ASYMMETRIC PRICE TRANSMISSION IN NIGERIA'S LIVESTOCK MARKETS

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ABSTRACT
This study examined the presence and effects of asymmetric price transmission (APT) in Nigeria's livestock markets, focusing on cattle, sheep, and goat markets across four states. The research was motivated by concerns over market inefficiencies and potential inequities in price transmission between states. Weekly retail price data from March 2021 to October 2023 were analysed using a Non-linear Autoregressive Distributed Lag (NARDL) model to assess whether price changes, particularly increases and decreases, were transmitted symmetrically or asymmetrically between markets. The findings indicated notable regional disparities in price transmission. While the northern livestock markets demonstrated symmetric price transmission, the southern sheep market exhibited significant asymmetry, with price increases being transmitted more strongly than price decreases. In the short run, positive price transmission coefficients ranged from 0.53 to 0.35, while negative coefficients varied from 0.57 to 0.25. However, none of the long-run coefficients were statistically significant. These results pointed to inefficiencies in the southern sheep markets, contributing to unequal market outcomes. Furthermore, Granger causality tests revealed a unidirectional flow of prices between markets, likely influenced by regional differences in livestock production volumes, marketing activities, and consumption preferences. The study highlights the need for policy interventions to address these market inefficiencies, promote equitable outcomes, and strengthen the livelihoods of those reliant on the livestock sector. The research contributes to the limited understanding of APT in Nigeria's livestock markets and offers insights for improving market performance through targeted policies.

Keywords: Causality, Market Integration, Livestock, Non-linear Autoregressive Distributive Lag (NARDL), Nigeria

INTRODUCTION
Nigeria's livestock sub-sector is a cornerstone of its economy, profoundly impacting the livelihoods of millions, especially in rural areas (FAO, 2019). This sector is essential not only for providing food, income, and employment but also for supplying raw materials to various industries. Nigeria's livestock markets, particularly in key regions known for cattle, sheep, and goat trading, are critical in meeting the protein demands of a growing population and supporting the economic well-being of local communities (FAO, 2021). Despite its significance, the livestock market in Nigeria is beset by challenges, including inefficiencies in market operations, inadequate infrastructure, and significant price volatility.

A critical aspect of market analysis in this context is price transmission—the process through which price changes in one market or region are communicated to another. Efficient price transmission is vital for the effective dissemination of price signals, which in turn facilitates optimal resource allocation and maximises welfare (Akintunde et al., 2018). However, the presence of asymmetric price transmission (APT), where price increases and decreases are not equally transmitted across regions or markets, raises significant concerns about market efficiency and equity (Liu et al., 2022; Meyer & von Cramon-Taubadel, 2004).

APT can emerge from various factors, including market power, transaction costs, and policy interventions, all of which can disrupt the smooth flow of prices between spatially separated markets (Alam et al., 2022). Understanding APT in Nigeria's livestock market is crucial for developing policies aimed at enhancing market integration and efficiency. Although there is extensive research on APT in agricultural markets globally, studies specifically focusing on the Nigerian livestock sector are limited (Inyeinyang & Ukpong, 2019; Abdulai, 2000; Goodwin & Holt, 1999).

Given the critical role of the livestock market in Nigeria's economy and the far-reaching implications of APT, this study sought to understand market dynamics by investigating the existence of asymmetry in selected livestock markets in Nigeria. This investigation is essential for informing policy decisions that could mitigate the adverse effects of APT and promote more equitable and efficient market outcomes.

Literature Review:

Spatial price transmission refers to how price changes in one geographic area impact the prices of the same or similar goods in another. In perfectly competitive markets, prices of identical goods across different locations should move together, with variations only due to transaction costs and other market frictions (Liu et al., 2022; Fackler & Goodwin, 2001). This concept is crucial for market integration, ensuring efficient resource allocation (Meyer & von Cramon-Taubadel, 2004). However, asymmetry in price transmission (APT) occurs when price increases in one market are not transmitted to another at the same rate as price decreases, often due to market power, transaction costs, or policy interventions (Bulutay et al., 2021). APT indicates that markets don't always respond uniformly to price changes, leading to inefficiencies and inequities, such as producers receiving lower prices during declines without consumers benefiting fully from reductions (Petropoulos et al., 2022). Livestock market dynamics, influenced by factors like seasonal variations, transportation costs, and feed availability, can cause significant regional price disparities, highlighting the need to understand these dynamics for better analysis of price transmission (Inyeinyang & Ukpong, 2019; Tiffin & Dawson, 2000; Abdulai, 2000).

