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Understanding the behaviour of house prices and household income per capita in South Africa: application of the asymmetric autoregressive distributed lag model

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Abstract

Purpose – Homeownership provides shelter and is a vital component of wealth, and house purchase signifies a lifetime achievement for many households. For South Africa confronted with social and structural challenges, homeownership by the low and lower middle-income household is pivotal for its structural transformation process. In spite of these potential benefits, research on the affordable housing market in the context of South Africa is limited. This study aims to contribute to this knowledge gap by answering the question "do changes in household income per capita have a symmetric or asymmetric effect on affordable house prices?"

Design/methodology/approach – A survey of the international literature on house prices and income revealed that linear modelling that assumes symmetric reaction of macroeconomic variables dominates the empirical strategy. This linearity assumption is restrictive and fails to capture possible asymmetric dynamics inherent in the housing market. The authors address this empirical limitation by using asymmetric non-linear autoregressive distributed lag models that can test and detect the existence of asymmetry in both the long and short run using data from 1985Q1 to 2016Q3.

Findings – The results revealed the presence of an asymmetric long-run relationship between affordable house prices and household income per capita. The estimated asymmetric long-run coefficients of logIncome [+] and logIncome[−] are 1.080 and −4.354, respectively, implying that a 1% increase/decrease in household income per capita induces a 1.08% rise/4.35% decline in affordable house prices everything being equal. The positive increase in affordable house prices creates wealth, helps low and middle-income household climb the property ladder and can reduce inequality, which provides support for the country's structural transformation process. Conversely, a decline in affordable house prices tends to reduce wealth and widen inequality.

Practical implications – This paper recommends both supply- and demand-side policies to support affordable housing development. Supply-side stimulants should include incentives to attract developers to affordable markets such as municipal serviced land and tax credit. Demand-side policy should focus on asset-based

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welfare policy; for example, the current Finance Linked Income Subsidy Programme (FLISP). Efficient management and coordination of the FLISP are essential to enhance the affordability of first-time buyers. Given the enormous size of the affordable property market, the practice of mortgage securitization by financial institutions should be monitored, as a persistent decline in income can trigger a systemic risk to the economy.

Social implications – The study results illustrate the importance of homeownership by low- and middle-income households and that the development of the affordable market segment can boost wealth creation and reduce residential segregation. This, in turn, provides support to the country's structural transformation process.

Originality/value – The affordable housing market in South Africa is of strategic importance to the economy, accounting for 71.4% of all residential properties. Homeownership by low and lower middle-income households creates wealth, reduces wealth inequality and improves revenue collection for local governments. This paper contributes to the empirical literature by modelling the asymmetric behaviour of affordable house prices to changes in household income per capita and other macroeconomic fundamentals. Based on available evidence, this is the first attempt to examine the dynamic asymmetry between affordable house prices and household income per capita in South Africa.

Keywords South Africa, House prices, Behaviour, Asymmetric autoregressive distributed lag models, Household income per capita, Linear autoregressive distributed lag models

Paper type Research paper

1. Introduction

Housing consumption provides shelter and is an important component of wealth for households in advanced economies such as the United Kingdom, USA and Australia (Al-Masum and Lee, 2019; Campbell and Cocco, 2007). Thus, house purchase signifies a lifetime achievement for many households and represents one of the largest items of household wealth (Knoll *et al.*, 2017; Nistor and Reianu, 2018). In South Africa, the share of home loans to gross loans and advances grew from ZAR923bn in 2017 to ZAR953bn in 2018, representing a growth of 3.3% (SARB, 2018). This translates into year-on-year house price index growth of 13.9% for the affordable housing market segment versus 4.9% for the luxury housing band (PropertyWheel, 2018) and the rapid growth is attributed to the zero transfer duties on properties valued below 1m rands (Delmendo, 2020). Homeownership, thus, represents a store of wealth for households and a source of revenue collection for local governments. Established evidence from the USA revealed that the development of affordable housing financed through the low-income housing tax credit reduced residential segregation and property crimes, and improved welfare (Diamond and McQuade, 2019). For South Africa, which confronted with similar social challenges, investment in affordable housing development will play a key role in supporting the country's economic transformation process. Yet in spite of these important wealth effects on low-income households and the South Africa economy, the nexus between affordable house prices and economic fundamentals such as household income per capita has received little empirical attention. This study seeks to contribute to this knowledge gap by answering the question "do changes in household income per capita have a symmetric or asymmetric effect on affordable house prices?"

The housing sector plays a central role in a country's economy because of the backward and forward linkages in the economic value chain (Gardner and Lockwood, 2019), and fluctuations in house prices affect consumer spending. For instance, rising house prices and a low-interest-rate environment boost housing finance and encourage household spending, which improves the performance of the economy. On the other hand, falling house prices tend to wield downward pressures on financial institutions, causing erosion on the balance sheets of borrowers (Simo-Kengne *et al.*, 2014, p. 179). These asymmetric movements in house prices increase house price risk, and Simo-Kengne *et al.* (2014, p. 179) argue that they are major sources of financial risk which can be severe in affordable market segments with residential properties valued at R700,000 or below, constituting approximately 71.4% of all residential properties in South Africa (Lightstone, 2018). Given this sizable market share, the affordable market segment is of systemic importance to the South African economy. Further housing affordability is a major challenge in spite of the government's Finance Linked Individual Subsidy Programme (FLISP) provided to first-time homebuyers earning between R3,501 and R22,000 per month.

Besides the lack of scholarship on affordable housing and income, a survey of the international literature on these two concepts revealed that the linear methodology dominates the empirical strategy (Chen *et al.*, 2007; Gallin, 2006; Zhou, 2010; Case and Shiller, 2003; Malpezzi, 1999). The strong assumption of linear modelling in the movements of economic variables is restrictive and fails to capture the dynamic asymmetric characteristic inherent in the housing markets, and inferences derived thereof may be misleading (Katrakilidis and Trachanas, 2012; Zhou, 2010). Notwithstanding, some noticeable exceptions to the linear strategy exist such as Rehman *et al.* (2020), Bahmani-Oskooee and Ghodsi (2216, 2017), Katrakilidis and Trachanas (2012), Kim and Bhattacharya (2009) and Nneji *et al.* (2013), to cite a few. This amplifies the uniqueness of the current study as household income is a major determinant of housing affordability.

