Moderate	Low	Very High
Sudan	High	High	High	Moderate	High	Very High
Ethiopia	High	Moderate	High	High	High	High
Djibouti	Low	Moderate	Moderate	High	Low	Moderate to High
Kenya	Moderate	Moderate	High	Moderate	Low	Moderate to High
Uganda	Moderate	Moderate	Moderate	High	Low	Moderate to High

Note: Source: Author Compilation (Using information from World Bank, IMF, UNCTAD, FAO, EM-DAT, Fragile State Index, Uppsala Conflict Data Program).

Wheat import in the IGAD bloc is handled entirely at the individual country level, depending on the national needs and severity of domestic shocks such as drought and conflict as seen in Figure 3. Country with a combination of high exposure to climate shocks and high instability tend to import more than those with relatively stable conditions, as domestic production is frequently disrupted and emergency procurement becomes the norm. This is case for Ethiopia, which recently embarked on an effort to reach national self-sufficiency in wheat production but recurring droughts, conflict-related displacement, and input shortages have continued to undermine domestic yields.

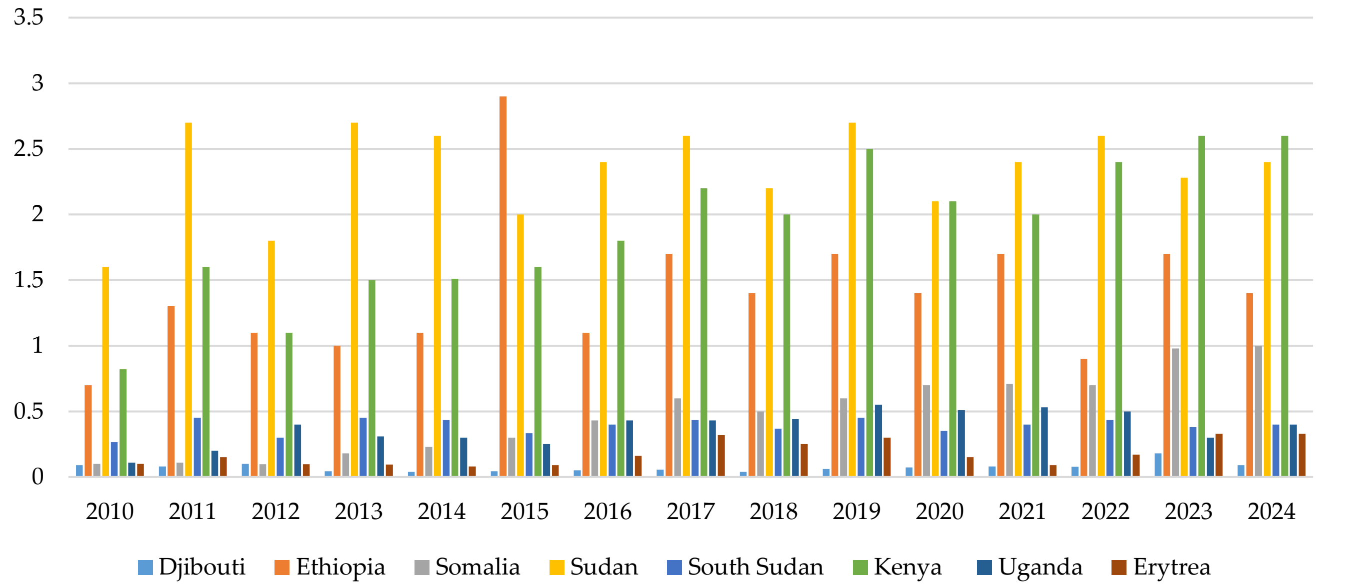

Figure 3. IGAD member countries wheat import per year (Source: Author Compilation (Using Indexmundi.com, Djibouti and South Sudan are estimated using respectively Ethiopia and Uganda Volume. Wheat import through Djibouti is mainly destined to Ethiopia while South Sudan procures wheat from Uganda)

As there is no regional purchasing strategy, no collective storage system, and no joint emergency response mechanism, each country acts on its own. This fragmented approach leads to reactive mechanism triggered by shortages or humanitarian emergencies—rather than based on pre-planned strategic reserve systems. In some cases, imports happen in a hurry after local crops fail or global prices surge, rather than in anticipation of such events. Even countries with some procurement capacity lack pro-activeness in the planning process (FAO, 2021; USAID, 2022).

The member countries import also exhibit a seasonal pattern, with volumes typically rising ahead of lean seasons or in anticipation of domestic shortfalls. For example, Ethiopia tends to ramp up wheat imports before the Meher harvest gap, while Sudan and Somalia adjust procurement based on rainfall forecasts and humanitarian needs. These seasonal surges, however, are not always well-coordinated or strategically planned, making countries more vulnerable when supply shocks occur unexpectedly.

Despite this lack of coordination, IGAD as a whole is a major wheat importer. The imports were on an upward trend as seen in Figure 4. The bloc imported over 8 million metric tons of wheat in 2024 campaign. This amount would place it among the top 5 wheat importers globally—alongside countries like Egypt, Indonesia, and China (USDA, 2023). But the lack of a joint procurement platform means IGAD countries miss out on potential advantages such as stronger bargaining power, shared transport logistics, and unified emergency reserves. individually, country pays individually—often under pressure—making the region more exposed and less competitive in the global market.

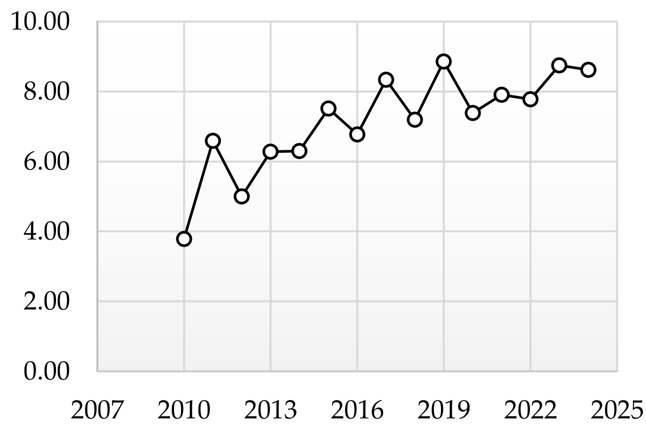

Figure 4. IGAD member countries combined wheat import per year (Source: Author Compilation (Using Indexmundi.com, Sum of individual countries imports)

Literature Review

As discussed in the theoretical background, there is an abundance of research exploring the price mechanics of wheat at the global level, especially how market shocks translate into volatility. Wheat prices are shaped by a combination of factors on both the supply and demand sides. On the supply end, studies have long established the role of climate variability, with droughts, floods, and extreme heat now becoming more frequent due to climate change (Wheeler & von Braun, 2013; Porter et al., 2014). At the same time, spikes in oil prices raise the cost of production and transportation, increasing the final price of wheat (Headey & Fan, 2010). Geopolitical disruptions—such as wars or trade bans—can further distort trade flows. The 2022 Russia-Ukraine war, for instance, disrupted one of the world's major grain corridors, causing a steep price surge (FAO, 2022c; World Bank, 2022). Another factor that adds fragility is the concentration of exports in a few countries—Russia, the EU, the US, Canada, and Australia. When any of these faces' disruptions, the ripple effects are global. Finally, chokepoints like the Black Sea corridor or the Suez Canal play a disproportionate role in maintaining trade flows, making the system highly sensitive to localized disruptions.

