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Suburbanization and Residential Desegregation in South Africa's Cities

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Abstract

Population density gradients for South Africa's cities are quite small in absolute value, indicating a relatively flat population distribution across the cities. In contrast employment is less flatly distributed than the population. The relationship between employment densities and distance across South African cities has remained constant between 1996 and 2001 whilst there has been on average a slight increase in population density further away from the city centres. As per capita income of the population rises, density in the central city areas decreases. Employment growth has no significant impact on suburbanization indicating that population settlement does not necessarily follow jobs. Finally, it is found that there have been decreases in segregation in South Africa's metropolitan cities since 1996 especially in the former white group areas, which could suggest that the formerly spatially excluded black population is slowly moving into former white areas, which are also closer to where economic activities are located.

Keywords: suburbanization, segregation, South Africa

JEL classification: R23, R11, O55

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1 Introduction

The growing literature on urbanization in South Africa is largely motivated by two features of the country's city landscape: the first is that rapid urbanization is putting pressure on cities' infrastructure and labour markets (Williams 2000); the second is that the country has a particular history where, under apartheid, racially segregated cities were imposed (Horn 2002). Understanding the evolution of population density and employment in central city areas, as opposed to suburban areas, after the abolition of apartheid in the early 1990s could, therefore, be important from the point of view of urban planning and anti-poverty strategies.

In most of the world, suburbanization has been a notable trend (Mills and Tan 1980). Suburbanization refers to the movement of residents away from a city's centre towards its periphery. It is not to be confused with de-urbanization, and indeed in most cases suburbanization is accompanied by increased urbanization. Suburbanization has not always had positive outcomes for all groups. In the USA, for instance, the suburbanization of employment has raised unemployment among blacks because, proportionally, the latter tend to reside in central city areas (Houston 2005). In South Africa, by contrast, suburbanization of employment and population might be positive as it could limit the potential spatial mismatch between employment opportunities and job seekers. Under apartheid, the black population generally resided at a distance from central city areas – around the central business district (CBD)[1] – where more economic activity was traditionally located. If, however, there is little suburbanization of employment in South Africa, then a potential spatial mismatch between employment opportunities and black job seekers can be limited only if there is a movement of the black population towards central city areas. Given historic residential patterns, the latter would result in significant declines in residential segregation. By contrast, under suburbanization of economic activity, less substantial declines in residential segregation might be observed.[2] Thus, in post-apartheid South Africa, it could be important to determine, first, whether or not suburbanization of employment and population is taking place in the cities, and, second, to determine how substantial the degree of desegregation is.

In this paper, data from 1996 and 2001 (corresponding to the two census years) are used to test whether, indeed, there has been suburbanization and desegregation in South Africa's cities. Attention will be confined to the country's six metropolitan cities. In terms of the country's legislation, metropolitan municipalities, local municipalities, or district municipalities are responsible for governance. Six metropolitan municipalities

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1 Traditionally in South African cities, the central business district (CBD) itself was not zoned for residential use but, rather, for commercial purposes. Thus, in this paper, central city areas would refer to the belt of residential areas immediately surrounding the CBD.

2 Due to the artificial nature of residential segregation in South Africa, as well as the fact that even under suburbanization of employment there will still be a demand for labour in central city areas, one would expect residential segregation, post-apartheid, to have declined overall (see, for instance, Brueckner 1996). The argument here is that the desegregation will be less substantial with suburbanization since employment opportunities are moving closer to where the majority of the black population is residing, thereby lowering the need for commuting costs and expensive job searches.

are recognized: the City of Cape Town, the Nelson Mandela Bay Metro (Port Elizabeth), Ethekwini Metro (Durban), Ekurhuleni Metro, the City of Johannesburg, and Tshwane Metro (Pretoria). Although the present focus is on these six metropolitan areas, it must be kept in mind that they are not the only urban areas. Naudé and Krugell (2003a, 2003b) discuss the economic profiles, roles, and sizes of these cities. Their dominance in terms of population (32 per cent) and economic size (60 per cent of GDP) is a motivation for focusing on them.