We extend this new emerging literature on asymmetric modelling in the context of South Africa focusing on the affordable housing market segment. We use the asymmetric non-linear autoregressive distributed lag (NARDL) model popularized by Shin *et al.* (2014) that tests the plausibility of asymmetry in both the short and long run. South Africa makes a suitable case as affordable housing is a challenge, and because of residential segregation and high wealth inequality. Finally, based on the available literature, this is the first attempt to quantify the asymmetric response of affordable house prices to changes in household income per capita in South Africa, hence the contribution of our study. From a policy perspective, distinguishing between the effect of a permanent positive and negative shock of household income per capita on house prices ensures that correct policies are implemented.

2. The South African housing market development

The South African housing market has witnessed immense transformation since the mid-1980s. Homeownership was mainly financed by building societies during the 19th and 20th centuries. Building societies are old British traditions that emerged because of housing shortages triggered by rapid urban migration in the 18th century during the agricultural and industrial revolutions. Thus, middle-class traders and craftsmen created non-profit friendly societies that encouraged savings among members for the procurement of houses. British settlers brought this tradition to South Africa and the first building societies were established in Port Elizabeth and Durban in 1855 and 1857, respectively (Luüs, 2005, p. 152). The early development of building societies, however, was sluggish and confined to the Eastern Cape and Natal and only started expanding to the Northern Cape and Gauteng in 1870 and 1886, respectively, when gold was discovered. Building societies were established on either a temporary or permanent basis. Temporary building societies terminated once their objectives were reached, whereas permanent building societies continued operation and, in some instances, developed into large financial institutions. For example, the United Building Society established in 1889 became a financial institution with a strong capital base and, in the 1990s, it was used as the merger vehicle to establish Amalgamated Banks of South Africa Limited (ABSA) (Luüs, 2005, p. 152).

With legislative changes over time, however, the distinction between building societies and banks narrowed, leading to building societies converting into banks, and by the mid-1990s, there were no building societies left in South Africa. Today, banks are the dominant providers of housing loans and mortgage advances constituting a significant proportion of the loan portfolios of banks (Luüs, 2005). Figure 1 depicts the year-on-year changes in mortgage advances by banking institutions and the mortgage interest rate on new loans in South Africa. With the global financial crisis, the growth in mortgage advances by banks declined from 20.2% in 2007 to 1.7% in 2013, whereas the rate on new mortgages dropped from 15% in 2008 to 10.25% in 2017.

Growth in disposable income has been on a decline from approximately 13% in 1991 to 6.3% in 2016, whereas the growth in affordable house prices experienced more growth volatility relative to household income per capita. The trend shown in Figure 2 suggests the existence of a long-run relationship between affordable house prices and household income per capita. However, establishing the exact form of this relationship, i.e. linear versus nonlinear, requires further empirical analysis.

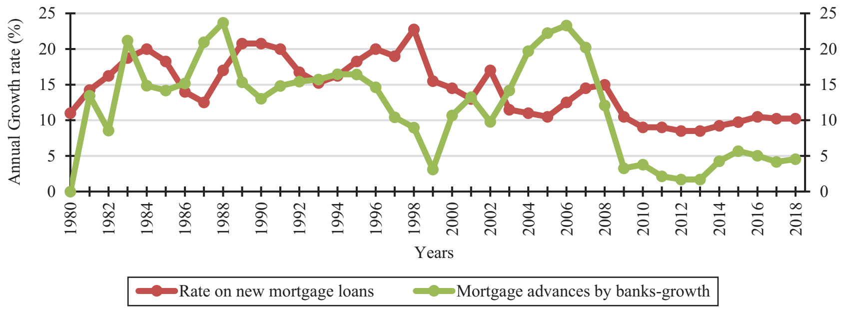
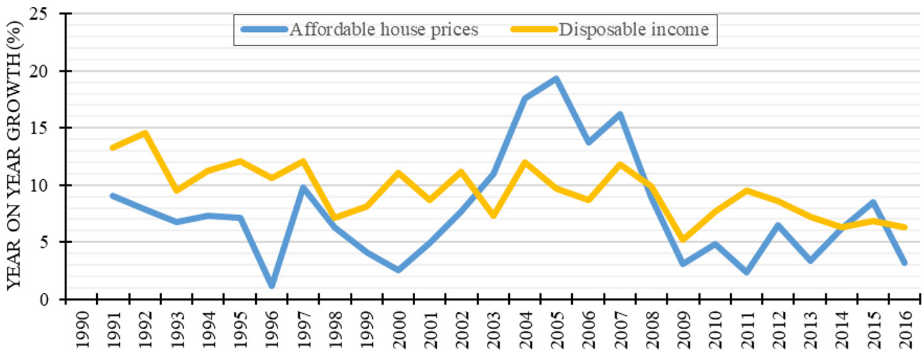


Figure 1. Annual growth in mortgage advances by banks and mortgage interest rate on new loans



Source: Authors using data from SARB and Quantec

Figure 2. Annual growth in affordable house prices and disposable income

3. Theoretical and empirical literature

3.1 Theoretical framework

The stock and flow model of housing supply and demand popularized by DiPasquale and Wheaton (1994) has been adopted for this analysis. This theoretical framework has been used by scholars such as Adams and Füss (2010), Arrazola *et al.* (2015), Asal (2018) and Steiner (2010) to model the long-run elasticities and macroeconomic determinants of housing markets. We adopt Steiner (2010, p. 604) in which the residential capital stock and residential investment are linked together through the following capital accumulation identity:

$$S_t = I_t(1-\delta)S_{t-1}, \tag{1}$$

where S_t denotes existing housing stock and equation (1) implies that residential capital stock in period t, S_t, is the sum of residential investment made in period t, I_t, and the level of the residential capital stock in $t-1$ net of depreciation, $(1-\delta)S_{t-1}$. On the other hand, the long-run demand for housing stock can be expressed as

$$D_t = \alpha_1 - \alpha_2 P_t + \alpha_3^{'} U_t \tag{2}$$

where D_t is the long-run demand for the stock of housing services and D_t is determined by house prices and a set of demand shifters captured by U_t such as population growth, income and mortgage interest rate. Thus, in the long run, the supply of existing housing stock as stated in equation (1) should equate to the demand

$$S_t = \alpha_1 - \alpha_2 P_t + \alpha_3^{'} U_t + \epsilon_t^s \tag{3}$$

where ϵ_t^s tracks the short-run deviation between the supply of existing housing stock and its desired level. Because the housing market is characterized by incomplete information, residential capital stock adjusts slowly to shocks and can take several years to achieve equilibrium (DiPasquale and Wheaton, 1994). Following Steiner (2010, p. 605), when ϵ_t^s is negative, the desired level of the housing stock is greater than the existing supply, implying that the housing market is in excess demand and real house prices will rise. Conversely, when ϵ_t^s is positive, housing supply exceeds demand, triggering a fall in house prices, and the reaction of house prices to these imbalances in the housing market can be represented as follows:

$$\Delta P_t = \gamma_1 + \gamma_2 \varepsilon_{t-1}^s + \gamma_3^{'} W_t + \mu_t \tag{4}$$