On the demand side, wheat is inelastic in the short term—people cannot easily replace it with alternatives—which means even small supply shocks can lead to big price jumps (Bobenrieth et al., 2013). Moreover, wheat trade in many countries is not consumer-driven but managed by governments and large millers, often with strategic stockpiling goals. During crises, states may even import more at high prices to avoid unrest. This behavior often contradicts standard economic models that expect demand to fall as prices rise. As Wright (2011) and Wright & Williams (1982) explain, this mismatch—rigid demand meeting unstable supply—makes the wheat market particularly vulnerable to cycles of spikes and shortages. When stocks are low, these effects are magnified, as seen during the 2007–2008 crisis. Lastly, policy responses like export bans, often meant to secure domestic markets, can actually make the global situation worse (Martin & Anderson, 2012).

On a parallel track, multilateral organizations have published policy papers addressing the challenges faced by low-income and fragile states in dealing with wheat supply shocks and price volatility. These contributions often approach the problem from a resilience-building perspective. FAO et al. (2024) has highlighted the importance of strengthening national grain reserves and regional early warning systems. USAID (2022) emphasizes the need to improve procurement strategies and storage capacity. The World Bank (2023) recommends integrated food security frameworks that include fiscal policy instruments, trade policy reforms, and targeted safety nets. However, these reports often remain broad in scope, and while they highlight the weaknesses, they do not always provide data-driven insights into the effectiveness of national or regional responses.

Post-2020 syntheses call for strengthening national reserves, targeted social protection, and macro-fiscal buffers alongside diversified sourcing to bolster resilience (FAO et al., 2024). Global reviews emphasize that elevated food and fertilizer costs, currency depreciation, and climate shocks continue to constrain access in lower-income regions, recommending risk-management tools and more predictable financing windows for crises (IFPRI, 2024). Complementary analyses document how conflict-related shocks and sanctions have tightened cereals markets and logistics, reinforcing the need for anticipatory procurement and regional coordination—issues central to our IGAD focus (OECD/FAO, 2022).

However, literature gets scarcer when it comes to the IGAD region. A handful of academic and institutional studies have touched on issues such as procurement delays, poor inter-agency coordination, and limited reserve capacity. FAO (2021) notes the lack of shared grain storage or joint procurement mechanisms across IGAD member states. Similarly, USAID (2022) points to a recurring pattern of reactive imports, often triggered by humanitarian emergencies or climatic shocks, rather than proactive strategies. Yet, most of these works are descriptive.

Going one step further, there is, to our knowledge, no empirical study that models how IGAD countries respond to global wheat price changes in a panel setting. There's also nothing that looks into the potential benefit of collective procurement or joint reserve systems from a data-driven angle. This paper tries to fill that gap by testing whether a shared response could make sense based on how countries react individually. In that sense, it hopes to bring something new—both as an analytical tool and as a policy input for future decision-making.

MATERIAL AND METHODS

Data Description

The dataset spans the first half of 2010 to the second half of 2022, comprising biannual observations across 26 time points. It covers the eight IGAD member states—Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, and Uganda—and includes a global wheat price indicator. The price series is derived from the Chicago Red Wheat Commodity Index, sourced from Index Mundi, a trusted platform for consolidated commodity data, valued for its consistency and precision in capturing price fluctuations. Similarly, country-level wheat import volumes are obtained from Index Mundi, which aggregates trade data from governmental and international sources, ensuring cross-country comparability and data reliability. Using a single source for both price and import data enhances methodological consistency throughout the analysis.

For the panel analysis, the Chicago Red Wheat Index serves as the unified global wheat price series across all IGAD countries. Although country-specific price variations may arise from transport costs, exchange rates, or policy interventions, employing a single price index is justified for several reasons. First, IGAD nations are primarily price takers in global wheat markets, relying on similar suppliers or international aid programs. Second, local price formation in many of these countries is heavily regulated or shaped by external procurement, especially in fragile states. Third, a common benchmark facilitates consistent cross-country comparisons and aligns with standard practices in panel studies of global commodities. Thus, the Chicago Red Wheat Index provides a reliable and policy-relevant proxy for wheat price exposure across the region.

Descriptive statistics for all variables are presented in Table 3. Wheat import volumes differ significantly across countries, reflecting variations in population, dietary reliance, domestic production, and trade infrastructure. Sudan exhibits the highest average import volume, followed by Kenya and Ethiopia, while Djibouti and South Sudan have the lowest averages. High standard deviations in Ethiopia and Kenya indicate substantial temporal variability. The global wheat price has a mean of 260.30 USD, ranging from 149.3 to 454.7, underscoring significant volatility over the study period. Skewness and kurtosis values reveal non-normal distributions in several country series, particularly Ethiopia, with high skewness (2.34) and kurtosis (10.05), as confirmed by the Jarque-Bera test ($p < 0.001$). These properties emphasize the need for econometric methods robust to non-normality and heteroskedasticity in subsequent analyses.

Table 3. Descriptive statistics

Statistics	Djibouti	Eritrea	Ethiopia	Kenya	Somalia	South Sudan	Sudan	Uganda	Wheat
Mean	32038.46	79230.77	692307.7	889615.4	202115.4	194769.2	1169231.	194588.5	260.2996
Median	30125.00	65550.00	625500.0	914000.0	203000.0	192000.0	1152000.	183100.0	255.6650
Max.	70000.00	186000.0	2088000.	1550000.	468600.0	279000.0	1674000.	380000.0	454.7000
Min.	12040.00	25200.00	266000.0	312000.0	38000.00	90000.00	540000.0	42000.00	149.3000
Std. D.	14777.72	44594.31	357314.6	327814.5	131962.4	56584.31	339375.5	90595.35	77.56995
Skew.	1.160389	1.019180	2.337400	0.115371	0.339769	-0.251989	-0.250459	0.312959	0.684332
Kurt.	3.873152	3.170475	10.04770	2.363574	1.896809	2.066960	2.063653	2.336813	2.828654
J-B.	6.660768	4.532638	77.48421	0.496470	1.818700	1.218270	1.221638	0.900889	2.061148
Prob.	0.035779	0.103693	0.000000	0.780177	0.402786	0.543821	0.542906	0.637345	0.356802
Obs.	26	26	26	26	26	26	26	26	26

Note: Source: Index Mundi (2025)

