“Ripple” Effects in South African House Prices[*]

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Abstract

This paper analyzes the so-called “ripple” effect of house prices in large-, medium- and small-sized houses of five major metropolitan areas of South Africa, namely, Cape Town, Durban Unicity, Greater Johannesburg, Port Elizabeth/Uitenhage and Pretoria, based on available quarterly data covering the period of 1966:Q1 to 2010:Q1. Following the extant literature, we contextualize the issue as a unit root problem, with one expecting the ratios of metropolitan house price to national house price to exhibit stationarity to an underlying trend value, if there is diffusion in house prices. Using Bayesian and non-linear unit root tests, besides the standard linear tests of stationarity with and without structural break, we find overwhelmingly support of the existence of robust ripple effects. Also factor analysis conducted suggested that the ripple effects originate in Cape Town for the large housing segment, and in Durban for the medium- and small-sized houses.

Keywords: House-price ratios, “Ripple” effects, Time series properties, Unit root tests
JEL Code: G10, C30, C50

1. INTRODUCTION

This paper analyzes the so-called “ripple” effect of house prices in five major metropolitan areas of South Africa, namely, Cape Town, Durban Unicity, Greater Johannesburg, Port Elizabeth/Uitenhage and Pretoria. In the prensence of a ripple effect, house price shocks in one area are likely to have transitory or permanent implications for house prices in other metropolitan areas (Pollakowski and Ray, 1997). Following Meen (1999) and more recently Canarella *et.al.* (forthcoming), we formulate the presence of a ripple effect as a unit root problem. In other words, we consider the time-series properties of each of the five metropolitan house prices relative to the national house price in South Africa, based on available quarterly data covering the period of 1966:Q1 to 2010:Q1, with one expecting the ratios to exhibit stationarity or mean reversion to an underlying trend value, if there is diffusion in house prices. If the ratio of metropolitan house prices to the national house is stationary, they eventully reach a steady

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path deriven by a common process. Besides analyzing if a ripple effect exists in the South African housing market, we also try and detect as to where this effect originates from based on factor analysis.

The motivation for the analysis emanates not only due to the lack of any studies analyzing ripple effect in the South African housing market, but more generally, because of the importance of analyzing the behavior of regional house prices due to boom and bust cycles undergone by many local housing markets across the world (Canarella *et al.,* 2010), including South Africa (see for example, Gupta and Das, 2008; Das *et al.,* 2011; Gupta *et al.,* 2010; Balcilar *et al.,* 2011). Moreover, with most analysts attributing the recent world-wide financial crisis emerging from the collapse of house prices, the need for careful investigation of the time-series properties of the house prices, to check if house price shock in one metropolitan area ripples over to other areas and the economy as a whole, cannot be underestimated. This is of crucial importance, since, if a regional shock gets transmitted to all regions, there exists implications for the entire economy. Theory suggests that impact of house prices on the aggregate economy come through several channels. For instance, as indicated by Case *et al.,* 2005; Benjamin *et al.,* 2004; Campbell and Cocco, 2007; Carroll *et al.,* 2006, changes in house prices affect aggregate consumption and saving. Further, house-price adjustments have implications for risk-sharing and asset pricing (Lustig and van Nieuwerburgh, 2005; Piazzesi *et al.,* 2007), and also distributional effects in heterogeneous-agent economies (Bajari *et al.,* 2005). Das *et al.,* (2011) points out that housing accounts for a major proportion of housing assets and wealth, with the numbers standing at 29.40 percent and 21.68 percent, respectively. More importantly, they show that there exists significant spillover from the housing market onto aggregate consumption. With South Africa being an inflation targeting country,[1] the wealth effect following a house price increase or decrease is likely to be inflationary or deflationary due to higher or lower aggregate demand. In light of this, it is important to find out if a house price shock in one region is likely to ripple to the entire economy, since it is likely to result in inflationary or deflationary pressures. If a ripple effect exists, identifying where the ripple effect originates from is also of paramount importance, since a house price change in that specific region, if identified, would allow the government to react much early to curb inflationary or deflationary effects from spreading to the entire economy. Although the relationships are weak, house prices also affect labor mobility as well as migration.[2] Finally, as far as the ability to predict house prices in a specific region of South Africa is concerned, it is likely to improve if we consider the significant effect of other regional house prices (see Gupta and Das (2008) in this regard). And given that house price have been shown to be a leading indicator of economic activity and inflation in South Africa by Gupta and Hartley (2011), the importance of designing appropriate models of house price forecasting, incorporating a spatial dimension, cannot be understated.

Against this backdrop, this paper is the first to provide a comprehensive analysis of the existence or non-existence of ripple effects in the South African housing market based on standard linear parametric tests of stationarity, with and without structural breaks, Bayesian and parametric non-linear unit root tests. Lee *et al.,* (2006) indicate that empirical verification of theories, in general, is sensitive to structural change in the data. While, Burger and Van Rensburg (2008) and Das *et al.,* (2010) highlight the importance of recognizing the possibility of structural breaks in South African regional house prices. Casual observation of the regional house price ratios reported in

[1] Since the announcement made by the minister of Finance in the February of 2000, the sole objective of the South African Reserve Bank (SARB) has been to keep the CPIX inflation rate, where CPIX is defined as Consumer Price Index (CPI) excluding interest rates on mortgage bonds, within the target band of 3 percent to 6 percent, using discretionary changes in the Repurchase (Repo) rate as its main policy instrument.
[2] The weakness of the relationship is understandable since most households move from one region to another not only for house-price differences but also for other factors (job opportunities etc).