Equation (4) allows housing prices to react to short-run deviation, ϵ_t^s with a lag of several years, γ_2 represents the speed of adjustment and is expected to be negative, and W_t summarizes other factors that affect house prices. Equation (4), therefore, leads to the following long-run relationship between affordable house prices and household income per capita:

$$logHP_t = \alpha + \beta_1 logHY_t + \beta_2 MR_t + \beta_3 logBPP_t + \beta_4 CPI_t + \mu_t \tag{5}$$

where *logHP* denotes affordable house prices, βs are the unknown parameters to be estimated, *logHY* denotes household income per capita, *MR* is the mortgage interest rate on new loans, *logBPP* is the index of the number of buildings plans passed, *CPI* is the consumer price inflation rate and μ captures the error term. The rate of inflation captures the macroeconomic environment that affects household behaviour, the number of buildings plans passed captures the supply of housing stock and the mortgage rate measures the costs of housing finance. The details of asymmetric testing of equation (5) are discussed in the subsequent section on empirical strategy.

3.2 Empirical literature review

Theoretically, household income is a key determinant of house prices, according to DiPasquale and Wheaton (1994) and Fraser *et al.* (2012), and this hypothesis has been confirmed by empirics (Al-Masum and Lee, 2019; Asal, 2018; Nistor and Reianu, 2018). However, the literature related to house price and income relationship is dominated by linear modelling with conflicting findings. For instance, Baffoe-Bonnie (1998), Case and Shiller (2003) and Malpezzi (1999) used error correction, VAR and panel techniques to study house prices and income dynamics in the USA. The findings from these studies revealed a positive linear association between house prices and income as well as other fundamentals, with Case and Shiller (2003) arguing that income growth alone explains most of the house price increases in the USA since 1985. Ka and Leung (2014) built a dynamic stochastic general equilibrium model to study error correction (ECM) in house prices and confirmed that income and house prices are cointegrated, consistent with Malpezzi (1999). However, the results rely on a strong assumption that only one national housing market and only one source of shock affect both the aggregate output and housing markets.

Similarly, McQuinn and O'Reilly (2008) used dynamic ordinary least squares (DOLS), an ECM and some counterfactual simulation to the Irish property market and their results corroborate the existence of a long-run relationship between actual house prices and the amount that individuals can borrow. The same finding was confirmed in 15 OECD countries by Kishor and Marfatia (2017) using DOLS, vector error correction model (VECM), Beveridge-Nelson trend-cycle decomposition and Gonzalo-Ng decomposition techniques. Their findings reveal a positive association between personal income and house prices for all 15 OECD countries. Additional evidence from Gonzalo-Ng decomposition of the ECM indicates that in 10 out of the 15 OECD countries, most deviations in house prices are transitory relative to movements in personal income and interest rates that are permanent.

Contrary to the positive linear relationship established between house prices and income, other studies such as Brissimis and Vlassopoulos (2008), Chen *et al.* (2007), Gallin (2006) and Zhou (2010) failed to find any evidence of a linear long-run relationship between house prices and household income. Chen *et al.* (2007) attributed the lack of cointegration to a possible nonlinear relationship that the linear methodology cannot detect because of high volatility in house prices relative to income, and Gallin (2006) added that standard cointegration tests suffer from low power, especially in small samples. Gallin (2006) validated his claim by applying panel cointegration tests in a panel of 95 USA metropolitan areas over 23 years using a bootstrap approach that allows for cross-section correlation in city-level house price shocks, and the hypothesis of no cointegration could not be rejected. Gallin (2006) concluded that house prices do not appear to have a stable long-run relationship with income and that the error specification established in the literature may be inappropriate. Chen *et al.* (2007) found similar results using traditional cointegration tests applied to re-examine the house price and income relationship in the Taiwan housing market. However, when they used a stochastic break test that allowed for temporary shocks during periods, they found evidence in support of a long-run relationship between house price and income. Similarly, Brissimis and Vlassopoulos (2008), using the Johnsen VECM, found that house prices are weakly exogenous and, consequently, do not react to disequilibria in the mortgage lending market. This suggests no long-run causality running from housing loans to housing prices. A commonality amongst all the studies reviewed is the assumption of the symmetric effect of fundamentals on house prices. However, this assumption does not reflect realistic behaviour of the housing markets. For example, when households experience a negative income shock, rather than selling their houses, some households may service their mortgage loans out of savings with the expectation of improved financial conditions in the future (Bahmani-Oskooee and Ghodsi, 2016). This suggests a possible asymmetric effect of income on house prices that needs to be modelled but has largely been ignored in the previous literature.

A new strand of housing literature has emerged that models the purported asymmetric effects of fundamentals on house prices; however, this literature is skewed to advanced housing markets. The majority of these scholarships (see Zhou, 2010; Bahmani-Oskooee and Ghodsi, 2016, 2017; Kim and Bhattacharya, 2009; Nneji *et al.*, 2013; Tsai and Peng, 2016), all drawn from the USA, illustrate an asymmetric relationship between house prices and income. For example, Kim and Bhattacharya (2009) used a smooth transition autoregressive (STAR) model of house prices in the USA to test for the nonlinearity of house price and income relationship. Their results revealed that house prices for the entire USA and all regions except the Midwest exhibit nonlinearity, and within the nonlinearity, employment and mortgage rates Granger-cause house prices. Zhou (2010) found similar results using data from ten USA cities. That is, when the standard linear cointegration test was used, only one city showed evidence of cointegration. However, when a two-step nonlinear cointegration test was applied, evidence of cointegration was found in six other cities. Nneji *et al.* (2013) used regime-switching to study the effect of booms, busts and tranquillity in the USA housing markets. They identified three regimes in the housing market: "steady-state", "boom" and "crash", and their empirical results showed that the sensitivity of the real estate market to economic changes is regime-dependent with prices generally being more sensitive during housing booms. Tsai and Peng (2016) argued in their study that modelling the behaviour of house prices using linear models risks underestimating the information reflected by housing returns.

