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Bubbles in South African House Prices and their Impact on Consumption

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Abstract

This paper tests for house price bubbles in the South African housing market, using quarterly data from 1969:Q2 to 2009:Q3, based on the unit root test developed by Phillips et al. (2010). This test allows us to detect whether a bubble exists or not, as well as the date of emergence and collapse of the same. Our findings show evidence of house price bubbles in the large, medium and small-middle segments, as well as, the aggregate middle-segment of the South African housing market. There is however, no evidence of bubbles in the luxury and affordable segments of the market. Next we estimate an Error Correction Model (ECM) to investigate the existence of spillover effects from the housing sector onto consumption. Results indicate significant spillovers, though there is no evidence of the effect being higher during the bubble period. Finally, we disentangle the effects of the house price acceleration and deceleration on consumption in an effort to investigate whether or not consumption reacts asymmetrically to movements in house prices. We find that consumption responds significantly to the house price acceleration but not to deceleration, with this effect also not showing any evidence of being higher during the identified bubble period. The asymmetric model is found to perform better both in terms of in-sample and out-of-sample performances, relative to the symmetric model. The fact that we do not observe consumption to be more responsive to house price acceleration (deceleration) during the bubble period is most likely due two reasons: First, the National Credit Act number 34 implemented in 2005, which enforced responsible granting and use of credit and prohibited reckless awarding of credits (NCA, 2006) and second, the findings of recent studies depicting evidence of pronounced discretionary changes by the South African Reserve Bank to counter the recent adverse movements in the financial markets.

Keywords: *House price, bubble, consumption*
JEL Classification: C22, E21, G1

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1 Introduction

The recession in the US in the recent past has stimulated wide spread interest in research on the housing market and the macroeconomy. Economists have started to believe that movements in the associated housing markets are not just the consequences of movements in the economy, but in fact, provide important impulses to business cycle fluctuations (Iacoviello, 2009). Leamer (2007) strongly argues that housing *is* the business cycle. Further, the Federal Reserve Chairman Ben Bernanke (2008), in his introductory remarks at a conference on Housing and Mortgage Markets in 2008, indicated that "Housing and housing finance played a central role in precipitating the current crisis".

Thus, the growth in the literature concerning the effects of spillovers from the housing market on to the real sector of the economy is hardly surprising (see for example, Green, 1997; Ng and Schaller, 1998; Iacoviello, 2005; Case et al., 2005; Leamer, 2007; Ghent and Owyang, 2009; Iacoviello, 2009; Pavlidis et al., 2009; Iacoviello and Neri, 2010). So much so, that research on housing is no longer confined to "real estate economics", but has become part of mainstream economics. It is only fair to say that research on housing related issues can no longer be dubbed as a niche topic anymore. The spillovers from the housing sector onto the real sector of the economy have gained more importance over time, and are in fact, concentrated on consumption (Iacoviello and Neri, 2010), given that consumption is the most dominant component of the Gross Domestic Product (GDP). In addition, there is evidence of strong comovement between house prices and consumption (Aoki et al., 2004; Christensen et al., 2009; Iacoviello, 2011). Rapach and Strauss (2006) indicate that consumption reacts more vigorously to variations in the housing wealth than fluctuations in the stock market wealth. Ng and Schaller (1998), and more recently, Pavlidis et al. (2009), contend that house price bubbles account for an important share in the fluctuation in consumer expenditure.

As indicated in Figure 1(a) and Figure 1(b), though not as drastic as the recent decline in US house prices, real house prices in the five major segments of the South African housing market, namely, luxury, large-middle-segment, medium-middle-segment, small-middle-segment and affordable, and the combined middle-segment[1] depict a relatively flat positive trend in recent years, starting around 2004:Q2. In fact, the growth rate in real house prices, as shown in Figure 1(c) has generally had a negative trend between 2004:Q2 and 2009:Q2. An important question is then whether such a movement in house prices is the result of a bubble in the market? The term "bubble" in economics refers to the increase in the price of an asset beyond the level required by economic fundamentals (Lansing, 2007). John Loos (a strategist at First National Bank[2]) argues that house prices in South Africa were 'grossly undervalued' during the late 1990s and the boom was mainly a 'normalization'[3]. Such a statement, though unlikely to be based on any econometric

[1] Please refer to Section 3 for further details on the categorization of housing in South Africa.
[2] One of the major financial service institutions in South Africa.
[3] Business Times, Pretoria News, February 4th, 2010: "House prices increasing but analysts are split on

modeling, tends to suggest that the the slowdown in the housing market is more likely due to the recession witnessed by the economy in general and not a bubble.

