University of Pretoria
Department of Economics Working Paper Series

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Sonali Das
CSIR, Pretoria
Rangan Gupta
University of Pretoria
Patrick A. Kaya
University of Pretoria
Working Paper: 2009-22
October 2009

Department of Economics
University of Pretoria
0002, Pretoria
South Africa
Tel: +27 12 420 2413
Fax: +27 12 362 5207

Convergence of Metropolitan House Prices in South Africa: A Re-Examination Using Efficient Unit Root Tests

Sonali Das[#] , Rangan Gupta[*] and Patrick A. Kaya[♣]

ABSTRACT

This paper analyzes whether the Law of One Price (LOOP) holds in the housing market of five metropolitan areas of South Africa, namely Cape Town, Durban, Greater Johannesburg, Port Elizabeth/Uitenhage and Pretoria. We test the existence of LOOP using the efficient unit root tests proposed by Elliott et al. (1996) [DF-GLS] and Elliott (1999) [DF-GLSu] based on monthly data on residential property prices covering the period of 1967:01 to 2009:03 for the large-, medium and small-middle segments of the housing market. Based on the DF-GLSu test, we find overwhelming evidence of the existence of LOOP in twelve of the fifteen cases, especially as the sample periods include more recent data. More importantly, our results are in sharp contrast with those obtained by Burger and Van Rensburg (2008) using quarterly data to based on the Im, Pesharan and Shin (IPS, 2003) test, which are, in turn, shown to be highly sensitive to frequency of the data and temporal aggregation. With the rejection of the null hypothesis of unit roots, based on panel data tests, not providing sufficient evidence to conclude that all the series in the panels have a unit root or not, more reliability should be placed on our results obtained from the efficient unit root tests.

JEL Classification: C12, C22, C21, D40, L85

Keywords: Efficient Unit Root Tests, House Prices, Law of One Price, Price Convergence, Single Market

1. Introduction

This paper analyzes whether the Law of One Price (LOOP) holds in the housing market of five major metropolitan areas of South Africa, namely Cape Town, Durban, Greater Johannesburg, Port Elizabeth/Uitenhage and Pretoria. In other words, we study whether the housing market in the five metropolitan areas function as a single market. We test the existence of LOOP using the efficient unit root tests proposed by Elliott et al. (1996) and Elliott (1999) based on monthly data on residential property prices covering the period of 1967:01 to 2009:03. The decision to use house price data for metropolitan areas only rather than a combination of both metropolitan and non-metropolitan parts of the country, originates from the expectation of a higher degree of homogeneity amongst the metropolitan segments, besides the issue of data availability and clarity regarding the area of coverage for the South African context.

Two houses in two different locations are believed to be sold within the same market, if house prices in one location impose a competitive constraint on house prices in the other location (Motta, 2004; Carlton and Perloff, 2005). In the long-run, given this competitive constraint, it is unreasonable to expect that house prices in different metropolitan areas will move far from each other indefinitely. However, if the prices do tend to move away

[#] Senior Researcher, Logistics and Quantitative Methods, CSIR Built Environment, P.O. Box: 395, Pretoria, 0001, South Africa. Email: SDas@csir.co.za, Phone: +27 12 841 3713, Fax: +27 12 841 3037.

[*] Corresponding author. Contact Details: Professor, Department of Economics, University of Pretoria, Pretoria, 0002, South Africa. Phone: +27 12 420 3460, Email: Rangan.Gupta@up.ac.za.

[♣] Graduate Student, Department of Economics, University of Pretoria, Pretoria, 0002, South Africa, Email: patrickayagu@yahoo.fr.

from each other, then we can conclude that the different geographical housing markets operate as mutually independent local markets and that their prices should diverge. In summary, the implication of the LOOP is that, if the housing market is single and not segmented, then their absolute prices should converge, meaning that their relative prices should be mean reverting or stationary.

At this stage, two questions arise: First, doesn't the heterogeneity and spatial fixity of houses, implying non-tradability, undermine the basis of arbitrage between the different geographical regions, leading to separate housing markets? The answer to this lies in the simple explanation that, even though houses are heterogeneous, they all provide an unobservable, but non-tradable commodity called housing service, and thus, one can ignore the physical heterogeneity (Smith et al., 1988). But given that houses are non-tradable, the second question that needs an answer is: Why would one expect prices of such non-tradable services to converge across geographical areas? As Burger and Van Rensburg (2008) indicate, the housing market is characterized by institutional and large individual investors who often have portfolios that contain outlays in more than one property, which in turn, is utilized to earn rental income and capital appreciation. Understandably, this is an attempt to reduce risk or balance between risk and return. Given this, if property prices in one area diverge too far off from another location, an arbitrage opportunity always exists (Goetzmann, 1993; Montezuma, 2004).

As pointed out by Burger and Van Rensburg (2008) and Gupta and Das (2008), products sold at different regions can only be comparable when a clear definition of the product is provided. Hence, as in these papers, we do not consider the residential market in general, but subdivide the market in terms of sizes and prices of the houses. Specifically, we use the ABSA[1] House Price Indices, which distinguishes between three price categories and thereafter, subdivides the middle segment category into three size categories of small, medium and large based on the square meters of house area.[2] Given that regional house price data is only available for the middle-segment houses, we restrict our analysis to this category only. In addition, with the monthly house price information dating back to 1967:01[3], we begin our analysis from that period, with the sample ending at 2009:03 .