Bahmani-Oskooee and Ghodsi (2016, 2017) used an asymmetric nonlinear autoregressive distributed lag (ARDL) approach to examine asymmetric causality and asymmetric cointegration between income and economic fundamentals in the USA housing market. They found that household income changes exhibit an asymmetric effect on house prices in both the short and long run in most states in the USA. Similar results were found in Greece by Katrakilidis and Trachanas (2012) using the NARDL approach. They observed substantial variances in the response of house prices to positive and negative shocks to changes in the explanatory variables, which led them to argue that ignoring the intrinsic nonlinearities may lead to incorrect inferences.

Other scholars such as Canepa and Chini (2016) and Fraser *et al.* (2012) used generalized smooth transition and structural decomposition techniques to examine the asymmetric relationship between house prices and household income in the USA, the UK, Ireland, Spain and New Zealand. Their findings concur with previous country-specific case studies. For example, Fraser *et al.* (2012) found that the New Zealand and UK housing markets are sensitive to both permanent and temporary shocks in disposable income, whereas the USA housing market reacts more to temporary shocks with the permanent components playing an insignificant role in house price composition. Conversely, Canepa and Chini (2016) observed that house prices increase at an exponential rate in the UK, Ireland, Spain and the USA during boom periods, implying that improved economic conditions boost the demand for housing above the potential stock. On the other hand, house prices decrease sluggishly, indicating that weak economic conditions drive down house prices below the expected values. Rehman *et al.* (2020) also confirmed the existence of an asymmetric long-run relationship between residential prices with economic fundamentals such as inflation rates, interest rates, oil prices and GDP per capita using a NARDL approach for the UK, Canada and the USA. Overall, studies that accounted for nonlinearities have consistently established that house prices respond asymmetrically to changes in fundamentals. However, empirical evidence is conspicuously missing in South Africa's housing studies.

Only two studies in South Africa, Ganiyu *et al.* (2017) and Massyn *et al.* (2015), have paid some qualitative attention to the affordable market, but they were not directly concerned with modelling asymmetries. These studies focused on sustainable ways to reduce the affordable housing deficits and challenges to deliver higher density affordable housing in Cape Town. Other macroeconomic fundamentals have received some attention in the literature but with mixed findings. For example, Aye *et al.* (2011) found no long-run relationship between house prices and stock prices using linear cointegration tests. However, using a nonparametric cointegration test, a one-to-one long-run relationship emerged, indicating that stability in the housing market drives stability in the equity market. Simo-Kengne *et al.* (2013) used a panel vector autoregression approach which showed that the aggregate effect of house price shock on consumption is positive and short-lived. Nevertheless, when the effect was decomposed into positive and negative shocks, they found that a positive shock to house price growth had a positive and significant effect on consumption, whereas the negative impact of a house price decrease caused an insignificant reduction in consumption.

To summarize, there is a gap in the literature on the asymmetric effect of affordable house prices on household income in the context of South Africa. Against this background, the asymmetric nonlinear ARDL approach has been chosen as the most suitable approach to address the thesis of the study given the aspects reviewed in the empirical literature.

4. Data and empirical strategy

4.1 Data sources

The study is based on secondary data sources. Table 1 provides a summary of the codes, description and sample period.

ABSA categorizes house prices data into three main market segments: luxury (ZAR 3.5m to ZAR 12.8m), middle (ZAR 480,000–ZAR 3.5m) and affordable (below ZAR 480,000 and

Codes	Description	Sources	Sample period
HP	Affordable houses: Total RSA: All sizes, new and old – Purchase price	Quantec EasyData	1985Q1 to 2016Q3
BC	Indicators of real economic activity: Buildings completed	South African Reserve Bank	1985Q1 to 2016Q3
BPP	Indicators of real economic activity: Building plans passed	South African Reserve Bank	1985Q1 to 2016Q3
EC	Economic indicators: Volume of production – Manufacturing	Quantec EasyData	1985Q1 to 2016Q3
CPI	CPI: South Africa, All urban areas – Headline history: All items	Quantec EasyData	1985Q1 to 2016Q3
NMR	Predominant rate on new mortgage loans: Banks – Dwelling units	South African Reserve Bank	1985Q1 to 2016Q3
DY	Disposable income of households	South African Reserve Bank	1985Q1 to 2016Q3
Tpop	Mid-year total population	Quantec Easy Data	1985Q1 to 2016Q3
DYPK	Disposable income of households per capita	Dy/Tpop*100	1985Q to 2016Q3

Source: By authors

Table 1. Data description and sources

area between 40 and 79 square metres) (Apergis *et al.*, 2014, p. 89). Data on house prices is available for all the market segments; however, the data set has not been updated after 2016q3. We focus the analysis on the affordable market segment (gap market) with households earning between ZAR 3,501 and ZAR 22,000 per month. These households are too rich to qualify for free government housing and do not have the credit history or sufficient income to qualify for a mortgage loan from formal financial institutions. All the series are log-transformed except for consumer price inflation and the mortgage interest rate on new loans.

4.2 Empirical strategy

The ARDL lag model approach has been the dominant methodology, particularly for single-country analysis, because of its suitability for small samples and to deal with stationary and non-stationary variables. However, markets are characterized by asymmetric information and high transaction costs, especially in the affordable housing market that is the focus of this study. As a result, not accounting for these asymmetries might lead to misleading inferences and conclusions (Shin *et al.*, 2014).

In a recent empirical contribution to address the restrictive assumption of linear adjustment in the ARDL model, Shin *et al.* (2014) expanded the linear ARDL approach into an asymmetric ARDL cointegration framework (NARDL). The NARDL framework provides a simple and flexible way to analyze both the long- and short-run asymmetries simultaneously. Similar to the linear ARDL, the nonlinear ARDL can be used to ascertain the asymmetric long- and short-run cointegration relationship between I(0) and I(1) variables. Some applications in the housing literature include Bahmani-Oskooee and Ghodsi (2016, 2017) and Katrakilidis and Trachanas (2012). This study also adopts the NARDL approach as the preferred empirical methodology to investigate the relationship between house prices and household income in South Africa.

