



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

Homeownership by the lower and middle-income households is crucial to create wealth, particularly for South Africa with high levels of economic and wealth inequality. However, scholarship has paid little attention to how **income affects the affordable housing market segment despite its systemic importance to the South African economy**. This study employs the asymmetric autoregressive distributed lag model to study the effect of household income per capita on the affordable house prices in South Africa using quarterly data from 1985 to 2016. 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 $\log\text{Income}[+]$ and $\log\text{Income}[-]$ 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. We argue that given the 71.4% market share of affordable housing in all residential properties in South Africa, a persistent fall in household income can trigger a systemic crisis, particularly with mortgage securitization. Thus, policymakers should closely monitor the practice of mortgage securitization, particularly in the affordable market segment to avoid systemic risk to the economy.

Keywords: House prices, household income per capita, symmetric and asymmetric autoregressive distributed lag models

JEL Classification: R3 C1 E2 E13.

1. Introduction

Housing consumption represents an important component of household wealth portfolio (Campbell and Cocco, 2007) and signifies a lifetime achievement. The share of home loans to gross loans and advances in South Africa grew from ZAR923 billion in 2017 to ZAR953 billion in 2018, representing a growth of 3.3% (SARB, 2018). This translate into year-on-year house price index growth of 13.9% for the low-income market segment versus 4.9% for the luxury housing band (PropertyWheel, 2018) and the rapid growth can be attributed to the zero transfer duties on properties valued below one million rands. For South Africa with high levels of income inequality, homeownership by the lower and low middle-income households is crucial to create wealth and is key in the country's economic transformation process. However, scholarship in the housing sector has not paid sufficient attention to these market segments and the depressed macroeconomic environment stemming from the coronavirus pandemic is expected to hurt the lower and middle-income segments harder. Thus, only a sustained income growth can preserve the current positive growth trend in the lower and middle-income segments. Nevertheless, scrutiny of disposable income data from the South African Reserve Bank (SARB) showed a downward trajectory since the 1990s and we are interested to find out how changes in household disposable income affect house prices in South Africa. This is because fluctuations in house prices affect consumer spending (Belsky and Prakken, 2004, p. 1). 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. Contrary, falling house prices tend to wield downward pressures on financial institutions causing corrosion on the balance sheets of borrowers (Simo-Kengne, Gupta, and Aye, 2014, p. 179). As a results fluctuations in house prices increase house price risk and are broadly considered as major sources of financial risk (Simo-Kengne et al. 2014, p. 179). Similarly, evidence from financial market activities confirm that individuals react differently to positive and negative shocks of similar magnitude Hatemi-J (2012) and because house prices are influenced by the level of economic activity, their movements are likely to mirror the nonlinearity of macroeconomic variables.

This study is motivated firstly by the scant scholarship at the lower and middle-income market segments. Specifically, the affordable housing segment with residential properties valued at R700 000 or below and which constitutes approximately 71.4% of all residential properties in South Africa (Lightstone, 2018). Thus, the affordable market segment is of systemic importance to the

South African economy and housing affordability a major challenge despite the government's Finance Linked Individual Subsidy Programme (FLISP) provided to first-time homebuyers earning between R3501 and R22000 per month. Secondly, the dominance of the linear modelling strategy in the available empirical literature (Chen et al. 2007; Gallin 2006; Zhou, 2010; Case and Shiller, 2003 and Malpezzi, 1999) just to cite a few fails to capture the dynamic asymmetric inherent in the housing markets. The implications are that inferences derived thereof may be misleading (Katrakilidis and Trachanas, 2012; Zhou, 2010). However, some noticeable exceptions to the linear strategy exist such as Rehman et al. (2020); Bahmani-Oskooee and Ghodsi (2017); Katrakilidis and Trachanas (2012); Kim and Bhattacharya (2009); Nneji, Brooks, and Ward (2013); Tsai, Lee, and Chiang (2012) and Zhou (2010). This amplifies the uniqueness of the current study as household income is a major determinant of housing affordability and as discussed earlier, rising house prices affect both the supply and demand-side of the housing market.

We address the limitations highlighted with the application of the asymmetric autoregressive distributed lag (NARDL) model popularized by Shin, Yu, and Greenwood-Nimmo (2014) that can test and detect the existence of a nonlinear relationship. By decomposing household income into partial cumulative positive and negative sums and examining their effects on house prices, we contribute to the empirical modelling strategy in the context of South Africa. From a policy perspective, distinguishing between the effect of a permanent positive and negative shocks of house prices on household income ensures correct policies are implemented.