APT is well-documented in agricultural markets, where factors like market power, transportation costs, and policy interventions can lead to asymmetry. For example, Abdulai (2002) found that in Ghana's maize markets, upward price movements were transmitted more quickly than downward ones due to traders' market power and high transportation costs. Similarly, Goodwin and Holt (1999) observed APT in U.S. meat markets, particularly where few dominant firms suggested imperfect competition. In Nigeria, most research has focused on crop commodity markets, with limited studies on livestock. For instance, Balcombe and Morrison (2002) identified challenges in market integration in Nigeria's rice and maize markets due to poor infrastructure and high transaction costs, emphasising the need to understand price dynamics in agricultural markets.

Livestock markets in Nigeria are crucial for rural livelihoods, yet they are poorly understood, especially regarding price transmission and market integration. Ogunniyi and Omotesho (2011) highlighted inefficiencies in goat marketing in Osun State, Nigeria, such as high transaction costs and poor market integration, which result in unequal benefit distribution, with producers often receiving lower prices due to weak bargaining power. Ajetomobi and Binuomote (2006) similarly found incomplete and slow price transmission in sheep and goat markets in Southwestern Nigeria, attributing this to poor infrastructure and market fragmentation. These studies underscore the challenges in Nigeria's livestock markets but do not specifically address APT, which this research aims to explore.

Globally, studies have shown asymmetric price transmission across various agricultural markets. For example, Cramon-Taubadel (1998) found that retail prices in the German pork market responded more quickly to wholesale price increases than decreases, suggesting that retailers might exploit rising prices to maintain or increase profit margins. Similarly, Abdulai (2000) identified APT in Ghana's maize markets, attributed to market power and transaction costs. In livestock markets, Goodwin and Holt (1999) discovered asymmetric price transmission in the U.S. beef sector, likely due to market power held by processors and retailers. Regional studies in Africa, such as Mutuc et al. (2011) in the Philippine rice market, also noted asymmetry, with price adjustments being more responsive during periods of rising prices due to market inefficiencies. In Nigeria, while research on price transmission has mainly focused on staple crops, studies suggest that factors like transportation challenges and market structure likely contribute to APT in the livestock sector.

Theoretical Framework: The theoretical framework for this study is grounded in the concept of market integration and the law of one price (LOP). According to the LOP, in a perfectly competitive market, the price of a homogeneous good should be the same across different locations, after accounting for transportation costs and other transaction costs (Fackler & Goodwin, 2001). Price transmission, therefore, is a measure of market integration, with symmetric price transmission indicating efficient markets where prices adjust fully and quickly to changes in supply and demand.
However, in reality, many agricultural markets, especially in developing countries, exhibit APT, where prices do not adjust uniformly. The reasons for APT are multifaceted and can include factors such as market power, as discussed by Peltzman (2000), where dominant firms can influence prices, causing asymmetric adjustments. Additionally, the role of transaction costs, as outlined by Barrett and Li (2002), can create barriers to market integration, leading to slower or incomplete price transmission.
In the context of livestock markets, the perishability of goods, transportation challenges, and the structure of the market can all contribute to APT. For instance, Baulch (1997) demonstrated that in markets with high transaction costs, such as those for perishable agricultural products, prices may adjust more slowly to positive shocks than to negative ones, reflecting the higher costs of storing or transporting these goods. This study builds on these theoretical foundations to explore APT in Nigeria's livestock markets.

METHODOLOGY

Study area: The study was conducted across selected cattle, sheep, and goat markets in four states of Nigeria viz. Abia, Gombe, Jigawa, and Oyo states (Figure 1). These states were chosen to represent diverse geographical and economic settings within the country, offering an insight to spatial price transmission dynamics across different regional livestock markets.