Following Shin *et al.* (2014) and Schorderet (2003), we specify the long-run asymmetric cointegration regression as:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \varepsilon_t, \tag{6}$$

where y_t is the house price, x_t^+ and x_t^- are the partial sum process of positive and negative changes in household income per capita (x_t) and ε_t is the error term, and $\beta^+\beta^-$ represent the associated asymmetric long-run parameters of household income per capita (x_t), and is decomposed as follows:

$$x_t = x_0 + x_t^+ + x_t^-, \tag{7}$$

where x_t^+ and x_t^- are partial sum processes of positive and negative changes in household income per capita x_t:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \text{ and } x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \tag{8}$$

Following Shin *et al.* (2014, p. 289), the nonlinear ARDL(p, q) model is given as:

$$y_t = \sum_{j=1}^{p} \varphi_j y_{t-j} + \sum_{j=0}^{q} \left(\theta_{t-j}^{+} + \theta_{t-j}^{-} \right) + \varepsilon_t, \tag{9}$$

where x_t is a k $\times$ 1 vector of multiple regressors defined as in equation (7) above, ϕ_j is the autoregressive parameter of house price, θ^+ and θ^- are the distributed lag parameters of household income per capita and ε_t is as defined in equation (6).

By associating equation (9) to Pesaran *et al.* (2001) ARDL(p, q), the following asymmetric error correction is derived:

$$\Delta y_t = \rho y_{t-1} + \theta^+ x_{t-1}^{+} + \theta^- x_{t-1}^{-} + \sum_{j=1}^{p-1} \psi_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(\eta_j^+ \Delta x_{t-j}^{+} + \eta_j^- \Delta x_{t-j}^{-} \right) + \mu_t$$

$$\Delta y_t = \rho \xi_{t-1} + \sum_{j=1}^{p-1} \psi_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(\eta_{t-j}^+ \Delta x_{t-j}^{+} + \eta_{t-j}^- \Delta x_{t-j}^{-} \right) + \varepsilon_t \tag{10}$$

where

$$\rho = \sum\nolimits_j^p \varphi_j - 1, \;\; \gamma_j = -\sum\nolimits_{i=j+1}^p \varphi_i,$$

for $j = 1, \ldots, P - 1,$

$$\theta^+ = \sum\nolimits_{j=0}^q \theta_j^+, \;\; \theta^- = \sum\nolimits_{j=0}^q \theta_j^-$$

$$\phi_0^+ = \theta_0^+, \phi_j^+ = -\sum\nolimits_{i=j+1}^q \theta_j^+$$

for j = 1, . . ., $q - 1$,

$$\phi_0^- = \theta_0^-, \phi_j^- = -\sum\nolimits_{i=j+1}^q \theta_j^-$$

for $j = 1, .., q - 1$, and

$$\xi_t = y_t - \beta^+ x_t^+ - \beta^- x_t^-.$$

This is the nonlinear error correction term, where $\beta^+ = -\frac{\theta^+}{\rho}$ and $\beta^- = -\frac{\theta^-}{\rho}$ are the associated asymmetric long-run parameters (Shin *et al.*, 2014, p. 289).

The NARDL method includes four steps (Elafif *et al.*, 2017, p. 108; Katrakilidis and Trachanas, 2012, p. 1066). In Step 1, equation (10) is estimated using standard OLS. Step 2 establishes the cointegration relationship between the levels of the series, y_t, x_t^+, x_t^-, by using the F**pss** statistic proposed by Shin *et al.* (2014), which refers to the joint null hypothesis of no cointegration, $\rho = \theta \;\; = \theta \; = 0$ in equation (10). Step 3 uses the Wald test to examine the long- and short-run symmetries, where $\theta \mp \theta \;\; = \theta \; = 0$, and the short-run symmetry can take one of the following forms: $\pi \;\; = \pi$ for all i =1, … q or

$\sum_{i=0}^{q-1}\pi_i^+ = \sum_{i=0}^{q-1}\pi_i^-$. Finally, in Step 4, equation (10) is used to derive the asymmetric cumulative dynamic multiplier effects of a unit change in x_t^+ and x_t^-, respectively, y^t, that is, positive and negative changes in household income per capita:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+} = \sum_{j=0}^{h} \lambda_j^+, m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-} = \sum_{j=0}^{h} \lambda_t^-, h = 0, 1, 2. \ldots \tag{11}$$

Note that as $h \to \infty, m_t^+ \to \beta^+$ and $m_t^- \to \beta^-$, where $\beta^+ = -\frac{\theta^+}{\rho}$ and $\beta^- = -\frac{\theta^-}{\rho}$ are the associated asymmetric long-run coefficients (Shin *et al.*, 2014, p. 292).

5. Results and discussion

5.1 Unit root and bounds test

As a preliminary step, we perform unit root tests using the augmented Dickey and Fuller and the Phillip Perron tests to determine the order of integration of variables. The results suggest that the null hypothesis of stationarity at levels was rejected for all the variables except for consumer price inflation. However, we fail to reject the null hypothesis of stationarity at first difference. Thus, all the variables are I(1) except for consumer price inflation that is I(0). Table 2 presents the unit root tests where the last column summarizes the order of integration.

Next, we proceed to test the existence of a long-run relationship using the linear and nonlinear framework of Pesaran *et al.* (2001) and Shin *et al.* (2014). The lag order selection statistics *varsoc* was used to select the optimal lag length structure of each variable and the ARDL (6 3 2 3 3) and NARDL (5 3) models were estimated. Because the consumer price inflation is stationary at levels, it enters the ARDL model only in the short run. Table 3 presents the results from Pesaran *et al.* (2001) and Shin *et al.* (2014) bounds test for the linear and nonlinear framework, respectively. Because the F-statistic (4.57) is greater than the 4.16

Variables	Deterministic terms	Augmented Dicky–Fuller	Phillips–Perron	Order of integration
Levels	Intercept	$Z(t)$	$Z(t)$	
Mortgage rate	Intercept	−1.66(0.45)	−1.61(0.47)	I(1)
CPI	Intercept	−2.91 (0.03)**	−3.06 (0.03)**	I(0)
LogBPP	Intercept	−1.48(0.54)	−1.46(0.55)	I(1)
logDYPK	Intercept and trend	−2.83(0.19)	−1.62(0.78)	I(1)
logBPP	Intercept	−2.22(0.48)	−2.53(0.31)	I(1)
LogEC	Intercept	−0.97(0.76)	−0.90(0.79)	I(1)
LogHouse prices	Intercept	−0.87(0.80)	−2.21(0.20)	I(1)
First difference				
ΔMortgage rate	Intercept	−4.97(0.00)***	−6.45(0.00)***	I(0)
ΔLog BPP	Intercept	−5.44(0.00)***	−13.36(0.00)***	I(0)
ΔLogDYPK	Intercept	−5.04(0.00)***	−13.64(0.00)***	I(0)
ΔLogBPP	Intercept	−5.44(0.00)***	−13.40(0.00)***	I(0)
ΔLogEC	Intercept	−5.54(0.00)***	−10.04(0.00)***	I(0)
ΔLogHouse price	Intercept	−5.58(0.00)***	−7.82(0.00)***	I(0)

Note: All unit root are testing using three lags
Source: By authors

Table 2. Augmented Dickey–Fuller and Phillip–Perron unit root test

(upper bounds), we reject the null hypothesis of no cointegration at the 5% level of significance. We conclude that there is a linear cointegration relationship between the variables under examination.