2. The South African housing market development

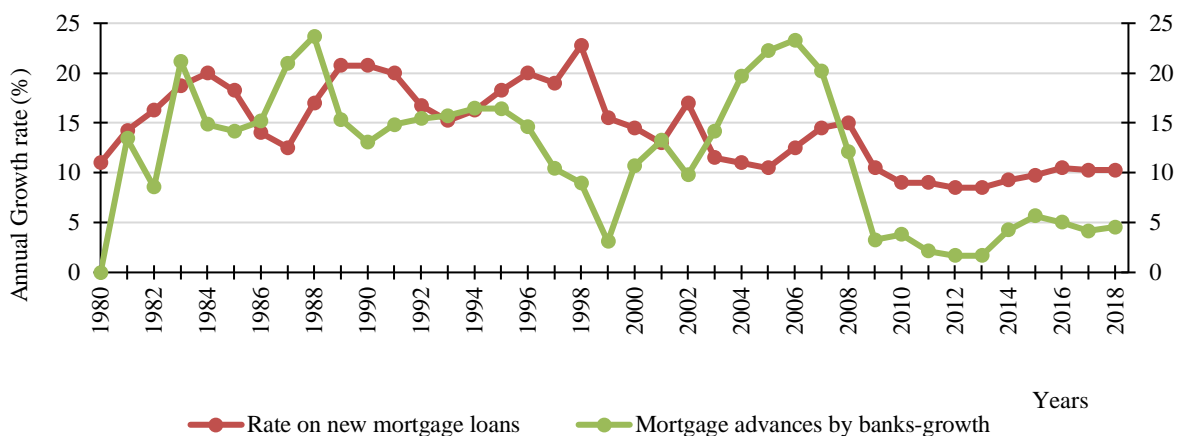
The South African housing market has witnessed immense transformation since the mid-1980s. Homeownership was mainly financed by building societies during the nineteenth and twentieth centuries. Building societies are old British traditions that emerged due to housing shortages triggered by rapid urban migration in the 18th century during the Agricultural and Industrial Revolutions. Thus middle-class traders and craftsmen create non-profit friendly societies that encourage savings among members for the procurement of houses. The British settlers brought this tradition into Southern Africa and the first building societies were established in Port Elizabeth and Durban in 1855 and 1857 respectively (Luüs, 2005, p. 152). 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 the 1870 and 1886 respectively when gold was discovered. Building societies were either established on 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 line between building societies and banks narrowed leading to building societies converting into banks and by the mid-1990s, there were no building societies in South Africa. Today, banks are the dominant providers of housing loans and mortgage advances constitute a significant proportion of the loan portfolios of banks (Luüs, 2005).

Figure 1 depicts the year on year changes in the mortgages advances by banking institutions and the mortgage interest rate on new loans in South Africa. **The rate on new mortgage loans has oscillated between 11 percent to 22.75 percent from 1980 to 1998 and dropped rapidly to 14.5 percent following the adoption of inflation targeting beginning 2000. Mortgage advances experienced a contraction in 1999/2000 following the banking crisis and pick up amidst some reforms such as the Financial Sector Charter Act of 2003 reaching a peak of 23 percent. However, the Consumer Credit Act of 2007 and the global financial crisis saw a steep decline in mortgage advances to 1.7 percent by 2012 whereas the rate on new mortgages continue to fall stabilizing at 10.25 percent on average from 2010 to 2018.**

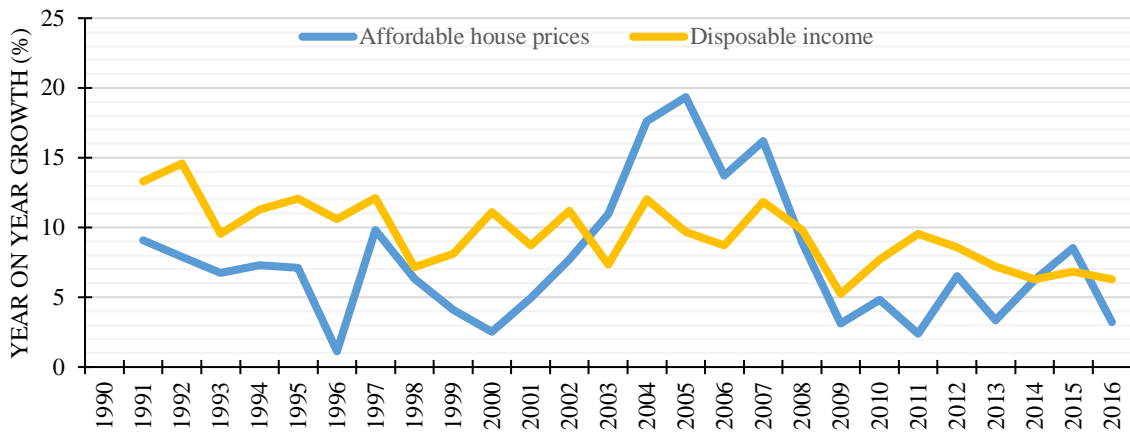
Figure 1: Annual growth in mortgage advances by banks and mortgage interest rate on new loans



Source: By Authors

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 from 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** is the task of empirical analysis.