Figures 1 through 3 tends to suggest one structural break.[3][4] In this regard note that, while, the Bayesian approach to unit root testing provides a more reasonable summary of sample information than the conventional parametric unit root approach, the unit root tests accounting for structural breaks allows one to detect structural change in the variable under consideration that results in a shift in the mean, or in the growth rate or both, whereby determining whether the series is a trend-stationary process with a one-time break occurring at an unknown point in time. The non-linear approach, on the other hand, helps one to account for possible structural breaks or regime switches in the variable under consideration, without making any assumptions regarding the number of structural breaks. Non-linear models do not assume exogenous breaks occurring at known dates, they are rather capable of generating intrinsic breaks by allowing the process switch form one regime to others via its dynamics. They also fit well to frequent outliers in the data rather than assuming these as the result of extreme events (see Granger and Teräsvirta, 1993). Note, over and above accounting for structural changes, the non-linear unit root tests allow shift in the autoregressive parameters, that is the dynamics of the model also changes, since the persistence is allowed to change as well. Moreover, Balcilar *et al.,* (2011) has highlighted that prices of the five segments of the South African housing market are characterized by non-linearity. Given this, it is well-known that linear unit root tests have low power and leads to wrong conclusions regarding stationarity at times. Due to the lack of robustness of the linear unit root tests in the presence of structural breaks and regime-switching in the data generating process, the importance of linear unit root tests with structural breaks and non-linear unit root tests needs to be considered explicitly while testing for the ripple effect. The remainder of the paper is organized as follows: Section 2 presents a literature review on international studies dealing with the ripple effect, while Section 3 outlines the basics of the various unit root tests. Section 4 discusses the similarities and dissimilarities of the five major metropolitan areas considered, the structure of the housing market in South Africa, besides the data used for the analysis. Section 5 presents the empirical results relating to the existence or non-existence of the ripple effect, as well as, provides evidence regarding the metropolitan areas that could be driving this effect. Finally, Section 6 concludes.

2. LITERATURE REVIEW:

The literature on ripple effects[5] in house prices is quite extensive, to say the least. UK housing experts identified a "ripple effect" of house prices that begins in the Southeast UK and proceeds toward the Northwest. Using the *ADF* unit-root test, Meen (1999) failed to find significant evidence of stationarity in the house-price ratios for the UK. However, Cook (2003) detected overwhelming convergence in a number of regions in the UK, using an asymmetric unit-root test. Further, Cook (2005b) detected stationarity by jointly applying the *DF-GLS* test (Elliott *et al.,* 1996) and the Kwaitkowski-Phillips-Schmidt-Shin (*KPSS*) stationarity test (Kwiatkowski *et al.,* 1992). Though early evidence (Tirtiroglu, 1992; Clapp and Tirtiroglu, 1994) for the US economy

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[3] The existence of one major structural break was also confirmed by the Bai and Perron (2003) tests of multiple structural breaks applied to the regional house prices. These results are available upon request from the authors.

[4] Studies such as Chien (2010) and Canarella *et al.,* (2010) have applied endogenous-two-structural-break test developed by Lumsdaine and Papell (1997) and Lee and Straizicich (2003) given that their data plots suggested two breaks.

[5] Standard economic theory and intuition suggest that different regional house prices should not move together, since house prices depend mostly on local housing market supply and demand factors, which, in turn, tend to differ substantially between regions due to differences in regional economic and demographic environments. However, Meen (1999) describes four different theories to explain the ripple effect, namely, migration, equity conversion, spatial arbitrage, and exogenous shocks with different timing of spatial effects. Please refer to Meen (1999) for further details.

provided little support to the existence of the ripple effect, recent studies by Pollakowski and Ray (1997) Meen (2002), Gupta and Miller (forthcoming a, b) and Canarella *et al.,* (2010) tend to show the existence of the ripple effect at not only census, but also metropolitan regions in the US.

Other than the UK and the US, Berg's (2002) test indicates that real price change of the second-hand housing market in the Stockholm area has a ripple effect on six other areas. Oikarinen's (2005) results show that housing price changes diffuse first from the Helsinki Metropolitan Area to the regional centers, and then to the peripheral areas. Luo *et al.,* (2007) detected the existence of ripple effects in eight capital cities of Australian states based on tests of stationarity and cointegration. Using data on twenty districts of Paris intra-muros, Roehner (1999) finds that the housing price diffusion originates from the wealthy districts of the south-west, and then moves northwards and eastwards to medium-priced districts, and then finally reaching the cheapest districts. Quite a bit of evidence for the ripple effect is found for Chinese cities. For example, Hong *et al.,* (2007) and Wang *et al.,* (2008) provide evidence of the existence of ripple effects in five and thirty-five cities across China based on cointegration and panel data techniques, respectively. While Huang *et al.*, (2010a) uses cointegration test, error correction models, impulse response analysis and variance decomposition to find evidence of the ripple effect in nine Chinese cities. Huang *et al.*, (2010b) extends the evidence to nineteen Chinese cities using a two-stage procedure of non-parametric testing and business cycle dating techniques. In addition Li *et al.*, (2010) indicated the existence of ripple effect within the urban regions of Wuhan. For Taiwan, Chien (2010) could not reject the existence of the ripple effect in regional house prices based on the endogenous-two-structural-break test developed by Lumsdaine and Papell (1997) and Lee and Straizicich (2003). More recently though, Lee and Chien (2011) uses the seemingly unrelated regressions augmented Dickey–Fuller (SURADF) test developed by Breuer *et al* (2002) to illustrate that Taiwan's regional house prices are a mixture of stationary and non-stationary processes, showing that the stationarity properties of these prices are dependent on the structure and properties of the various regions. Clearly, the literature on ripple effects is quite large, but to the best of our knowledge this is the first attempt to analyze the existence and the nature of the same in South Africa.

3. ALTERNATIVE UNIT ROOT TESTS:

In detecting ripple effects in the house price of the five major metropolitan areas of South Africa, we analyze whether the ratios of the metropolitan house prices to the national house price is stationary or not. In this regard, to test for existence of ripple effect, we employ a Bayesian, a non-linear and a host of the linear unit root tests, the basics of which we outline below.

3.1. Linear Unit root tests

It is widely concurred that conventional unit-root tests such as Augmented Dickey-Fuller (1981) (ADF) and Phillips-Perron (1988) (PP) tests have low power. Therefore, this paper uses other efficient and robust procedures for testing the null hypothesis that each series contains a unit root. These include the Dickey-Fuller test with generalized least squares detrending (DF-GLS), the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) (1992) test; the Elliot, Rothenberg, and Stock (ERS) (1996) point optimal test, the Ng-Perron (2001) modified versions of the PP (NP-MZ_t) test and the ERS point optimal (NP-MP_T) test. Since these tests have been widely used in various applications of detecting stationarity, the mathematical details of these tests have been suppressed to avoid unnecessary lengthening of the paper. Conventional unit root tests, which assume structural stability and linear adjustment, can interpret departures from linearity and structural instabilities as permanent stochastic disturbances. We control for two sources of nonlinearities in the dynamics of the relative house prices when applying unit-root tests. First, nonlinearities can exist in the form of threshold effects, whereby the relative price dynamics follows a nonstationary process at some threshold, but follows a stationary process outside of the threshold (Teräsvirta, 1994). Kapetanios *et al.,* (2003) propose a nonlinear unit-root test, which permits a stable dynamic process with an inherently nonlinear adjustment caused by market frictions and transaction costs, and show that the nonlinear test proves more powerful than the standard unit-root tests.Second, nonlinearities can also exist when the economic series suffer from structural changes. Perron (1989) showed that the power to reject a unit root decreases when the stationary alternative is true and a structural break is ignored. Given this, we consider the Zivot & Andrews (1992) unit root tests with endogenously determined one structural break and non-linear unit root tests.