For the NARDL model, Shin *et al.* (2014) stated that drawing precise conclusions on whether there is evidence of asymmetric cointegration or not is complicated because of the dependence structure that exists between the partial sum decomposition of the positive and negative (x_t^+ and x_t^-), respectively. That is, the exact value of K is not clear, and, according to Shin *et al.* (2014, p. 291), assuming $K = 1$ critical values results in a more conservative test so that at a pragmatic level, rejecting the null of no long-run relationship using these critical values provides strong evidence of the existence of a long-run relationship. Applying this general rule, the test statistics show F_PSS = 7.56 > 6.84 of lower bound at the 1% and T_BDM = −4.19 > −3.82 in absolute terms of the upper bound at the 1% level, and so we reject the null of no long-run asymmetric relationship between the examined variables.

The next section presents the linear ARDL and NARDL outputs, respectively.

5.2 Autoregressive distributed lag results – baseline

The ARDL results are reported in Table 4 and the evidence confirms the existence of a positive long-run linear relationship between household income per capita and affordable house prices at the 1% level. The coefficient of the error correction term is −0.057 and significant at 1%, suggesting it takes approximately 4.5 quarters (18 months) for house prices to adjust to full equilibrium in case of any disturbance in household income per capita. However, a possible asymmetric relationship has not been accounted for and the ARDL is used as a baseline estimation. The focus here is to test the plausibility of asymmetry in both the short and long run between house prices and household income per capita.

5.3 Non-linear autoregressive distributed lag results

The results of the NARDL are divided into dynamic asymmetric estimates (Table 5), long-run asymmetric coefficients and diagnostic statistics (Tables 6 and 7) and dynamic multipliers (Figure 3).

The results in Table 5 confirm evidence of a dynamic asymmetric effect of household income per capita and other macroeconomic fundamentals on house prices. The partial sum decomposition of household income per capita for both positive and negative shocks is positive and significant at 1%, with a negative shock exerting a greater effect on house prices than a positive shock. The presence of asymmetric long- and short-run relationship is tested using the Wald test. The null hypothesis is that the coefficients of both the positive and negative partial sums are equal against the alternative hypothesis of not equal. The

Dependent variable	Test statistics	10%	5%	Outcome
ΔLog house price				
		I(0)	I(1)	
Linear ARDL	$F_{PSS} = 4.57$	2.42	4.16	Cointegration
ARDL(6 3 2 3 3)	$t = -2.68$	−2.50	−3.93	Cointegration
NADRL	$F_{PSS} = 7.56$			Cointegration
NARDL(5 3)	$T_{BDM} = -4.19$			

Source: By authors

Table 3. Bounds test for cointegration in the linear and nonlinear ARDL

Table 4.
Linear ARDL estimates – dependent variable: Δhouse prices

	Coefficients	*t*-Statistics
ADJ – Error correct (ECM)	−0.055***	−3.15
Log house price		
Long run		
Log household income per capita	0.527***	3.68
Mortgage rate on new loans	−0.018***	−3.77
Log index of buildings completed	0.745***	3.97
CPI	−0.002	−0.36
Short-run		
Log house prices		
LD	0.863***	9.44
L2D	−0.670***	−6.79
L3D	0.439***	4.28
L4D	−0.482***	−5.19
L5D	0.213***	2.94
Log household income per capita	0.020	0.39
D1	−0.012	−0.25
LD	0.053	1.07
L2D		
Mortgage rate on new loans	−0.002**	−2.44
D1	0.002**	2.21
LD		
Log index of buildings plans passed	−0.023	−1.49
D1	−0.008	−0.54
LD	−0.008	−0.58
L2D		
CPI	−0.001**	−2.46
D1	0.001*	1.85
LD	0.000	0.17
L2D	0.134***	3.88
Constant		

Note: *, ** and *** denote 10, 5 and 1%, respectively
Source: By authors

results are presented in the lower panel of Table 6. The null hypothesis of a symmetric short run cannot be rejected except for the mortgage interest rate. However, the Wald test rejected the null hypothesis of long-run symmetry of both the positive and negative partial sums decomposition for all the variables, thus corroborating our earlier argument that the behaviour of macroeconomic variables is not necessarily linear.

Our results confirm the presence of an asymmetric long-run effect of household income per capita, consumer price index, building plans passed and the mortgage interest rate on affordable house prices. The estimated asymmetric long-run coefficients of logIncome [+] and logIncome[−] are 1.080 and −4.354, respectively. This implies that a 1% increase in household income per capita induces a 1.080% increase in affordable house prices, and this concurs with Asal (2018) who documented a similar magnitude in Sweden. The rise in affordable house prices, in turn, makes low and lower middle-income households feel richer because the value of their properties has increased, thereby increasing their chances of borrowing (Adams and Füss, 2010). This wealth effect boosts consumption and helps reduce assets and income inequality. Conversely, a 1% fall in household income per