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



Source: Authors using data from SARB and Quantec

3. Theoretical framework

This study adopts the theoretical framework of house prices discussed in Chen et al. (2007) and Malpezzi (1999). We start with the framework of Malpezzi, (1999) who posited that house price, P and income, Y are linearly related as follows:

$$\frac{P^e}{Y^e} = k \quad , \quad (1)$$

Where k is the price-to-income ratio (PIR). The above is an equilibrium price model, defined as the point where is no systematic tendency to depart, conditional on the values of representing market conditions (Chen et al., 2007, p. 248; Malpezzi, 1999, p. 34). However, in real-world situations, this might be an unrealistic assumption and there is no reason to believe that things will

be the same across markets. Letting t to denote the periods under investigation, the above equilibrium condition for a representative market can be rewritten as:

$$\frac{P_t^e}{Y_t^e} = k_t = Z\delta + \eta_t \quad (2)$$

Where Z is a vector of market conditions and other determinants of k , δ is the vector of corresponding parameters, and η is a well-behaved error term. However, the stable equilibrium relationship (k) will be affected by supply-side factors such as the number of building completed and or building plan passed, land availability, an increase in investment demand and regulations. Because of the cyclical behaviour of house prices and stable increase in household income, these two variables usually deviate over time, resulting in the crisis of affordability.

According to Chen et al. (2007), the demand for housing is a function of income, house price, user cost, availability of substitutes and demography. Housing supply is inelastic in the short run but in the long run, supply is a function of the factors affecting real-estate developers to construct new houses such as construction costs, interest rates, price of land and seasonal factors. Thus, k is unlikely to maintain a stable equilibrium because other factors will disrupt the articulated equilibrium. We combine the Malpezzi (1999), Chen et al. (2007) and Tu, De Haan and Boelhouwer (2018) models to include demand and supply-side factors. The model to be estimated is specified as follows:

$$\log HP_t = \alpha + \beta_1 \log HY_t + \beta_2 MR_t + \beta_3 \log HC_t + \beta_4 \pi_t + \mu_t, \quad (3)$$

Where HP denotes affordable house prices, β 's are the unknown parameters to be estimated, HY denotes household income per capita, MR is the mortgage interest rate on new loans, $\log HC$ is the number of buildings completed, π is the inflation rate and μ captures the error term. The rate of inflation captures the macroeconomic environment that affects household behaviour, the number of buildings completed indicates the level of economic activities and also captures supply-side shocks and the mortgage rate affects housing financing cost, the monthly repayment which in turn affects the house prices.

4. Empirical literature review

A considerable amount of literature has been published on the relationship between house prices and household income. However, these studies are dominated by scholarships from advanced

housing markets. The majority of these studies adopted a linear framework as the strategy of empirical analysis with conflicting evidence provided about the relationship between house prices and household income. For example, Malpezzi, (1999) uses an error-correction framework to study the dynamics of house prices and household income in 133 metropolitan areas in the USA. The results revealed that faster rates of population growth and income growth were associated with higher conditional price changes which suggest less than a perfect elastic short-run housing supply while higher mortgage rates lowered price changes. Ka and Leung (2014), using a dynamic stochastic general equilibrium model, corroborates Malpezzi's (1999) earlier evidence that house prices are tied to the dynamics of the house-price-to-income ratio. Baffoe-Bonnie (1998) employed a VAR methodology using quarterly data collected at the regional and national level in the USA from 1973 to 1994 and found that employment rates, mortgage rates, and interest rates, both at the national and regional level, affect house prices. Case and Shiller (2003) applied panel techniques to compare house price growth and household income in the USA. They found that income growth alone explains most of the house price increases in the USA since 1985. They argue that a combination of low-interest rates and high-income growth from 2000 to 2002 made housing more affordable.

Literature from the OECD countries including Égert and Mihaljek (2007); Kishor and Marfatia (2017); McQuinn and O'Reilly (2008) based on linear methodologies corroborate the positive relationship between house prices and household income. McQuinn and O'Reilly (2008) employ threshold and Johansen cointegration techniques to the Irish property market and their evidence revealed house price has a long-run relationship with the actual amount that individuals can borrow. Égert and Mihaljek (2007) confirm in 19 OECD and Eight Central and Eastern Europe (CEE) countries that house prices are determined to a large extent by GDP per capita, real interest rates, credit growth, and demographic factors. Furthermore, they added that institutional development of the housing market and house finance are important determinants of house prices in the CEE. Recently, Kishor and Marfatia (2017) used several tests such as Beveridge and Nelson decomposition technique, VECM, Gonzalo and Granger test to establish the relationship among house prices, income and interest rates. Their findings further support the existence of a positive relationship between house prices and personal income. Specifically, evidence from the decomposition technique showed that in 10 out of the 15 OECD countries, most of the variations in house prices are transitory as compared to the movement in income and interest rates that are

permanent. Similarly, the Apergis (2003) results of the study on the impact of macroeconomic variables on house prices in Greece using VECM suggest that house prices do respond to specific macroeconomic variables. The results from variance decomposition revealed that the housing mortgage rate is the variable with the highest explanatory power over the variation in real housing prices, followed by the inflation rate.