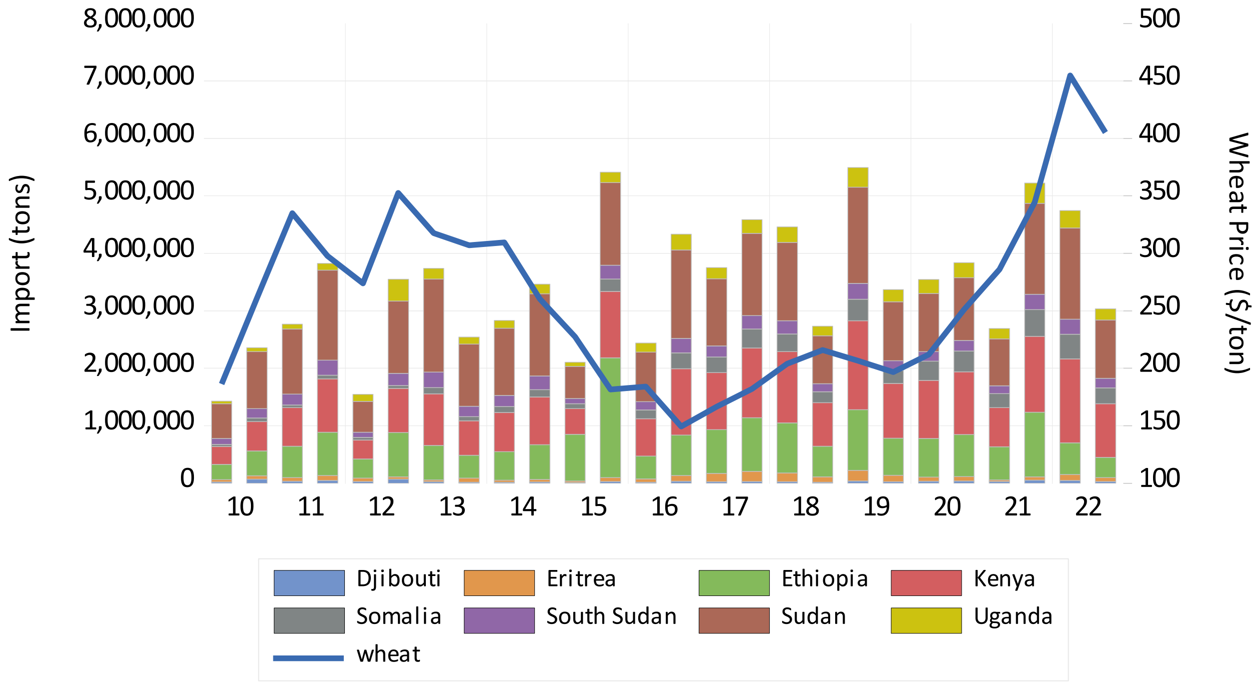

Figure 5. IGAD members' wheat imports and global wheat price (Source: Index Mundi, 2025)

Figure 5 depicts the interplay between total wheat import volumes in IGAD countries and global wheat prices from 2010 to 2022. Both series display significant variability, revealing a nuanced dynamic. During price surges in 2011, 2013, and notably 2022, import volumes do not consistently decrease, indicating relatively inelastic short-term demand for wheat in the region. In contrast, the mid-2010s show a concurrent decline in both prices and imports, suggesting potential demand-side limitations. Overall, the figure underscores a complex, potentially bidirectional relationship between prices and imports, which is subsequently validated by the Granger causality findings.

Country-Level Analysis: ARDL Approach

To examine the dynamic relationship between global wheat prices and wheat import volumes at the country level, we employ the Autoregressive Distributed Lag (ARDL) modeling framework, initially developed by Pesaran & Shin (1995) and further refined by Pesaran et al. (2001). The ARDL model is well-suited for small-sample time series data, enabling the estimation of both short-run and long-run relationships within a unified framework.

The ARDL approach is particularly effective when variables are a mix of I(0) (stationary) and I(1) (non-stationary) but not I(2) or higher, making it ideal for macroeconomic studies in developing and fragile contexts where data constraints are prevalent (Bölük & Mert, 2015). Unlike traditional cointegration methods that demand large sample sizes, the ARDL bounds testing approach performs reliably with smaller samples (N < 50) and is robust to issues like serial correlation, omitted variable bias, and potential endogeneity in regressors (Ozturk & Karagoz, 2012).

Prior to ARDL estimation, we conduct unit root tests, such as the Phillips & Perron (1988) (PP) test, to ensure no variables are integrated of order two, as I(2) variables would undermine the bounds testing procedure for cointegration by risking spurious regression results (Qamruzzaman & Jianguo, 2018).

For a dependent variable y_t (e.g., wheat imports) and an independent variable x_t (e.g., wheat price), the ARDL (p, q) model can be written as in Equation 1:

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

where:

- y_t: dependent variable (e.g., wheat imports)
- x_t: independent variable (e.g., wheat price)
- p, q: lag of orders for dependent and independent variables, respectively

- ε_t: white noise error term
- α_0: constant term

To examine cointegration (i.e., long-run relationships), the ARDL model is often reparameterized into an Error Correction Model (ECM) form as in Equation 2:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p-1} \delta_i \Delta y_{t-i} + \sum_{i=0}^{q-1} \theta_j x_{t-j} + \emptyset_1 y_{t-1} + \emptyset_2 x_{t-1} + \varepsilon_t \quad (2)$$

where:

- Δ : denotes the first difference
- $\emptyset_1$ and $\emptyset_2$: capture long-run relationship
- $The\ term\ \emptyset_1 y_{t-1} + \emptyset_2 x_{t-1}$ forms the error correction term, and significant negative coefficient on this term indicates adjustment toward long-run equilibrium.

ARDL models are estimated separately for each IGAD country in this study to capture their unique import sensitivities and price adjustment mechanisms. All variables are used in their natural logarithmic form, allowing the estimated coefficients to be interpreted as elasticities. The estimation and diagnostic procedures were carried out using EViews software, which supports flexible ARDL modeling, lag length selection, and bounds testing for cointegration.

Bloc-Level Analysis: Panel Granger Causality Approach

The panel Granger causality test in this study adopts the methodology of Juodis et al. (2021), an improvement over traditional fixed-effects panel model. This approach addresses common issues in macroeconomic panel data, such as cross-sectional dependence and individual-specific heterogeneity (Raifu et al., 2025). It accommodates country-specific dynamics and employs bootstrap-based inference, ensuring robustness in panels with moderate time dimensions and interdependent units (Simionescu & Schneider, 2022). As the method requires stationary variables, we first-difference the global wheat price and import volume series to achieve I(0) status, confirmed by second-generation panel unit root tests.

The strength of the Juodis et al. (2021) approach lies in its adaptability and reliability in complex empirical settings. Unlike conventional Granger causality tests, which often assume slope homogeneity and cross-sectional independence, this method accounts for the diverse structural characteristics and external vulnerabilities across IGAD countries. By permitting heterogeneous slope coefficients, it captures varied responses of import volumes to global wheat price changes. Additionally, bootstrap techniques improve the accuracy of statistical inference in small samples by correcting for potential biases in standard error estimation. This methodology is thus well-suited for analyzing causal dynamics in interconnected developing economies with diverse policy contexts.

The method is implemented using the xtgrangert command in Stata with the following specification:

xtgrangert depvar indepvar, maxlags(#) het bootstrap(#, seed(#))

This command estimates panel Granger causality where:

- depvar and indepvar are the first-differenced, stationary variables,
- maxlags(#) specifies the number of lags,
- het allows for heterogeneous panel structure, and
- bootstrap(#, seed(#)) ensures robust inference via bootstrap replication.