Abia State, located in south-eastern Nigeria, is characterised by its agricultural economy, with livestock trading playing a significant role in the locals' livelihoods. Major markets in Abia, such as the Umuahia and Aba livestock markets, serve as crucial hubs for cattle, sheep, and goat trading, connecting local producers with consumers and traders from neighbouring states.

Gombe State, in north-eastern Nigeria, is an important livestock-producing area, with a significant portion of the population engaged in pastoralism and livestock trade. The state's markets, including the Gombe main market, are vital for the distribution of livestock across the north-eastern region, influencing price dynamics within and beyond the state.
Jigawa State, located in the north-western part of Nigeria, is known for its vibrant livestock markets, particularly for cattle and goats. The Maigatari international cattle market, one of the largest in the region, attracts traders from across Nigeria and neighbouring countries, making it a key point for analysing price transmission and market integration.

Oyo State in south-western Nigeria, is a major commercial centre with a long history of livestock trading. The Bodija market in Ibadan -the state capital, is one of the largest livestock markets in southern Nigeria, where cattle, sheep, and goats are traded extensively. This market plays a crucial role in shaping livestock prices in the south-western region.

The selection of these markets allows for the examination of price transmission dynamics across diverse economic and geographical contexts in Nigeria, providing insights into the regional variations and inefficiencies that may exist in livestock market integration.

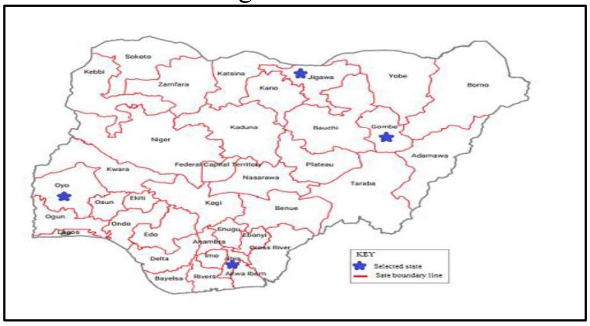

Figure 1: Map of Nigeria showing the selected states where the markets are located

Data Source: In this study, six variables were used: prices of cattle, sheep and goats in Abia, Gome, Jigawa and Ibadan markets. All the livestock were males. The dataset consisted of weekly nominal retail prices from March 2021 to October 2023, totalling 139 observations. The choice of period of coverage and data frequency were made based on availability of data which were sourced from FAO'S Famine and Early Warning Systems Network (FEWS NET) data base.

Analytical Techniques:

Unit Root Test: As a requirement in time series analysis, the data have to be tested for stationarity to avoid the problem of spurious regression and its consequences. Hence, in the first step of the analysis process, Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1979) and Phillip Perron tests were employed to establish unit roots of the data series. Optimum lags were determined by the Akaike Information Criterion (AIC). The mathematical expression of the test is defines as:-

$$\Delta P_t = \alpha + \beta P_{t-1} + \sum_{m=1}^{M} \theta_m \Delta P_{t-m} + \varepsilon_t \text{ ------(1)}$$

Where, P is retail price of livestock under consideration for market under consideration in ₦, Δ is the difference operator, t is time trend, m represents the number of lags in the model, α, β and θ are parameters to be estimated, ε_t is a white noise error term. The result is tested against a null hypothesis (δ = 0) of the presence of unit root in the series under consideration.

There was a total of eight market retail price variables (P_t) composed of ABCT = Abia cattle, ABGT = Abia goat, ABSP = Abia sheep, GMCL = Gombe cattle, GMGT = Gombe goat, GMSP = Gombe sheep, IBCL = Ibadan cattle, IBGT = Ibadan goat, IBSP = Ibadan sheep, JGCL = Jigawa cattle, JGGT = Jigawa goat and JGSP = Jigawa sheep.