The next section of the paper describes the empirical methodology. This is followed by a section setting out the results and the paper closes with the conclusions drawn.

2 Methodology

According to Sridhar (2007: 322), suburbanization is 'the process where the percentage of the population living in the suburbs rises'. Similarly, suburbanization of employment takes place when there is an increase in the percentage of a city's jobs that are located in the suburbs. The literature on suburbanization addresses the measurement of suburbanization (for example, McDonald 1989; Mills 1992) and the determinants of suburbanization (for example, Margo 1992; Mieszkowski and Mills 1993; Anas *et al*. 1998). Most commonly, suburbanization is measured either by estimating or calculating the density gradient of either population or employment (as in Mills 1992; Sridhar 2007), or by estimating a cubic-spline population density function (as in Zheng 1991). Variations and extensions on these approaches are summarized in Martori and Suriñach (2001).

2.1 Density gradients

The density gradient is the coefficient in a negative exponential equation of either population density or employment density against distance from the city centre (Sridhar 2007: 322). It was proposed by Clark (1951), who postulates that density in cities will decline as one moves away from the city centre (as in the monocentric city model) and that, over time, density will decrease in the centre and increase in the suburbs, so that the territory of the city will increase (Martori and Suriñach 2001:3). The negative exponential function can be written as:

$$D(x) = D_0 e^{\beta x} \qquad (1)$$

where $D(x)$ is the population (or employment) density at distance of x kilometres from the city centre, $D_0 > 0$ is the density at the city centre, and **e** is the base of the natural logarithm. Edmonston and Davies (1978) discuss the interpretation of the negative exponential function, noting that, according to Papageorgiou (1971: 24), the negative exponential function will result from 'a situation of transportation costs increasing at a constant rate with distance from the city centre' (quoted in Edmonston and Davies 1978: 236). Declines in the absolute value of the density gradient (β) over time can be taken as evidence in favour of suburbanization (Mieszkowski and Mills 1993).

The coefficient β can either be estimated using regression analysis (Equation 1 is then estimated in log-linear form), or calculated using Mills' two-point method. Using regression analysis requires much data, which are not always available; in the present case, there are insufficient data available on a sub-city level to estimate β for each individual city using population or employment density as dependent variable, so that β can be estimated only for the various cities using the proportion of the population and proportion of employment on a particular sub-city level as dependent variable. In addition, Mills' two-point method is used to calculate β for 1996 and 2001 for the six metropolitan cities. Sridhar (2007: 323–4) explains that Mills' two-point method is based on using an algorithm to calculate β from Equation 1. She shows that Equation 1 can be written as:

$$\frac{P_c}{P} = \frac{1 - e^{-\beta R_c} - \beta P_c e^{-\beta R_c}}{1 - e^{-\beta R} - \beta P e^{-\beta R}} \quad (2)$$

Where P_c is the population (or employment) in the CBD and P the population (or employment) in the total metropolitan area, R_c the radius of the central city (in kilometres) and R the radius (in kilometres) of the entire metropolitan area.

Kim (2007) shows that the radius of the city centres and the entire metropolitan area (R_c and R) can be calculated if the surface area of the particular area (in kilometres^2) is known. This makes use of the relationship between the radius and surface of a circle and can be written as:

$$R = \sqrt{\frac{2}{f} A} \quad (3)$$

Where R is the radius, A is the surface area of a region, and $f = 2\pi$ if the city is circular, and $f = \pi$ if the city is half-circular (for example, in the case of a coastal city). Once R has been calculated, Equation 2 can be solved for β using an algorithm. In the present case, we have used Microsoft Excel's Goal Seek function to find a solution for β for each of the six metropolitan cities for 1996 and 2001. The density gradients for South Africa's cities, as estimated using ordinary least squares (OLS) and calculated using the two-point method, are discussed later in the paper.