The test provides both individual coefficient estimates and a joint Wald statistic (HPJ test) to evaluate the null hypothesis of no Granger causality across the panel. This method is particularly well-suited for panels with a moderate time dimension (T) and cross-sectional units (N), as is the case with this study's dataset (Xiao et al., 2023). The method can be expressed as follows:

$$y_{i,t} = \alpha_i + \sum_{p=1}^{p} \beta_{i,p}\, y_{i,t-p} + \sum_{i=0}^{q} \gamma_{i,p}\, x_{i,t-p} + \varepsilon_{i,t} \quad (3)$$

where:

- $y_{i,t}$: dependent variable (e.g., wheat imports) for unit i at time t

- $x_{i,t}$: independent variable (e.g., wheat price)
- α_i : unit-specific intercept
- $\beta_{i,p}$: autoregressive coefficients (lags of y)
- $\gamma_{i,p}$: coefficients on lagged values of x
- p : maximum lag order
- $\varepsilon_{i,t}$: error term

In the context of the Juodis et al. (2021) panel Granger causality test, the null hypothesis states that the lagged values of the independent variable do not Granger-cause the dependent variable in any of the cross-sectional units. In other words, the past values of one variable (e.g., wheat prices) do not contain predictive information about the current values of another variable (e.g., wheat import volumes). Rejecting the null hypothesis implies the presence of Granger causality in at least some of the units in the panel, indicating a dynamic interdependence.

Before performing the panel Granger causality test, it is crucial to verify the stationarity of the variables involved, as the methodology assumes that the series are integrated of order zero I(0). Given the economic and structural linkages among IGAD countries, we first tested for cross-sectional dependence using Breusch-Pagan LM (Breusch & Pagan, 1980), Pesaran CD LM test (Pesaran, 2004), and LM adjusted Pesaran test (Pesaran et al., 2008). Detecting significant dependence among countries justifies the use of a second-generation panel stationarity test. Accordingly, we employed the Hadri test with bootstrap critical values, which is robust to cross-sectional dependence and suitable for moderate time dimensions. This two-step approach ensures that the stationarity diagnosis is both methodologically sound and tailored to the characteristics of our data.

RESULTS AND DISCUSSION

This study examined country-level dynamics using ARDL models to identify both short- and long-run relationships between wheat import volumes and global wheat prices across IGAD countries. It also complements these findings with bloc-level panel analyses to explore broader causal patterns and interdependencies. The results provide insight into how individual countries and the region as a whole respond to price shocks, offering a nuanced basis for policy interpretation.

Country-Level ARDL Results

The first stage of the empirical analysis focuses on country-specific dynamics using the Autoregressive Distributed Lag (ARDL) modeling framework. This method is well-suited for small samples and allows for mixed integration orders among variables, making it ideal for the diverse economic conditions found within the IGAD region. Prior to model estimation, we test for the order of integration of each variable to ensure the validity of the ARDL bounds testing procedure.

Unit Root Test Results

Before estimating the ARDL models, we conducted stationarity tests to ensure that the time series variables meet the integration conditions required for the ARDL bounds testing approach. Specifically, we employed the Phillips & Perron (1988) (PP) unit root test, which is well-suited for small sample sizes and allows for heteroskedasticity and autocorrelation in the error terms—a common feature in macroeconomic time series, especially in fragile or conflict-affected countries like those in the IGAD region.

The ARDL model, as developed by Pesaran et al. (2001), permits the inclusion of regressors that are integrated of order zero I(0) or order one I(1), but not of order two I(2). Thus, it is critical to verify that none of the variables in the model are I(2), which would invalidate the use of the ARDL approach.

Table 4 presents the PP test statistics for the wheat import series of each IGAD country and the global wheat price series. The results show a mix of integration orders across the countries. The import series for Djibouti, Ethiopia, Kenya, South Sudan, Sudan, and Uganda are stationary at level I(0), as their test statistics exceed the critical values for rejecting the null hypothesis of a unit root. On the other hand, the series for Eritrea and Somalia are found to be stationary only after first differencing I(1). This variation is acceptable within the ARDL framework, which allows a combination of I(0) and I(1) regressors. Notably, the global wheat price series is integrated of order one I(1), as expected for international commodity price data.

Table 4. Unit root test results

Country	Level		First Difference		Conclusion (95%)
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	
Djibouti	-4.383	-4.300	-12.336	-21.998	I(0)
Eritrea	-2.736	-2.757	-6.915	-6.761	I(1)
Ethiopia	-5.151	-5.034	-12.704	-25.257	I(0)
Kenya	-4.615	-7.244	-21.327	-27.984	I(0)
Somalia	-1.842	-4.283	-12.120	-13.517	I(1)
South Sudan	-9.562	-13.170	-27.721	-22.554	I(0)
Sudan	-9.552	-11.716	-21.763	-22.595	I(0)
Uganda	-3.682	-4.482	-8.558	-9.782	I(0)
Wheat Price	-1.405	-1.339	-4.031	-4.171	I(1)

Note: Critical values for the PP unit root test are -3.724 (1%), -2.986 (5%), and -2.633 (10%) under the intercept specification, and -4.374 (1%), -3.603 (5%), and -3.238 (10%) under the intercept and trend specification.

Table 5. ARDL long run estimates

Variables	Djibouti	Eritrea	Ethiopia	Kenya	Somalia	South Sudan	Sudan	Uganda
Wheat	0.344	-1.899	-0.506	-0.614	4.775	-0.129	-0.130	-0.466
	(0.200)	(0.001)	(0.055)	(0.048)	(0.764)	(0.47)	(0.468)	(0.375)
Constant	8.353	21.55	16.186	17.022	-10.020	12.855	14.650	14.706
	(0.000)	(0.000)	(0.000)	(0.000)	(0.879)	(0.000)	(0.000)	(0.000)
ARDL Bound Test								
F-Statistics	10.606***	5.584**	11.079***	10.360***	5.231**	19.642***	19.645***	5.307**
Model Selection	(1, 1)	(1, 3)	(1, 0)	(1, 2)	(3, 4)	(1,2)	(1, 2)	(1, 2)
Model Statistics								
R-Square	0.308	0.561	0.151	0.288	0.902	0.344	0.345	0.250
Adj. R-Square	0.209	0.431	0.739	0.138	0.841	0.206	0.207	0.092
F-Statistics	3.118**	4.339***	1.958	1.924	14.964***	2.499*	2.502*	1.582
Diagnostics								
Normality	1.144	3.072	2.329	0.794	0.913	1.753	1.732	0.067
Serial Correlation	1.535	0.675	2.136	1.000	2.812	0.265	0.262	4.427**
Heteroscedasticity	2.280	0.353	0.269	0.521	0.767	1.355	1.365	1.546
CUSUM Stability	Stable	Stable	Stable	Instable	Stable	Stable	Stable	Stable
CUSUM Sq. Stability	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable

Note: Critical values for the ARDL F-bounds test (finite sample, n=30) are 3.797 (10%), 4.663 (5%), and 6.760 (1%). Heteroskedasticity Test: Breusch-Pagan-Godfrey

Table 6. ARDL short run estimates

Variables	Djibouti	Eritrea	Ethiopia	Kenya	Somalia	South Sudan	Sudan	Uganda
D(Wheat)	1.715 (0.007)	-0.335 (0.626)	-0.559 (0.061)	-0.036 (0.945)	0.051 (0.920)	-0.209 (0.626)	-0.209 (0.623)	0.672 (0.302)
D(Wheat (-1))		1.230 (0.138)		1.266 (0.028)	-0.008 (0.992)	0.957 (0.039)	0.957 (0.039)	0.234 (0.724)
D(Wheat (-2))		1.425 (0.067)			-1.080 (0.087)			
D(Wheat (-3))					-1.047 (0.073)			
Cointegration (ECM)	-1.173 (0.000)	-0.852 (0.001)	-1.130 (0.000)	-1.037 (0.000)	-0.064 (0.662)	-1.405 (0.000)	-1.405 (0.000)	-0.720 (0.000)

Long-Run Relationships

The results of the ARDL long-run estimations are presented in Table 5. All eight IGAD countries demonstrate the existence of a long-run relationship between wheat import volumes and global wheat prices, as confirmed by the ARDL bounds testing procedure. The F-statistics for each model exceed the critical threshold values at conventional significance levels (1%, 5%, or 10%), indicating the presence of cointegration between the dependent and independent variables.