3.2. Linear Unit Root Test with Endogenous-One-Structural-Break:

As already indicated, the conventional unit root tests fail to allow for the possibility of a structural break. Perron (1989) therefore developed an approach that incorporated an exogenous structural break in the model and then tested for the presence of a unit root. However, Zivot and Andrews (1992) argued that selection of the structural break *a priori* could lead to an over rejection of the unit root hypothesis. Therefore, Zivot and Andrews (ZA) developed a variation of Perron's (1989) original test and they assumed that the exact time of the break-point is unknown. They used the following regression equations to test a unit root hypothesis against the alternative of a one-time structural break:

$$\Delta y_t = c + \alpha y_{t-1} + \beta t + \gamma DU_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{1}$$

$$\Delta y_t = c + \alpha y_{t-1} + \beta t + \theta DT_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{2}$$

$$\Delta y_t = c + \alpha y_{t-1} + \beta t + \gamma DT_t + \theta DU_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{3}$$

Where DU_t is an indicator dummy variable for a mean shift occurring at each possible break-date (TB) and DT_t is corresponding trend variable.

Therefore; $DU_t = \begin{cases} 1 \ldots\ldots if\ t > TB \\ 0 \ldots otherwise \end{cases}$

$DT_t = \begin{cases} t - TB \ldots.if\ t > TB \\ 0 \ldots\ldots\ldots.otherwise \end{cases}$

$H_0: \alpha = 0$ [series $\{y_t\}$ contains a unit root with a drift that excludes any structural break]

$H_1: \alpha < 0$ [series $\{y_t\}$ is a trend stationary process with a one-time break occurring at an unknown point in time]

Equation 1 presents model A, which allows for a one-time change in the level of the series, equation 2 depicts model B and allows for a one-time change in the slope of the trend functions and Model C is presented by equation 3 and combines one-time change in the level and the slope of the function of the series. In literature, model A has primarily been applied, hence in this paper, we conventionally choose model A for our analysis, even though we report results from models B and C as well for the sake of completeness. The choice of model A, more importantly, is also vindicated by the behavior of the housing price ratios depicted in figures 1, 2 and 3, since there are no evident changes in the slope of trend functions, but mainly one-time change in the level of the series.

3.3. Bayesian Unit Root Test

Consider the simple univariate model:

$$y_t = \beta y_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim iid\ N(0,\sigma^2) \tag{4}$$

Suppose we initially put a probability of α uniformly on the interval (0, 1) and probability 1-α on β =1, and independently a uniform prior on $log(\sigma^2)=log(Var[\varepsilon_t])$. Then the likelihood has a normal-inverse-gamma form, conditional on the initial observations with the marginal likelihood of β being a *t*-distribution with *T-1* degrees of freedom and scale parameter: $\sigma_p = \sqrt{\sigma^2 / \sum y_{t-1}^2}$. The Bayesian approach uses odds ratios as proposed by Sims (1988), with the criterion comparing the test statistic (t^2) with the Schwarz limit ($-\log(\sigma_\rho^2)$) and small sample limit ($2\log\left[\frac{1-\alpha}{\alpha}\right] - \log(\sigma_\rho^2) + 2\log(1 - 2^{-\frac{1}{s}})$), which are the asymptotic and small sample critical values for the test statistic; where α is set at 0.8 as suggested by Sims (1988) and *s* denotes the number of periods per year. If the test statistic is greater than both the Schwarz and small sample limits, then one would reject the unit root hypothesis. However, if the test statistic lies between the Schwarz limit and the small sample limit, the test fails to reject the unit root hypothesis using a large sample approach but not the small sample limit, which depends on the choice of α and the lower limit for stationary prior, set at 0.5 following Sims (1988).

3.4. Non-linear unit root tests

The parametric non-linear unit root tests used in this paper include the Kapetanios, Shin, and Snell (2003) (KSS) test:

In the KSS (2003) test, the null of a unit root process is tested against an alternative of a non-linear exponential smooth transition autoregressive (ESTAR) process, which is globally stationary. Consider the exponential smooth transition autoregressive model of order one, ESTAR(1):

$$y_t = \beta y_{t-1} + \gamma y_{t-1}[1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_{t,} \tag{5}$$

where β and γ are unknown parameters, $\varepsilon_t \sim iid(0,\sigma^2)$, with y_t assumed to be a mean zero stochastic process. Equation (5) can be reparameterised as follows:

$$\Delta y_t = \phi y_{t-1} + \gamma y_{t-1}[1 - \exp(-\theta y_{t-d}^2)] + \varepsilon_{t,} \tag{6}$$

where $\phi = \beta - 1$

Keeping with the empirical practice to date, we set $\phi = 0$ and *d*=1, leading to the specific ESTAR model;

$$\Delta y_t = \gamma y_{t-1}[1 - \exp(-\theta y_{t-1}^2)] + \varepsilon_{t,} \quad (7)$$

The focus is to test;

$$H_0: \theta = 0 \quad (8)$$

$$H_1: \theta > 0 \quad (9)$$

Testing the null hypothesis of a unit root in Equation (8) against the non-linear stationary alternative given in Equation (9) is not directly feasible since γ is not identified under the null. So, following Luukkonen *et al.,* (1988) computing a first-order Taylor series approximation to the ESTAR model under the null, the following auxiliary regression is derived;

$$\Delta y_t = \delta y_{t-1}^3 + \varepsilon_{t,} \quad (10)$$

hence the *t*-statistic for $\delta = 0$ against $\delta < 0$ *is* $t_{NL} = \frac{\hat{\delta}}{s.e(\hat{\delta})}$ (11)

where $\hat{\delta}$ is the OLS estimate for δ and s.e.($\hat{\delta}$) is the standard error of $\hat{\delta}$.