[Insert Figure 1 about here]

Against this backdrop, this paper, to the best of our knowledge, makes the first attempt to: (i) statistically test for the existence, emergence and bust of house price bubbles in five segments and the aggregate middle segment of the South African housing market, based on the unit root test developed by Phillips et al. (2010); (ii) analyze the size of the spillover of house price acceleration and deceleration and the impact of bubbles, if detected, on the growth rate of consumption using an Error Correction Model (ECM) developed by Pavlidis et al. (2009), and; (iii) following Apergis and Miller (2006) investigate if there exists possible asymmetric effects of house price acceleration and deceleration on consumption, .

Note, from a policy perspective, Pavlidis et al. (2009) argues that the existence of a bubble in housing market should concern monetary authorities because of the possible effect of the bubble on consumption. This, in turn, has led to recent discussions on whether central banks should target house price inflation (see for example, Finocchiaro and Queijo von Heideken, 2007; Taylor, 2007; Jarocinski and Smets, 2008; Paris and Notarpietro, 2008; Vargas-Silva, 2008b,a; Demary, 2009; Bernanke, 2010; Naraidoo and Ndahiriwe, 2010; Naraidoo and Paya, 2010). The rest of the paper is organized as follows: section 2 discusses the methodology, section 3 presents the data and results for both the tests for bubbles and the impact of house prices on consumption and finally section 4 concludes.

2 Methodology

Though, there exists a huge literature[4] on ways to detect bubbles in asset prices, we follow the methodology outlined in Phillips et al. (2010), since it not only detects whether a bubble exists and if it exists, helps in identifying the dates corresponding to the start and end of the bubble.

According to Phillips et al. (2010), a bubble[5] exists when the null hypothesis (H_0) of Unit Root is rejected against the alternative hypothesis (H_1) of an explosive series based on the regression:

$$s_t = \mu + \phi s_{t-1} + \sum_{j=1}^{J} \xi_j \delta s_{t-j} + \varepsilon_{s,t} \tag{1}$$

where s_t is the asset (house) price; $\varepsilon_{s,t} \rightarrow N(0, \sigma_s^2)$; H_0: $\phi = 1$; H_1: $\phi > 1$. The Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) were used to select

outlook" by Ethel Hazelhurst.

[4] Gurkaynak (2005) gives an extensive review of many other methodologies used to detect bubbles in asset prices.

[5] The increase in the price of an asset beyond the level required by economic fundamentals (Lansing, 2007)

the appropriate lag length J[6].

The Phillips et al. (2010) unit root test consists of two tests: a right-side Augmented Dickey-Fuller (ADF) test and a *sup* Augmented Dickey-Fuller test which involves recursively estimating equation (1)[7]. Under the null hypothesis, the test statistics for the right-side and sup Augmented Dickey-Fuller tests denoted by ADF_r and $\sup_{r\in[r_0,1]} ADF_r$, respectively, are defined as follows:

$$ADF_r = \frac{\int_0^r W dW}{\int_0^r W^2} \tag{2}$$

$$\sup_{r\in[r_0,1]} ADF_r = \sup_{r\in[r_0,1]} \frac{\int_0^r W dW}{\int_0^r W^2} \tag{3}$$

where W is a Brownian motion and $r \in [r_0, 1]$ represents a fraction of the whole sample, which we set to 0.25 (Pavlidis et al., 2009).

Following Pavlidis et al. (2009), we estimate an ECM to investigate the possible effect of house price on consumption. However, our framework differs slightly from the specification in Pavlidis et al. (2009), as we explicitly incorporate the role of real interest rate in the model. We follow a general-to-specific approach to formulate the following model,[8] which, though cannot ensure normality[9], but guarantees no serial correlation at the 5% level[10] and heteroscedasticity:

$$\Delta c_t = \beta_0 + \sum_{i=1}^{4} \beta_i \Delta c_{t-i} + \beta_5 \Delta w_{t-2} + \beta_6 \Delta y_t + \beta_7 \Delta r_t + \beta_8 ecm_{t-1} + \beta_9 [d(\Delta rhp)]_{t-1} + \varepsilon_t \tag{4}$$

where, Δ is the first-difference operator, c is the log of real consumption (non-durables and services), w is the log of real all share index, y represents the log of real personal disposable income and r is the real interest rate. The price acceleration (deceleration) term $[d(\Delta rhp)]_{t-1}$ is defined as $\Delta rhp_{t-1} - \Delta rhp_{t-2}$, with rhp being the log of real house price and $ecm_{t-1} = c_{t-1} - w_{t-1} - y_{t-1} - r_{t-1}$ represents the error correction term[11].

[6] Both the AIC and SIC suggested zero lags for all categories of housing, except medium-middle-segment. In this case, the AIC suggested 8, but we use the SIC which continued to choose zero lags.