Other scholars including Brissimis and Vlassopoulos (2008); Chen et al. (2007) and Gallin (2006) failed to find any evidence of a long-run relationship between house prices and household income using linear methodologies. This likely points to the possibility of a nonlinear relationship that the linear methodology cannot detect due to high volatility in house prices relative to income (Chen et al. 2007) and standard cointegration tests suffer from low power especially in sample samples (Gallin, 2006). Gallin thus fails to reject the null hypothesis of no cointegration using the augmented Engel and Granger as well as a bootstrapping approach that allows for cross-section correlations in city-level house price shocks. Gallin (2006) concluded that the error specification obtained by most scholars regarding the relationship between house prices and income in the literature may be inappropriate. Further evidence from Greece by Brissimis and Vlassopoulos (2008) using the Johansen 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 house prices.

The second strand of literature that has emerged offers deeper insights into the relationship between house prices and household income by employing nonlinear methodologies. This includes Bahmani-Oskooee and Ghodsi (2017); Katrakilidis and Trachanas (2012); Kim and Bhattacharya (2009); Nneji, Brooks, and Ward (2013); Tsai et al. (2012) and Zhou (2010). Zhou (2010) used a two-step procedure. Firstly, she applied an algorithm, the alternative conditional expectations to transform the nonlinear into a linear relationship, and in the second step, the augmented Engle and Granger test was applied to the transformed relationship. Following this two-step procedure, Zhou (2010) found evidence of a nonlinear cointegration relationship for six cities and only one city showed evidence of a linear relationship between house prices and economic fundamentals. These results concur with Tsai et al. (2012) who used a multivariate threshold autoregressive model and found that cointegration exists among the USA housing and stock markets, but adjustments toward its long-run equilibrium are asymmetric. Furthermore, Nneji et al. (2013) used regime-switching to study the effect of booms, busts and tranquillity in the USA housing markets. They found

evidence of three regimes in the housing market namely 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.

A nonlinear NARDL approach was employed by Bahmani-Oskooee and Ghodsi (2017) which allowed for possible asymmetric effects to examine whether the effect of income on house prices was symmetric or asymmetric in the USA housing market. Their results confirm that household income changes indeed have an asymmetric effect on house prices in most of the states in the USA. They found that while asymmetry adjustment is borne out by the results in all states, the asymmetric short-run impact was evidenced in 18 states and significant asymmetric long-run impact in 21 states. 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 United Kingdom, Canada and the USA. Additionally, Katrakilidis and Trachanas (2012) using the NARDL approach on monthly data from 1999 to 2011 found evidence of asymmetric long-run effects from the consumer price index and the industrial production index (a proxy for income) towards house prices in Greece. They also observed statistically significant asymmetric effects in the short run time horizon running from all the variables examined towards house prices. Katrakilidis and Trachanas concluded that imposing a linear symmetric model could be misleading in the case of the Greek housing market.

As cited in Section 1 scholarship on the house prices and household income nexus is limited and the available studies in South Africa have produced mixed findings. For example, Aye, Balcilar and Gupta (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, Gupta, and Bittencourt (2013) using a panel vector autoregression approach 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, while the negative impact of a house price decrease caused an insignificant reduction in consumption.

Overall, the empirical literature on house prices and household income provides mixed evidence particularly from studies that have adopted a linear modelling empirical strategy. Conversely, evidence from nonlinear empirical methodologies confirms that the relationship between house prices and household income is nonlinear. **Against this background, the chosen nonlinear NARDL approach is the most suitable to address the thesis of the study given the literature review.**

5. The empirical strategy

The autoregressive distributed (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 the 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 (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 Yann Schorderet (2003), we specify the long-run asymmetric cointegration regression as:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \varepsilon_t, \quad (4)$$

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, β^+ and β^- represent the associated asymmetric long-run parameters of household income per capita (x_t) and is decomposed as follows:

$$x_t = x_0 + x_t^+ + x_t^-, \quad (5)$$

Where, x_t^+ and x_t^- are partial sum processes of positive and negative changes in household income per capita x_t .

$$x_t^+ = \sum_{j=1}^t \Delta x_j^+ = \sum_{j=1}^t \max(\Delta x_j, 0) \text{ and } x_t^- = \sum_{j=1}^t \Delta x_j^- = \sum_{j=1}^t \min(\Delta x_j, 0) \quad (6)$$

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

$$y_t = \sum_{j=1}^p \phi_j y_{t-j} + \sum_{j=0}^q (\theta_{t-j}^+ + \theta_{t-j}^-) + \varepsilon_t, \quad (7)$$

Where x_t is a $k \times 1$ vector of multiple regressors defined as in Equation 5 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 4.