2.2 Cubic-spline density function

Density gradients are useful and informative for estimation or calculation – in particular, as there is a rich literature on the sizes and evolution of density gradients for cities across the world, which makes comparisons interesting. They do, however, have a number of shortcomings, especially the two-point method as discussed, for instance, in Mieszkowski and Mills (1993) and Sridhar (2007). As a result of these shortcomings, researchers have extended, for instance, the basic regression to include various powers of distance. One such extension is the cubic-spline density function.

The general spatial structure of South Africa's cities will therefore also be estimated here using the cubic-spline density function approach. This approach improves upon the earlier popular use of the population density function approach (for example, in McDonald 1989). According to Anderson (1982) and Zheng (1991), the cubic-spline density function approach is 'flexible enough to describe the relationship in a city-area between population density and distance from the centre'; that is, to test for suburbanization. It consists of using OLS to estimate the density–distance relationship by using a few piece-wise, continuous cubic polynomials. Due to a lack of sufficient data on a sub-city level, the cubic-spline density function is estimated for the total number of cities and sub-city areas for which population and employment density data are available. This will give a generalized view of suburbanization in the country.

The cubic-spline density function can be written as:

$$D_t = \alpha + \beta(X_t - X_o) + \delta(X_t - X_o)^2 + \phi_1(X_t - X_o)^3 + \sum_{i=1}^{n-1}(\phi_{i+1} - \phi_i)(X_t - X_o)^3 Y_i + \mu_t \quad (4)$$

(Zheng 1991: 89), where D_t is the proportion of the population (or employment) in the sub-city area (suburb), X_t is the distance between the suburb t and the centre, and X_i are knots dividing the total distance interval in the city $[X_o, X_b]$ into n segments of equal length. The α, β, δ, and ϕ are parameters to be estimated and μ_t is a random error term. Y_i is defined as a dummy variable with $Y_i = 1$ if $X_t > X_i$, otherwise $Y_i = 0$.

The decision on the optimal number of segments (n) to use in Equation 1 should be determined by the minimum standard error of the regression, as well as the statistical significance of the coefficients (Zheng 1991: 90). Here, the use of criteria indicated that $n = 2$ should be adopted so that Equation 4 is estimated with the first six terms on the right-hand side included.

2.3 Determinants of suburbanization

Once the density function is estimated and the city structure described, it can be asked what the determinants of suburbanization are. Generally, the literature finds that these depend on household income; transportation (commuting) costs; the size of the city; its age and history; socio-political barriers; and push-factors in the central city, such as congestion and crime. Mieszkowski and Mills (1993: 136–7) discuss two theoretical approaches to suburbanization. The first sees suburbanization as a ‘natural evolution’ as a city develops in size, incomes, and transport infrastructure. The second sees suburbanization as a ‘flight from blight’ due to higher taxes, congestion, and crime in central city areas.

The determinants of suburbanization of South Africa’s metropolitan cities are estimated using a varying parameter regression model. In this model, the parameters to be estimated are regarded as functions of other independent (right-hand side) variables (Zheng 1991: 98). In the present case, an attempt is made to model how the density at city centre and the density gradient vary with income, the availability of jobs, and how push-factors (such as crime) affect the density gradient.

Following Zheng (1991: 98–9) the changes in density over time $\left(\frac{\Delta D_t}{D_t}\right)$ can be written as a function of distance from the centre (X_t):

$$\frac{\Delta D_t}{D_t} = a + b \log X_t + \nu_t \quad (5)$$

where **a** is the density variation rate at or near the city centre; and **b** is the relation between the density variation rate and the distance from the centre. With $a > 0$ and $B < 0$ population, density towards the centre is increasing; conversely, with $a < 0$ and $B > 0$ density towards the suburbs is increasing (suburbanization). With both $a > 0$ and $b > 0$, density across the city is increasing, with the relative sizes of **a** and **b** indicating whether density growth is highest near the city centre or in the suburbs.