The motivation of the current analysis emanates form a recent work by Burger and Van Rensburg (2008) in which they use the panel data unit root test, proposed by Im, Pesharan and Shin (IPS, 2003), on quarterly data of the abovementioned five metropolitan areas and found strong evidence of convergence in the large middle-segment house prices, while the evidence of LOOP was found to be weak and non-existent for the medium middle-segment and small middle-segment house prices respectively. The authors conclude that there exists a national market for large, and also possibly for the medium middle-segment houses, in these five metropolitan areas, but the housing market for the small middle-segment houses seems to be segmented.[4]

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[1] ABSA is a leading private bank of South Africa.

[2] The South African residential property market is categorised into three major segments: luxury houses (R 2.6 million to R9.5 million), middle-segment houses (R226,000 to R2.6 million) and affordable houses (R226,000 and below with an area in the range of 40-79 m^2). The middle-segment houses are further subdivided into small (80-140 m^2), medium (141-220 m^2) and large (221-400 m^2).

[3] For the metropolitan area of Cape Town, the house price data is available form the February of 1967.

[4] Though not the main objective of the paper, Gupta and Das (2008) also partially corroborated these findings based on spatial and non-spatial classical and Bayesian versions of Vector Autoregressive models for six (including Bloemfontein, besides the above mentioned five) metropolitan areas of South Africa, using monthly data over the period of 1993:07 to 2007:06.

As the title suggests, in this paper, we *revisit* the issue of LOOP in the context of the five major metropolitan areas of South Africa. The two main reasons for this revisit are: First, is specific to the study by Burger and Van Rensburg (2008) and deals with their usage of quarterly data to test for stationarity, even though house prices are available at monthly frequency. The authors indicate that their decision to use quarterly data is motivated out of the fact that most macroeconomic series are available at this frequency. However, given that the objective of this paper is to test stationarity of house prices, and does not involve any other macroeconomic variable, the reasoning does not seem appropriate. This is more so, when we show in the next section that the results obtained by Burger and Van Rensburg (2008) change drastically if we revisit their results using monthly data. The second reason is a more general one, and relates to the use of panel data unit root tests to check for the stationarity. Although, the panel data unit root tests improve significantly, at least on the power property of the widely-used Augmented Dickey-Fuller (ADF, 1981) test generally used to test for stationarity, the power of the panel data unit root tests in itself has been questioned by Karlsson and Löthgren (2000). The authors, using Monte Carlo simulations for panels with short spans of data, as is the case with Burger and Van Rensburg (2008), observe that the null hypothesis is frequently not rejected even when a large fraction of the series is stationary. On the other hand, they also indicate that the null hypothesis of unit roots could be mistakenly rejected even when only a small proportion of the series is stationary for panels with long spans of data. Thus, it is clear that the rejection or the non-rejection of the null hypothesis of unit roots, based on panel data tests, do not provide sufficient evidence to conclude that all the series in the panels have a unit root, or that they are all stationary. In addition, Rogoff (1996) and Papell (1997) found that the panel unit root tests results can be sensitive to the countries/regions included and the size of the panel could also play an important role in shaping the results. Finally, as we show below, and have pointed out above, panel data results seem to depend also on the frequency of the data (and temporal aggregation).

Against this backdrop, we use the efficient unit root tests to analyze the existence of LOOP in the five major metropolitan areas of South Africa. It has been shown that efficient unit root tests tend to provide substantial power gain over the ADF test. Thus, they provide an alternative to using panel unit root tests and allow us to avoid the problems associated with the empirical methodology as discussed above. Note, an alternative to using the efficient unit root tests is the test proposed by Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) where the null hypothesis is that of stationarity. However, Caner and Kilian (2000) have indicated that the KPSS test is found to have serious distortions. Given this, the choice of the efficient unit root tests proposed by Elliott et al. (1996) and Elliott (1999), was natural. To the best of our knowledge, this is the first attempt of using the efficient unit root tests for checking the LOOP in the context of housing markets. The remainder of the paper is organized as follows: Section 2 lays out the basics of the efficient unit root tests, while Section 3 presents and discusses the results. Finally, Section 4 concludes.

2. Efficient Unit Root Tests

We first define the variable that will be used to validate the LOOP in the five metropolitan areas of South Africa. If the absolute prices of houses in two different locations, in our case two metropolitan areas, converges in the long-run, one could conclude that they are part of the same market, and hence the log of their price ratio must then be stationary (Forni, 2004). Let q_{it} be the relative real price differential of the

i^{th} location at time t, and defined as the log-difference between the actual price level of each of the five metropolitan area from the cross-sectional mean. Formally, let

$$q_{it} = \ln\left(\frac{p_{it}}{\overline{p}_t}\right) \qquad (1)$$

where p_{it} is the nominal price level of metropolitan area *i*, at time period *t*, and $\overline{p}_i$ is the cross-sectional average at time *t*. Note, LOOP for the metropolitan house price would imply that q_{it} is mean reverting or stationary (Dreher and Krieger, 2005). The common approach, as discussed above, is to apply unit root tests, primarily the ADF test, to examine the stationarity property of the variable under consideration. The rejection of the null hypothesis of a unit root would imply that the time series of relative prices, q_{it}'s, are stationary, implying that the relative prices will converge in the long-run. If we fail to reject the null hypothesis of unit roots, then the relative prices would be believed to follow a random walk. In other words, any deviation from the "one price" would be permanent (Fan and Wei, 2005) and hence, houses in different geographical locations would indicate the existence of separate markets. Note alternative ways of analyzing convergence are also based on cointegration techniques (see for example, Ahmed (2005), Hsing (2009) and Rashid (2009)) and measures of half-life (see for example Sedgley and Elmslie (2004) and Mokoena et al. (2009)).