4. THE FIVE METROPOLITAN AREAS, THE SOUTH AFRICAN HOUSING MARKET AND THE DATA[6]:

Figure 4 presents a map of South Africa indicating the five major metropolitan areas considered in this paper. Johannesburg, Pretoria, Cape Town, Durban and Port-Elizabeth have common attributes in the sense that all of them have strong manufacturing, tourism, transportation, finance and government sectors, allowing for job creation for variety of skill types. Johannesburg, Pretoria, Cape Town, Durban and Port-Elizabeth are South Africa's largest metropolitan cities, with population having increased over the last fifteen years on averages between 26 percent and 32 percent for all the cities except Port-Elizabeth, which had only an increase of 7.7 percent. The population estimates of the cities, based on last available estimates in 2007, stand at: 3 888 180, 2 345 908, 3 497 097, 3 468 086 and 1 050 930 for Johannesburg, Pretoria, Cape Town, Durban and Port-Elizabeth, respectively. All the cities also contribute significantly to Gross Domestic Product of South Africa, with Johannesburg contributing a large proportion (14.98 percent), followed by Cape Town (14.01 percent), Pretoria (8.55 percent), Durban (7.77 percent) and Port-Elizabeth (2.46 percent). Industries in Durban have developed around manufacturing and trade (automotive, steel, plastic, food products, clothing and textiles, shipbuilding and repair); agriculture (fishing, sugar); followed by finance or business services, tourism, transport, wholesale and retail trade. Similarly for Cape Town of which its major sectors are manufacturing and trade (paper, textile and clothing, shipbuilding, wine); business service which include finance, tourism and transport. Port-Elizabeth is considered for its automotive manufacturing and port and harbor facilities. Pretoria and Johannesburg are not so far off, where the major sectors are services (financial, telecommunication and media, research and development); followed by manufacturing (telecom, high-tech appliances) and heavy industries (steel, iron, and mining).Therefore, basic range of industries are quite uniform across

[6] It is important to emphasize that regional macroeconomic data in South Africa is mainly available at the provincial level, of which these five metropolitans are part of. Hence, quite a bit of the information on population, industries, and output contributions reported in the following paragraphs, has been obtained from private sources on the web.

these metropolitan areas, however, their importance varies based on their geographical locations, i.e., whether they are a port-city or not, and also their weather conditions, especially in terms of agricultural production. Pretoria and Johannesburg, are quite densely populated, given that they are smaller in area compared to the other cities, but have highest population due to them being the political and financial capitals, respectively. The decision to use data for metropolitan areas only rather than a combination for both metropolitan and non-metropolitan (rural) areas, originates from this high degree of homogeneity observed in the former segment of the housing market. Further, considering only metropolitan areas also helps us avoid issues relating to data availability and clarity regarding the area of coverage.

The average year-on-year house price inflation has consistently been around 6 percent for the entire sample-period, with it increasing sharply and staying above the average since the mid- to late 1980s. Post 2000, this figure escalated to double digit numbers and reached as high as 30 percent during 2004-2006. This is due to a large number of factors, namely, the domestic financial market liberalization in 1985 that led to lowering/abolition of the credit-constraints, the creation of democratic South Africa in 1994 which resulted in higher labor market participation since for the previously disadvantaged community, increased and stable growth rate of over 5 percent since 1994 due to foreign direct investment and controlled inflation in wake of the the informal inflation targeting in 1990 and the formal inflation targeting in 2000 (Kasai and Gupta 2010; Balcilar *et al.,* 2011; Das *et al.,* 2011). The financial crisis in which hit South Africa in 2008 and 2009, cased property prices to register negative nominal growth rates. However, recent figures stand close to the 8 percent.[7],As far as the information on house prices are concerned, we use seasonally-adjusted quarterly house price data obtained from the Allied Banks of South Africa (ABSA)[8] Housing Price Survey, for the period 1966:Q1 to 2010:Q1- covering the earliest to the most recent period of data available. The survey distinguishes between three price categories as: affordable (R430,000 and area below $40m^2$ -$79m^2$), middle (R430,000 to R3,1million) and luxury (R3,1 million to R11.5 million). The data is further subdivided for the middle segment of the housing market, based on sizes (square meters), into small ($80m^2$ – $140m^2$), medium ($141m^2$ – $220m^2$) and large ($221m^2$ – $400m^2$). We focus on the three categories of middle-segment housing since house price data for the metropolitan areas, namely Cape Town (CT), Durban Unicity (DBN), Greater Johannesburg (JHB), Port Elizabeth/Uitenhage (PE) and Pretoria (PTA), are not available for the luxury and affordable segments of the South African housing markets. We apply different unit root tests on the regional house price ratios constructed by dividing the house price of each metropolitan area for the three middle-segments with the national house price corresponding to the appropriate middle-segment under consideration. If the unit root is rejected, this is interpreted as evidence in favor of the ripple effect since the house prices then converge to common trend in the long-run rather than drifting apart.[9]

5. EVIDENCE OF "RIPPLE" EFFECTS:

In this section, we discuss the results from the unit root tests reported in tables and sub-tables 1 through 4, and, hence, provide evidence on the (non-)existence of "ripple" effects in the five major metropolitan areas of South Africa across different house-size categories. We also use factor analysis to determine which metropolitan area(s) within a specific housing category might be driving the housing market for that particular category.

[7] The growth rates are based on our own calculations, and monthly ABSA housing review reports.
[8] ABSA is one of the leading private banks in South Africa.
[9] Note lag lengths for all the tests were based on the Akaike Information Criterion (AIC).

As can be seen from Tables 1(a), (b) and (c), the linear unit root tests provide ample evidence of stationarity, and hence, the existence of ripple effects in all the five metropolitan areas across the three house-size categories. The null of unit root is rejected consistently by at least four of the six linear tests utilized across the three housing categories for all the five metropolitan cities. These results are overwhelmingly supported by model A (the appropriate model in our case) of the Zivot and Andrews (1992) test of one endogenous structural breaks reported in Table 2.[10] This implies robustness of the findings in the presence of non-linearity, when the same is characterized by structural changes. The Bayesian unit root test proposed by Sims (1988) and reported in Tables 3(a) and (b), which provides a more reasonable summary of sample information than the conventional parametric unit root approach, also presents strong evidence of stationarity, and thus, a single housing market. The evidence of ripple effect is somewhat diluted, when we consider the Kapetanios *et al.,* (2003) test, which, in turn, allow nonlinearities to exist in the form of threshold effects. As reported in Tables 4(a) and (b), house price diffusion seems to exist for three out of the five metropolitan areas each for the large (Johannesburg , Port Elizabeth and Pretoria), medium (Durban, Johannesburg and Pretoria) and small (Cape Town, Port Elizabeth and Pretoria). Since, there exists quite strong evidence of ripple effects for all the five metropolitan cities across all the three house size categories when allowing for structural breaks, the results of the KSS test could be interpreted as follows: Though, it is impossible to gauge exactly the data-generating processes for these fifteen relative prices precisely, it seems that the main form of non-linearity that exists in the relative house prices arise via structural changes, with nine of these 15 cases, also having an additional form of non-linearity due to threshold effects.[11] Overall, it will not be unfair to conclude that there exists overwhelming evidence of the presence of ripple effects in the housing markets of metropolitan areas of South Africa.