[7] i.e. estimating equation (1) for some fraction of the entire sample, r_0, and then successively adding one more observation.

[8] Note we started from a general specification which included four lags of Δc_t, and both contemporaneous and four lags of Δw_t, Δy_t, Δr_t and $ddeltarhp_t$.

[9] Due to the non-normality in the error structure, we complemented the OLS estimates with Least Absolute Deviations (LAD) estimates. In general, the coefficient estimates were quantitatively similar to the OLS estimates. However, the LAD estimation procedure did not yield significant spillover effects. Further, the fit of the models were significantly reduced and normaility was still not ensured. Due to these reasons, we have not reported the LAD estimates to save space. They are, however, available upon request from the authors.

[10] See Tables 2 and 3.

[11] At this stage, it is important to emphasize on two issues regarding the framework: First, based on the Trace and Eigen value tests, only one cointegrating vector was obtained between c, w, y and r, and,

To gain more insight on the spillover from the housing sector onto the real sector of the economy over a sub-sample and the bubble-period, if and once identified by the unit root test of Phillips et al. (2010), we estimate equation (4) recursively[12], starting with the period 1969:Q2-1985:Q4. The choice of the period 1985:Q4 coincides with the liberalization of the financial sector in South Africa, following recommendations of the de Kock commission (Ludi and Ground, 2006; du Plessis et al., 2007).

In addition, based on the work of Apergis and Miller (2006), we investigate possible asymmetric (both positive and negative) effects of all variables and house prices, in particular on consumption, by distinguishing the "Plus" and "Minus" values for all variables in (4) barring the ecm_{t-1} term.[13] For this purpose, we estimate the following Error Correction Model:

$$\begin{aligned}\Delta c_t = \beta_0 + \sum_{j=1}^{4}\sum_{i=1}^{4}\beta_j \Delta c_{t-i}^{(+)} + \sum_{j=5}^{8}\sum_{i=1}^{4}\beta_j \Delta c_{t-i}^{(-)} + \beta_9 \Delta w_{t-2}^{(+)} + \beta_{10}\Delta w_{t-2}^{(-)} + \beta_{11}\Delta y_t^{(+)} \\ + \beta_{12}\Delta y_t^{(-)} + \beta_{13}\Delta r_t^{(+)} + \beta_{14}\Delta r_t^{(-)} + \beta_{15} ecm_{t-1} + \beta_{16}[d(\Delta rhp)]_{t-1}^{(+)} \\ + \beta_{17}[d(\Delta rhp)]_{t-1}^{(-)} + \varepsilon_t\end{aligned} \quad (5)$$

3 Data and results

3.1 Data

We use quarterly house price data available from the ABSA[14] Housing Price Survey. The survey categorizes houses in three price segments: luxury (R3.1 million to R11.5 million); middle-segment (R430,000 to R3.1 million) and affordable (below R430,000 and area below 40 m^2 - 79 m^2). The middle-segment is further subdivided in three types based on size: large (between 221 m^2 and 400 m^2); medium (between 141 m^2 and 220 m^2) and small (from 80 m^2 to 140 m^2). The real house price is computed as the nominal house price divided by headline CPI. The quarterly seasonally adjusted data on real consumption (non-durables and services), real personal disposable income, real all share stock index (used as a measure of financial wealth following Hall et al., 2009) and the 90-

hence, the decision to use an ECM, instead of a Vector ECM (VECM), is well-motivated, and; second, even though the use of contemporaneous values of explanatory variables are permissible in an ECM, there is a concern of endogeneity, especially, with respect to personal disposable income. But, the exogeneity test performed on the cointegrating vector revealed that the concurrent values of the real personal disposable income is, in fact, exogenous.

[12] We first run a regression for the sub-sample 1969:Q2 (starting point of our sample)-1985:Q4, then we sequentially extend the initial sample by adding one more observation until 2009:Q3 (end point of our sample) and analyze the way in which both the coefficients and the respective t-stats of the house price acceleration (deceleration) evolve.

[13] Note, ideally one would want to use a non-linear framework to analyze asymmetric effects, see for example, Apergis and Miller (2004), Apergis and Miller (2005a), Apergis and Miller (2005b). We, however, leave this out for future research.

[14] ABSA is one of the largest private financial services institutions in South Africa.

day nominal treasury bill rate are obtained from the official website of the South African Reserve Bank (SARB). Note, the real interest rate is obtained by subtracting the inflation rate (percentage change of the headline CPI) from the nominal treasury bill rate. Data availability on all the variables at the time of writing the paper gives us a sample period of 1969:Q2 till 2009:Q3. Finally note that, when estimating the ECM, we use the house price of the aggregate middle-segment of the market to compute the house price acceleration (deceleration) variable, since data on consumption is only available economy-wide and not based on choices of housing category.