The conventional ADF tests involve estimating the following equation:

$$q_{it} = \alpha_0 + \rho q_{it-1} + \sum_{i=1}^{k} \alpha_i \Delta q_{it-1} + \varepsilon_t, \qquad (2)$$

where, α_0 is a constant, Δ is the first difference operator, i.e., $\Delta q_{it} = q_{it} - q_{it-1}$, and ε_t is a serially uncorrelated error process. LOOP requires that $\rho < 1$, while if $\rho = 1$, it implies that there is a unit root in q_t and that the LOOP does not hold.

The efficient unit root tests of Elliott et al. (1996) and Elliott (1999) are quite similar, with the difference being only in the assumption of the initial condition. The efficient unit root test of Elliott et al. (1996) is based on the point optimal tests. Though, no uniformly most powerful unit root test of $H_0 : \rho = 1$ against the alternative $H_A : \rho < 1$ exists, there is however, an optimal test, against a specific local alternative $H_A : \rho = \overline{\rho} < 1$, where $\overline{\rho} = 1 + \overline{c}/T$, $\overline{c} < 0$ being a specific constant, and *T* being the sample size. Elliott et al. (1996) derived the asymptotic maximal power envelope, using a sequence of Neyman-Person tests of the null hypothesis of a unit root against a set of stationary local alternatives. Elliott et al. (1996) then showed, based on power calculations, that substantial power gain over the standard ADF test could be obtained from this modified ADF test, which they called the Dickey Fuller-Generalized Least Square (DF-GLS) test. The DF-GLS test estimates the following equation:

$$\Delta q_{it}^d = \delta_0 q_{it-1}^d + \sum_{i=1}^{k} \delta_i \Delta q_{it-1}^d + \zeta_t^d \qquad (3)$$

where q_{it}^d is the locally detrended series of q_{it} where

$$q_{it}^d = q_{it} - z_t \beta, \qquad (4)$$

and $z_t = (1, t)$, for the locally detrended series with a constant and a linear trend, and $z_t = 1$, for series with just the constant, and ζ_t^d is a serially uncorrelated error process,.

From q_{it} plots of the three categories of the middle-segment houses in Figures 1 through 3, the choice of $z_t = 1$ is obvious. Note the acronyms used in the Figures and Tables that follow are: CT: Cape Town, DU: Durban Unicity, JO: Greater Johannesburg, PE: Port Elizabeth/Uitenhage and PR: Pretoria. Finally, β is the vector regression coefficients, obtained from the OLS estimation, of $\tilde{q}_{it} = \left[q_{i1}, (1-\bar{\rho}L) q_{i2}, ..., (1-\bar{\rho}L) q_{iT} \right]'$ on $\tilde{z}_t = [z_1, (1-\bar{\rho}L)z_2, ..., (1-\bar{\rho}L)z_T]'$, and L is the lag operator, i.e., $Lz_t = z_{t-1}$. A t-test is used to test the null hypothesis: $H_0 : \delta_0 = 0$ against $H_A : \delta_0 < 1$.

The main difference of Elliott's (1999) efficient unit root test, denoted as DF-GLSu, from that of the Elliott *et al.* (1996) test, lies in its assumption about the initial value of the alternative model. Specifically, both Elliott *et al.* (1996) and Elliott (1999) assume that the data $\{y_t\}_{t=1}^{T}$ generating process is given by

$$y_t = d_t + u_t \tag{5}$$

$$u_t = \rho u_{t-1} + v_t \tag{6}$$

where d_t is a deterministic component which may or may not contain a deterministic linear trend (understandably, based on Figures 1 through 3, in our case it does not), and v_t is a stationary error process which may or may not be serially correlated. Elliott *et al.* (1996) assumed that the initial value of u_t, say u_o, is zero both when $\rho = 1$ and when $\rho < 1$ in equation (6), implying that $u_1 = v_1$. Elliott (1999) however assumed that, u_0 is zero when $\rho = 1$, while when $\rho < 1$, u_1 has mean zero and variance $\frac{Var(v_t)}{(1-\rho^2)}$. Elliott (1999) has shown that, since the unknown parameter ρ, now involved in the alternative assumption, does not disappear asymptotically, the likelihood test statistics and the power of the test will differ from the DF-GLS test, and hence, a different set of the critical values for the DF-GLSu test statistics are derived in Elliott (1999). To implement the DF-GLSu test, equation (3) is estimated by least squares, with q_t^d, z_t, β defined as before, but now $\tilde{q}_t = \left[(1-\bar{\rho}^2)^{1/2} q_1, (1-\bar{\rho}L)q_2, ..., (1-\bar{\rho}L)q_T \right]'$, and

$\tilde{z}_t = \left[(1-\bar{\rho}^2)^{1/2} z_1, (1-\bar{\rho}L)z_2, ..., (1-\bar{\rho}L)z_T \right]'$.