Asymmetric Price Transmission in NARDL Framework: Upon confirmation of stationarity among price pairs, a Non-linear Autoregressive Distributive Lag (NARDL) framework was employed to examine the asymmetric price transmission between the livestock regional markets in terms of analysing the long run relationship between livestock regional markets across regions was modelled. To begin with a simple model expressing the relationship given as:

$$P_t^1 = \beta_0 + \beta_1 P_t^2 + \varepsilon_t \text{-----------(2)}$$

where P^1 is price of livestock in market under consideration in ₦, P^2 is price of livestock in counterpart market in ₦, β are coefficients to be estimated, t -s time trend and ε is a random error term.

NARDL defines an asymmetric non-linear relationship between variables under consideration it also aids in determining the likelihood of asymmetric influence of explanatory variables' positive and negative shocks on the dependent variable in the long and short run (Granger, 1969). In this case, it explains the non-linear adjustment process where the dependent variable (in this case-prices) respond differently to appreciations and depreciations in the independent variable. To account for this, an NARDL model as developed by Shin et al. (2014) features an asymmetric extension to the standard ARDL model and bears the strengths of the standard ARDL model including its and is applicability to time series which are stationary at level, at the first difference, or of mixed order of integration even though the sample is small (Shin et al., 2014). Thus, the asymmetric cointegration form of equation (2) is expressed as:

$$P_t^1 = \alpha_0 + \beta_1 P_t^{2+} + \beta_2 P_t^{2-} + \mu_t \text{ --------(3)}$$

where P_t^{2+} and P_t^{2-} indicate the partial sum of positive and negative changes in explanatory variable (prices of livestocks). The explanatory variable in equation (3) is then decomposed into two new variables that will represent positive and negative shocks in the prices as follows:

$$P_t^{2+} = \sum_{j=1}^{t} \Delta P_t^{2+} = \sum_{j=1}^{t} \max(\Delta P_t^2, 0) \text{ -----(4)}$$

and

$$P_t^{2-} = \sum_{j=1}^{t} \Delta P_t^{2-} = \sum_{j=1}^{t} \min(\Delta P_t^2, 0) \text{ -----(5)}$$

The asymmetric long-run and short-run relationship among concerned variables can be developed by transforming Equation (3) into Equation (6) following Shin et al. (2014):

$$\Delta P_t^1 = \alpha_0 + \beta_t P_{t-1}^1 + \beta_2 P_t^{2+} + \beta_3 P_t^{2-} + \sum_{i=1}^{p} \beta_i \Delta P_{t-1}^1 + \sum_{i=1}^{q} \gamma_{2i} \Delta P_{t-1}^{2+} + \sum_{i=1}^{r} \gamma_{3i} \Delta P_{t-1}^{2-} + \delta ECM_{t-1} + \mu_t \text{ ----------(6)}$$

where Δ first difference operator, t is time period, p, q, r indicates the respective lag orders, parameters with ∑ symbol denote the short-run coefficients, and others are long-run coefficients, δ represents the elasticity of lag error correction term and μ is the error term.

For verification of long run co-integration, the null hypothesis of no co-integration is tested using the F-statistic. Furthermore, the presence of asymmetry is confirmed through a Wald test.

RESULTS AND DISCUSSION

A summary of the price series in form of descriptive statistics is outlined in Table 1. Regional comparison within the time period of analysis shows that Abia market registered the highest mean prices for cattle and goat while mean price for sheep was highest in Ibadan market. There seems to be some appreciable level of consistency in the market as observed by the coefficient of variation (CV) values which mostly fell within an acceptable range of less than 30%.

Stationarity: Following convention in time series analysis, ADF and PP unit root tests were performed on the variables to determine their stationarity statuses. The tests were conducted at both constant and trend specifications, under Akaike Information Criteria lag length selection. The results as presented in Table 2 shows that the variables achieved stationarity at either level or first difference, thus, validating the condition for employing the NARDL technique.