3.2 Tests for bubbles

Results in Table 1 show evidence of bubbles in the small-middle, medium-middle and large-middle segments of South Africa's housing market. For all these segments, the null hypothesis of a unit root is rejected in favor of the alternative hypothesis suggesting the presence of a bubble. Furthermore, a bubble is detected for the entire South African housing market. There is however no presence of bubbles in the luxury and affordable segments. The result is expected, given that, prices in the affordable section is in general, government controlled, while the demand in the luxury segment of the housing market is dominated by, understandably, the most affluent in the country and also foreigners, whose housing decisions are less likely to be affected by pricing or other economic fundamentals (Gupta et al., 2010).

Figure 2 plots the recursive ADF t-stat and the 5% critical value based on Phillips et al. (2010). As can be seen from the figure, the whole of the middle-segment of South Africa has been experiencing a house price bubble starting around 2002:Q4. Furthermore, the test identifies the origination of a bubble in the large-middle segment starting in 2001:Q1, while the medium-middle and the small-middle segments are indicated to have been under the influence of bubbles from 2003:Q2 and 2004:Q4 respectively. More importantly, barring the bubble in the small-middle segment, which appears to be close to busting by 2009:Q3, none of the other segments are found to have witnessed the collapse of their bubbles.

[Insert Table 1 & Figure 2 about here]

3.3 Impact of House prices on consumption

Table 2 reports results from the consumption regression equation (4). The first lag of the real house price acceleration (deceleration) is significant at the 5% level, suggesting that movements in house prices have had a significant positive impact on the movements of consumption over the whole sample period. Furthermore, barring the first insignificant lag of the growth rate of consumption, all the coefficients are in line with economic theory. Interestingly, real interest rate is not found to have a significant negative influence on consumption. When compared to equation (4), the fit of the ECM without the lagged house price acceleration (deceleration) term is worsened.

[Insert Table 2 about here]

Results from the consumption regression equation (5), as reported in Table 3, show that house price acceleration rather than deceleration has a significant effect (at the 5% level) on consumption. In addition, the effect of the real interest rate on consumption becomes significant under this specification, with the model suggesting that consumption reacts significantly to negative movements in the real interest rate only. Furthermore, the negative movements in the second lag of the wealth variable and positive movements in the real personal disposable income and the second and fourth lag of the growth rate of consumption appear to have a significant effect on consumption. The results highlight the existence of asymmetric movements of consumption to the explanatory variables. The Wald tests revealed that, with the exception of the coefficient on the house price acceleration and deceleration, all the coefficients on the plus and minus terms of a specific explanatory variable are significantly different[15]. As with the symmetric ECM specification, the fit of the asymmetric ECM without the lagged house price acceleration and deceleration terms is reduced relative to the asymmetric ECM which includes these terms. Finally, in all the specifications, the error correction term is always significant and a negative fraction, highlighting that short-run dynamics correct for any possible disequilibrium from the long-run relationship.

Figure 3 and Figure 4 show the recursive estimates of the coefficients of the price acceleration (deceleration) from the symmetric model (4) and price acceleration from the asymmetric version of the same (5), respectively. In addition, the figures also plot the way in which the corresponding t-statistics of the coefficient has evolved. In both cases, estimates of the coefficients are significant. However, there is no evidence of their effects on consumption being higher during the period of the bubble (starting around 2002:Q4), as observed for the US (Pavlidis et al., 2009). We believe that this is mainly due to two reasons: First, based on non-linear Taylor rules, Naraidoo and Ndahiriwe (2010); Naraidoo and Paya (2010) argue that the SARB carefully considers a financial conditions index, and tries to insulate the economy from adverse movements of the same when setting the interest rate. Note the index was obtained as a weighted average of the real house prices, real effective exchange rate, real stock prices, credit spread and futures interest rate; second, the National Credit Act (NCA) number 34 implemented in 2005 enforced responsible granting and use of credit, and prohibited reckless awarding of credits (NCA, 2006). In fact, as seen from Figure 4, the liberalization of financial markets in South Africa following the de Kock commission's (1985) recommendation, coupled with deregulation of the international capital markets and abolition of exchange rate controls in the early 1980s, possibly caused diversification of investment portfolios, so much so, that the effect of house prices on consumption started to come down since the late 1980s.

[Insert Table 3 and Figures 3 & 4 about here]

[15]The results from the Wald tests are available upon requests from the authors.