The long-run coefficients associated with the wheat price variable vary in both magnitude and sign across countries, reflecting the heterogeneous structural and economic characteristics of IGAD member states. Some countries exhibit negative long-run elasticities, suggesting that rising wheat prices are associated with lower import volumes in the long term, while others show either positive or statistically insignificant relationships. This variation aligns with differences in procurement strategies, aid dependency, foreign exchange constraints, and domestic policy responses.

It is important to note that the presence of cointegration in all cases provides a robust foundation for interpreting both short- and long-run dynamics. The model diagnostics further support the reliability of the ARDL specifications, with most models passing tests for normality, heteroscedasticity, and structural stability. The relatively high R-squared values in several cases also suggest that a meaningful proportion of the variation in import volumes is explained by the global wheat price over the long term.

Short-Run Dynamics

The short-run dynamics estimated through the ARDL error correction models are reported in Table 6. These results capture the immediate or lagged responses of wheat import volumes to changes in global wheat prices across IGAD countries. While the short-run coefficients vary in sign and statistical significance, several countries exhibit meaningful short-run sensitivity, indicating that import decisions in the region can be influenced by short-term price fluctuations, though not uniformly.

More importantly, the error correction terms (ECM) across most models are negative and statistically significant at the 1% level, confirming the existence of a stable long-run relationship and validating the error correction framework. The magnitude of the ECM coefficients indicates the speed at which deviations from long-run equilibrium are corrected following a short-term shock. In most cases, these coefficients suggest a relatively fast adjustment process, with a substantial portion of disequilibrium corrected within a single period. Somalia is the only exception, showing a statistically insignificant ECM term, likely reflecting weak or delayed adjustment mechanisms in that context.

The short-run coefficients for differenced wheat prices and their lags further highlight the heterogeneity across IGAD member states. Some countries respond immediately, while others exhibit delayed responses over one or more lags.

Country-Specific Interpretations

The ARDL results have been presented for each IGAD member country individually, highlighting both long-run and short-run relationships between global wheat prices and national import volumes. While all countries exhibit cointegration, the direction, magnitude, and statistical significance of their responses vary considerably, reflecting differences in economic structure, import dependency, aid reliance, and policy frameworks. These interpretations draw from the earlier empirical outputs but place them in the context of each country's unique circumstances.

Djibouti

The ARDL bounds test for Djibouti yields an F-statistic of 10.606 (significant at 1%), confirming cointegration between wheat prices and imports. The long-run elasticity is 0.344 (p=0.200, not significant), indicating that a 1% increase in wheat prices would increase imports by 0.34%, reflecting a positive but statistically insignificant relationship. In the short run, the elasticity is 1.715 (p=0.007), significant at 1%, showing that imports increase by 1.72% in response to a 1% price increase, suggesting high price elasticity in the short term likely due to Djibouti's reliance on imported wheat and limited substitution. The ECM coefficient is -1.173 (p=0.000), indicating rapid adjustment (117% correction per period) toward the long-run equilibrium. However, these results need to be read with caution. Djibouti is mainly a re-export hub, serving Ethiopia's wheat demand rather than its own consumption. The pattern is therefore more a reflection of Ethiopian procurement routed through Djibouti port than of Djibouti itself.

Eritrea

The ARDL bounds test yields F = 5.584 (significant at 5%), confirming cointegration. The long-run elasticity is -1.899 (p=0.001, significant at 1%), indicating a 1% increase in wheat prices reduces imports by 1.9%, showing strong price sensitivity likely due to foreign exchange constraints. Short-run elasticities are not significant except for a marginally significant D(Wheat(-2)) at 1.425 (p=0.067), indicating a delayed positive response, potentially due to procurement processes or policy adjustments. The ECM is -0.852 (p=0.001), confirming stable and relatively fast adjustment toward equilibrium (85% per period). Eritrea's price responsiveness in the long run may reflect import rationing, foreign exchange scarcity, and prioritization of essential imports, resulting in import reductions during price surges.

Ethiopia

Ethiopia's ARDL bounds test yields F = 11.079 (significant at 1%), indicating cointegration. The long-run elasticity is -0.506 (p=0.055, marginally significant), indicating that a 1% increase in wheat prices leads to a 0.51% reduction in imports, consistent with Ethiopia's efforts to substitute imports with domestic production. The short-run elasticity is -0.559 (p=0.061), marginally significant, reinforcing the price-sensitive nature of Ethiopia's import behavior. The ECM coefficient is -1.130 (p=0.000), indicating rapid correction (113% per period) toward long-run equilibrium. This reflects Ethiopia's import substitution policies and possible fiscal discipline on imports in the face of rising prices.

Kenya

Kenya's ARDL bounds test shows F = 10.360 (significant at 1%), confirming cointegration. The long-run elasticity is -0.614 (p=0.048, significant), implying that a 1% increase in wheat prices reduces imports by 0.61% in the long run. Short-run elasticity is insignificant contemporaneously (-0.036, p=0.945) but becomes significantly positive at lag one (1.266, p=0.028), indicating a 1% price increase increases imports by 1.27% after one period, suggesting a delayed response to price increases, possibly due to procurement contract structures. The ECM coefficient is -1.037 (p=0.000), indicating rapid correction (104% per period) to the equilibrium path. Kenya's pattern may reflect partial local production, policy buffers, and structured import scheduling that causes a lagged but strong import reaction to price changes.

Somalia

Somalia's ARDL bounds test result is F = 5.231 (significant at 5%), confirming cointegration. The long-run elasticity is 4.775 (p=0.764, not significant), suggesting wheat prices do not meaningfully impact import volumes in the long run. Short-run elasticities are mostly insignificant except for D(Wheat(-2)) = -1.080 (p=0.087) and D(Wheat(-3)) = -1.047 (p=0.073), marginally significant, indicating a 1% increase in wheat prices reduces imports by ~1% after 2–3 periods. The ECM coefficient is -0.064 (p=0.662, insignificant), reflecting weak evidence of adjustment toward equilibrium. These results align with Somalia's aid-dependent wheat supply and informal trade, which decouples import behavior from market price signals.