By associating Equation (7) to Pesaran et al. (2001) ARDL(p, q), the following asymmetric error correction is derived:

$$\begin{aligned} \Delta y_t &= \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \psi_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\eta_j^+ \Delta x_{t-j}^+ + \eta_j^- \Delta x_{t-j}^-) + \mu_t \\ \Delta y_t &= \rho \xi_{t-1} + \sum_{j=1}^{p-1} \psi_j \Delta y_{t-j} + \sum_{j=0}^{q-1} (\eta_{t-j}^+ \Delta x_{t-j}^+ + \eta_{t-j}^- \Delta x_{t-j}^-) + \varepsilon_t \end{aligned} \quad (8)$$

Where $\rho = \sum_{j=1}^p \phi_j - 1$, $\gamma_j = -\sum_{i=j+1}^p \phi_i$ for $j = 1, \dots, P-1$, $\theta^+ = \sum_{j=0}^q \theta_j^+$, $\theta^- = \sum_{j=0}^q \theta_j^-$

$\varphi_0^+ = \theta_0^+$, $\varphi_j^+ = -\sum_{i=j+1}^q \theta_i^+$ for $j = 1, \dots, q-1$, $\varphi_0^- = \theta_0^-$, $\varphi_j^- = -\sum_{i=j+1}^q \theta_i^-$ for $j = 1, \dots, q-1$,

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, Alsamara, Mrabet and Gangopadhyay, 2017, p. 108; Katrakilidis and Trachanas, 2012, p.1066). Step one, Equation (8) is estimated using standard OLS. Step two, 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 (8). Step three uses the Wald test to examine the long and short-run symmetries where, $\theta = \theta^+ = \theta^- = 0$, and the short-run symmetry can take one of the following forms $\pi^+ = \pi^-$ for all $i = 1, \dots, q$ or $\sum_{i=0}^{q-1} \pi_i^+ = \sum_{i=0}^{q-1} \pi_i^-$. Finally, in step four, Equation (8) is used to derive the asymmetric cumulative dynamic multiplier effects of a unit change in x_t^+ and x_t^- respectively on y_t . That is, positive and negative changes in household income per capita.

$$m_h^+ = \sum_{j=0}^h \frac{\partial y_{t+j}}{\partial x_t^+} = \sum_{j=0}^h \lambda_j^+, \quad m_h^- = \sum_{j=0}^h \frac{\partial y_{t+j}}{\partial x_t^-} = \sum_{j=0}^h \lambda_j^-, \quad h = 0, 1, 2, \dots \quad (9)$$

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

6. Data and Empirical Results

6.1 Data sources and unit root tests

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

Table 1: Data description and sources

Codes	Description	Sources	Sample period
HP	Affordable houses: Total RSA: All sizes, new & 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

The Amalgamated Bank of South Africa (ABSA) categorizes house prices data into three main market segments: luxury (ZAR 3.5 million to ZAR 12.8 million), middle (ZAR 480 000 – ZAR 3.5 million), and affordable (below ZAR 480 000 and area between 40 to 79 square meters) (Apergis et al., 2014, p. 89). Data on house prices is available for all the market segments, however, the dataset has not been updated after 2016Q3. We focus the analysis on the affordable market segment (gap market) with households earning between ZAR 3500 to ZAR 22000 per month. These households are too rich to qualify for free government housing and don't 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.

As a preliminary step, we perform unit root tests using the Augmented Dickey and Fuller (ADF) 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 the 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 below presents the unit root tests where the last column summarises the order of integration.

Table 3: Augmented Dickey-Fuller and Phillip Perron Unit root test

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)
LogBC	intercept	-0.95(0.73)	-1.47(0.53)	I(1)
lnDYPK	Intercept & trend	-2.83(0.19)	-1.62(0.78)	I(1)
lnBPP	Intercept	--2.22(0.48)	-2.53(0.31)	I(1)
lnEC	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				
Δ Mortgage rate	intercept	-4.97(0.00)***	-6.45(0.00)***	I(0)
Δ Log BC	intercept	-5.63(0.00)***	-17.67(0.00)***	I(0)
Δ LogDYPK	Intercept	-5.04(0.00)***	-13.64(0.00)***	I(0)
Δ LogBPP	intercept	-5.44(0.00)***	-13.40(0.00)***	I(0)
Δ LogEC	intercept	-5.54(0.00)***	-10.04(0.00)***	I(0)
Δ LogHouse price	intercept	-5.58(0.00)***	-7.82(0.00)***	I(0)

All unit root are testing using three lags

Source: By Authors

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. Since the consumer price inflation is stationary at levels, it enters the ARDL model only in the short run. Table 4 below presents the results from Pesaran et al. (2001) and Shin et al. (2014) bounds test for the linear and nonlinear framework respectively. Since the F-statistics (4.57) is greater than the 4.16 (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.

Table 4: Bounds test for cointegration in the linear and nonlinear ARDL

Dependent variable	Test statistics	10%	5%	Outcome
Δ Log 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

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 $F_{PSS} = 7.56 > 6.84$ of lower bound at the 1% and $T_{BDM} = -4.19 > -3.82$ in absolute terms of the upper bound at the 1% level, we reject the null of no long-run asymmetric relationship between the examined variables. In what follows, the next section presents the linear ARDL and NARDL outputs respectively.

