RESEARCH ARTICLE

Ripple Effect in Regional Housing Markets

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Abstract

This paper examines the ripple effect in the Nigerian regional housing market by analysing the long run connectedness and lead-lag relationship among housing returns of three cities in the country. Data on the investment returns of housing assets of bungalow, block of flat and detached house used for the study in the 1999-2022 period were collected from real estate firms in Lagos, Abuja, and Port Harcourt, Nigeria. Stationarity was tested using Augmented Dickey Fuller and Philip Perron unit root tests while Johansen and Juselius and Granger causality tests were employed to examine the long run convergence and lead-lag relationship between the housing assets. The results of the cointegration test showed long run convergence among the returns of the various residential property assets in the three regions, indicating the possibility of ripple effect. However, the Granger causality test revealed differences in the lead-lag relationship among the regional housing returns based on housing typology. The study concludes that the existence of ripple effect in the housing markets across the three locations is limited by variations in housing typologies which reduces the extent of price diffusion in the housing markets. The findings have profound implications for investors participating in the Nigerian housing market.

***Keywords**: Housing returns, housing market, ripple effect, cointegration, lead-lag effect, Nigeria*

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Introduction

Generally, the role of housing in catering for a wide variety of man's desire has fueled its increasing recognition as an all-encompassing phenomenon of the human habitat. In this light, Hadizadeh (2019) affirmed the housing component of the real estate sector as a key driver of economic activities in several countries. In addition to its role in offering shelter, housing is the biggest and the most singular vital household investment, store of wealth and savings for many families, particularly in developing countries such as Nigeria. For these cash strapped families, housing is one of their most precious possessions. To demonstrate its importance, Anaekwe (2023) affirmed that housing investment accounts for about 35% of the real estate sector's 7.9% contribution to national wealth in Nigeria with about 20% of Nigerians as house owners. The popularity of housing as a prime asset attracting the participation of individual and institutional investments in Nigeria is underscored by the economic and cultural attachment attached to housing. At the institutional level, investors have often invested in housing across the various geographical areas known as geo-political zones in the country.

However, the nature of housing as a tangible, but immovable asset implies its inability to visibly circulate; as such, housing returns in a particular city or region are significantly impacted and influenced by local market and economic as well as demographic situations (Ma & Liu, 2013). Since the housing market is very localized, the local forces affecting its operations differs across cities and regions (Teye *et al*., 2017). These variations

suggest that there should be some degree of divergence in housing returns across cities/regions (Shi, Young & Hargreaves, 2009). However, practically, available evidence revealed the presence of convergence in housing prices across regions. According to Meen (1996), the pattern of housing price formation in a particular city/region is often transmitted out to other cities/regions resulting in the comovement of housing prices and returns. This convergence of regional house prices indicates the existence of price diffusion/ripple effect (Cook, 2003; Brady, 2014; Blake & Gharleghi, 2018; Payne, 2023). The extent and drivers of the occurrence of ripple effect in housing prices have been extensively discussed in the literature. However, these studies have documented price diffusion in housing markets of developed economies, particularly the United Kingdom, Netherlands, Australia and the United States. Limited attention has been paid to developing countries despite the status of housing investment as the most significant household undertakings and wealth indicator in these countries. More so, the degree and nature of causality in the connectedness of regional house prices has not received adequate attention, thereby calling for additional evidence.

The enormous investment potential in the Nigerian housing market stemming from the need for additional housing assets to close the housing gap underscores the increasing participation of institutional investors in the market. Currently, the existing administrative and political structure of the country comprise six geo-political zones. These regions serve as clusters of economic activities upon which the prosperity of the country is aggregately measured. To seamlessly benefit from the locational attributes of these geographic areas, the investment portfolio of investors is spread across these regions with housing assets located in cities across the six geo-political zones.

It is not however clear if there is presence of convergence in the price and return generating behaviour of these regional housing market. More so, the degree of connectedness and causal relationship between the regional house price returns which could limit the transmission of diversification and risk reduction benefits is unknown.

Knowledge of the existence of ripple effect across regional housing markets in Nigeria is important for several reasons. First, the possibility of price diffusion spreading from one region to another would be of particular interest to housing investors. Since there are variations in the economic structure of these regions which significantly influence the operation of the housing market, market performance in one region could spread and influence that of others. For instance, the South-West region with Lagos as the predominant city is generally accepted as the most economically developed and commercial hub of the country. Housing market performance in Lagos could diffuse into the city of Abuja in the North-Central region - the political capital and administrative headquarters of the country, as well as Port Harcourt - the biggest and most economically developed city in the oil-rich Niger-Delta region. Second, regional housing investment is predicated on the potential to enjoy geographic diversification benefits. Based on the degree of causality and interconnectedness of housing returns of these regions, the possibility of transmitting diversification benefits to investor's portfolio within the Nigerian regional housing markets is unraveled. Third, the existence of information on the lead-lag association among regional housing markets is beneficial to investors seeking to optimize their investment decisions as their capacity to make rational decisions particularly on asset allocation and proportioning is strengthened. More importantly, the preponderance of housing investment decisions based on the diversity of housing types in Nigeria underscores the need for an empirical investigation on the price diffusion and transmission capability across the Nigerian housing markets. This becomes essential since in a bid to enjoy the benefits accruable from geographic diversification, housing investors in Nigeria have been