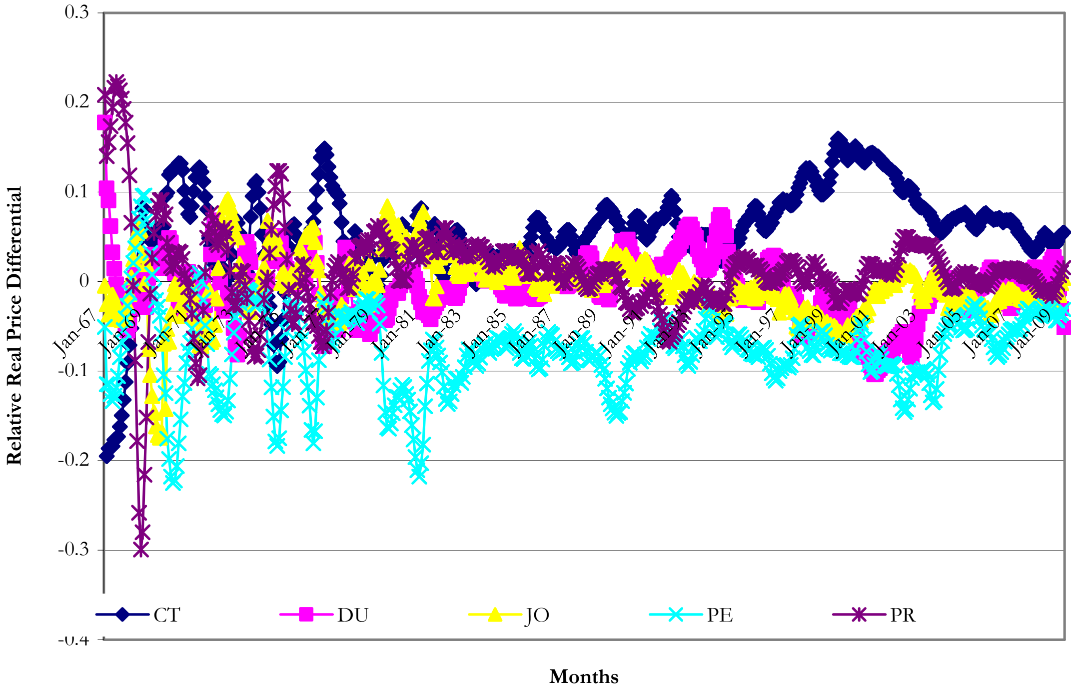

Figure 1: Relative Real Price Differential for Large Middle-Segment (1967:01-2009:03).

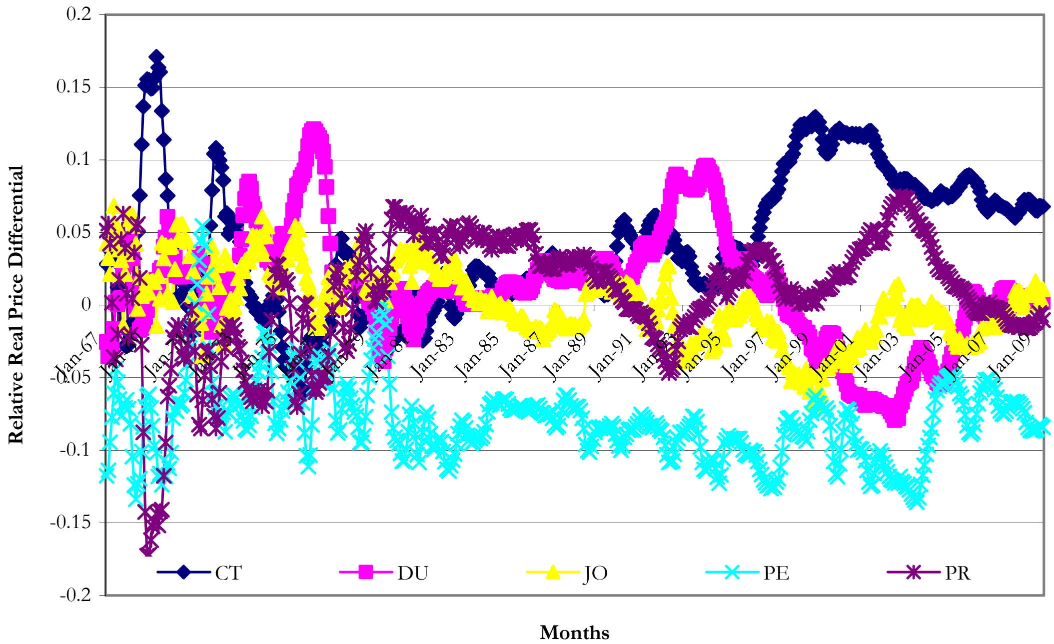

Figure 2: Relative Real Price Differential for Medium Middle-Segment (1967:01-2009:03).