6.2 The linear autoregressive distributed lag (ARDL) model

The ARDL results are reported in Table 5 and the evidence confirm 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. These findings corroborate Malpezzi's (1999) findings of a positive relationship between house prices and household income using an error correction framework.

Table 5: Linear ARDL estimates: Dependent variable - Δ house prices (edited)

	<i>Coefficients</i>	<i>t-statistics</i>
<i>ADJ – Error correct (ECM)</i>		
<i>log house price</i>	-0.057***	-2.68
<i>Long run</i>		
<i>Log household income per capita</i>	0.584***	4.35
<i>Mortgage rate on new loans</i>	-0.016***	-3.11
<i>Log index of buildings completed</i>	0.584***	3.87
<i>CPI</i>	-0.008	-1.14
<i>Short-run</i>		
<i>Log house prices</i>		
<i>LD</i>	0.988***	10.94
<i>L2D</i>	-0.766***	-7.05
<i>L3D</i>	0.514***	4.84
<i>L4D</i>	-0.463***	-4.90
<i>L5D</i>	0.233***	3.15
<i>Log household income per capita</i>		
<i>D1</i>	0.055	0.99
<i>LD</i>	0.010	0.20
<i>L2D</i>	0.085	1.63
<i>Mortgage rate on new loans</i>		
<i>D1</i>	-0.002*	-1.89
<i>LD</i>	0.003***	2.91
<i>Log index of buildings completed</i>		
<i>D1</i>	-0.029*	-1.88
<i>LD</i>	-0.001	-0.07
<i>L2D</i>	-0.010	-0.70
<i>CPI</i>		
<i>D1</i>	-0.001**	-2.64
<i>LD</i>	0.001**	2.23
<i>L2D</i>	0.000	0.13
<i>Constant</i>	0.143***	3.70

*, **, *** denotes 10%, 5% and 1% respectively.

Source: By Authors

However, the contribution of this study is not the use of a linear ARDL approach. We are particularly interested in the NARDL which captures the actual asymmetric reaction of economic agents and movements in the macroeconomic variables.

6.3 The nonlinear autoregressive distributed lag (NARDL)

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

Table 6a: Dynamic Asymmetric estimates - Dependent variable: Δ House prices

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)
Δ Log House Prices _(t-1)	0.667 ^{***} (8.21)
Δ Log House Prices _(t-2)	-0.534 ^{***} (-5.44)
Δ Log House Prices _(t-3)	0.229 ^{**} (2.43)
Δ Log House Prices _(t-4)	-0.350 ^{***} (-5.08)
Δ LogIncome _{pos}	0.089(1.37)
Δ LogIncome _{pos(t-1)}	-0.047(-0.82)
Δ LogIncome _{pos(t-2)}	0.053(0.91)
Δ LogIncome _{neg}	0.249(0.97)
Δ LogIncome _{neg(t-1)}	-0.190(0.79)
Δ LogIncome _{neg(t-2)}	-0.333(-1.43)
Δ CPI _{-pos}	0.001(0.93)
Δ CPI _{-pos(t-1)}	0.001(0.52)
Δ CPI _{-pos(t-2)}	-0.001(-0.67)
Δ CPI _{-neg}	-0.002 [*] (-1.77)
Δ CPI _{-neg(t-1)}	0.001(1.33)
Δ CPI _{-neg(t-2)}	0.003 ^{***} (3.33)
Δ Logbuilding plan completed _{-pos}	-0.016(-0.65)
Δ Logbuilding plan completed _{-pos(t-1)}	0.005(0.17)
Δ Logbuilding plan completed _{-pos(t-2)}	0.018(0.600)
Δ Logbuilding plan completed _{-neg}	0.043(1.61)
Δ Logbuilding plan completed _{-neg(t-1)}	-0.012(-0.43)
Δ Logbuilding plan completed _{-neg(t-2)}	-0.040 [*] (-1.67)
Δ Mortgage _{-pos}	-0.004 ^{***} (3.11)
Δ Mortgage _{-neg(t-1)}	0.002 [*] (1.76)
Δ Mortgage _{-pos(t-2)}	0.004 ^{***} (2.85)
Δ Mortgage _{-neg}	-0.002(-1.36)
Δ Mortgage _{-neg(t-1)}	-0.001(-0.42)
Δ Mortgage _{-neg(t-2)}	-0.003 ^{**} (-2.33)
Constant	0.438^{***} (4.36)

^{*}, ^{**}, ^{***} denotes 10%, 5%, and 1% level of significance respectively

Table 6b: Long run asymmetric coefficients

Exog variables	Long-run effect [+]		Long-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 plan 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
LogIncome	9.77***	0.612
CPI	9.57***	0.260
LogBuilding plan passed	5.42**	0.053
Mortgage rate	8.77***	8.14***