documented by studies such as Anaekwe (2023) to be influenced by housing typology in investing across several regional areas. More so, most of the housing investors resort to predicating their investment and allocation decisions on housing typology based on their previous experiences in other regions. This often leads to an anchoring bias effect which could negatively impact investment outcomes given the variations in the dynamics of housing market behaviour across regions.

Therefore, in a bid to provide information on the existence of ripple effect in the Nigerian regional housing market and document the degree of the causality and causal relationship among housing assets across the varying geographic areas, which could influence the nature of diversification benefits gained by housing investors in the country, this study analysed the ripple effect in the housing markets of Lagos, Abuja and Port Harcourt. These three first tier cities with significant housing investment activities, are spread across the three main regions of South-West, North-Central and South-South (Niger Delta) with substantial economic and real estate dealings in the country. The remainder of the paper is structured as follows: following this introductory background is the review of previous studies which reflects the existing thoughts upon which the study is anchored in section two. The methodology adopted for the study is contained in section three while section four presents and discusses the findings. The paper concludes in section five.

Review Of Previous Studies

The issue of ripple effects in regional housing markets have attracted the attention of scholars and researchers. As such, it has received considerable attention as evident in the extant studies devoted to it. Following the seminar work of Meen (1996) which documented the existence of price diffusing properties in regional housing markets with shocks rippling out to the entire economy, several studies have investigated the existence and nature of the ripple effect in housing prices. These studies have however concentrated on the developed economies, particularly in the United Kingdom, Australia and China. As such, little evidence of the nature of ripple effects in regional housing markets in developing economies could be found in the literature while the evidence is minimal in emerging/nascent African economies. Thus, to distill the evolution of knowledge on housing ripple effects, it is pertinent to track the flow of knowledge in these countries so as to appropriately guide prospective local and international investors desirous of committing investment funds in the attractive housing markets of these countries. For instance, in the UK, studies succeeding the work of Meen (1996) such as Meen (1999) confirmed the existence of a ripple effect generating spatial movements in house prices across the regional housing markets and that shocks in house prices originate in the South of England before spreading to other parts. Similarly, Cook (2003) investigated the existence of ripple effects in regional housing markets by analyzing the degree of convergence in house prices in 13 regions across the United Kingdom. The study established convergence in the house prices across the regions and affirmed the transmission of price from one region to another which is an indication of the presence of a ripple effect. Holmes (2007) unraveled the ripple effects in housing market by investigating the long run cointegrating properties of regional house prices in the United Kingdom. Using econometric methodology comprising panel data unit root tests, the study found limited evidence of convergence among house prices in the UK suggesting segmentation of the housing markets, rather than ripple effect.

Holmes and Grimes (2008) using principal component analysis and unit root test established the presence of long run cointegrating relationships in the UK regional housing markets which is an indication of regional adjustment to price shocks across the market. Likewise, Holly, Pesaran and Yamagata (2011) examined the spatial and temporal diffusion of housing prices in the United Kingdom. The study

explored this issue by using non-stationary dynamic systems to model the spatial and temporal transmission of shocks in the regional housing markets. Findings from the study established the existence of price diffusion in the regional housing markets. Additionally, the study confirmed the dominance of London as the key source of shocks transmission while housing price across regions specifically respond to London shocks and this is internally absorbed by the dynamics of the local housing market. Cutsforth and White (2021) provided a more recent evidence of the presence or otherwise of housing market ripple effect by exploring the issue of spillover, contagion and interconnectedness of local house prices in the United Kingdom. The findings showed that the local house prices are connected and that the degree of convergence varies across regions, often reflecting local market disaggregation.

In a bid to unravel the existence of a ripple effect in the regional housing market of the United States, Payne (2012) investigated the long run convergence of regional house prices across 9 nine regions in the United States using ARDL bounds test. The findings revealed that although house prices across the regions differ in the short and long runs, regional house prices converge in the long run, thereby indicating the presence of ripple effects in the housing markets. Canarella, Miller and Polland (2012) examined the price dynamics of regional housing markets in the United States. The study employed time series analysis of the capital gains from the sale of houses to unravel the existence of ripple effect hypothesis in regional housing markets. The findings revealed inconsistencies suggesting conflicting evidence on the presence of ripple effect in house prices. Again, Brady (2014) also investigated the spatial diffusion in the regional housing prices of the United States by analysing data across 48 adjoining states from 1975 to 2011. Findings, based on the estimation of spatial impulse response function using single equation autoregressive model indicated that house prices were spatially diffused across the geographical areas, with significant implication for housing choices. Chiang and Tsai (2016) affirmed that house prices in the USA are closely related and that housing shocks originate from Los Angeles, New York and Maimi in the West, East and South respectively. Also, Antonakakis, Chatziantoniou and Gabauer (2021) examined the lead-lag relationship between housing prices and sales transaction volume among four regional housing markets in the United States. The connectedness of the housing markets was analysed using time-varying vector autoregressive model and the results indicated a nexus between house prices and sale volume arising from the existence of lead-lag relations, which is transmitted across the regions.