Having established the existence of ripple effect, we now turn our attention to detecting which city could be driving or leading the ripple effect within each of the three size categories. For this purpose, we take a principal component or factor analysis approach, whereby, we derive one common factor for each of the three housing-size categories, and then analyze which of the five metropolitan areas within a size category explain best the movement of this specific factor. We do this by regressing the factor of a specific housing category on each of the five relative house price for the same housing category considered individually, and then capturing the R-squared for that regression, with the idea that the specific relative house price that produces the highest R-square will be considered to be driving the market within that specific category. In this regard, we borrow from Del Negro and Otrok (2007) and Ludvigsons and Ng (2009, forthcoming), and interested readers are refereed to these papers for further details. Based on the R-quare values obtained from these fifteen bi-variate regressions, we could draw the following conclusions: In case of the large-middle segment we found that Cape Town had the largest R-quare (0.5906) followed by Pretoria (0.4755), Port Elizabeth (0.3365), Johannesburg (0.1350) and Durban (0.0684). For the medium segment, Durban lead the pack with a R-squre of 0.4741 followed

[10] March, 1974 was found to be the break date for Durban and Pretoria in the large segment, for Cape Town, Durban, Johannesburg and Pretoria for the medium segment, and for all the five cities in the small-segment. For Cape Town, Johannesburg and Port Elizabeth in the large segment, the break dates were April, 1994, March, 1992, and January, 1979 respectively, while for Port Elizabeth in the medium segment, April, 2003 was identified as the break point.

[11] In addition to these tests, we also used the two-regime threshold autoregressive unit root tests proposed by Caner and Hansen (2001), as well as non-parametric unit root tests, which makes no assumption regarding the data-generating process of the relative house price, proposed by Bierens (1997) and Breitung (2002). The Caner and Hansen (2001) test, the Bierens (1997) and Breitung (2002) tests rejected the null of unit root in six, nine and seven cases respectively, implying that barring the large-middle segment in Cape Town, there was at least one form of parametric or non-parametric non-linear unit root test, which suggested stationarity in the relative house price. These results seem to suggest that the form of non-linearity present for the large-middle segment in Cape Town is a result of structural break. These additional results from the Caner and Hansen (2001), Bierens (1997) and Breitung (2002) tests have been suppressed to save space, but are available upon request from the authors.

closely by Pretoria (0.4700) and Johannesburg (0.4173). Cape Town and Port Elizabeth had respective R-square values of 0.2768 and 0.1699. Finally, for the small-middle segment, as with the medium segment, Durban produces the highest R-square of 0.7368. Cape Town and Johannesburg came in second and thir with R-square values of 0.7013 and 0.5761. Pretoria was found to explain virtually nothing of the movements in the common factor with a R-square of 0.0050, while, Port Elizabeth produced a slightly better fit with a R-square of 0.1935. The results seem to suggest that Cape Town drives the large middle-segment, with Durban being the driving force in the medium and small middle segments. Note, as a robustness check, we carried out Granger causality tests by putting the prices of the five metropolitan areas within each category, along with the national price for that specific housing size, in a VAR model. The results, suppressed here to conserve space, but available upon request from the authors, yielded similar conclusion to the factor analysis, in the sense that Cape Town for the large-middle segment and Durban for the medium- and small-middle segments was found to Granger cause the maximum number (and being Granger caused by the minimum, if any) of house prices, including the national house price within that category.

As indicated earlier, this is the first study that analyzes ripple effects in the South African housing market. Hence, no prior empirical evidence exists to confirm or invalidate our results regarding where the ripple effects might be originating from. However, the results seem to make lot of sense when we account for what we have heard from private sector housing analysts over the years regarding propagation of shocks within the housing market. Land values in Cape Town are in general exceptionally high, mainly due to its brilliant geographical location resulting in stunning scenic beauty. Besides, house sizes in Cape Town also tends to be on the larger side, and are bought and owned by not only by the richer South Africans, but also foreigners. In Durban, the importance of buying and owning a property tends to follow suit, with people in the next income category acquiring housing, due to its great beaches on the warm Indian ocean. Hence, a shock to the aggregate economy is likely to affect the housing markets in these two cities first. Also note, that the basic area size of these two cities, and to certain extent in Port Elizabeth, that is available for construction is limited or virtually non-existent due their respective ocean boundaries, and the fact that being port-cities these cities were subjected to the earliest settlements and constructions carried out in the country. Hence, a demand shock in these cities, with limited posisibility of a matching increase in supply is likely to increase house prices in these cities first, before getting transmitted to the rest of the economy. Hence these cities, unlike Pretoria and Johannesburg have not tended to grow in area. Pretoria and Johannesburg, being the political and financial capitals respectively, have a large population that reside there due to work related purposes mainly, rather than the idea of owning property. In light of all these, our results regarding Cape Town and Durban being the drivers of a house price shock does not seem too far fetched.

4. CONCLUSION

This paper analyzes the "ripple" effect of house prices in five major metropolitan areas of South Africa, namely, Cape Town, Durban Unicity, Greater Johannesburg, Port Elizabeth/Uitenhage and Pretoria. Note, if a ripple effect exists, the five metropolitan house prices relative to the national house price in South Africa, based on available quarterly data covering the period of 1966:Q1 to 2010:Q1, is expected to exhibit stationarity or mean reversion to an underlying trend value. In other words, we cast the issue as a unit root problem.