Note: [+] 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 *, **, *** denotes 10%, 5% and 1% respectively

Model diagnostics**Statistics**

Portmanteau test up to lag 40 (Chi2)	32.23(0.80)
Breusch/Pagan heteroskedasticity test (chi2)	0.023(0.88)
Ramsey RESET test (F)	1.03(0.38)
Jarque-Bera test on normality (chi2)	2.70(0.26)
Number of observations	122
Adj. R-Squared	0.70
RMSE	0.005

Source: By Authors

The results in Table 6a suggest 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 are positive and significant at 1% with a negative shock existing a greater effect on house prices than to 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 results are presented in the lower panel of Table 6b. The null hypothesis of symmetric short run cannot be rejected except for mortgage interest rate whereas the Wald test rejected the null hypothesis of long-run symmetric of both the positive and negative partial sums decomposition. These findings corroborate our earlier argument that the behaviour of macroeconomic variables are not necessarily linear.

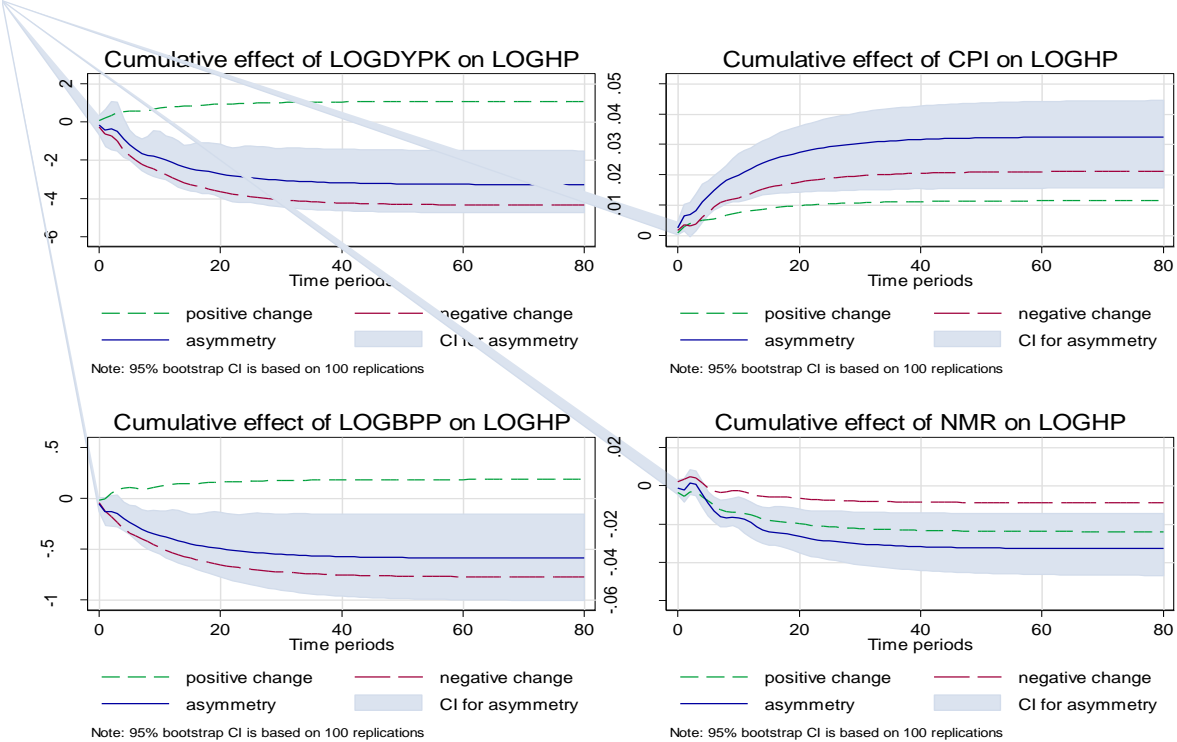
Our results confirm the presence of asymmetric long-run effect of household income per capita, consumer price index, building plan passed and the mortgage interest rate on house prices. The estimated asymmetric long-run coefficients of $\log\text{Income}[+]$ and $\log\text{Income}[-]$ are 1.080 and -4.354 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. Meanwhile, a 1% fall in household income per capita leads to a 4.354% decline in affordable house prices and this corroborates Bahmani-Oskooee and Ghodsi (2017) and Katrakilidis and Trachanas (2012) who found higher magnitudes of negative shocks of income on house prices in the USA and Greece housing markets respectively. Contractions in household income per capita reduce household's ability to borrow to finance housing and nonhousing consumption leading to low demand for housing. Furthermore, some risk-averse investors may sell off their properties thereby increasing the supply of housing stock relative to the demand, thus triggering a fall in house prices. This decline in household income per capita deteriorates the balance sheet of financial institutions through rapid default on monthly mortgage payment corroborating Simo-Kengne et al. (2014) narrative that dynamics in house prices increase the house price risk which are prime sources of financial risk. We argue that given the large size of the affordable housing 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.