Bound Test of Cointegration: Upon confirmation of stationarity, a cointegration test was applied to examine the presence of cointegration relationships to reveal if the variable pairs had long-run non-linear co-integration relationships. Table 3 presents the test results of the Wald cointegration tests. Based on the F-statistics, the null hypothesis of a linear cointegration relationship for most of the market pairs were rejected. As shown in the table, all the modelled livestock markets in the northern part of the country and only the sheep market in the southern part were co-integrated. This means that price changes in one of the market pair are transmitted to the other market pair, suggesting the markets were integrated. These results make sense considering some factors. Available literature (Boffa & Varela, 2019) lists potential drivers of market integration to include transport costs, commodity specific characteristics, state level production and regional consumption preferences. To understand further, we explore two of these drivers. In Nigeria, the northern part is the major producer and supplier of livestock across the country. Traditionally, livestock is transported from the north to the south. However, some few states in the south raise livestock, particularly cattle and goat but sheep it is rare. So, it is possible for prices of sheep to be transmitted between Abia and Ibadan markets since they both rely on the north for supply. This reliance on a common source for sheep could enable quick dissemination of information about price changes (Sendhil et al., 2023) resulting in market integration.

Similar outcome of market integration was reported by Kidane (2022) in regional grain markets of Ethiopia. Ultimately, only those market pairs that were co-integrated were considered for NARDL estimation.

Estimated Coefficients: The results from the dynamic Non-linear Autoregressive Distributive Lag (NARDL) model provided valuable insights into the APT dynamics in Nigeria's livestock markets, with particular focus on cattle, sheep, and goat markets. The results in Table 4 show a distinct pattern where positive shocks (price increases) tend to be transmitted more strongly than negative shocks (price decreases), especially in long-run price linkages between the markets.

The results show that in the long run, a 1% increase in the price of sheep in Ibadan led to a 0.105% increase in the price of sheep in the Abia market, while a 1% decrease in sheep prices in Ibadan caused only a 0.038% rise in prices in Abia. This demonstrates a stronger price transmission effect for positive shocks compared to negative ones, which reflects asymmetry in price responses across regions. Such asymmetry was also observed in the Gombe-Jigawa sheep and goat markets, with the goat market in particular registering the highest long-run coefficients. This asymmetry suggests that livestock markets are more responsive to price increases than decreases, a phenomenon often linked to the presence of market frictions such as transportation costs, imperfect market integration, and adjustment lags. The persistence of price shocks from one period to another, as indicated by the significance of lagged explanatory variables, suggests that past prices continue to influence current market prices, reinforcing the notion of price stickiness in livestock markets. Similar conclusions were drawn by Meyer and von Cramon-Taubadel (2004), who found that asymmetric price transmission often stems from costs related to transportation, transaction delays, and other structural rigidities that prevent markets from adjusting quickly to negative price changes.

In the short-run, all shocks were significant at least at the 10% level. For instance, in the southern cattle market (Abia), a positive shock from Ibadan led to a 0.533 increase, while a negative shock resulted in a 0.574 effect on retail cattle prices. This indicates that both positive and negative shocks had nearly equal impacts on Abia's cattle market, with prices adjusting relatively symmetrically in the short run. This pattern was also observed in northern markets where a 1% increase in cattle and sheep prices in Jigawa resulted in a 0.351% and 0.352% increase in Gombe, while a 1% decrease caused a 0.247% and 0.256% drop, respectively. However, the goat markets showed a marginally weaker response, which could be attributed to lower demand elasticity or different consumption patterns for goat meat, as noted by Tadesse and Shively (2013). These short-run dynamics highlight that livestock prices respond quickly to market shocks, indicating that regional markets are relatively well-integrated in the short term. However, the near-equal influence of price increases and decreases contrasts with the long-run asymmetry, suggesting that market forces like transportation costs or delayed information may take longer to influence market behaviour in the long run, a point also made by Goodwin and Holt (1999) in their study on agricultural market integration.

The error correction terms (ECT) were statistically significant and bore the expected negative signs across all livestock markets, implying that deviations from long-run equilibrium would eventually be corrected over time. The statistical significance of ECT values suggests that price adjustments across markets are functioning effectively, driven by market forces and free from significant restrictions on livestock trade. This result aligns with the findings of Zhang (2017), who noted that well-functioning markets tend to adjust price deviations over time, albeit at varying speeds. However, the relatively slow adjustment speeds—such as the 11% correction of deviations in the Gombe-Jigawa goat market—indicate that while markets are moving toward equilibrium, they do so at a slow pace. This slow adjustment might reflect infrastructural challenges, such as poor road networks, transportation bottlenecks, or delays in the flow of market information, which are common in many developing country markets as highlighted by Waiswa and Yavuz (2023). In such cases, policy interventions aimed at improving market infrastructure, transportation systems, and information dissemination could significantly enhance market efficiency and reduce the observed lags in price adjustments.