Though the in-sample fit of the asymmetric model is higher than the symmetric model, and hence, can be believed to fit the data better, , in Table 4 we compare the ability of the two models in forecasting one- to eight-quarters-ahead level of consumption, as an alternative measure of choosing the appropriate model.[16] As can be seen, the Root Mean Squared Errors (RMSEs) of the asymmetric model (expressed as a percentage of the random walk model[17]) are lower than the corresponding RMSEs of the symmetric model (also expressed as percentage of the 'naive' model) for one- to eight-quarters-ahead, based on an in-sample of 1969:Q2- 1985:Q4 and a recursively extended out-of-sample of 1986:Q1-2009:Q3.

[Insert Table 4 about here]

4 Conclusion

In this paper, we test for bubbles in the South African housing market using the Phillips et al. (2010) unit root test. A "bubble" refers to the increase in the price of an asset beyond the level required by economic fundamentals (Lansing, 2007). We find evidence of bubbles in all three subdivisions (large, medium and small) and the aggregate of the middle segment of the South African housing market. Results for the affordable and luxury segments show no evidence of any house price bubbles. Following Pavlidis et al. (2009), we further investigate the effect of house prices on consumption, and find significant evidence of spillovers from the housing sector to the real sector. However, the effects of the housing market spillover on the real economy do not appear to be higher during the period associated with a bubble. Based on the Error Correction Model framework of Apergis and Miller (2006), which allows us to incorporate asymmetric effects on consumption from the explanatory variables, we find that there is a significant reaction of consumption on house price acceleration, but not for deceleration. This model is found to have better fit for both the in- and out-of-sample estimations, when compared to the symmetric ECM. However, as with the symmetric ECM, findings from the asymmetric model also suggest that the effect of the house price acceleration on consumption is not higher during the bubble period. The fact that we do not observe consumption to be more responsive to house price acceleration (deceleration) during the bubble period, possibly reflects the effect of the NCA (number 34) implemented in 2005 (NCA, 2006) and also corroborates the findings of recent studies on the behavior of the SARB in response to movements in asset prices. Based on non-linear Taylor rules, Naraidoo and Ndahiriwe (2010) and Naraidoo and Paya (2010) depict evidence of pronounced discretionary changes on behalf of the central bank to counter the recent adverse movements of a financial index, which includes real property

[16] Note the models were estimated in first-difference and then the RMSEs were computed for the forecasts of consumption in levels, recovered using the actual lagged value of the same.

[17] The decision to use the random walk model as the benchmark emanates from such an implication of a version of the Permanent Income Hypothesis (PIH) outlined in Hall (1978) (see Gupta and Ziramba (2010) for further details.)

prices besides other asset prices.

Future research on this topic would aim to revisit the question of spillovers in a Vector Autoregressive (VAR) framework, which would allow us to look at the effect of a real house price shock on a number of variables, besides consumption. In addition, one might also want to look into the issue in a more general time-varying Factor Augmented VAR (FAVAR) framework, which would account for not only any structural breaks in the data, but also the fact that house prices are determined by a large number of macroeconomic variables, over and above the few we choose in small-scale VARs due to the curse of dimensionality (Das et al., 2009, 2010a,b). As far as large number of variables determining the house prices is concerned, one can also use a large-scale Bayesian VAR, which through its estimation method can also handle the degrees of freedom problem. Finally, one should ideally be trying to delve into the issue of spillovers based on a small open economy new Keynesian Dynamic Stochastic General Equilibrium (DSGE) model (see for example, Christensen et al., 2009), which in turn, unlike the VARs, is immune to the Lucas (1976) critique.

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Appendix

Table 1: Phillips et al. (2010) Unit Root test for bubbles

Category	**sup** ADF_r	ADF_1
SA	2.3373***	0.3955
Large	2.3597***	-0.3609
Medium	2.4252***	-0.0387
Small	1.1893*	0.0137
Luxury	1.1239	-1.4672
Affordable	-0.2350	-0.6360

Note: ***, ** & * denote significance at the 1%, 5% & 10% levels

Table 2: Consumption regression with symmetric effects results

	Regression (4)	
	(a)	*(b)*
β_0	0.0069**	0.0067*
	(2.1014)	(1.9626)
	[0.0033]	[0.0034]
β_1	-0.0515	-0.0437
	(-0.4813)	(-0.4165)
	[0.1069]	[0.1050]
β_2	0.241***	0.2225***
	(3.7963)	(3.2826)
	[0.0635]	[0.0678]
β_3	0.1354*	0.1329*
	(1.9144)	-1.9065
	[0.0707]	[0.0697]
β_4	0.2799***	0.2902***
	(3.5636)	(3.4830)
	[0.0785]	[0.0833]
β_5	0.0294***	0.0328***
	(2.7639)	(3.3193)
	[0.0107]	[0.0099]
β_6	0.1789***	0.1838***
	(4.7101)	(4.7794)
	[0.0380]	[0.0384]
β_7	-0.0009	-0.0010*
	(-1.6265)	(-1.7160)
	[0.0006]	[0.0006]
β_8	-0.0869***	-0.0801**
	(-2.7724)	(-2.4625)
	[0.0313]	[0.0325]
β_9	0.1346**	-
	(1.8197)	
	[0.0739]	
$\overline{R^2}$	0.3979	0.3863
JB	11.9100	11.4919
	[0.0026]	[0.0032]
$BG(4)$	2.3116	2.0658
	[0.0606]	[0.0883]
$ARCH(4)$	1.1275	1.0640
	[0.3458]	[0.3766]