To the best of our knowledge, this is the only study that looks into the existence of ripple effects in the context of South Africa. We find overwhelming evidence of the existence of ripple effect in South Africa based on standard linear unit root tests. The results are robust to non-linearities in the form of structural breaks and threshold regimes. Further, Bayesian unit root tests, which allows for a more reasonable summary of sample information than the conventional parametric unit root approach, also confirms that South africa within each of the three housing-size category has an unified market. Finally, based on factor analysis, we identify Cape Town and Durban to be the cities that tends to drive the housing markets in South Africa – a result in line with the existing anectotal views of housing experts in the country.

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Figure 1: House Price-Ratios for the Large Middle-Segment in Five Metropolitan Areas

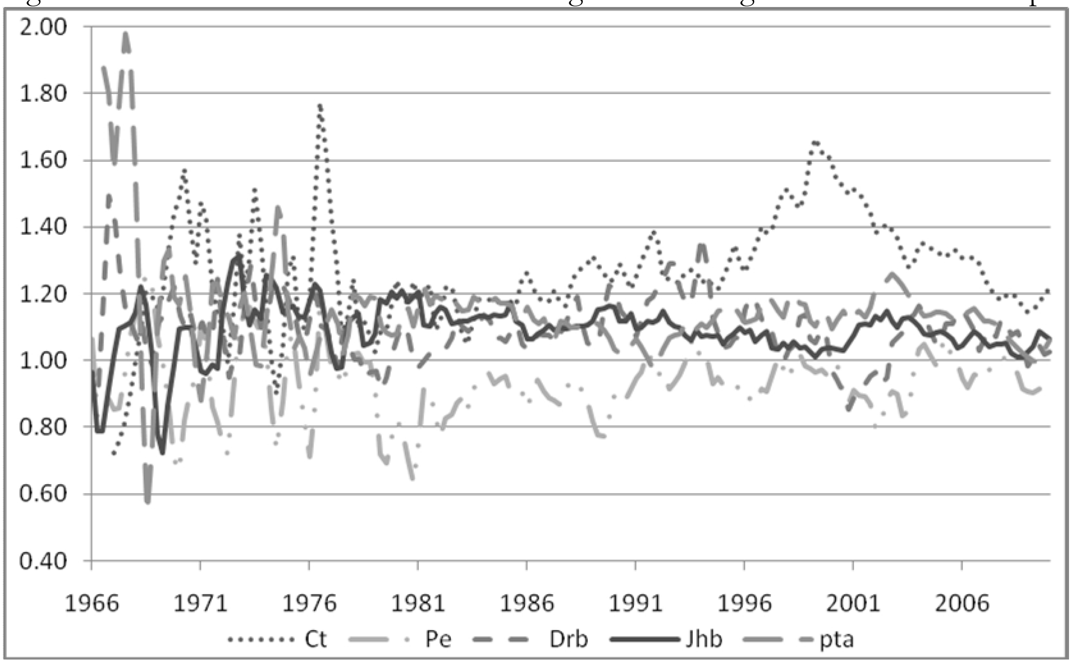


Figure 2: House Price-Ratios for the Medium Middle-Segment in Five Metropolitan Areas

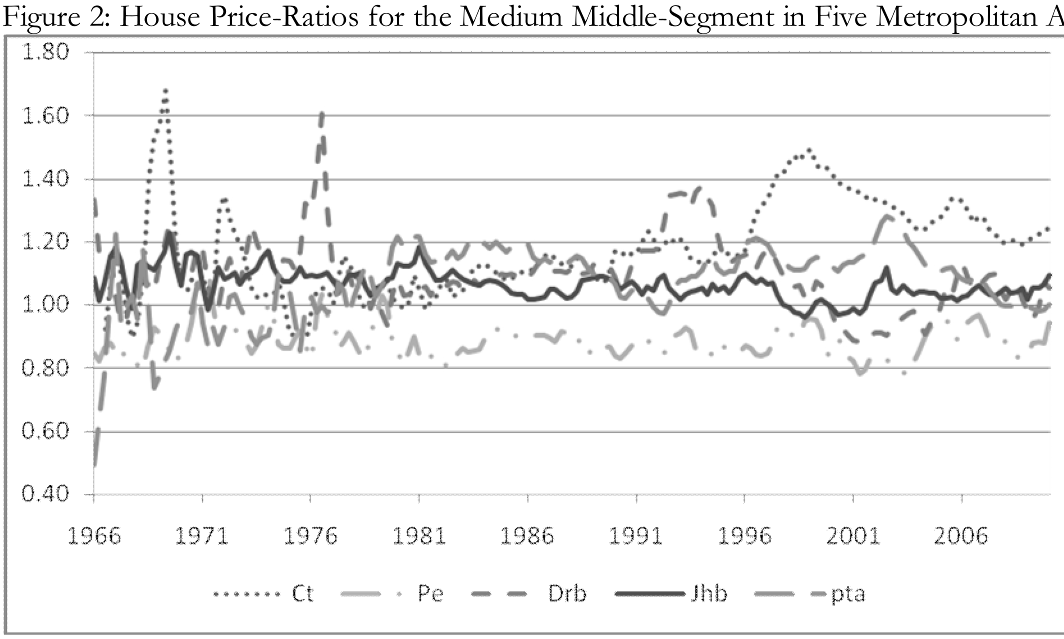


Figure 3: House Price-Ratios for the Small Middle-Segment in Five Metropolitan Areas