The persistence of asymmetric price transmission has important policy implications. The stronger response to price increases compared to decreases may exacerbate inequities in market outcomes, particularly for smallholder farmers and consumers who are more vulnerable to price spikes. Price asymmetry can also signal inefficiencies in market structure, as it indicates that certain costs—such as transportation or adjustment costs—are disproportionately affecting how prices are transmitted across regions. This phenomenon has been widely observed in agricultural markets, with studies such as Peltzman (2000) and Meyer and von Cramon-Taubadel (2004) demonstrating that APT is often driven by factors such as market power, transportation costs, and delayed information flow. Moreover, the slow speed of adjustment, as indicated by the ECT results, highlights a need for policies that improve market connectivity. Investment in infrastructure to reduce transportation costs and improve market information systems could help accelerate the speed at which markets return to equilibrium aftershocks. This would not only reduce the impact of price volatility on vulnerable populations but also promote more equitable market outcomes, as suggested by Tadesse and Shively (2013) in their study on market efficiency in Ethiopia.

Bound Test of Asymmetry: Both positive and the negative changes had long-run positive effects on the responding markets. A wald test of asymmetry was performed to confirm if the coefficients were equal. Table 4, also contains the results of which clearly shows that the null hypothesis of equality was rejected for only the south sheep market since its p-value was less than 0.05. This means there was presence of asymmetry in the long-run impact of Ibadan sheep market on Abia sheep market. As for the remainder market pairs, it is evident the long run changes were symmetrical. The implication is that sheep prices in Abia market respond to a positive shock from Ibadan market differently to response of a negative shock. Frey & Manera (2007) and von Cramon-Taubadel & Meyer, (2004) noted that non-competitive behaviour and adjustment costs (or transaction methods) are causes of asymmetry in price transmission. Therefore, based on the results, it is safe to conclude that all the markets with the exception of Abia and Ibadan cattle markets were competitive. This is interesting and needs further explanation on reasons for this behaviour. From a regional meat preference perspective, the northern region's common meat is beef and mutton while the popular meat in the south is chevon. Other uses of these livestock in the north include cow as a source of milk which is a common food source and the use of sheep and goat as a means of savings and investment. Hence, demand for cattle may be low in the south which makes it uncompetitive as supported by Okeowo and Akanni (2022) who found out that cattle market in southwest Nigeria was weakly competitive.

Granger Causality Test: Granger causality tests were performed to examine the direction of the price flow in the form of causality between target market prices and influencing market prices. In all cases as shown in Table 5, there were unidirectional Granger causal relationship between the markets pairs. One may conclude that livestock prices in Gombe adjust to price changes in Jigawa markets for all the livestock. This unidirectional flow of prices between the markets could be attributed to a large extent to volume and intensity of livestock production, marketing and consumption preferences between the regions. Furthermore, the results underscore an uneven nature of market integration across regions. This finding suggests that markets in more agriculturally productive or economically dominant regions (such as Jigawa in the north) tend to drive price changes in less dominant regions. Such unidirectional price flows can create dependencies that may hinder market competition, as described by Fackler and Goodwin (2001), who found similar patterns in agricultural commodity markets. Addressing these asymmetries may require targeted policies to support market integration in less dominant regions, potentially through subsidies for transportation or investment in local market infrastructure.