Notes: t-statistic in ( ), Newey-West robust standard errors in [ ]. ***, ** & * denote significance at 1%, 5% & 10% levels. JB is the Jarque-Bera test for normality. $BG(4)$ is the Breusch-Godfrey test for serial correlation. $ARCH(4)$ is the heteroskedasticity test for residuals. For the JB, $BG(4)$ and $ARCH(4)$ statistics, p-values are given in [ ].

Table 3: Consumption regression with asymmetric effects results

	Regression (5)	
	(a)	*(b)*
β_0	0.0052	0.0072*
	(1.2670)	(1.7366)
	[0.0041]	[0.0042]
β_1	-0.0566	-0.0486
	(-0.7367)	(-0.6208)
	[0.0768]	[0.0783]
β_2	0.2176***	0.2241***
	(2.9683)	(3.0290)
	[0.0733]	[0.0734]
β_3	0.0930	0.1163
	(1.2231)	(1.5206)
	[0.0760]	[0.0765]
β_4	0.2540***	0.2496***
	(3.4476)	(3.3323)
	[0.0737]	[0.0749]
β_5	-1.5312	-1.8588
	(-1.1294)	(-1.3497)
	[1.3557]	[1.3772]
β_6	-0.7190	-0.5102
	(-0.5180)	(-0.3616)
	[1.3880]	[1.4111]
β_7	1.0399	1.3256
	(0.7495)	(0.9397)
	[1.3875]	[1.4107]
β_8	2.4418	2.5041
	(1.6280)	(1.6367)
	[1.4999]	[1.5299]
β_9	0.0066	0.0171
	(0.3295)	(0.8524)
	[0.0201]	[0.0201]
β_{10}	0.0399**	0.0423**
	(2.0462)	(2.1321)
	[0.0195]	[0.0198]
β_{11}	0.2049***	0.2038***
	(5.8898)	(5.8013)
	[0.0348]	[0.0351]
β_{12}	0.0112	0.0199
	(0.1019)	(0.1783)
	[0.1096]	[0.1115]
β_{13}	0.0003	0.0005
	(0.2694)	(0.3794)
	[0.0012]	[0.0012]
β_{14}	-0.0027**	-0.0020*
	(-2.3455)	(-1.7589)
	[0.0012]	[0.0011]
β_{15}	-0.0865**	-0.0780**
	(-2.2568)	(-2.0065)
	[0.0383]	[0.0389]
β_{16}	0.1194**	-
	(2.3229)	
	[0.0514]	
β_{17}	0.1299	-
	(0.5569)	
	[0.2332]	
$\overline{R^2}$	0.4136	0.3896
JB	10.2171	13.2084
	[0.0060]	[0.0014]
$BG(4)$	1.1363	1.9165
	[0.3421]	[0.1111]
$ARCH(4)$	2.3131	2.2070
	[0.0600]	[0.0710]

Notes: t-statistic in ( ), Newey-West robust standard errors in [ ]. ***, ** & * denote significance at 1%, 5% & 10% levels. JB is the Jarque-Bera test for normality. $BG(4)$ is the Breusch-Godfrey test for serial correlation. $ARCH(4)$ is the heteroskedasticity test for residuals. For the JB, $BG(4)$ and $ARCH(4)$ statistics, p-values are given in [ ].

Table 4: Relative RMSEs (1986:1 - 2009:3)

QA	**Symmetric model**	**Asymmetric model**
1	0.9711	0.8711
2	0.6930	0.6283
3	0.4735	0.3109
4	0.3677	0.2737
5	0.2682	0.2025
6	0.2375	0.2182
7	0.1982	0.1617
8	0.1836	0.1531
Average	0.4241	0.3524

Notes: QA: Quarter(s) Ahead, Relative RMSEs: RMSEs relative to the Random Walk benchmark model.