To identify the determinants of the changes in density, **a** and **b** can be specified as functions of certain variables.[3] Following Zheng (1991), changes in per capita income is selected as one such variable influencing **a** and **b**. Another is changes in job opportunities (here represented by E, standing for employment creation). Thus, one can write **a** and **b** as follows.

$$a = c_1 \frac{\Delta Y_t}{Y_t} + g_1 \frac{\Delta E_t}{E} \quad (6)$$

$$b = c_2 \frac{\Delta Y_t}{Y_t} + g_2 \frac{\Delta E_t}{E} \quad (7)$$

In Equations 6 and 7, c_1 and c_2 are expected to be negative, reflecting the frequent observation that, as income rises, density at the centre will decrease, as more of the labour force finds that they can afford the commuting costs and prefer to reside in the suburbs. Substituting for **a** and **b** in (5) yields:

$$\frac{\Delta D_t}{D_t} = k_0 + c_1 \frac{\Delta Y_t}{Y_t} + g_1 \frac{\Delta E_t}{E_t} + c_2 \frac{\Delta Y_t}{Y_t} \log X_t + g_2 \frac{\Delta E_t}{E_t} \log X_t + v_t \quad (8)$$

Equation 8 can be estimated by OLS. It contains measures of incomes (Y) and employment (E), the standard explanations of one strand of the literature that sees suburbanization as a natural evolution in a city's development. However, as was pointed out, there is also a view – the 'flight from blight' view – which sees push-factors such as congestion and crime playing a role (Mieszkowski and Mills 1993). Due to a lack of sufficiently disaggregated data on crime and property taxes, incorporation of these factors is left as an avenue for future research.

The results from calculating the density gradients using Mills' two-point method and the regression results from estimating Equations 1, 5 and 8 is reported below. This allows the potential degree of suburbanization and its determinants to be identified.

2.4 Desegregation

Given South Africa's apartheid past, it is also necessary to conduct direct investigation of the degree to which segregation has declined since the abolition of apartheid (after 1991). This paper follows Massey (2005), who provides an overview of measures to calculate the degree of segregation in a city. He points out that the so-called index of

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3 In the literature, transport (commuting costs) is often used as a determinant of the spatial structure of cities. Lack of such data for the six South African cities rules this out in the present case.

dissimilarity (or index of segregation) is the most often used index in this regard. The segregation index (SI) can be calculated as follows (seen also in Christopher 2005: 2309):

$$SI_y = 0.5\sum|y_i - x_i| \qquad (9)$$

where SI_y is the segregation index of the *Y*th group of the population (here, *Y* will alternatively stand for black, white, coloured, and Asian); y_i is the proportion of the *Y*th population group in the *i*th census tract (enumerator area), and x_i is the remainder of the population in the *i*th tract.

The values of the various indices for South Africa's six metropolitan cities are set out below.

3 Empirical results

3.1 Data description

Equations 1, 2, 5, 8, and 9 were variously calculated (Equations 1 and 9) and estimated using OLS (Equations 2, 5, and 8) using population density, employment, and per capita income data based on the 1996 and 2001 censuses. These data were obtained from two main sources:

- Global Insight Southern Africa (www.globalinsight.co.za), which provides data based on the Statistics South Africa census data on the level of the various magisterial districts that comprise a particular city, as well as the physical sizes of these various magisterial districts
- Quantec Research (www.quantec.co.za), which provides data on population, employment and GDP in the six cities, but on a finer sub-city scale corresponding to different suburbs.

While the latter data include more data points (on 234 suburbs in total) as compared with the former dataset (which includes data on 36 magisterial district levels), they do not include data on the physical sizes of each of the suburbs. Thus, major caveats to note when interpreting the empirical results in this paper is that less than ideal data are used, and that a relatively short time period (five years) is used. However, by using multiple approaches, as outlined in the previous section, some form of robustness check on whether or not there is evidence of suburbanization of population and employment can be provided. It can also be assumed that, given the artificial restrictions on urbanization before the end of apartheid, that the five year period would be sufficient to reflect changes in urbanization patterns.