Variables	Coefficients/t-statistics
LogHouse prices$(_{t-1})$	−0.094***(−4.19)
LogIncome_{pos}	0.101***(3.72)
LogIncome_{neg}	0.409***(3.68)
CPI_{pos}	0.001***(2.09)
CPI_{neg}	−0.002***(−3.31)
LogBuilding plan completed_{pos}	0.017(1.02)
LogBuilding plan completed_{neg}	0.073***(7.28)
Mortgage_{pos}	−0.002***(−4.14)
Mortgage_{neg}	0.001(1.35)
ΔLog house prices$(_{t-1})$	0.667***(8.21)
ΔLog house prices$(_{t-2})$	−0.534***(−5.44)
ΔLog house prices$(_{t-3})$	0.229**(2.43)
ΔLog house prices$(_{t-4})$	−0.350***(−5.08)
$\Delta\text{LogIncome}_{pos}$	0.089(1.37)
$\Delta\text{LogIncome}_{pos(t-1)}$	−0.047(−0.82)
$\Delta\text{LogIncome}_{pos(t-2)}$	0.053(0.91)
$\Delta\text{LogIncome}_{neg}$	0.249(0.97)
$\Delta\text{LogIncome}_{neg(t-1)}$	−0.190(0.79)
$\Delta\text{LogIncome}_{neg(t-2)}$	−0.333(−1.43)
$\Delta\text{CPI-}_{pos}$	0.001(0.93)
$\Delta\text{CPI}_{\text{-}pos(t-1)}$	0.001(0.52)
$\Delta\text{CPI}_{\text{-}pos(t-2)}$	−0.001(−0.67)
$\Delta\text{CPI}_{\text{-}neg}$	−0.002*(−1.77)
$\Delta\text{CPI}_{\text{-}neg(t-1)}$	0.001(1.33)
$\Delta\text{CPI}_{\text{-}neg(t-2)}$	0.003***(3.33)
ΔLogbuilding plan $\text{completed}_{\text{-}pos}$	−0.016(−0.65)
ΔLogbuilding plan $\text{completed}_{\text{-}pos(t-1)}$	0.005(0.17)
ΔLogbuilding plan $\text{completed}_{\text{-}pos(t-2)}$	0.018(0.600)
ΔLogbuilding plan $\text{completed}_{\text{-}neg}$	0.043(1.61)
ΔLogbuilding plan $\text{completed}_{\text{-}neg(t-1)}$	−0.012(−0.43)
ΔLogbuilding plan $\text{completed}_{\text{-}neg(t-2)}$	−0.040*(−1.67)
$\Delta\text{Mortgage}_{\text{-}pos}$	−0.004***(3.11)
$\Delta\text{Mortgage}_{\text{-}neg(t-1)}$	0.002*(1.76)
$\Delta\text{Mortgage}_{\text{-}pos(t-2)}$	0.004***(2.85)
$\Delta\text{Mortgage}_{\text{-}neg}$	−0.002(−1.36)
$\Delta\text{Mortgage}_{\text{-}neg(t-1)}$	−0.001(−0.42)
$\Delta\text{Mortgage}_{\text{-}neg(t-2)}$	−0.003**(−2.33)
Constant	0.438***(4.36)

Notes: *, ** and *** denote 10, 5 and 1% level of significance, respectively

Table 5. Dynamic asymmetric estimates – dependent variable: Δhouse prices

capita leads to a 4.354% decline in affordable house prices. This finding corroborates Bahmani-Oskooee and Ghodsi (2017) and Katrakilidis and Trachanas (2012) who found similar higher negative magnitudes of income shock on house prices in the USA and Greece, respectively. Contractions in household income per capita reduce households' ability to borrow to finance housing and non-housing consumption, leading to low demand for housing. Furthermore, some risk-averse investors may sell their properties, thereby increasing the supply of housing stock relative to the demand, and this triggers a decline in house prices. These negative wealth and consumption effects deteriorate the balance sheet of financial institutions through rapid default on monthly mortgage obligations, according to Simo-Kengne *et al.* (2014). Consequently, given the large size of the affordable housing

Table 6. Long-run asymmetric coefficients

Exog variables	Long-run effect [+]		Log-run effects [−]	
	Coef	F-stat	Coef	F-stats
Log income	1.080***	18.16	−4.354***	13.81
CPI	0.011**	4.42	0.021**	6.24
Log building plans passed	0.185	1.23	−0.777***	21.86
Mortgage rate	−0.024***	8.74	−0.009	1.72
	Long-run asymmetry Wald test		Short-run asymmetry Wald test	
Log income	9.77***		0.612	
CPI	9.57***		0.260	
Log building plans passed	5.42**		0.053	
Mortgage rate	8.77***		8.14***	

Notes: [+] and [−] denote the long-run coefficients associated with positive and negative changes in the exogenous variables. That is, a permanent change in exogenous variables by −1; *, ** and *** denote 10, 5 and 1%, respectively

Table 7. Model diagnostics

Model diagnostics	Statistics
Portmanteau test up to lag 40 (Chi^2)	32.23(0.80)
Breusch/Pagan heteroskedasticity test (Chi^2)	0.023(0.88)
Ramsey RESET test (F)	1.03(0.38)
Jarque–Bera test on normality (Chi^2)	2.70(0.26)
Number of observations	122
Adj. R-squared	0.70
RMSE	0.005

market in South Africa (71.4% of all residential properties), a persistent decline in household income per capita can trigger a systemic risk to the economy, especially with the practice of mortgage securitization by financial institutions.

Consumer price inflation (CPI) also displayed an asymmetric relationship with affordable house prices, with estimated long-run coefficients on CPI[+] of 0.011 and CPI[−] of 0.021. That is, a 1% rise in the CPI induces a 1.1% increase in affordable house prices, suggesting that affordable houses act as a hedge for investors during rising CPI. Similarly, a 1% fall in CPI increases affordable house prices by 2.1%. That is, low CPI reduces the cost of servicing a mortgage loan, making affordable housing attractive to investors and households in the higher income quintiles who want to downscale into the affordable housing segment to cut costs because of the declining economy. For the number of building plans passed and mortgage interest rate, a significant long-run impact is detected only for the negative and positive components, respectively. That is, a 1% fall in the number of building plans passed results in a 0.78% fall in affordable house prices. This, however, contradicts theoretical expectations as one would expect, everything being equal, house prices to rise as a result of a decline in the supply of new affordable housing stock. Conversely, a 1% increase in the mortgage rate increases the financing costs of real estate projects, depressing demand and leading to a fall in affordable house prices by 2.4%. This concurs with Demary's (2010) finding that changes in the interest rate lower real