Fig. 1: Real house prices and real house price growth rates in South Africa

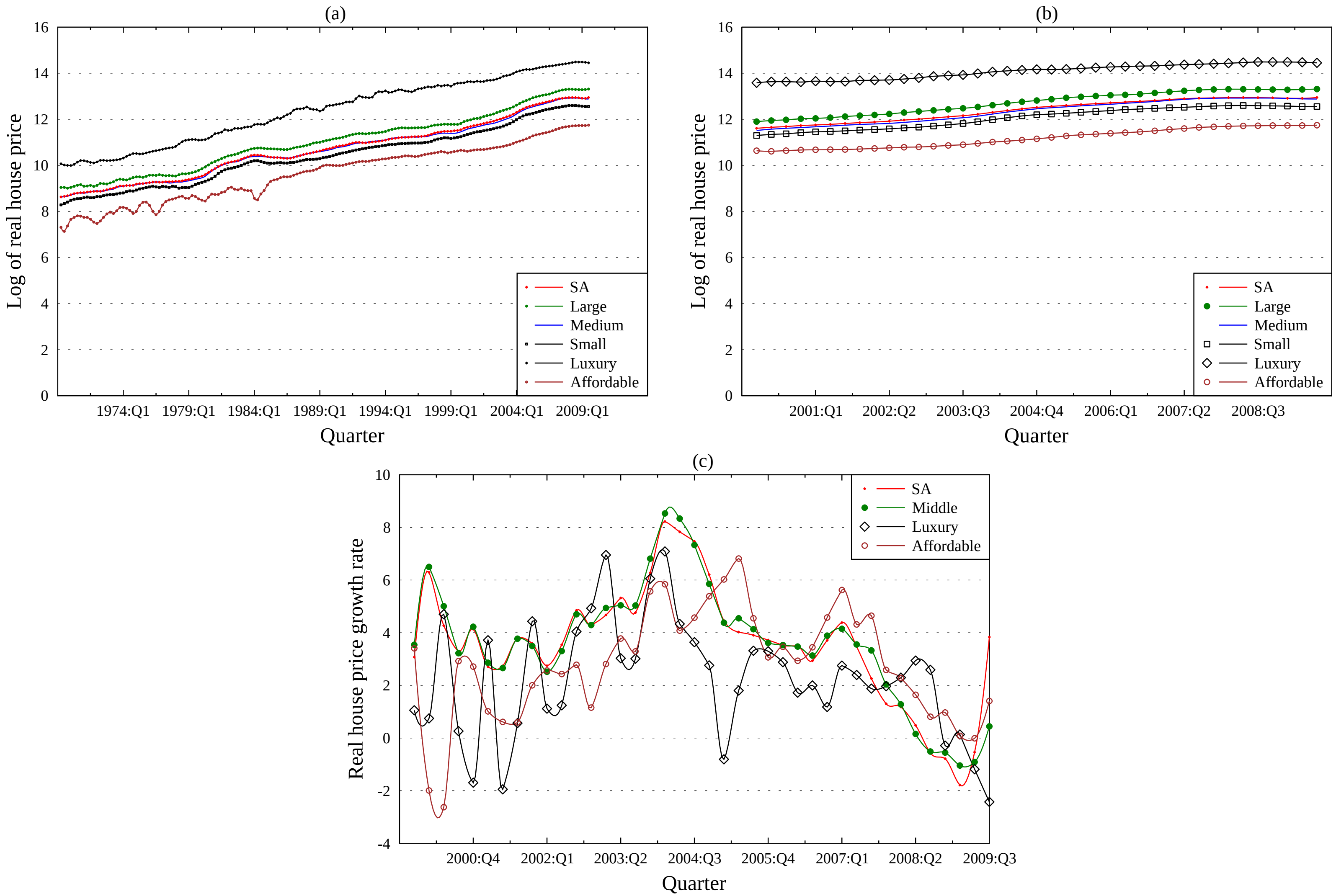

Fig. 2: House price bubbles

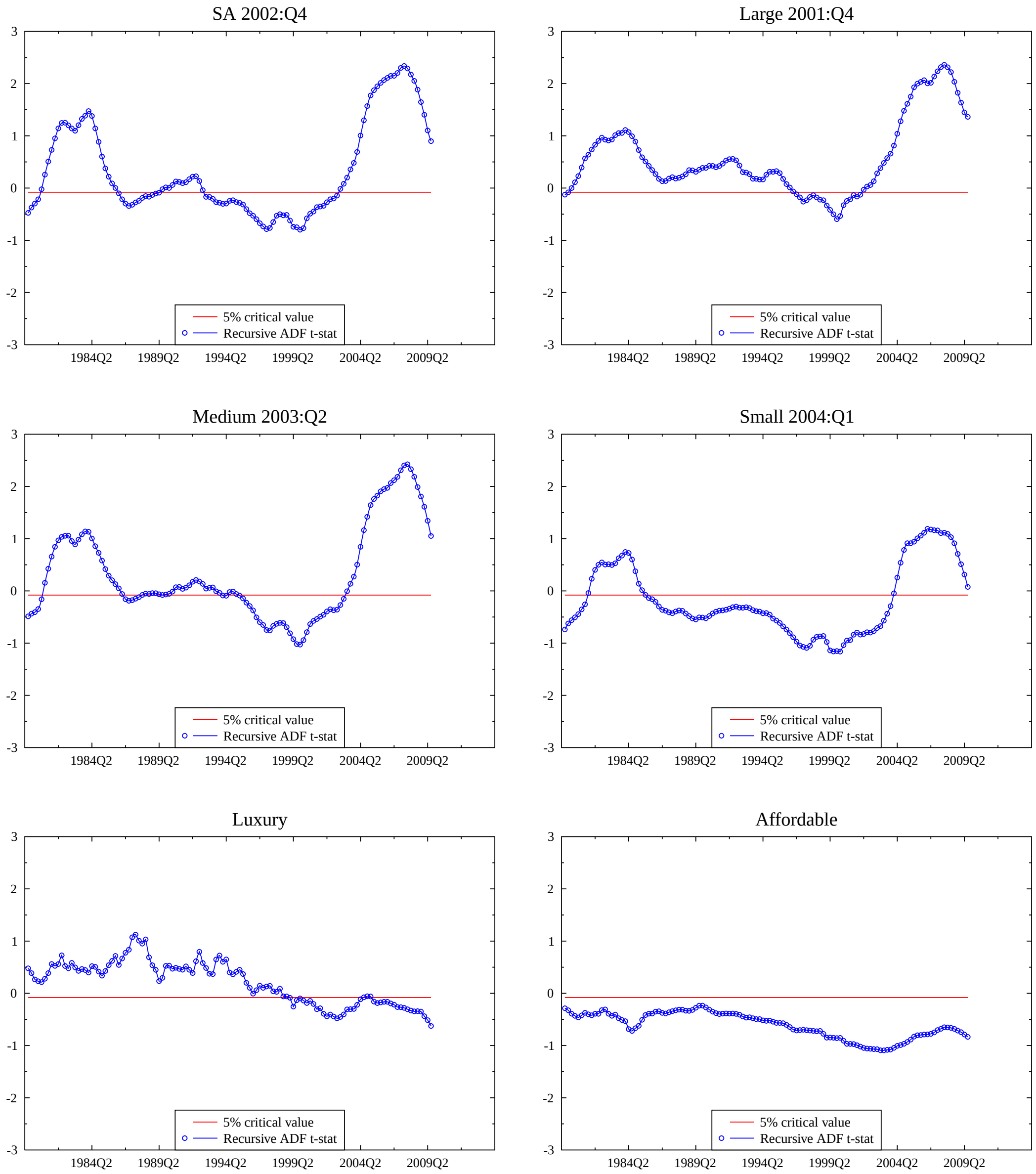

Fig. 3: Recursive plots: spillovers on consumption. The shaded region indicates the presence of