CONCLUSION

Market integration techniques has been adopted in this study to examine asymmetric price transmission between selected regional livestock market pairs in Nigeria. This study is relevant as most of the price transmission studies reported for Nigeria focused on food crop commodities while dynamics of this phenomenon in the country's livestock markets has received minimal attention. Such an examination will guide policy interventions in the livestock sub-sector. As evidenced by the study findings, most of the livestock markets analysed had symmetric price transmission effects on their counterparts. In these markets, obviously, price appreciations in the markets seemed to be passed on faster between the market pairs while price depreciations manifested weakly on their counterparts. In contrast, Ibadan sheep market had a statistically significant asymmetric price transmission impact on its Abia counterpart. Implying that marketers in Ibadan could benefit from policies which focus more on boosting trade. It is therefore safe to say that most of the markets in this study were efficient, competitive and integrated, which could enhance trade flow. The results suggest the leading role of Jigawa in the region's livestock market as indicated by the adjustment response behaviour of Gombe market and the Granger causality test results. Based on the findings, the study advocates for development of effective policies to boost production and market so as to promote and maintain sustainability of the livestock markets in the north and policies in support of improving efficiencies of livestock markets in the south. Finally, these findings point out to the need for future empirical work in this area to examine the underlying reasons for the difference in the observed price transmission dynamics between the regions.

Although this study sought to present a detailed examination of asymmetric price transmission in livestock markets in Nigeria, it is not devoid of limitations. First, the analysis was based on a limited number of livestock market pairs, which may not fully capture the complexity of price transmission dynamics across the entire country. Second, the study does not account for other external factors such as seasonality, regional economic shocks, or political instability, which could influence livestock prices. Third, variables representing transportation, infrastructure and supply chain logistics, which are known to significantly impact market integration, were included in the analyses. Finally, the use of weekly price data, while useful for capturing short-term dynamics, may overlook longer-term trends or structural changes in the market. Future research should therefore, address these limitations by expanding the scope of market pairs analysed, incorporating additional external variables, and employing more granular data to capture broader patterns in livestock market studies.

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Table 1: Summary statistics of regional cowpea price series

Variable	Retail Price in Naira per Average Male				
	Mean	Maximum	Minimum	St. Deviation	CV(%)
ABCL	617591.10	795000.00	283000.00	124263.50	20.12
GMCL	253946.50	283600.00	201680.00	12043.80	4.74
IBCL	263635.30	330000.00	140000.00	52052.31	19.74
JGCL	222690.30	314000.00	146500.00	44062.22	19.79
ABGT	61660.69	81460.00	19400.00	14676.97	23.80
GMGT	35842.18	59200.00	18000.00	8836.83	24.65
IBGT	44261.51	68800.00	24000.00	13447.37	30.38
JGGT	21545.07	40400.00	15280.00	5482.73	25.45
ABSP	72095.43	88500.00	28300.00	12008.10	16.66
GMSP	61028.11	94200.00	44640.00	7905.76	12.95
IBSP	76856.22	108000.00	44400.00	18677.28	24.30
JGSP	54921.87	107000.00	30890.00	14428.20	26.27

Table 2: Results of unit root tests

Variable	ADF		PP		Conclusion
	Level	First difference	Level	First difference	
	t-statistic	t-statistic	t-statistic	t-statistic	
LABCL	-2.890	-8.463***	-2.669	-20.127***	I(1)
LABSP	-2.321	-7.530***	-2.496	-12.679***	I(1)
LABGT	-4.070***	-4.949***	-1.768	-11.878***	I(0)
LIBCL	-2.577	-11.753***	-2.612	-11.761***	I(1)
LIBSP	-2.692	-14.864***	-3.183*	-15.831***	I(0)
LIBGT	-3.490**	-12.326***	-3.389**	-13.967***	I(0)
LJGCL	-1.592	-12.863***	-1.675	-12.806***	I(1)
LJGSP	-2.683	-10.596***	-2.727	-10.611***	I(1)
LJGGT	-2.525	-11.914***	-2.725	-11.914***	I(1)
LGMCL	-5.094***	-11.737***	-8.502***	-23.708***	I(0)
LGMSP	-4.983***	-8.347***	-5.014***	-27.649***	I(0)
LGMGT	-3.217*	-18.518***	-4.496***	-18.867***	I(0)

Table 3: Results of bounds test for nonlinear co-integration

Equation	K	F-statistic	Narayan (2001) Critical values at 5%	
			I(0)	I(1)
LABCL-LIBCL	1	2.981	3.62	4.16
LABSP-LIBSP	1	8.108**	3.62	4.16
LABGT-LIBGT	1	2.010	3.62	4.16
LGMCL-LJGCL	1	6.036**	3.62	4.16
LGMSP-LJGSP	1	6.339**	3.62	4.16
LGMGT-LJGGT	1	9.641**	3.62	4.16

Note: ** denote statistically significant at 5% levels. K is the number of exogenous variables in the equation.