In calculating the density gradient using Mills' two-point method, a direct measurement of distance is not needed, since the formula is based on the area of a circle. However, in the estimation of the density gradient as well as in the cubic-spline density function, a direct measurement of distance is needed. For purposes of this paper, the distance variable was calculated as the shortest actual distance by road from the centre of a suburb within a city to the city centre itself. For the city centre itself, an arbitrary low value of 2 kilometres is chosen, since non-negative values are required for all places. The distances are calculated using the navigator tool on the website of Shell (www.shellgeostar.co.za).

3.2 Results: density gradients

This section reports the results from the estimation and calculation of density gradients for population and employment in South Africa's six metropolitan cities. Table 1 contains the population density gradients as estimated using OLS and calculated using the Mills' two-point method.

Table 1: Population density gradients for South Africa's metropolitan cities, 1996 and 2001

	Density gradient (Two-point method)		Density gradient (OLS)			
City	1996	2001	1996		2001	
Cape Town	0.005	0.07	-0.051	(-3.4)*	-0.047	(-3.14)*
Ethekwini (Durban)	-0.047	-0.044	-0.054	(-3.28)*	-0.052	(-3.14)*
Ekurhuleni	0.022	0.027	0.034	(1.38)	0.033	(1.33)
City of Johannesburg	-0.009	0.016	-0.067	(-2.25)*	-0.062	(-2.19)*
Nelson Mandela Bay Metro	-0.036	-0.036	-0.049	(-0.47)	-0.045	(-0.44)
City of Tshwane (Pretoria)	-0.044	-0.041	-0.075	(-2.14)*	-0.075	(2.31)*

Note: *t*-ratio's in brackets. An asterisk indicates significance at the 5% level.
Source: Author's calculations.

Table 1 shows that the population density gradients for South Africa's cities are quite small in absolute value, indicating a relatively flat population distribution across the cities. The absolute values of the coefficients, ranging between 0.005 and 0.047 is comparable with those found for Bangalore in India by Sridhar (2007: 336), ranging over time between 0.05 and 0.10. This could be a legacy of South Africa's apartheid city planning since other countries where there has been strong political interference in city planning and management, such as Russia and Korea, show similar flat and inverted population density gradients (Sridhar 2007: 340).

In most – but not all – cases, the coefficient is negative, which indicates that population density (proportion) is slowly declining from the city centre with distance. The possible exceptions are Cape Town, Ekurhuleni, and the City of Johannesburg, where population density is increasing away from the city centre according to at least one of the density gradients. Bertaud and Malpezzi (2003), in a study of suburbanization in 48 countries around the world, find a positive slope for the density gradient in Cape Town and a negative slope for the City of Johannesburg, consistent with the results in Table 2.

Whether or not there could be a spatial mismatch in South Africa's metropolitan labour markets might depend not only on the suburbanization of the population, but also on whether employment opportunities are also being suburbanized.

Table 2 reports the employment density gradients for the six cities in order to facilitate comparison with the population density gradients.

Table 2: Employment density gradients for South Africa's metropolitan cities, 1996 and 2001

	Density gradient (Two-point method)		Density gradient (OLS)			
City	1996	2001	1996		2001	
Cape Town	-0.166	-0.159	-0.063	(-4.54)*	-0.061	(-4.38)*
Ethekwini (Durban)	-0.108	-0.108	-0.066	(-3.61)*	-0.067	(-3.69)*
Ekurhuleni	-0.079	-0.082	-0.047	(-1.42)*	-0.053	(-1.58)
City of Johannesburg	-0.075	-0.079	-0.093	(-3.15)*	-0.096	(-3.16)*
Nelson Mandela Bay Metro	-0.063	-0.063	-0.15	(-4.6)*	-0.14	(-4.60)*
City of Tshwane (Pretoria)	-0.113	-0.117	-0.047	(-1.26)	-0.049	(1.32)

Note: t-ratios in brackets. An asterisk indicates significance at the 5% level.
Source: Author's calculations based on Quantec Research Data.