a bubble according to Phillips et al. (2010) Unit Root test.

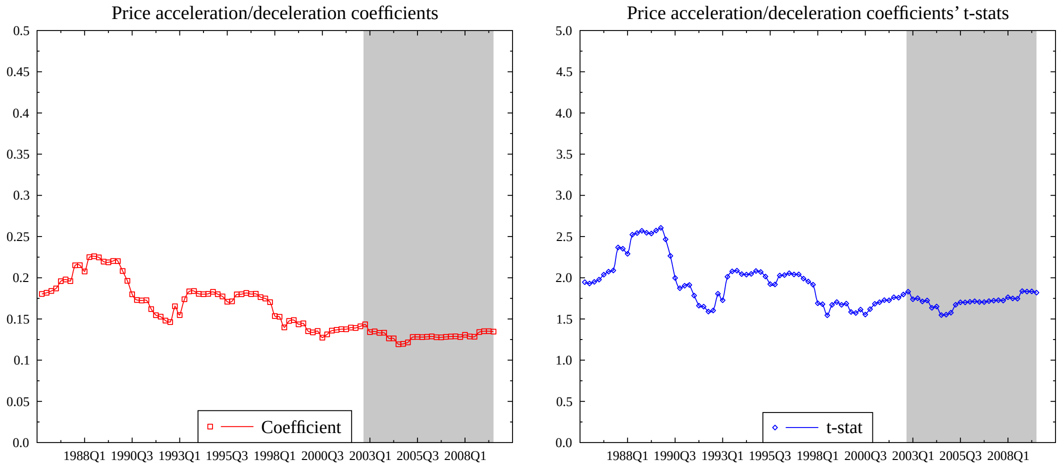

Fig. 4: Recursive plots: spillovers on consumption with asymmetric effects. The shaded region indicates the presence of a bubble according to Phillips et al. (2010) Unit Root test.