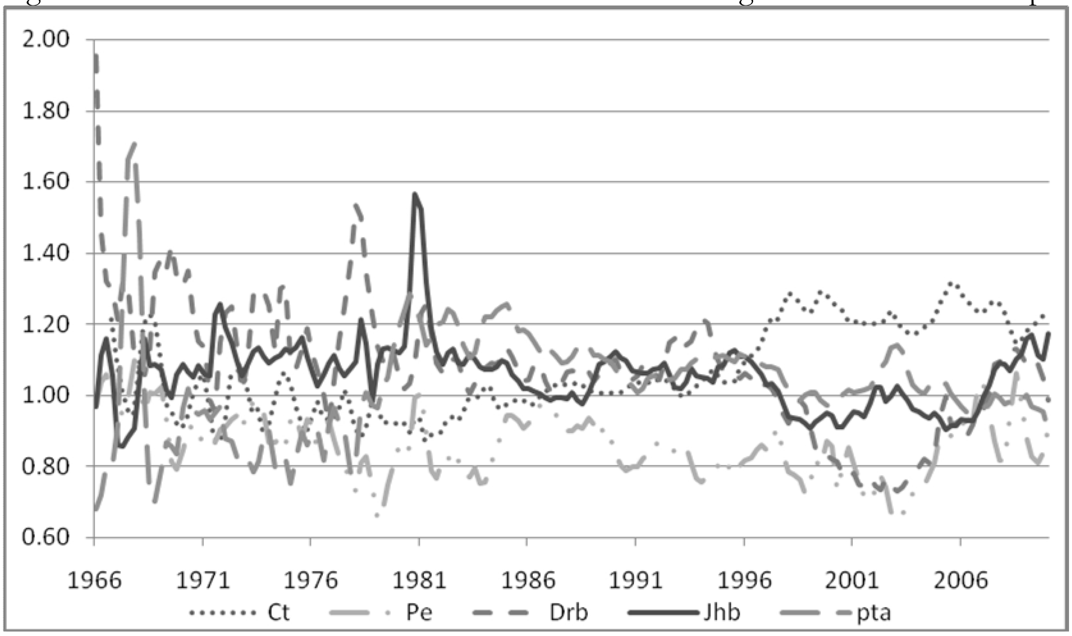
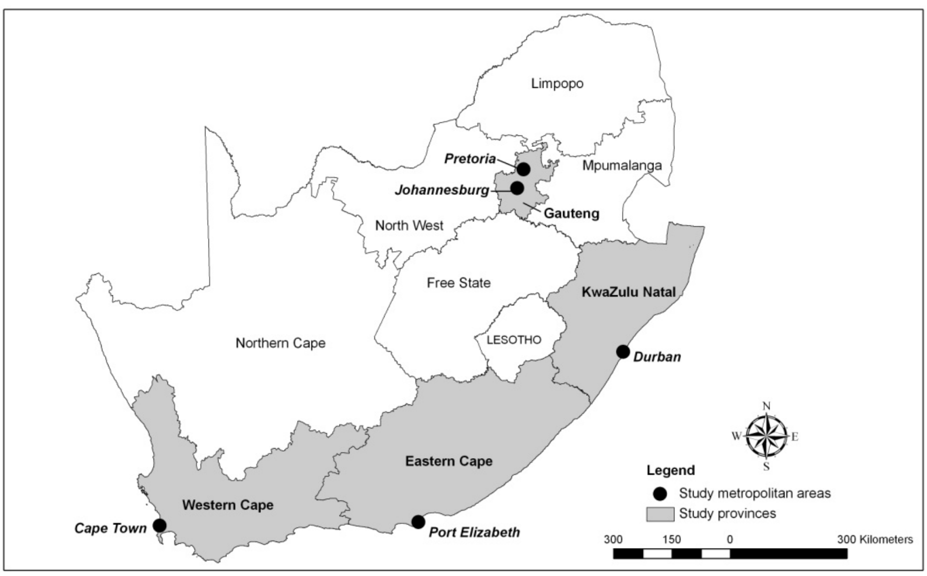


Figure 4: Provincial Map of South Africa



Source: Council for Scientific and Industrial Research (CSIR), Pretoria

Table 1 (a): Linear unit root results (Large middle-segment)

series			ADF	DF-GLS	PP	KPSS	ERS	Ng-P	
								MZ_t	MP_T
CT	*level*	Trend	-2.73*	-0.49	-4.40***	0.56**	21.91***	-0.41	30.71
		Trend & intercept	-2.60	-1.27	-4.33***	0.09	18.03***	-1.16	25.79
		none	-0.03		0.28				
DBN	*level*	Trend	-3.81***	-1.91*	-5.13***	0.21	2.78*	-1.33	6.82***
		Trend & intercept	-3.83**	-2.74*	-5.37***	0.09	5.53*	-1.88	12.50***
		none	-0.66		0.13				
JHB	*level*	Trend	-4.01***	-1.73*	-3.69***	0.25	3.17**	-1.68*	4.28**
		Trend & intercept	-4.19***	-2.48	-3.42*	0.21***	6.23**	-2.39	7.98***
		none	0.01		0.32				
PE	*level*	Trend	-4.08***	-1.67*	-4.21***	0.13	0.31	-1.68*	4.26**
		Trend & intercept	-4.10***	-2.69*	-4.18***	0.12*	0.64	-2.94**	5.29*
		none	-0.50		-0.58				
PTA	*level*	Trend	-2.82*	0.23	-6.51***	0.36*	147.15***	0.95	221.85***
		Trend & intercept	-2.8	2.00	-5.99***	0.14*	120.69***	-0.33	168.01***
		none	-0.57		-1.51				

Notes: *, **, *** denotes significance levels of 10%, 5% and 1%, respectively at which the null hypothesis of unit root is rejected for all tests barring the KPSS test. For the latter, *, **, *** denotes significance levels of 10%, 5% and 1%, respectively at which the null hypothesis of stationarity is not rejected.

Table 1 (b): Linear unit root results (Medium middle-segment)

			ADF	DF-GLS	PP	KPSS	ERS	Ng-P	
								MZ_t	MP_T
CT	*level*	Trend	-0.71	-0.71	-2.52	1.19***	27.55***	-0.68	25.31***
		Trend & intercept	-3.25*	-0.98	-4.02***	0.30***	70.86***	-0.79	58.50***
		none	0.21		-0.14				
DBN	*level*	Trend	-2.81*	0.05	-5.49***	1.13***	39.02***	0.49	113.93***
		Trend & intercept	-4.17***	-1.93	-6.30***	0.07	10.49***	-1.34	21.48***
		none	-0.69		-1.88*				
JHB	*level*	Trend	-3.23**	-2.50**	-3.56***	0.52**	2.45*	-2.41**	2.35*
		Trend & intercept	-3.31*	-2.89*	-3.67**	0.12*	5.79**	-2.77*	5.97**
		none	-0.12		0.53				
PE	*level*	Trend	-3.35**	-1.92*	-3.47***	0.49**	2.32*	-2.05**	2.90*
		Trend & intercept	-3.43**	-3.13**	-3.57**	0.11	3.56	-3.53***	3.84
		none	-0.52		-0.42				
PTA	*level*	Trend	-3.50***	-1.56	-3.75***	0.32	6.79***	-0.46	41.24***
		Trend & intercept	-3.63***	-3.12**	-3.64**	0.24***	8.98***	-0.97	31.74***
		none	-1.09		-0.05				

See notes to Table 1 (a).