Table 2 shows that the absolute values of the employment density gradients in South Africa's cities range from 0.063 to 0.166, and are generally larger in size than the population density gradients. This suggests that employment is less flatly distributed than the population. The size of the coefficient is largest in the case of Cape Town and Tshwane, which are, respectively, the legislative and administrative capitals of South Africa, with substantial public sector employment located in the central city areas. Overall, the larger coefficients in Table 2 are consistent with a situation where proportionately more employment opportunities are located in central city areas than population. Comparing the changes in the employment density over time shows a decline (that is, suburbanization of employment) in only one case – that of the City of Cape Town. In most of the other cities, the indication is of an increase in the density in central areas.

3.3 Regression results: cubic-spline density functions

A number of potential weaknesses of the density gradient approach have already been identified. Thus, the density gradient approach is extended by estimating a cubic-spline density function as described in Equation 4 with the dependent variable – respectively, the proportion of the population and the proportion of employment (per place of work) per sub-city area. The best estimates obtained from estimating Equation 4 using OLS for 1996 and 2001 are shown in Table 3 below.

Table 3: Regression estimates of cubic-spline density function for: (a) proportion of the population; and (b) proportion of employment by place of work

	(a) Population				(b) Employment			
Parameter	1996		2001		1996		2001	
α	-0.91	(-1.74)*	-0.93	(-1.68)*	-0.32	(-1.59)	-0.32	(-1.62)
β	0.079	(1.81)*	0.081	(1.78)*	0.03	(1.77)*	0.03	(1.80)*
δ	-0.002	(-1.84)*	-0.002	(-1.81)*	-0.0008	(-1.86)*	-0.0008	(-1.89)*
ϕ1	0.000	(1.67)	0.000	(1.65)	0.000	(1.69)*	0.000	(1.73)*
ϕ2	0.000	(1.82)*	0.000	(1.71)*	0.000	(2.83)**	0.000	(2.80)**
ϕ3	-0.000	(-1.86)*	-0.000	(-1.78)*	-0.000	(-2.86)**	-0.000	(-2.85)**
	N= 55		N = 55		N = 55		N = 55	
	R2 = 0.19		R2 = 0.17		R2 = 0.30		R2 = 0.28	

Notes: Robust t-ratios in brackets; * indicates significance at the 5% level.

The results in Table 3 show that most of the parameters are significant. The shape of the density function(s) suggested by these estimates is consistent with a situation where business activities are predominantly situated in the centre of cities whilst residents live outside (Zheng 1991: 94).

The results in Table 3 are consistent with the results from the density gradients in that they show, on average:

i. Density in South African cities is highest near the central city areas (but not the actual city centre) and decline from there on, as indicated first by the positive sign on β and the negative sign on δ; and
ii. has increased slightly over time (from 0.079 to 0.081), which implies that density away from city centres has increased for the broad sample by more than density in city centres.

This is consistent with the suburbanization of population results from the previous section.

Table 3 also shows that slightly higher proportions of employment are found close to, but not in, the actual city centres. This could indicate, on average, some small degree of 'suburbanization' of employment away from traditional CBDs but not substantially, and also to a much lesser degree than the suburbanization of population, as reflected in the much smaller β coefficient (0.03 compared with 0.081).

3.4 Regression results: determinants of suburbanization

To identify the determinants of the spatial population structure in the cities (as discussed earlier), the results from the varying-parameter regression are contained in Tables 4 and 5 below.

Table 4 contains the results from estimation of Equation 5. It can be seen that **a** is negative and **b** positive, indicating overall growth in density away from city centres in South Africa's metropolitan cities. This is a further indication of suburbanization of the population. When a regression of changes in employment density on distance is run, the coefficients are not significant, and have the opposite signs to those in Table 4.