Furthermore, Teye *et al*. (2017) investigated the presence of ripple effects in the Amsterdam, Netherlands housing market and its transmission to other regional housing markets in the country. The study employed lead-lag relationship and long-run comovement between housing markets based on Granger causality test and cointegration analysis as indicator of ripple effects in house prices. Based on the analysis of data, the study established the presence of long run connection between the Amsterdam house price and that of other regions. More so, the causality tests revealed the existence of lead-lag relationship between Amsterdam and regional housing prices, which is an indication of the existence of a ripple effect. Similarly, Teye and Ahelegbey (2017) investigated the existence of spatial dependence in temporal house prices and detected the price diffusion pattern among 12 provinces in the Netherlands. The findings established the presence of temporal dependence and price diffusing properties in provincial house prices. More so, Teye, de Haan and Elsinga (2018) found a long run lead-lag relationship among sub-districts house prices with causal effects flowing from the central area to the peripheral sub-urban districts in the Netherlands.

Studies focusing on developing countries include Hui (2010) which examined price

diffusing properties of regional house prices in three Malaysian cities of Klang Valley, Penang and Johor. The study found evidence of long run cointegration and a short-term bi-directional causality between house prices in the three regions. Similarly, Chen, Chien and Lee (2011) investigated price diffusion in regional housing market by examining the long run cointegration and lead-lag relations among four regional house price indices in Taiwan. Following the Johansen cointegration test, a stable long run relationship was found among the regional house price. More so, the outcome of the Toda and Yamamoto Granger causality test revealed a mixed bi-directional lead-lag relationship between housing prices in the study area, implying variations in the price diffusion properties of regional housing markets in Taiwan. The work of Lean and Smyth (2012) examined the existence of a ripple effect in regional housing prices in Malaysia. Based on the analysis of data on five residential property types across 14 regions, the findings revealed the presence of ripple effect in housing prices across the regions using aggregate house price. Nanda and Yeh (2014) examined price diffusion and regional housing dynamics and interaction among local housing sub-markets in the Taipei region of Taiwan based on the analysis of residential land prices in 41 geographic areas in Taipei. Employing panel data and Granger causality tests, the results revealed that land prices in the central regions significantly influence that of adjoining areas and that the presence of substitution effects aided land prices in peripheral areas to lead that of the city centre.

In China, Gong, Hu and Boelhouwer (2016) analysed spatial causality, convergence and diffusion patterns to investigate the spatial interrelationships among housing prices of 10 housing markets in the Pan-Peral River Delta area. The results based on the analysis of data using Toda-Yamamoto Granger causality test affirmed the existence of a lead-lag relationship among the residential property markets. Limited evidence of long run cointegration between the housing markets was however found. Nonetheless, the study further established the transmission of shocks across cities thereby confirming the existence of price diffusing properties between the housing markets. Likewise, Gholipor and Lean (2017) investigated the ripple effects of land and residential property prices by analysing the cointegration among housing and land prices across 18 provinces in Iran. The findings from the study indicated that while the land prices are integrated, house prices across the province are segmented. The study concluded that the potential of price rise transmission across provinces is an indication of ripple effects in the Iranian housing market. Again, Hadizadeh (2019) analysed the stationary properties of regional housing prices across 20 provisional headquarter cities in Iran. Employing Fourier quantile unit root test and liner unit root and stationarity tests, the study found limited level of convergence among housing prices across the provincial cities as no unit root was found in 15 out of the 20 provinces.

By disaggregating Shanghai municipal area of China to 25 sub-markets, Xu *et al* (2020) established the presence of diversified price diffusion with similar upward movement paths for the sub-markets overtime. In the same vein, Yang, Yuan and Lu (2022) explored the existence of ripple effect in China by examining housing market networks using conditional causality test. The findings revealed variations in the connectedness of the housing markets based on the level of development of the market. Second tier markets were found to exhibit greater influence relative to first tier markets. The study concluded by affirming the moderating effect of geographic situation and state of economic growth of local housing markets in influencing the level of connectivity and information flow to the overall housing market. Xu and Zhang (2023a) employed vector error correction model and directed acyclic graphs to analyse the causality between house prices across 10 cities in China in order to reveal the existence of lead-lag relationship. The findings revealed substantial differences in the nature of the causal relationship among the house prices of the cities, based on economic status of the housing markets.