South Sudan

South Sudan's ARDL bounds test yields F = 19.642 (significant at 1%), confirming strong cointegration. The long-run elasticity is -0.129 (p=0.470, insignificant), indicating a weak long-run price-import relationship. In the short run, the immediate effect is insignificant, but D(Wheat(-1)) = 0.957 (p=0.040, significant), showing that a 1% price increase in the previous period increases imports by 0.96% currently, suggesting delayed import responses due to administrative lags or aid delivery timing. The ECM coefficient is -1.405 (p=0.000), indicating very rapid adjustment (140% per period) to long-run equilibrium. This pattern may reflect reliance on external food aid and volatile import timing in a conflict-affected environment.

Sudan

Sudan's ARDL bounds test shows F = 19.645 (significant at 1%), indicating cointegration. The long-run elasticity is -0.130 (p=0.468, insignificant), indicating weak responsiveness of imports to price changes. Short-run effects are not significant, while the ECM is -1.405 (p=0.000), showing rapid adjustment (140% per period) toward the long-run equilibrium. This pattern may result from Sudan's economic volatility, inflation, currency depreciation, and import subsidy or aid programs that buffer wheat imports from direct price responsiveness.

Uganda

Uganda's ARDL bounds test yields F = 5.307 (significant at 5%), confirming cointegration. The long-run elasticity is -0.466 (p=0.375, insignificant), indicating limited long-run price elasticity of imports. Short-run elasticity is 0.672 (p=0.302, insignificant), and the ECM is -0.720 (p=0.000), showing stable adjustment (72% per period) toward equilibrium. Uganda's low wheat consumption, the availability of local substitutes, and stable domestic demand likely explain the limited responsiveness of imports to price changes.

General Evaluation

The ARDL bounds testing confirms that all countries in the analysis exhibit cointegration between wheat prices and import volumes, indicating the existence of stable long-run relationships despite short-term fluctuations. In terms of long-run elasticities, Eritrea (-1.90), Kenya (-0.61), and marginally Ethiopia (-0.51) demonstrate significant negative responsiveness, suggesting that higher wheat prices lead to meaningful reductions in import volumes in these countries over time. This aligns with economic realities such as foreign exchange constraints and import substitution policies, leading to price-sensitive import demand.

In the short run, wheat price responsiveness varies across countries with biannual frequency, meaning each lag reflects a 6-month delay. Djibouti shows immediate, highly significant positive elasticity (+1.72, p=0.007), indicating that a 1% increase in wheat prices leads to a 1.72% rise in imports within the same 6-month period, reflecting inelastic, food security-driven import demand despite rising costs. Ethiopia exhibits a marginally significant immediate negative elasticity (-0.56, p=0.061), suggesting that price increases reduce imports by 0.56% within six months, consistent with substitution or import reduction behavior under foreign exchange or policy constraints. Kenya (+1.27, p=0.028), South Sudan (+0.96, p=0.039) and Sudan Sudan (+0.96, p=0.039) display significant positive elasticities at a one-period lag, indicating that wheat price increases lead to higher imports after six months, possibly reflecting procurement cycles, administrative processes, or aid delivery lags. Additionally, Eritrea (+1.43, p=0.067) and Somalia (-1.08, p=0.087; -1.05, p=0.073) demonstrate marginally significant effects at 12–18-month lags, indicating delayed import responsiveness where Eritrea increases imports after a year of price increases, while Somalia reduces imports with a longer delay, likely reflecting aid delivery dynamics or informal trade adjustments. These findings highlight the diversity in short-run price elasticity across countries, shaped by their specific institutional structures, aid dependencies, import reliance, and policy environments, despite all countries maintaining long-run equilibrium relationships.

The Error Correction Mechanism (ECM) coefficient captures the speed at which deviations from the long-run equilibrium adjust back following short-run shocks. Economically, a negative and significant ECM indicates that if wheat import volumes deviate from their long-run relationship with prices, a portion of this disequilibrium is corrected in each period (here, every 6 months), reflecting how quickly trade adjusts back toward equilibrium after shocks such as price spikes, policy changes, or supply disruptions. Countries with high ECM magnitudes adjust quickly to shocks, reflecting rapid and flexible trade system responses, while countries with lower ECM magnitudes exhibit slower, more gradual adjustments, indicating structural or policy-related frictions delaying convergence toward equilibrium. The Error Correction Mechanism (ECM) coefficients across the countries are negative and highly significant (except for Somalia), confirming rapid adjustment toward the long-run equilibrium after short-run deviations. Notably, South Sudan and Sudan exhibit the fastest adjustment speeds (~140% correction per period), followed by Djibouti (117%), Ethiopia (113%), and Kenya (104%), while Uganda (72%) and Eritrea (85%) also maintain stable long-run adjustment paths. Somalia, with an insignificant ECM, indicates weaker adjustment dynamics, consistent with its aid-dependent and informal trade environment. Comparative summary of elasticity significance is presented in Table 7.

Bloc-Level Panel Granger Causality Results

The second stage of the empirical analysis shifts from individual country behavior to regional dynamics, using a panel Granger causality framework to assess the direction and strength of the relationship between global wheat prices and import volumes across the IGAD bloc. Before estimating the panel model, it is important to test the underlying data structure for interdependencies and parameter consistency across countries to ensure the validity and robustness of the panel-based inference.

Cross-Sectional Dependence and Homogeneity Tests

Before proceeding with the panel Granger causality analysis, we tested the suitability of the panel data structure by examining cross-sectional dependence and slope homogeneity. These diagnostics are essential in panel settings where countries may be interlinked through shared external exposures or similar structural characteristic conditions likely present among IGAD member states.

Table 7. Comparative summary of elasticity significance

Country	Long-run Elasticity (Significance & Sign)	Short-run Elasticity (Significance & Timing)
Djibouti	Not significant (+)	Significant immediate (+)
Eritrea	Significant (-)	Marginal at lag 2 (+)
Ethiopia	Marginally significant (-)	Marginally immediate (-)
Kenya	Significant (-)	Significant at lag 1 (+)
Somalia	Not significant (+)	Marginal at lag 2-3 (-), ECM not Significant
South Sudan	Not significant (-)	Significant at lag 1 (+)
Sudan	Not significant (-)	Insignificant
Uganda	Not significant (-)	Insignificant

Table 8. Cross-section dependence and homogeneity tests

Test	Price		Export	
	Statistic	**Prob.**	**Statistic**	**Prob.**
Breusch-Pagan LM	728.00	0.000	241.25	0.000
Pesaran scaled LM	93.54	0.000	28.49	0.000
Bias-corrected scaled LM	93.38	0.000	28.33	0.000
Pesaran CD	26.98	0.000	14.42	0.000
Delta Tilde	-1.970	0.976	0.999	0.159
Delta Tilde Adjusted	-2.094	0.982	1.062	0.144

Table 9. Panel unit root test

	Test	Price		Import	
		Constant	**Constant & Trend**	**Constant**	**Constant & Trend**
Level	t-bar statistics	-0.398	5.525	4.538	3.526
	Bootstrap CV 10%	3.266	4.247	2.087	2.941
	Bootstrap CV 5%	4.405	5.147	2.712	3.462
	Bootstrap CV 1%	7.146	6.488	4.502	4.768
First Difference	t-bar statistics	-0.046	5.322	0.033	0.686
	Bootstrap CV 10%	3.569	4.477	2.387	3.491
	Bootstrap CV 5%	4.805	5.330	3.635	4.281
	Bootstrap CV 1%	7.039	6.609	5.341	5.680

Note: Long-run variance estimator: Bartlett; Number of Bootstrap replications: 1000.