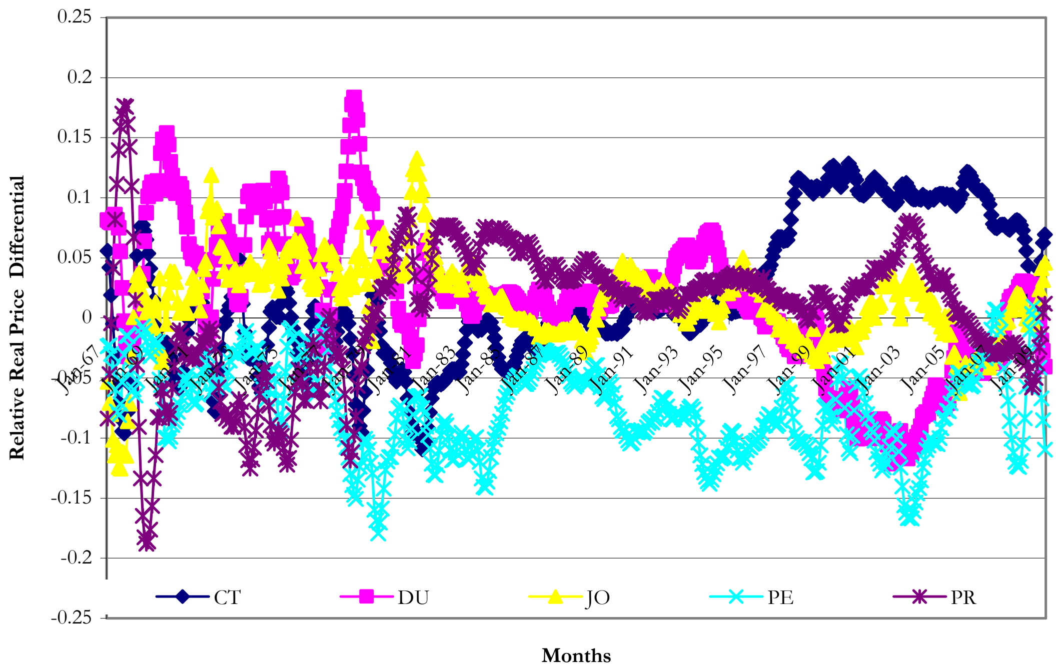

Figure 3: Relative Real Price Differential for Small Middle-Segment (1967:01-2009:03)

We report test results for both DF-GLS and DF-GLSu tests, as in reality, it is difficult to know whether the sample data we are using conform to the data generating processes of Elliott et al. (1996) or Elliott (1999). Following Elliott et al. (1996), for the DF-GLS test, we use $\bar{c} = -7$ for test with a constant, with asymptotic critical values of the test statistics obtained from Elliott *et al* (1996). For the DF-GLSu test, we follow Elliott (1999) and use $\bar{c} = -10$ in the test with a constant, and use the asymptotic critical values of the test statistics reported in Elliott (1999).

3. Empirical Results

We start the discussion by attempting to recover the results of the IPS test obtained by Burger and Van Rensburg (2008) which was based on quarterly data, by using monthly version of the same. As in their paper, we also use the Modified Akaike Information Criterion (MAIC) and the Modified Schwarz Information Criterion (MSIC) to select the number of lags, besides applying the IPS test, in a recursive fashion, to control for the sensitiveness of the results to the number of observations and period covered. As evidenced from Table 1, unlike Burger and Van Rensburg (2008), we find strong evidence of the LOOP across all categories of the middle segment housing for the whole sample as well as in the sub-periods. The only exception is for the medium middle-segment over the sub-samples of 1967:01-2002-12, and 1967:01-2007:12 and the full-sample of 1967:01-2009:03 under the MAIC. Our results are in sharp contrast with those of Burger and Van Rensburg (2008), who had observed strong convergence in large middle-segment house prices only, while the evidence of LOOP was found to be weak and non-existent for the medium middle-segment and small middle-segment house prices respectively. Clearly then, the IPS test results are sensitive to data frequency and temporal aggregation of the data from monthly frequency into quarterly.[5]

Table 1: Panel Data

	Large		Medium		Small	
Sub-Samples	**MAIC**	**MSIC**	**MAIC**	**MSIC**	**MAIC**	**MSIC**
1967:01-2009:03	-6.490***	-11.103***	-2.296	-4.498***	2.54770**	-4.616***
1967:01-2007:12	-6.473***	-10.477***	-2.312	-3.843***	-4.299***	-2.542**
1967:01-2002:12	-6.353***	-9.753***	-1.461	-2.816***	-1.798***	-3.624***
1967:01-1997:12	-6.098***	-10.415***	-2.790**	-4.307***	-3.017***	-4.372***
1967:01-1992:12	-6.144***	-9.408***	-3.095**	-4.611***	-3.910***	-4.889***
1997:01-1987:12	-6.281***	-8.563***	-3.805***	-5.110***	-4.252***	-5.554***
1997:01-1982:12	-5.442***	-8.120***	-4.413***	-5.765***	-3.807***	-6.031***

Note:*, **, *** denote the rejection of the null hypothesis at the 10%, 5% and 1%.

Further, given that the rejection or the non-rejection of the null hypothesis of unit roots, based on panel data tests, do not provide sufficient evidence to conclude that all the series in the panels have a unit root or that they are all stationary, we now turn to the efficient unit root tests, which have been shown to have excellent power property.

[INSERT TABLES 2 THROUGH 4]

In Tables 2 though 4 we present the results of the efficient root tests for the large-, medium- and small-middle-segment houses, respectively, using the DF-GLS (Panel A) and DF-GLSu (Panel B). The conclusion from the tables are summarised below.