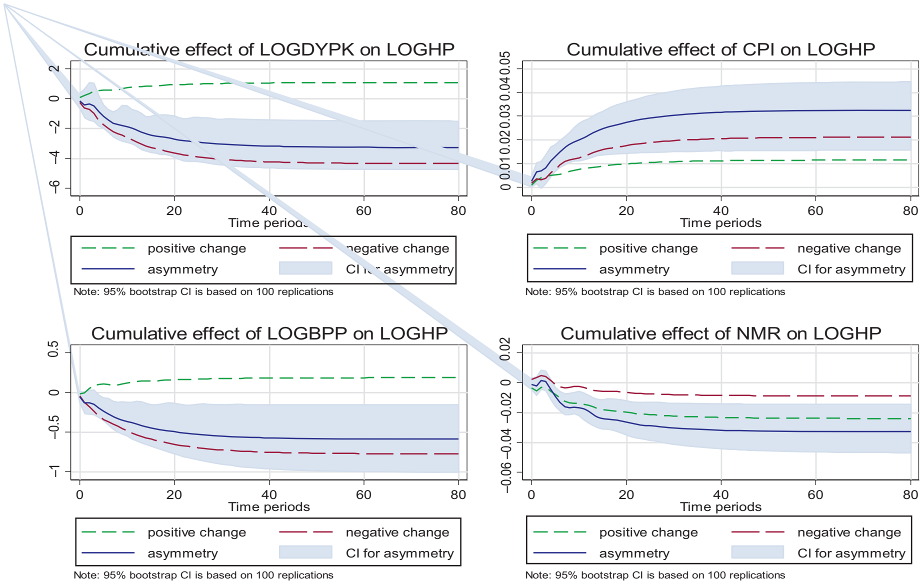


Figure 3.
Asymmetric cumulative impact of dynamic multipliers

house prices and explain between 12% and 24% of the variation in house prices in ten OECD countries.

Finally, we plot the asymmetric cumulative dynamic multiplier effects of a unit change in both positive and negative changes in income, mortgage rate, number of building plans passed and the CPI on affordable house prices as shown in Figure 3.

As can be seen in Figure 3, affordable house prices respond more rapidly to negative shocks in household income per capita than positive shocks and become persistent after approximately 23 months. However, an increase in household income per capita causes only a modest rise in affordable house prices, possibly because households spend their income on housing and a range of non-housing expenditure. Affordable house prices react positively to positive and negative shocks in the CPI, and respond faster to increases than reductions in the mortgage interest rate. Overall, the cumulative dynamic multipliers support the estimated asymmetric coefficient over 80 months and confirm a strong reaction of affordable house prices to negative rather than positive changes in household income per capita. The diagnostic tests reported in *Model diagnostics statistics* showed an adjusted R-squared of 70% and the model passed all diagnostic tests, and hence are reliable for statistical inferences.

As a robustness test, we re-estimated the model with two additional variables: the index of the number of buildings completed and volume of production. The results of the long-run asymmetric tests reported in Appendix 1 confirm the existence of an asymmetric long-run relationship between household income per capita and affordable house prices. Again, a negative shock in household income per capita exerts a greater impact on affordable house prices than a positive shock.

6. Conclusion and implications

This study examines the nexus between affordable house prices and household per capita income while controlling for the effect of mortgage interest rate, CPI and the index of the number of building plans passed. The study uses the asymmetric cointegration technique, a nonlinear autoregressive distributed lag (NARDL) model that allows the modelling of possible asymmetric effects in both the long and short run. The results revealed the existence of asymmetric response of affordable house prices to a shock in household income per capita, with a negative income shock exerting a disproportionate higher effect on affordable house prices relative to a positive shock. Specifically, a 1% increase in household income per capita leads to a 1.08% rise in affordable house prices. Similarly, a 1% fall in household income per capita leads to a 4.35% decline in affordable house prices. The positive increase in affordable house prices creates wealth for the low and lower middle-income households and helps reduce inequality, thereby providing support to the country's structural transformation process. Rising affordable house prices, therefore, helps low- and lower middle-income households to climb the property market ladder. Conversely, a decline in affordable house prices tends to widen inequality and may trigger a systemic risk because of the size of the market and the practice of mortgage securitization.

Additionally, the CPI, the index of the number of building plans passed and mortgage interest rate equally exhibit an asymmetric long-run relationship with affordable house prices. However, only the mortgage interest rate has a statistically significant short-run asymmetric relationship.

The findings have policy implications for stakeholders charged with policy design and implementation. Besides the wealth creation and consumption effects, affordable housing market development in the USA has been shown to reduce residential segregation, violence and property crimes. Similar structural and social challenges confront the South African economy and, consequently, low- and lower middle-income homeownership through affordable housing development should be prioritized and supported from both supply- and demand-side policies. Supply-side stimulants should include incentives to attract developers into the affordable housing markets such as municipal serviced land and tax credit for developers. Policy to support the demand side should focus on asset-based welfare policy. For example, the current FLISP, hence efficient management and coordination of the FLISP, is essential to ensure the subsidy is effective in boosting the affordability of low- and lower middle-income first-time buyers. Furthermore, given the large size of the affordable property market, the practice of mortgage securitization by financial institutions should be monitored as a persistent decline in income can trigger a systemic risk to the economy.

As alluded to previously, homeownership enhances wealth creation and helps to reduce inequality. Nevertheless, this study used affordable house prices and not statistics on homeownership. Scholars interested in housing research can expand the study by using statistics on homeownership to examine the effects on wealth distribution in South Africa.

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Further reading

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Appendix. Robustness test

Exogenous variables	Long-run effect [+] Coef.	F-stat	Log-run effects [−] Coef.	F-stats
Asymmetry statistics				
Log income per capita	0.786***	14.20	−2.675***	9.07
Log building completed	0.453***	8.412	−0.256***	7.85
Log building plans passed	−0.024	0.022	−0.577***	10.61
Mortgage rate	−0.011**	4.589	0.007**	4.19
Log volume of production	1.823***	8.847	0.092	0.03
	Long-run asymmetry Wald test		Short-run asymmetry Wald test	
Log income per capita	6.676**		0.314	
Log building completed	1.209		3.820*	
Log building plans passed	4.628**		0.834	
Mortgage rate	1.244		6.302**	
Log volume of production	6.504**		0.429	
Cointegration test statistics: t_BDM = -4.4752; F_PSS = 6.6484				
Model diagnostics				Statistics
Portmanteau test up to lag 40 (Chi^2)				40.5(0.45)
Breusch/Pagan heteroskedasticity test (Chi^2)				1.92(0.17)
Ramsey RESET test (F)				0.09(0.97)
Jarque–Bera test on normality (Chi^2)				1.09(0.58)

Notes: Long-run effect [−] refers to a permanent change in exogenous variables by −1 and *, ** and *** denote 10, 5 and 1%, respectively

Table A1.

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