Table 1 (c): Linear unit root results (Small middle-segment)

series			ADF	DF-GLS	PP	KPSS	ERS	Ng-P	
								MZ_t	MP_T
CT	*level*	Trend	-1.84	-0.97	-2.91**	0.91***	10.27***	-0.77	13.26***
		Trend & intercept	-3.09*	-3.21**	-3.18*	0.17**		-2.93**	5.37*
		none	-0.19		0.22		4.66**		
DBN	*level*	Trend	-2.43	-0.76	-3.87***	0.31	6.75***	-0.69	15.21***
		Trend & intercept	-2.73	-2.53	-3.86**	0.12*	6.41**	-2.31	8.49***
		none	-0.33		-0.79				
JHB	*level*	Trend	-2.80*	-2.48**	-4.73***	1.17***	1.17	-2.96***	1.41
		Trend & intercept	-4.32***	-3.68***	-5.55***	0.08	0.06	-8.51***	0.71
		none	-0.33		0.02				
PE	*level*	Trend	-4.28***	-2.85***	-3.49***	0.15	0.06	-3.66***	1.09
		Trend & intercept	-4.55***	-3.37**	-3.30*	0.05	0.04	-5.39***	1.61
		none	0.21		0.52				
PTA	*level*	Trend	-1.15	-0.42	-5.70***	0.76***	220.8***	0.36	194.66***
		Trend & intercept	-0.73	-1.51	-5.68***	0.27***	194.3***	-0.02	116.49***
		none	-0.27		0.37				

See notes to Table 1 (a).

Table 2: Result of Zivot and Andrews (1992) one-endogenous-structural-break test

	Model A	Model B	Model C
Large segment			
CT	-6.502282***	-3.191727	-4.909823*
PE	-6.268239***	-3.737137	-4.756892
DBN	-5.621901***	-2.586551	-3.059491
JHB	-7.346862***	-4.852336**	-6.103414***
PTA	-6.754504***	-3.004307	-3.403827
Medium segment			
CT	-9.738784***	-4.265397*	-4.356654
PE	-5.735443***	-3.732888	-3.936874
DBN	-5.502179***	-2.485418	-3.02002
JHB	-4.882258**	-3.925589	-4.467979
PTA	-5.765087***	-1.946508	-2.276795
Small segment			
CT	-4.812906**	-3.271407	-4.496696
PE	-4.979873**	-3.918252	-4.334308
DBN	-6.294625***	-2.96839	-4.125205
JHB	-5.970965***	-3.214678	-3.156685
PTA	-5.386997***	-3.169682	-5.329581**
Critical Value			
1%	-5.34	-4.93	-5.57
5%	-4.8	-4.42	-5.08
10%	-4.58	-4.11	-4.82

Note: **, *** denotes significance levels of 10%, 5% and 1% respectively, at which the null hypothesis of unit root is rejected.

Table 3 (a): Bayesian Unit root test results (without trend)

	CT	**PE**	**DBN**	**JHB**	**PTA**
Large segment					
Squared *t*	13.629	26.521	12.528	5.887	6.816
Schwarz limit	6.546	5.654	5.988	5.730	5.537
Small sample limit	0.549	-0.343	-0.009	-0.267	-0.460
Marginal alpha	0.0057	0.0000	0.0075	0.1557	0.0954
Medium segment					
Squared *t*	6.080	25.741	8.930	5.835	4.628
Schwarz limit	7.304	5.741	6.540	5.984	6.927
Small sample limit	1.307	-0.256	0.543	-0.013	0.930
Marginal alpha	0.2689	0.0000	0.0570	0.1769	0.3864
Small segment					
Squared *t*	0.464	13.013	4.572	6.203	2.870
Schwarz limit	8.237	6.442	7.227	6.556	7.505
Small sample limit	2.241	0.445	1.230	0.560	1.508
Marginal alpha	0.9067	0.0074	0.4293	0.1923	0.6694

Notes: If the test statistic is greater than both the Schwarz and small sample limits, then one would reject the unit root hypothesis. However, if the test statistic lies between the Schwarz limit and the small sample limit, the test fails to reject the unit root hypothesis using a large sample approach but not the small sample limit. The value corresponding to the "Marginal alpha" is the value of "alpha" for which the posterior odds for and against the unit root are even. A small value indicates strong evidence against unit root in the data.

Table 3 (b): Bayesian Unit root test results (with trend)

	CT	PE	DBN	JHB	PTA
Large					
Squared t	14.281	26.783	12.997	7.233	6.887
Schwarz limit	6.354	5.650	5.962	5.667	5.526
Small sample limit	0.357	-0.347	-0.035	-0.330	-0.471
Marginal alpha	0.0038	0.000	0.0059	0.0835	0.0917
Medium					
Squared t	7.954	28.266	10.851	9.638	5.736
Schwarz limit	6.911	5.680	6.429	5.027	6.619
Small sample limit	0.914	-0.317	0.432	-0.970	0.622
Marginal alpha	0.1059	0.0000	0.0214	0.0195	0.2367
Small					
Squared t	10.261	13.026	7.478	7.708	1.910
Schwarz limit	7.209	6.295	6.291	6.255	7.439
Small sample limit	1.212	0.299	0.294	0.258	1.442
Marginal alpha	0.0416	0.0068	0.0992	0.0880	0.7599

Notes: See notes to Table 3(a).

Non-linear Unit Root Tests:

Table 4 (a): Kapetanios, Shin and Snell (KSS) STAR Unit root test results (with drift)

	CT	PE	DBN	JHB	PTA
Test statistic					
Large segment	-1.9217	-4.2319***	-2.2314	-3.2303**	-4.2632***
Medium Segment	-1.0014	-2.926	-5.6166***	-3.2476**	-2.8776***
Small Segment	-2.0618	-3.0025**	-1.6827	-2.6202	-4.1132***

Notes: *, **, *** denotes significance levels of 10%, 5% and 1%, respectively at which the null hypothesis of unit root is rejected with critical values for 1%, 5% and 10% being -3.48, -2.93 and -2.66, respectively.

Table 4 (b): Kapetanios, Shin and Snell (KSS) STAR Unit root test results (with trend)

	CT	PE	DBN	JHB	PTA
Test statistic					
Large segment	-2.1778	-4.2471***	-2.1875	-3.9243***	-5.1851***
Medium Segment	-1.7857	-3.0791	-5.5909	-4.4019***	-1.8538
Small Segment	-3.2906*	-3.1317*	-2.3064	-2.5891	-3.9997***

Notes: See notes to Table 4(a).