(i) Panel-A results based on the DF-GLS test, under the lag selection criteria of MAIC and MSIC, reveals the following:

Large middle-segment houses

a. For Cape Town, Durban and Port Elizabeth/Uitenhage, the DF-GLS test, across all the sub-samples, fails to reject the null hypothesis of non-stationarity of the series. This indicates that for these three metropolitan areas, the large middle-segment housing market is segmented.
b. For Greater Johannesburg and Pretoria, across all the sub-samples, the DF-GLS test rejects the null-hypothesis of non-stationarity. This indicates that for these two cities, that are part of the Gauteng Province, there is evidence of the existence of the LOOP, and that the large middle-segment housing market in these two cities behaves as a single market. The only exception to this is for the sub-sample period of 1967:01-1982:12 for Greater Johannesburg, which is also the shortest sub-sample.

Medium middle-segment houses

c. For Durban, the results almost consistently fail to reject the null-hypothesis of non-stationarity across all the sub-samples. However, as the sub-samples become longer, there is weak evidence of the existence of LOOP based on the MSIC for Durban with the other four metropolitan areas.
d. For the other four metropolitan areas, as the sub-samples become longer with the inclusion of more recent values, the existence of LOOP for the

[5] As in Burger and Van Rensburg (2008), instead of using cross-sectional mean as the denominator in calculating the relative house price, we also used each metropolitan house price series as the denominator. Our results, however, continued to overwhelmingly support the LOOP.

medium middle-segment houses becomes apparent based on the MSIC lag-selection criteria. This indicates that the housing market in this category of houses in Cape Town, Port Elizabeth/Uitenhage, Greater Johannesburg and Pretoria are tending to behave as a single market.

Small middle-segment houses

e. For Cape Town, across all the sub-samples, the DF-GLS fails to reject the null-hypothesis. This indicates that for Cape Town the small middle-segment housing market behaves as a separate entity.
f. For Durban, up to sub-sample period 1967:01-1997:12, the null-hypothesis of non-stationarity was rejected, but with the inclusion of more recent values, there is evidence that here too the housing market is behaving as a single entity.
g. For Port Elizabeth/Uitenhage, Greater Johannesburg and Pretoria the results are mixed across the various sub-samples. But if we focus on the last two longest sub-samples, there seems to be an indication of these three metropolitan areas behaving as a single housing market.

(ii) Panel B results based on the DF-GLSu test, using the lag selection criteria of MAIC and MSIC, reveals the following

Large middle-segment houses

a. For Durban, almost consistently across all the sub-samples, the test fails to reject the null-hypothesis, suggesting that the Durban large middle-segment houses behave as a separate entity.
b. For all the remaining four metropolitan areas, across all the sub-samples, there is an over whelming evidence of the existence of LOOP, suggesting that large middle-segment houses across Cape Town, Port Elizabeth/Uitenhage, Greater Johannesburg and Pretoria, behave as a single market.

Medium middle-segment houses

c. For Durban, in this category of houses, almost consistently across all the sub-samples, the market behaves as a separate entity.
d. For the remaining four metropolitan areas, although Port Elizabeth/Uitenhage behaved as a separate market for sub-samples till 1992:12, as the sub-samples included more recent data, the results indicate the existence of LOOP across Cape Town, Port Elizabeth/Uitenhage, Greater Johannesburg and Pretoria.

Small middle-segment houses

e. For Cape Town, except for the sub-sample 1967:01-1992:12, there is an overwhelming evidence of the market behaving as a separate entity.
f. For Durban, after the sub-sample period 1967:01-1992:12, the market has consistently behaved as a separate entity.
g. For Port Elizabeth/Uitenhage and Greater Johannesburg, results indicate that the market behaves almost as a single entity, especially in the longer series that include more recent values.
h. For Pretoria, the small medium-segment house market behaved opposite of Durban, that is, up until the sub-sample 1967:01-1992:12 it

seems to have segmented market, but as the sub-samples become longer and recent, it exhibits the LOOP behaviour along with Port Elizabeth/Uitenhage and Greater Johannesburg.

The results based on the DF-GLS under the longest sub-sample, indicates a LOOP only for Greater Johannesburg and Pretoria for the large middle-segment houses, a LOOP for Cape Town, Port Elizabeth/Uitenhage and Pretoria in the medium middle-segment houses, while for the small middle-segment houses, the results are not very obvious. Overall, for the longest sub-samples that includes data up to 2009:03, except for Durban in the categories of medium- and small- middle-segments and Cape Town in the category of small-middle-segment, the DF-GLSu overwhelmingly indicates the existence of LOOP for all the three categories of middle-segment houses. Unfortunately, at this stage, there exists no practical way to determine whether the DF-GLS test or the DF-GLSu is more appropriate for our data sample, and, hence, it is difficult to choose between these two sets of results. It may be the case that the DF-GLSu test is a more powerful test than the DF-GLS test. This can be identified as an interesting area of future research. However, since we are looking for evidence in favour of the LOOP, we are inclined to accept the more favorable results provided by the DF-GLSu test.[6]

4. Conclusions

This paper analyzes whether the Law of One Price (LOOP) holds in the housing market of five major metropolitan areas of South Africa, namely Cape Town, Durban, Greater Johannesburg, Port Elizabeth/Uitenhage and Pretoria. We test the existence of LOOP using the efficient unit root tests proposed by Elliott et al. (1996) and Elliott (1999) based on monthly data on residential property prices covering the period of 1967:01 to 2009:03 for the large-, medium and small-middle segments of the South African housing market. Based on the DF-GLSu test, except for Durban in the categories of medium- and small-middle-segments and Cape Town in the category of small-middle-segment, we find an overwhelming evidence of the existence of LOOP for all the three categories of middle-segment housing, especially as the sample period becomes more recent.