As shown in Table 8, the Breusch-Pagan LM statistic (728.00, p = 0.000), the Pesaran scaled LM (93.54, p = 0.000), Bias-corrected scaled LM test (93.38, p=0.000), and the Pesaran CD test (26.98, p = 0.000) all strongly reject the null hypothesis of cross-sectional independence. Given our panel structure—large time dimension (T = 180) and relatively small cross-sectional dimension (N = 8)— the Pesaran CD test is especially appropriate and robust. These results confirm the presence of significant interdependence among IGAD countries, which is theoretically expected, particularly because the countries are all exposed to the same global wheat price series. Using a common exogenous variable introduces a natural linkage across panel units, reinforcing the economic interpretation of cross-sectional dependence in this context.

In contrast, the Delta Tilde test (-1.970, p = 0.976) and its adjusted version (-2.094, p = 0.982) fail to reject the null hypothesis of slope homogeneity, suggesting that countries may exhibit similar average responses to global wheat price shocks in the Granger causality framework. Given the structural similarities across IGAD member states—such as high import dependency, fiscal limitations, and exposure to global markets—this result is theoretically reasonable. However, to ensure robustness regardless of these findings, the panel Granger causality test employed in this study, developed by Juodis et al. (2021) and implemented using the xtgrangert command in Stata, explicitly allows for slope heterogeneity and adjusts for cross-sectional dependence through a bootstrap-based inference procedure. Therefore, the presence of either cross-sectional dependence or (non-)homogeneity does not compromise the validity of the results presented in the subsequent panel causality analysis.

Panel Unit Root Tests

To assess the stationarity properties of the panel data, we employed the second-generation Hadri (2000) panel stationarity test with bootstrap-based critical values, which is appropriate in the presence of cross-sectional dependence. Unlike traditional first-generation unit root tests, the Hadri test assumes stationarity under the null hypothesis and tests for the presence of unit roots in the panel. The use of bootstrap distributions further enhances robustness by correcting for potential cross-sectional correlation and small-sample bias, which are particularly relevant given the interconnected nature of IGAD economies and the shared global wheat price series.

The test was conducted under both constant and constant-plus-trend specifications. As shown in Table 9, the t-bar statistic for the wheat price series at level is -0.398, which falls well below the 10% bootstrap critical value of 3.266, leading to rejection of the null hypothesis of stationarity. Similarly, the import volume series at level yields a t-bar of 4.538, also below its critical threshold (2.087), again indicating non-stationarity at level. However, when both series are first-differenced, the test statistics rise significantly—5.322 for wheat price and 0.686 for imports—both exceeding their respective bootstrap critical values, meaning that we fail to reject the null of stationarity in first differences.

These findings confirm that both global wheat prices and import volumes are integrated of order one, I(1), and justify the use of Granger causality analysis in first differences. The stationarity of the differenced series ensures that the panel regression results are not spurious and that the assumptions underlying the heterogeneous panel Granger causality test are satisfied.

Granger Causality Findings

To examine the causal relationship between global wheat prices and wheat import volumes within the IGAD bloc, we applied the heterogeneous panel Granger non-causality test developed by Juodis et al. (2021), implemented in Stata using the xtgrangert command. The test was executed with the following options:

```
xtgrangert D.export D.wheatprice , maxlags(2) het bootstrap (100, seed(20171020))
```

This specification uses two lags of the differenced series (biannual frequency), allows for heterogeneous dynamics across countries (het option), and employs bootstrap-based inference with 100 replications to ensure robustness to cross-sectional dependence (bootstrap option with a fixed seed for reproducibility).

The results, presented in Table 10, show that the lagged value of global wheat price has a positive and statistically significant effect on wheat import volumes. Specifically, the coefficient on wheatprice(-1) is 0.491 with a z-statistic of 2.57 and a p-value of 0.010, indicating a significant predictive relationship. The HPJ Wald test statistic further supports this result, with a test value of 6.604 and a bootstrap-adjusted p-value of 0.010.

Taken together, these results lead us to reject the null hypothesis that wheat prices do not Granger-cause import volumes. This implies that, within the panel of IGAD countries, past movements in global wheat prices help predict changes in national import volumes, although the strength and timing of this relationship may differ across countries.

To test the reverse relationship—whether wheat import volumes Granger-cause global wheat prices—we employed the same heterogeneous panel Granger non-causality framework using the following Stata command:

```
xtgrangert D.wheatprice D.export, maxlags(2) het bootstrap(100, seed(20171020))
```

Table 10. Results for the panel causality test

	Coefficient	**Std. Error**	**z**	$P > \|z\|$
$wheatprice_{(-1)}$	***0.491***	0.191	**2.57**	0.010
JKS Non-Causality Result	**HPJ Walt Test**	6.604	**P-Value**	0.010

Table 11. Results for the panel causality test

	Coefficient	**Std. Error**	**z**	$P > \|z\|$
$export_{(-1)}$	***0.048***	0.009	5.04	0.000
JKS Non-Causality Result	**HPJ Walt Test**	25.362	**P-Value**	0.000

This test again uses two lags of the differenced variables, accommodates heterogeneous country-specific dynamics, and applies bootstrap-based inference to correct for cross-sectional dependence.

The results, reported in Table 11, show that the lagged value of import volumes has a positive and highly significant effect on wheat prices. The estimated coefficient for export(-1) is 0.048, with a z-statistic of 5.04 and a p-value of 0.000. The HPJ Wald test strongly confirms this causal relationship, with a test statistic of 25.362 and a bootstrap-adjusted p-value of 0.000.

These findings lead us to reject the null hypothesis that import volumes do not Granger-cause wheat prices. This result is noteworthy—and somewhat unexpected—given IGAD's relatively modest share in the global wheat market. The causal influence may reflect localized market volatility, timing shifts in bulk procurement, or aggregate demand pressure that feeds back into global price expectations. The fact that such a relationship appears in the absence of coordinated import strategies suggests that collective regional behavior, even if unintentional, may generate measurable signals in international markets. This insight holds meaningful implications for policy, particularly with respect to exploring regional procurement coordination and buffer stock strategies.

Impulse Response Functions

To complement the Granger causality results and explore the dynamic interactions over time, Impulse Response Functions (IRFs) were derived from a panel VAR model. The IRFs trace the response of each variable to a one-standard-deviation shock in the other, over a horizon of five periods (equivalent to 2.5 years, given the biannual frequency of the data).

As illustrated in Figure 6, the top-right panel (D_wheatprice → D_export) shows that a positive shock to global wheat prices leads to a temporary increase in wheat import volumes in the IGAD bloc, peaking in the second period before gradually declining. This pattern aligns with the earlier panel Granger causality findings, reinforcing the idea that price signals influence short-term procurement decisions or emergency import responses.