The housing prices in top tier cities of Shanghai and Shenzhen were found to significantly influence the housing market dynamics of other cities.

Xu and Zhang (2023b) employed vector error correction modelling, causality approaches of directed acyclic graphs and innovation accounting to analyse the lead-lag relations and causality among residential property prices in ten key cities in China. The findings indicated the presence of complex relationship in the Chinese housing markets. The study averred that this complexity is fueled by price shocks mainly led by the top tier cities of Beijing, Guangzhou and Shenzhen upon which shock are transmitted to other housing markets. Xu and Zhang (2023c) investigated the price transmission possibility in the Chinese housing market by analysing the housing price information flow among 12 key cities in China using linear and non-linear causality tests based on time and frequency domains. The findings showed a long-term lead-lag relationship among the housing markets implying the ability of the house prices in the various locations to influence each other.

In the sub-Saharan African country of South Africa, Balcilar, Beyene, Gupta and Seleteng (2013) analysed the ripple effects of housing prices in five metropolitan cities. Utilizing data from 1966 to 2010, analysed using unit root and Bayesian test, the findings revealed the existence of ripple effects in the house price of the housing markets. More so, variation was found in the origination of the ripple effect as that of large dwelling emanated from Cape Town, while Durban was the source for small and medium sized apartments.

It could be gleaned from the foregoing that studies investigating the ripple effect in housing markets have largely concentrated on developed Western economies. Studies focusing on developing economies have largely focused on Asian and the Middle-East regions with varying levels of social, economic and cultural preferences which may influence housing investment decisions. Apart from the work of Balcilar *et al*. (2013) conducted in South Africa, the study is unaware of other studies investigating the ripple effect in housing market of sub-Saharan African countries. More so, there is paucity of studies investigating ripple effect in Nigerian housing markets as this study has no knowledge of any previous study that has explored this issue in the country. As such, the existence of and pattern of ripple effects in regional housing markets is yet to be adequately explored in emerging sub-Saharan African economies, thereby calling for additional knowledge. Besides, previous studies have holistically analysed the price diffusing properties of regional housing market at the aggregate level without disaggregating to sub-asset classes to reflect the various housing typologies. In a bid to rectify this gap and enrich the housing market literature, this study investigates ripple effect in the Nigerian housing market by analysing the long run convergence and lead-lag relationship among three key residential property types of bungalow, detached house and block of flats across three key regional areas in the country.

Data And Methodology

Data employed for this study centers on housing investment returns. Learning from Lean and Smyth (2012), the data were obtained on the three major forms of residential property investments in Nigeria, namely: bungalow, detached house and block of flats. Sequel to the consideration of the presence of ripple effect in regional housing market as the existence of long-run co-movement and/or lead-lag causality in housing prices by this study, the data used were collected to reflect the diverse housing typologies across three regions. As such, the data were sourced from the cities of Lagos, Abuja and Port-Harcourt. These three first tier cities with significant housing investment activities, are spread across the three main regions of South-West, North-Central and South-South (Niger Delta) of Nigeria respectively with substantial economic and real estate dealings in the country. Besides, these cities have the highest level of demand for residential dwelling

as they continue to witness the influx of people, most especially young school leavers arising from the huge economic and employment prospects inherent in these cities (Anaekwe, 2023). In this light, Lagos, Abuja and Port Harcourt are the three first-tier cities having the largest concentration of and transactions in housing investments in the country (Odusote, 2008). This is because investors are often motivated and attracted to these locations to enjoy their enormous real estate investment potential and patronage. Thus, these three locations remain the prime destination of most institutional and large-scale housing investment activities in the country (Ekemode, 2021). More so, the potential of a housing price shocks in one region spreading to others is rife across these three regions. Considering the opaque nature of the Nigerian property market where information is unstructured and organized, and property transactions and dealings are shrouded in secrecy and often undocumented (Olapade, Ekemode & Olaleye, 2019), transaction prices were deemed unreliable and inaccurate for the study. The study, therefore resorted to the use of investment returns on the residential property assets as a proxy for prices and this is consistent with the approach of Teye *et al* (2018). In the absence of a unified database for the recordation, storage and retrieval of property transactional information, recourse was made to appraisal-based property indices. The study thus resorted to appraisal-based property data as evidenced by the annual rental and capital values passing on the residential property investments. In this wise, information on the rental and capital values of residential property assets were elicited from estate surveying and valuation firms involved in the management of these assets in Lagos, Abuja and Port Harcourt respectively. Preliminary discussions with key property practitioners revealed that some estate surveying and valuation firms in a bid to develop a property transaction database have embraced the use of digital and electronic platforms for property data storage. Purposive sampling technique was therefore employed to select estate surveying and valuation firms storing historic property information for a 25-year period required for the study in the three locations. This facilitated the seamless retrieval of the required data. The extracted data span a 24-year period from January 1999 to December 2022. This time span covers the entire period of economic renaissance heralded by the return to democratic rule in the country beginning from 1999. Annual total returns were derived from the extracted data using holding period returns computed as:

$$= \frac{P_1 - P_o + a_1}{P}$$

Where, b refers to the annual return, P_o represents price /capital value at the beginning, P_1 is the ending price/capital value, while a_1 means income/dividend received during the holding period. The limitation of appraisal-based property returns in accurately accounting for property returns owing to the existence of the smoothing problem necessitates the smoothing of the housing investment returns. The residential property returns were de-smoothened using the autoregressive reverse filter approach of Geltner (1993), computed as:

$$r_t = \frac{(r_t^* - \propto r_{t-1}^*)}{1 - \propto}$$

is computed valuation-based return, connotes the 'true' original return, refers to the smoothing parameter – which is the previous valuation information weight lying between 0 and 1 (0). Owing to the similarity in rent review pattern in the Nigerian property market where rent is review on a biennial basis, with rates often reflecting the previous ones, a constant smoothing parameter spanning the entire period was adopted. The observed returns thus represent the actual annual returns of the housing investments. Learning from previous studies such as Teye *et al* (2017), a two-prong approach of long-run co-movement and lead-lag causality was used to ascertain the ripple effect in housing markets by this study. This began with the analysis of the housing returns to determine their level of stationarity using unit root tests. Both the automated Dickey Fuller (ADF) and Philip Perron unit root tests were adopted to reveal a precise understanding of the order of stationarity of the data series. Thereafter, the long run connection and causal relationship between the housing investment returns across the locations were analysed using Johansen and Juselius cointegration and Granger causality tests respectively (see Johansen and Juselius (1990) and Granger (1988) for a detailed description of these techniques). Owing to the sensitivity of these approaches to lag length and order of the variables, the Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) were used to ascertain the order of the variables. The tests were then conducted using the lag with the lowest value.

Results And Discussions

The presentation and discussion of results is organized into four parts. The first part presents the results of the descriptive statistics of the aggregate returns of the housing asset across the three locations, while results of the unit root tests for the assets is contained in section two. The third part discusses the outcome of the long run cointegration test while the fourth part presents the outcome of the VAR Granger causality test.

Descriptive Statistics

Table 1: Descriptive Statistics of the Housing Types across the Regions (1999-2022)

Location	Housing Type	Mean	Standard Deviation	Skewness	Kurtosis
Lagos	Bungalow	15.85	158.58	-0.04	-0.48
	Block of Flats	19.18	157.58	0.37	0.90
	Detached House	1.30	123.63	0.67	0.08
	Aggregate	12.11	109.82	-0.32	-0.91
Abuja	Bungalow	2.80	114.64	-0.59	-0.35
	Block of Flats	7.49	54.74	0.25	-1.24
	Detached House	6.67	62.44	0.98	1.26
	Aggregate	5.65	50.69	0.20	-0.15
Port Harcourt	Bungalow	10.97	84.07	0.29	-1.27
	Block of Flats	1.32	115.05	-0.2	-1.37
	Detached House	8.98	70.12	-0.01	-0.02
	Aggregate	7.09	68.73	-0.05	-0.40

The descriptive statistics of the annualized returns of the housing assets summarized in Table 1 revealed that the housing assets exhibited varying levels of return across the three locations. Block of flats in Lagos with a mean return of 19.18% experienced the highest return compared with the other housing types in the three locations. Likewise, detached house in Lagos had the lowest return of 1.30%. Overall, the housing assets had returns of 12.11% in Lagos, 5.65% in Abuja and 7.09% in Port Harcourt. It could be gleaned from these results that residential property assets in the housing markets across the three locations offers stable

and attractive returns indicating the ability of the housing market to compensate investors for their housing investment activities. This is consistent with the results of previous studies such as Ekemode and Obayomi (2024) among others. In this regard, housing investors participating and contemplating investment decision in the Nigerian housing market could enjoy relatively stable and consistent return on investment in the country. With an acute housing shortage, coupled with explosive demographic dynamics, the Nigerian housing market remains a prime investment destination for investors. Besides, the superior performance experienced in Lagos relative to that of Abuja and Port Harcourt connotes the ability of property investors in the Lagos housing market to gain more return performance relative to other locations. The economic and demographic nature of Lagos as the economic nerve centre and the most populous city in the country could account for this outcome.

Unit Root Test

Presented in Tables 2 and 3 are the results of the Philip Perron and ADF unit toot tests conducted for the study.