More importantly, our results are in sharp contrast with those obtained by Burger and Van Rensburg (2008) in which they use quarterly data to test for stationarity based on the IPS test. Our conclusions are however, in line with IPS test when repeated for monthly data. But, given that, and as we show above, the rejection or the non-rejection of the null hypothesis of unit roots, based on panel data tests, do not provide sufficient evidence to conclude that all the series in the panels have a unit root or that they are all stationary, more reliability should be placed on our results obtained from the efficient unit root tests, which are shown to have excellent power properties.

[6] See Ahking (2003) for further details.

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Table 2. Efficient Unit Root Tests for Large Middle-Segment (1967:01-2009:03)

Panel A: DF-GLS								
Regions	Lag Criteria	1967:01-1982:12	1967:01-1987:12	1967:01-1992:12	1967:01-1997:12	1967:01-2002:12	1967:01-2007:12	1967:01-2009:03
CT	MAIC	-0.39	-0.277	-0.248	0.048	-0.176	-0.339	-0.276
	MSIC	-0.49	-0.394	-0.093	0.199	-0.07	-0.25	-0.195
DU	MAIC	-0.336	-0.368	-0.613	-0.019	-0.057	-0.429	-0.211
	MSIC	-0.336	-0.368	-0.613	-0.019	-0.057	-0.429	-0.211
JO	MAIC	-2.664	-3.070 ****	-3.068****	-3.286****	-3.354****	-3.545 ****	-3.608****
	MSIC	-4.336****	-4.893****	-5.360 ****	-5.672****	-5.768****	-6.146 ****	-6.250 ****
PE	MAIC	-2.831****	-3.116 ****	-3.282****	-3.489****	-3.573****	-3.820****	-3.846 ****
	MSIC	-3.794****	-4.107****	-5.063****	-5.505****	-5.708****	-5.973****	-6.024 ****
PR	MAIC	-0.782	-0.638	-0.469	-0.586	-0.663	-0.545	-0.564
	MSIC	-1.444	-1.321	-1.201	-0.547	-0.625	-0.503	-0.516
Panel B:DF-GLSu								
Regions	Lag Criteria	1967:01-1982:12	1967:01-1987:12	1967:01-1992:12	1967:01-1997:12	1967:01-2002:12	1967:01-2007:12	1967:01-2009:03
CT	MAIC	-2.937 **	-3.351 ****	-3.626****	-4.028 ****	-3.416****	-3.485 ****	-3.605****
	MSIC	-3.424****	-3.907****	-3.671****	-4.086 ****	-3.444****	-3.524 ****	-3.649
DU	MAIC	-2.137	-2.388	-2.207	-2.735**	-2.097	-2.452	-2.64
	MSIC	-2.137	-2.388	-2.207	-2.735 **	-2.097	-2.452	-2.640*
JO	MAIC	-2.736 **	-3.209 ***	-3.266***	-3.342 ****	-3.360****	-3.540****	-3.610 ****
	MSIC	-4.377****	-4.988****	-5.515 ****	-5.722****	-5.772****	-6.143 ****	-6.250****
PE	MAIC	3.199 ***	-3.683****	-4.096 ****	-4.460****	-4.796 ****	-4.869 ****	-4.775 ****
	MSIC	-4.053****	-4.516****	-5.899****	-6.534 ****	-6.976****	-7.180****	-7.116****
PR	MAIC	-4.083****	-4.718****	-4.842 ****	-5.095 ****	-5.004 ****	-5.611****	-5.553****
	MSIC	-4.956 ****	-5.653 ****	-6.080****	-5.562****	-5.469****	-6.103 ****	-6.035****

Note:*, **, ***, **** denote the rejection of the null hypothesis at the 10%, 5%, 2.5% and 1%.

Table 3. Efficient Unit Root Tests for Medium Middle-Segment (1967:01-2009:03)