Table 4: Results of NARDL model for Nigeria's livestock markets

Independent variable	Dependent variable			
	LABSHP	LGMCL	LGMSP	LGMGT
Panel A: Adjusting (short-run) dynamics				
ΔLIBSHP_POS	0.533***(4.527)			
ΔLIBSHP_NEG	0.574***(2.833)			
$\Delta LGMCL_{t-1}$		-0.293***(3.504)		
$\Delta LJGCL\_POS_{t-1}$		0.351**(2.414)		
$\Delta LJGCL\_NEG_{t-2}$		0.247*(1.902)		
ΔLJGSP_POS			0.352***(3.140)	

$\Delta LJGSP\_NEG_{t-1}$			0.256**(2.280)	
$\Delta LGMT_{t-1}$				-0.432***(-5.156)
$\Delta LJGT\text{-}NEG_{t-1}$				0.279**(2.343)
Panel B: Cointegrating (long-run) dynamics				
$LABSHP_{t-1}$	-0.133***(-4.442)			
$LIBSHP\text{-}POS_{t-1}$	0.014(0.328)			
$LIBSHP\text{-}NEG_{t-1}$	-0.005(-0.066)			
$LGMCL_{t-1}$		-0.470**(-4.870)		
$LJGCL\_POS_{t-1}$		0.022(1.005)		
$LJGCL\_NEG_{t-2}$		0.022(0.877)		
$LJGCL_{t-1}$				
$LGMSP_{t-1}$			-0.326***(-5.351)	
$LJWSP\text{-}POS_{t-1}$			0.026(0.934)	
$LJGSP\text{-}NEG_{t-1}$			-0.002(-0.080)	
$LGMGT_{t-1}$				-0.108*(-1.780)
LJGGT_POS				0.045(1.298)
$LJGGT\_NEG_{t-1}$				0.027(0.710)
Constant	1.478***(4.529)	5.846***(4.869)	3.525***(3.545)	1.109*(1.808)
Asymmetric long-run price Transmission elasticities				
β^{+}	0.105	0.047	0.080	0.417
B^{-}	0.038	0.047	0.006	0.250
Wald test value	19.770***[0.000]	1.184[0.279]	0.208[0.649]	0.495[0.499]
Panel C: Diagnostics				
ECT	-0.133***[-5.939]	-0.470***[-4.912]	-0.326***[-5.601]	-0.108***[-3.492]
R^2	0.332	0.453	0.294	0.290
Adjusted R^2	0.307	0.422	0.273	0.269
BG-LM	0.513[0.600]	0.633[0.533]	0.826[0.440]	0.459[0.633]
JB	279.85[0.000]	601.475[0.000]	130.549[0.000]	224.902[0.000]

Note: ***, ** and * denote significance at 1%, 5% and 10% levels, respectively. Figures in parenthesis (…) are t-statistics while figures in brackets […] are p-values.

Table 5: Pairwise Granger Causality Tests

Null hypothesis	F-Statistic	Probability	Decision	Direction
ABSP ≠> IBSP	3.144	0.046**	Reject	Unidirectional
IBSP ≠> ABSP	1.629	0.200	Accept	
GMCL ≠> JGCL	1.021	0.363	Accept	Unidirectional
JGCL ≠> GMCL	6.130	0.003***	Reject	
GMSP ≠> JGSP	0.433	0.650	Accept	Unidirectional
JGSP ≠> GMSP	8.275	0.000***	Reject	
GMGT ≠> JGGT	0.417	0.660	Accept	Unidirectional
JGGT ≠> GMGT	3.449	0.035**	Reject	

Note: '≠>' stands for 'does not Granger cause', while ***, ** and * denote significant levels at 1%, 5% and 10% levels, respectively