Table 2: Philip Perron Unit Root Test of the Housing Types

Location	Housing Type	At Level			First Difference			ORDER
		Test Statistics	Critical Value	*p*-value	Test Statistics	Critical Value	*p*-value	
Lagos	Bungalow	-8.197	-8.968	0.000	-16.510	-18.344	0.000	I(1)
	Block of Flats	-5.015	-5.173	0.000	-12.049	-13.663	0.000	I(1)
	Detached House	-3.246	-5.169	0.031	-9.443	-9.804	0.000	I(1)
	Aggregate	-5.012	-6.11	0.000	-13.857	-16.981	0.000	I(1)
Abuja	Bungalow	-5.601	-8.639	0.000	-11.183	-11.184	0.000	I(1)
	Block of Flats	-5.528	-5.352	0.000	-9.483	-9.226	0.000	I(1)
	Detached House	-5.298	-5.185	0.000	-20.563	-23.034	0.000	I(1)
	Aggregate	-4.011	-4.266	0.006	-15.072	-14.856	0.000	I(1)
Port Harcourt	Bungalow	-6.429	-8.648	0.000	-17.956	-17.551	0.000	I(1)
	Block of Flats	-4.178	-4.522	0.004	-10.145	-9.867	0.000	I(1)
	Detached House	-6.189	-6.115	0.000	-21.959	-24.433	0.000	I(1)
	Aggregate	-4.748	-4.978	0.003	-18.426	-18.649	0.000	I(1)

Table 3: Augmented Dickey Fuller (ADF) Unit Root Test of the Housing Types

Location	Housing Type	At Level			First Difference			ORDER
		Test Statistics	Critical Value	*p*-value	Test Statistics	Critical Value	*p*-value	
Lagos	Bungalow	-4.898	-4.974	0.000	-5.690	-5.869	0.000	I(1)
	Block of Flats	-4.608	-4.692	0.000	-6.762	-6.962	0.000	I(1)
	Detached House	-3.422	-3.506	0.001	-5.128	-5.230	0.000	I(1)
	Aggregate	-4.251	-4.380	0.000	-7.391	-7.495	0.000	I(1)
Abuja	Bungalow	-4.888	-5.026	0.000	-5.854	-5.947	0.000	I(1)
	Block of Flats	-5.528	-5.400	0.000	-9.227	-9.466	0.000	I(1)
	Detached House	-5.298	-5.369	0.000	-5.119	-5.265	0.000	I(1)
	Aggregate	-4.057	-4.119	0.000	-4.495	-4.339	0.000	I(1)
Port Harcourt	Bungalow	-4.854	-4.842	0.000	-4.954	-5.103	0.000	I(1)
	Block of Flats	-4.170	-4.267	0.004	-8.119	-8.348	0.000	I(1)
	Detached House	-5.825	-5.808	0.000	-7.071	-7.324	0.000	I(1)
	Aggregate	-4.749	-4.772	0.000	-7.758	-7.976	0.000	I(1)

Note: All critical values are at 1% level of significance based on MacKinnon (1996) critical values

The results of the Philip Perron unit root test showed that all the variables exhibit zeroth order of integration, implying their stationarity at level. On further differencing, all the variables were found to be stationary indicating stationarity at level and at first difference. Similar outcome was also established by the confirmatory ADF test which at levels rejected the null hypothesis of a unit root and reported evidence in favor of stationarity. Also, at first difference, the null hypothesis of unit root was rejected by all the variables, suggesting that the variables exhibit convergence at level and first difference. These outcome indicate that the variables are integrated at order I(1) which is a confirmation of their suitability for co-integration analysis. Based on these results, the data series were subjected to cointegration and causality tests to ascertain their price diffusing and spatial dependence characteristics.

Long Run Convergence

Sequel to the discovery of stationarity in the housing data series, the variables were subjected to Johansen and Juselius cointegration test so as to determine their long run convergence.

Table 4: Johansen and Juselius Rank Cointegration Tests

Data Series/Location	No. of Cointegrating Equations	Trace			Maximum Eigenvalue		
		Statistics	Critical Value	*P*-values	Statistics	Critical Value	*P*-values
Bungalow (Lagos)	None*	60.218	29.795	0.000	34.569	21.131	0.000
Bungalow (Abuja)	At Most 1*	25.649	15.495	0.001	17.029	14.265	0.017
Bungalow (Port Harcourt)	At Most 2*	8.619	3.842	0.003	8.617	3.841	0.003
Block of Flats (Lagos)	None*	51.487	29.797	0.000	35.162	21.132	0.000
Block of Flats (Abuja)	At Most 1*	16.325	15.495	0.037	11.771	14.265	0.119
Block of Flats (Port Harcourt)	At Most 2*	4.554	3.841	0.033	4.554	3.841	0.033
Detached House (Lagos)	None*	49.903	29.797	0.000	25.931	21.132	0.009
Detached House (Abuja)	At Most 1*	23.972	15.495	0.002	14.600	14.265	0.044
Detached House (Port Harcourt)	At Most 2*	9.372	3.841	0.002	9.372	3.841	0.002
Aggregate (Lagos)	None*	49.387	29.797	0.000	27.898	21.132	0.001
Aggregate (Abuja)	At Most 1*	21.489	15.494	0.000	16.220	14.264	0.002
Aggregate (Port Harcourt)	At Most 2*	5.268	3.841	0.001	5.268	3.841	0.000