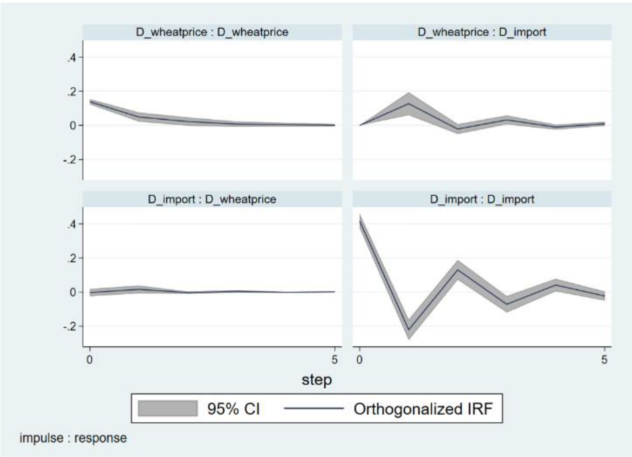

Figure 6. Impulse response functions (IRFS)

Conversely, the bottom-left panel (D_export → D_wheatprice) reveals that a shock to IGAD's aggregate import volumes also has a mild but persistent positive effect on global wheat prices. While this result may initially appear counterintuitive given the bloc's relatively small share in global wheat trade, it suggests that regional demand surges—particularly under stress conditions—can have ripple effects on international markets, possibly by affecting expectations or tightening localized supply channels.

Overall, the IRFs confirm a bidirectional relationship between wheat prices and import volumes, with feedback effects evolving over several periods. These dynamics underscore the importance of timing and coordination in wheat procurement across IGAD countries, particularly during episodes of global price volatility.

This study investigates the response of wheat import volumes in IGAD countries to global wheat price fluctuations, using a dual-method approach combining country-level ARDL models with bloc-level heterogeneous panel Granger causality analysis. The findings reveal both anticipated and unexpected dynamics, offering key policy implications for food security and trade coordination in the region.

At the country level, ARDL results confirm a long-run cointegrating relationship between wheat prices and import volumes across all IGAD member states. However, price elasticities vary significantly. Ethiopia, Kenya, and Eritrea exhibit strong negative long-run elasticities, indicating that higher prices reduce imports over time, likely due to domestic substitution, foreign exchange limitations, or policy constraints. Conversely, Djibouti and South Sudan show positive short-run elasticities, suggesting imports increase despite price rises, driven by urgent needs, limited local alternatives, or aid-driven procurement. These findings highlight the diverse wheat import behaviors across IGAD, influenced by factors such as import dependency, institutional capacity, and geopolitical fragility.

The bloc-level analysis reinforces these country-specific insights. Tests for cross-sectional dependence and homogeneity confirm interlinked wheat import behaviors across IGAD countries, supporting the use of second-generation panel methods. The panel Granger causality test, robust to cross-sectional dependence and heterogeneity, identifies significant bidirectional causality between wheat prices and import volumes. Global price changes predict IGAD's import patterns, but, surprisingly, the bloc's collective imports also influence global price movements, despite IGAD's modest role in global wheat trade. This feedback effect may stem from timing mismatches, demand surges, or market perceptions of regional instability.

Collectively, these results underscore the need for coordinated wheat procurement strategies across the IGAD bloc. The observed differences in short-run and long-run responsiveness highlight structural vulnerabilities that regional cooperation could address. Joint procurement mechanisms, regional grain reserves, or coordinated price-risk management tools, such as futures contracts or hedging instruments, could mitigate exposure to global price volatility and ensure stable access to this essential commodity.

This study enriches the sparse literature on commodity trade sensitivity in Eastern Africa by integrating macroeconomic time series methods with a regional development perspective. The dual-method approach captures both country-specific dynamics and systemic bloc-wide patterns, offering insights that single-method studies might overlook. As global food markets grow increasingly volatile, evidence-based strategies like those proposed here are critical for enhancing economic and food resilience in vulnerable regions like IGAD.

CONCLUSION

From a policy standpoint, the paper offers three key recommendations:

- Enhance regional coordination in wheat procurement to increase bargaining power and stabilize domestic markets.
- Invest in domestic production and substitution capacity where feasible, especially in countries showing strong negative long-run elasticities.
- Establish contingency frameworks, such as emergency reserves or import financing buffers, to address price-driven import surges in fragile states.

To make these recommendations more tangible, IGAD countries can draw useful lessons from other regions that have set up similar mechanisms. One example is the ECOWAS Regional Food Security Reserve, created in 2013 to complement national reserves and provide quick support during crises. It works through a structured governance framework, pooled country contributions, and a regional coordination unit. The reserve has been activated several times to help member states facing droughts and price spikes (ECOWAS, 2013; FAO, 2020). Another example is the ASEAN+3 Emergency Rice Reserve (APTERR), which is based on pre-agreed stockpiles and flexible release mechanisms; this arrangement has helped stabilize rice markets and deliver rapid emergency grain to member countries when shocks occur (APTERR Secretariat, 2022). At the national level, India's wheat buffer stock program provides a practical model of how strategic reserves can stabilize domestic markets. The Food Corporation of India maintains buffer norms that trigger procurement and release depending on market conditions, helping to smooth prices and maintain availability during shocks (Government of India, 2017).

For IGAD, a realistic path would be to start with national strategic stocks in key transit or gateway countries—such as Djibouti, Kenya, or Sudan—while gradually building a regional reserve framework coordinated by IGAD or a dedicated agency. This could be combined with joint procurement arrangements and, over time, the use of forward contracts or hedging instruments to manage price risks collectively. A governance charter could define participation rules, cost-sharing, and release criteria, and existing humanitarian corridors and logistics hubs (e.g., the Djibouti–Addis corridor) could serve as initial reserve sites. Over time, this could evolve into a more integrated regional reserve system, strengthening the bloc's bargaining power and resilience to external shocks.

However, the study has several limitations. First, the dataset, covering biannual observations from 2010 to 2022, includes only 26 time points, which may limit the detection of short-term shocks or policy interventions occurring at higher frequencies. While sufficient for ARDL and panel causality analyses, this restricts temporal granularity. Second, the focus on wheat price and import volume excludes other relevant factors such as exchange rates, domestic production, food aid, or broader macroeconomic indicators (e.g., inflation, conflict intensity). This narrow scope isolates the price-import relationship but may miss key contextual drivers. Third, while the panel Granger causality test is robust to cross-sectional dependence and heterogeneity, alternative methods like panel vector autoregression (PVAR), time-varying parameter models, or machine learning could provide additional insights.

Future research could address these limitations by extending the time horizon and using higher-frequency data (e.g., quarterly or monthly) to better capture short-term shocks and policy changes. Incorporating additional variables, such as transportation costs, domestic policy responses, or international aid flows, would offer a more comprehensive view of wheat import dynamics in fragile contexts. Additionally, exploring spillover effects across IGAD countries, given their interconnected trade routes and shared vulnerabilities, could be pursued using spatial econometric or network-based approaches.

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Compliance with Ethical Standards

Authors' Contributions

AMD: Conceptualization, Writing – original draft, Investigation.

AA: Supervision, Writing – review & editing, Methodology, Formal Analysis.

All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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Data Availability

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

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The authors used generative-AI tools (OpenAI ChatGPT) only to help with readability, phrasing, and some brainstorming for a few narrative sections. All the actual research work — including the data collection, econometric modeling and the analysis remain the sole responsibility of the authors and bear full responsibility for the content as submitted.

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