The consumer price inflation (CPI) also displayed an asymmetric relationship with affordable house prices with estimated long-run coefficients on $\text{CPI}[+]$ of 0.011 and $\text{CPI}[-]$ of 0.021. That is, a 1% rise in the CPI induces a 1.1% (100×0.011) 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%. A possible explanation is that low CPI reduces the cost of servicing a mortgage loan, making affordable housing attractive to potential buyers. Furthermore, some households in the higher income quintiles are downscaling and moving back into the affordable housing segment to cut cost because of the declining economy. For the number of building plan 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. However, this contradicts theoretical articulation as one would expect house prices to rise everything being equal, 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 leads to a fall in affordable house prices by 2.4%. This concurs with Demary (2010) findings that changes in the interest rate lower real house prices and explain between 12% and 24% of the variation in house prices in the 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 plan passed and the CPI on affordable house prices as shown in Figure 3 below.

Figure 3: Asymmetric cumulative impact dynamic multipliers



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 households income per capita causes only a modest rise in affordable house prices possibly because household 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. Meanwhile, affordable house prices also respond faster to increases than reductions in the mortgage interest rate. Overall, the cumulative dynamic multipliers support the estimated

asymmetric coefficient over 80 month time period and confirm a strong reaction of affordable house prices to negative than positive changes in household income per capita. The diagnostic tests reported at the bottom of Table 6b showed an adjusted R-squared of 70% and the model passed diagnostic all tests, hence reliable for statistical inferences.

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

7. Conclusion

This study has examined the nexus between affordable house prices and household per capita income from 1985q1 to 2016q3 using the nonlinear ARDL model popularized by Shin et al (2014) that dictates the possibility of asymmetric effects in both the long and short run. The baseline estimation using the linear ARDL model shows that household income per capita has a positive and statistically significant relationship with affordable house prices and the error correction (adj) is negative and statistically significant at the 1% level. However, inferences the linear ARDL model fail to account for the potential of asymmetric responses in the behaviour of households and macroeconomic variables, hence, the motivation for the nonlinear ARDL.

The NARDL results reveal the presence of a long-run asymmetric relationship between affordable house prices and household income per capita in South Africa. The Wald test rejected the null hypothesis that both the positive and negative partial sums of household income per capita are equal for the long run but not for the short run. The estimated long-run coefficients for LogIncome[+] and LogIncome[-] are 1.080 and -4.354 respectively. A 1% increase in household income per capita results in a 1.08% rise in affordable house prices. Similarly, 1% fall in household income per capita leads to 4.35% decline in affordable house prices. We argue that given the 71.4% market share of affordable housing in all residential properties in South Africa, a persistent fall in household income can trigger a systemic crisis, particularly with mortgage securitization.

Additionally, the CPI, the index of the number of building plan passed and mortgage interest rate equally exhibit an asymmetric long-run relationship with affordable house prices. The estimated coefficients for the partial sums decomposition of CPI are both positive and statistically

significant, suggesting during periods of rising CPI, affordable housing serves as a hedge to potential investors and a fall in the CPI improves housing affordability thereby stimulating demand which in turn leads to a rise in affordable house prices.

Our findings represent an enrichment of the scant empirical literature on affordable house prices and household income in developing economies. Modelling the dynamic asymmetric behaviour of affordable house prices and household income per capita provide insightful information that can't be captured by the linear model. Specifically, knowledge of how both positive and negative shocks in household income are transmitted helps in policy formulation and the management of the asset price bubble in the housing sector through both fiscal and monetary policies. **Thus, policymakers should closely monitor the practice of mortgage securitization, particularly in the affordable market segment to avoid systemic risk to the economy. Strategies to support income growth for the lower and middle-income households are recommended to improve housing affordability and also ensuring the effective coordination and management of the FLISP subsidy.**

We have used affordable house prices and not homeownership statistics. Scholars interested in housing can expand the study to examine how homeownership affect wealth distribution in South Africa.

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Annexure 1: Robustness test

Asymmetry statistics

Exogenous. variables.	Long-run effect [+]		Long-run effect [-]	
	coef.	F-stat	coef.	F-stat
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 plan passed	-0.024	0.022	-0.577***	10.61
Mortgage Rate	-0.011**	4.589	0.007**	4.19
Log vol 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 plan passed	4.628**		0.834	
Mortgage Rate	1.244		6.302**	
Log volume of production	6.504**		0.429	

Note: Long-run effect [-] refers to a permanent change in exog. var. by -1

Cointegration test statistics: $t_BDM = -4.4752$

$F_PSS = 6.6484$

Model diagnostics

Statistics

Portmanteau test up to lag 40 (Chi2)	40.5(0.45)
Breusch/Pagan heteroskedasticity test (chi2)	1.92(0.17)
Ramsey RESET test (F)	0.09(0.97)
Jarque-Bera test on normality (chi2)	1.09(0.58)

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