In order to test the degree of long run connection between the returns of the housing assets across the three locations, the cointegration of each housing type and the aggregate returns across the three locations were tested. The results contained in Table 4 revealed that both the trace statistics and maximum eigenvalue statistics, at 5% level of significance supports the existence of cointegrating relationship among all the variables. This shows that in the long run, the variables of Bungalow, Block of Flats and Detached house in Lagos, Abuja and Port Harcourt respectively will converge to their long run equilibrium path and model. When the housing returns were aggregated, similar pattern was also found across the locations. It could be inferred from this outcome that cointegration exists among the variables implying the presence of a long-run relationship among the housing assets. The long convergence in housing returns across the three locations suggest the evidence of dynamism among the variables. It is indicative

of the possibility of shock and volatility transmission across the housing markets of the three geographic areas which confirms the potential of the occurrence of price diffusion across the markets. As such, the housing markets in the three areas are likely to be influenced by and responsive to happenings within them. This indicates that price formation and return generating behaviour might be expected to follow a similar pattern across the three markets. One key implication of this is that while investors might be desirous of enjoying diversification and risk reduction benefits accruable from investing across the three geographical areas, their expectation might be impaired by the convergence in the return generating behaviour of these markets due to the transmission of price diffusing properties. In essence, housing portfolio investors investing in Lagos, Abuja and Port Harcourt housing markets should be cautious in their asset allocation endeavors across the locations as the flow of diversification properties might be limited based on the existence of a ripple effect among these regional housing markets. While this finding agrees with that of studies such as Hui (2010), Lean and Smyth (2012), Xu and Zhang (2023b), etc., it refutes that of Blake and Gharleghi (2018) which found no evidence long run connection and lack of ripple effect in housing prices. More so, these findings have profound implication on portfolio allocation and diversification activities as limited risk reduction benefits might be gained by investors investing in these residential property assets in the locations.

VAR Causality test

The results of the VAR Granger causality test conducted on the housing returns are summarized and presented in Table 5. In this wise, the causality test statistics and the respective p-values in parenthesis are reported for each of the pair of housing assets across the three locations in the Table. In analysing the results, a 5% (0.05) threshold of p-value indicating the statistical significance of the results was adopted. Thus, test statistics with p-values exceeding this threshold were deemed insignificant. The results showed that displaying test statistic of 1.205 and p-value of 0.547 which exceeds the 5% level of significance, there is no causality between the returns of bungalow in Lagos and Abuja. In the same vein, there is no lead-lag relations between bungalow in Abuja and Lagos as they exhibited test statistics of 2.093 with an insignificant p-value of 0.351 at 5% level of significance. Similarly, with a test statistic of 0.916 and p-value of 0.632, the returns of bungalow in Port Harcourt is not Granger-caused by that of Abuja. With a test statistic of 10.428 and p-value of 0.005 which is statistically significant, the returns of bungalow in Port Harcourt was found to Granger cause that of Lagos indicating evidence of a lead-lag relationship. This shows that returns of bungalow in Port Harcourt leads that of Abuja. It is apparent from these results that while there is no causality in the returns of bungalow in Lagos and Abuja, that of Lagos and Abuja exhibited evidence of Granger causality. This implies that while the past values of bungalow assets in Lagos do not improve or aid the prediction or current values of this asset class in Abuja, past values of bungalow in Port Harcourt provides statistically significant information for forecasting the future returns of the asset in Lagos.

Table 5: VAR Granger Causality Test of Housing Types in the three Locations

Location	Housing Types	LAGOS				ABUJA				PORT HARCOURT			
		Bungalow	Block of Flat	Detached House	Aggregate	Bungalow	Block of Flat	Detached House	Aggregate	Bungalow	Block of Flat	Detached House	Aggregate
LAGOS	**Bungalow**	1				2.093 (0.351)				10.427 (0.005)			
	Block of Flat		1				8.356 (0.015)				1.580 (0.454)		
	Detached House			1				1.310 (0.519)				2.371 (0.306)	
	Aggregate				1				0.162 (0.922)				2.165 (0.339)
ABUJA	**Bungalow**	1.205 (0.574)				1				1.669 (0.764)			
	Block of Flat		1.119 (0.572)				1				2.165 (0.539)		
	Detached House			0.440 (0.803)				1				0.121 (0.941)	
	Aggregate				0.612 (0.737)				1				0.490 (0.783)
PORT HARCOURT	**Bungalow**	0.452 (0.798)				1.345 (0.511)				1			
	Block of Flat		2.401 (0.301)				8.059 (0.018)				1		
	Detached House			1.475 (0.478)				0.764 (0.683)				1	
	Aggregate				5.584 (0.061)				10.432 (0.005)				1