Panel A: DF-GLS								
Regions	**Lag Criteria**	**1967:01-1982:12**	**1967:01-1987:12**	**1967:01-1992:12**	**1967:01-1997:12**	**1967:01-2002:12**	**1967:01-2007:12**	**1967:01-2009:03**
CT	**MAIC**	-2.795****	-2.846 ****	-3.131 ****	-3.107****	-2.678 ****	-2.803 ****	-2.834 ****
	MSIC	-3.597 ***	-4.066****	-3.471****	-3.459****	-2.678 ****	-2.803 ****	-2.834****
DU	**MAIC**	-1.409	-1.175	-0.591	-1.273	-1.27	-1.496	-1.517
	MSIC	-1.44	-1.475	-1.032	-1.531	-1.532	-1.760 *	-1.785*
JO	**MAIC**	-3.221	-1.352	-0.851	-0.399	-0.955	-1.056	-1.111
	MSIC	-3.221 ****	-2.240****	-2.033**	-1.542	-1.703 *	-1.777*	-1.802 *
PE	**MAIC**	-1.411	-1.421	-1.606	-1.602	-1.905*	-1.727 *	-1.831*
	MSIC	-2.008**	-1.421	-1.606	-2.909****	-1.905 *	-1.870 *	-1.973 **
PR	**MAIC**	-1.334	-1.451	-1.377	-1.619	-1.754*	-1.746 *	-1.712 *
	MSIC	-2.223**	-1.754 *	-1.41	-1.637 *	-1.776*	-1.758*	-1.726 *
Panel B:DF-GLSu								
Regions	**Lag Criteria**	**1967:01-1982:12**	**1967:01-1987:12**	**1967:01-1992:12**	**1967:01-1997:12**	**1967:01-2002:12**	**1967:01-2007:12**	**1967:01-2009:03**
CT	**MAIC**	-3.040***	-3.144***	-3.394****	-3.211***	-2.687*	-2.836 **	-2.880**
	MSIC	-3.859****	-4.496****	-3.820****	-3.610****	-2.687 *	-2.836 **	-2.880 **
DU	**MAIC**	-2.086	-2.02	-1.854	-2.11	-1.268	-1.819	-1.846
	MSIC	-2.205	-2.529 *	-2.503*	-2.624*	-1.77	-2.232	-2.265
JO	**MAIC**	-4.341****	-2.825 **	-2.885**	-2.399	-2.551 *	-2.714 *	-2.749 *
	MSIC	-4.341****	-3.571****	-3.706 ****	-3.218***	-3.197***	-3.349 ****	-3.410 ****
PE	**MAIC**	-2.388	-2.770**	-2.909	-3.038***	-2.826**	-3.427 ****	-3.490 ****
	MSIC	-3.274***	-2.770 **	-2.909**	-2.972 **	-2.826 **	-3.307 ****	-3.377****
PR	**MAIC**	-1.918	-1.874	-2.115	-2.389	-2.274	-2.613*	-2.629 *
	MSIC	-3.238****	-2.317	-2.222	-2.481*	-2.364	-2.695 *	-2.715 *

Note:*, **, ***, **** denote the rejection of the null hypothesis at the 10%, 5% , 2.5% and 1% .

Table 4.Efficient Unit Root Tests for Small Middle-Segment (1967:01-2009:03)

Panel A: DF-GLS								
Regions	**LagCriteria**	**1967:01-1982:12**	**1967:01-1987:12**	**1967:01-1992:12**	**1967:01-1997:12**	**1967:01-2002:12**	**1967:01-2007:12**	**1967:01-2009:03**
CT	**MAIC**	-0.853	-1.171	-1.232	-1.194	-1.062	-1.336	-1.346
	MSIC	-0.853	-1.392	-1.232	-1.243	-1.116	-1.336	-1.414
DU	**MAIC**	-3.859****	-2.115 **	-2.152 **	-1.824*	-0.494	-1.329	-1.196
	MSIC	-3.859 ****	-3.394 ****	-3.343****	-2.860 ****	-0.789	-1.549	-1.403
JO	**MAIC**	-1.308	-0.771	-0.716	-0.852	-0.709	-0.956	-0.843
	MSIC	-1.578	-1.670*	-1.705*	-1.787*	-1.769 *	-1.923 *	-1.866 *
PE	**MAIC**	-1.43	-1.343	-1.454	-1.373	-0.984	-1.648*	-1.5
	MSIC	-1.43	-1.850*	-1.856*	-1.770 *	-1.479	-2.126 **	-2.399 **
PR	**MAIC**	-1.705*	-1.526	-1.597	-1.614	-1.26	-1.741*	-1.668*
	MSIC	-1.705 *	-1.526	-1.597	-1.614	-1.26	-1.741 *	-1.668 *

Panel B:DF-GLSu								
Regions	**Lag Criteria**	**1967:01-1982:12**	**1967:01-1987:12**	**1967:01-1992:12**	**1967:01-1997:12**	**1967:01-2002:12**	**1967:01-2007:12**	**1967:01-2009:03**
CT	**MAIC**	-2.128	-2.435	-2.566 *	-1.421	-0.902	-1.216	-1.288
	MSIC	-2.128	-2.976 **	-2.566 *	-1.29	-0.886	-1.216	-1.317
DU	**MAIC**	-4.252****	-2.657*	-2.863**	-2.926 **	-1.327	-1.964	-1.979
	MSIC	-4.252****	-4.219****	-4.493****	-4.367 ****	-1.593	-2.202	-2.212
JO	**MAIC**	-3.594****	-2.831	-3.173 ***	-3.244***	-3.385****	-3.326 ****	-3.452 ****
	MSIC	-4.038 ****	-4.059 ****	-4.508****	-4.762 ****	-4.982****	-4.985 ****	-5.123****
PE	**MAIC**	-2.225	-2.122	-2.665*	-2.827 **	-2.801**	-3.538****	-3.197***
	MSIC	-2.225	-2.654*	-3.011 ***	-3.190 ***	-3.286****	-4.104 ****	-4.595 ****
PR	**MAIC**	-2.016	-1.971	-2.204	-2.383 *	-2.296	-2.647*	-2.738**
	MSIC	-2.016	-1.971	-2.204	-2.383	-2.296	-2.647*	-2.738**

Note:*, **, ***, **** denote the rejection of the null hypothesis at the 10%, 5% , 2.5% and 1% .