(P-values in Parenthesis)

Regarding block of flats, the causality of the asset in Lagos and Abuja returned a test statistic of 1.112 with a p-value of 0.572. Likewise, causality between block of flats in Port Harcourt and Lagos had a statistic of 1.580 with p-value of 0.454. These results revealed no evidence of causality between the returns of block of flats in the two locations. However, the asset returns in Abuja and Lagos exhibited Granger causality with test statistic of 8.356 and p-value of 0.015. A similar pattern was also observed for this asset class in Abuja and Port Harcourt. This suggests that there is causality between the returns of block of flats in Abuja and Port Harcourt on one hand and Abuja and Lagos on the other hand. Pertaining to detached house, all the test statistics and p-values were found to be statistically insignificant. This shows that there is no evidence of causality between housing assets returns across the three locations implying the inability of price diffusion and limited prediction of current or future changes in returns based on the past returns of detached house in these locations.

It is apparent from the foregoing that the nature of the Granger causality and lead-lag effects between the housing markets is mixed for the housing types across the locations. While a lack of causality was found between Block of flats in Lagos and Abuja, as well as Abuja and Port Harcourt respectively, Block of flats in Abuja granger cause that of Lagos. This suggest that past values of this house type in Abuja influence its current value in Lagos. There was also the transmission of significant causality from the housing returns in Port Harcourt and Abuja to Lagos as well as from Lagos to Port Harcourt and Abuja. This confirms the existence of a lead-lag relationship. More so, while Bungalow in Port Harcourt affect the current value of Bungalow in Lagos, no evidence of causality was established from Lagos and Abuja to Port Harcourt for this asset. No evidence of causality was found for Detached house across the three locations. On the aggregate, the housing asset in Lagos precede that of Port Harcourt, while aggregate housing returns in Port Harcourt is granger caused by that of Abuja. The joint overall causality revealed that housing returns in Lagos and Abuja could significantly predict that of Port Harcourt housing market. This implies that although a long run lead-lag relationship exists among the housing markets, indicating the potential of the housing returns to

stimulate each other, its occurrence is sensitive to housing typology and location considerations. Thus, the possibility of price and volatility transmission might be significantly influenced by the variations in housing typologies and location characteristics. Previous studies such as Ma and Liu (2013), Teye *et al*. (2017), Cutsforth and White (2021) among others validate this outcome.

Conclusion

The existence of ripple effect in housing markets across the three key regions in Nigeria was examined by this study. The ripple effect was investigated as a long run co-movement and lead-lag relationship among the housing returns which was analysed using cointegration and VAR causality tests. The results of the cointegration test showed long run convergence among the returns of the various residential property assets in the three regions. The aggregated housing returns were also found to converge in the long run. The outcome of the VAR causality test revealed differences in the lead-lag relationship among the regional housing returns based on housing typology. While causality was established between block of flats in Abuja and Lagos, no causality was found between block of flats in Lagos and Abuja, as well as Abuja and Port Harcourt respectively. Besides, bungalow in Port Harcourt influence the current value of bungalow in Lagos, whereas no evidence of causality was established for bungalow in Lagos and Abuja to Port Harcourt. However, detached house across the three locations were found to exhibit no causality. When aggregated, residential property returns in Lagos lead that of Port Harcourt, while housing returns in Port Harcourt is granger caused by that of Abuja. Overall, the findings affirmed the potential of housing returns in Lagos and Abuja in significantly predicting housing returns in Port Harcourt.

Given these findings, the study concludes that while ripple effect exists in the housing markets across the three locations indicating the transmission of shocks and volatility across the housing markets, the variations in housing typologies could limit the extent of price diffusion in the regional housing markets. The findings espoused by this study have some profound implications for investors and housing market regulators in Nigeria. First, the interconnectedness among the various house returns across the three locations indicates the possibility of using housing returns in one area to predict that of other areas. This could enhance investment decision making as investors contemplating investment decisions in a location are guided in making rational choices based on bubble and bust considerations. Second, the variations in lead-lag effect based on housing typologies suggests the limitation of the extent of shock and volatility transmission across the areas and this could influence inter-asset relationship. Overall, these results implies that investors combining these housing assets across the three regions may receive limited diversification and volatility reduction gains to their portfolio and this should guide their strategic asset allocation decisions. While the study examined the ripple effects in regional housing markets of the Nigerian property market based on the analysis of data from Lagos, Abuja and Port Harcourt, it only utilised property transactional information obtained from estate surveying and valuation firms involved in housing management activities in the study area. As such, other housing market participants particularly property development companies and estate agents were excluded. More so, the study focused on three housing types of bungalow, block of flat and detached house and did not consider other housing types notably semi-detached house, duplex and condominium. Further studies in this area could be undertaken to explore these issues. These limitations notwithstanding, the study highlighted insightful information capable of enhancing residential property investment decisions by existing and prospective investors in the Nigerian market.

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