Table 4: Results of OLS regression of change in population proportion on distance from city centres

Variable (parameter) – see equation (5)	Coefficient
Constant (a)	-0.234
	(-1.67)**
Distance (b)	0.112
	(2.60)*
R2 = 0.04	Number of observations = 165

Notes: t-ratio' in brackets. * and ** indicate significance at the 1% and 5% levels, respectively.

Table 5 contains the results of estimating Equation 8.

Table 5: Results of OLS regression of change in population proportion on distance, income, and employment

Variable (parameter) – see equation (5)	Coefficient
Constant (k_0)	0.125
	(3.12)*
Income (c_1)	-9.79
	(-2.58)*
Employment (g_1)	-0.03
	(-0.01)
Income×distance (c_2)	2.60
	(2.24)*
Employment×distance (g_2)	2.73
	(1.43)
R^2= 0.22	Number of observations = 165

Notes: t-ratios in brackets; * indicates significance at the 5% level.

In Table 5, the fact that changes in employment (by place of work) is not a significant determinant of changes in population proportion implies that population settlement does not necessarily follow jobs, and leaves open the possibility for a spatial mismatch in labour markets.

With the absolute value of $c_1 > c_2$, the regression results indicate that in South Africa's cities, higher income would lead to less density in the central areas of the city, with suburbanization occurring. Higher income individuals and households often prefer to live in suburban areas and commute to work in central areas, as they can afford the transport costs. However, the results suggest that lower-income households would tend to move closer to the central city areas where perhaps more jobs are located.

The significance of the intercept term indicates that, even in the presence of no changes in unemployment and incomes, South Africa's cities are experiencing growth in population density – and also in central city areas. These findings are consistent with a process of urbanization and of possible adjustments in urban spatial structure after apartheid.

In the next section, indices of segregation are constructed for South Africa's cities to determine the significance of the implied de-segregation that has occurred since the 1990s.

3.5 Results: residential desegregation in South African cities

It was established that population density closer to city centres in South Africa's six metropolitan cities increased between 1996 and 2001. It might be important to determine whether this reflects, in part, a greater movement of the black population towards central city areas, given that this group is now freer to reside in city centre areas than before. Here, the degree of desegregation that has taken place in South Africa's six metropolitan cities is quantified using the methodology as already outlined. The work of Christopher (2005) is extended: first, in that where he confines himself to 1996 and 2001 census data, the present paper extends the period to 2004 using recently published data from Global Insight Southern Africa and Quantec Research. Second, where Christopher (2005) uses measures of all urban areas in South Africa, this paper focuses only on the six metropolitan cities. It could be argued that desegregation might be more rapid in the largest metropolitan areas and not as rapid in smaller and secondary cities and towns, since South Africa is witnessing a significant migration of people from rural areas, secondary cities, and towns towards the larger metropolitan areas.

The segregation index for South Africa's six metropolitan cities, using more recent data from Global Insight's Regional Economic Focus, is shown in Table 6 below.

Table 6: Segregation index for South Africa's metropolitan cities, 1996–2001

City	Black		White		Coloured		Asian	
	1996	2001	1996	2001	1996	2001	1996	2001
Cape Town	51	38	41	37	25	26	44	44
Ethekwini	39	38	59	59	43	44	45	45
Ekurhuleni	39	39	22	16	42	34	38	33
Johannesburg	34	35	50	42	57	25	60	49
Nelson Mandela Metro	28	29	10	8	12	12	11	12
Tshwane	42	38	61	55	57	52	63	59

Source: Data obtained from Global Insight, Regional Economic Focus, November 2005.

Table 6 shows that segregation indices have generally declined between 1996 and 2001. The table suggests that largest declines in segregation are amongst the white population, reflecting Christopher's remark that 'it is in the former white group areas that most of the developments leading to integration are taking place' (Christopher 2005: 2317). This could imply that the formerly spatially excluded black population is slowly moving into former white areas, which are also closer to where economic activities are located.

4 Conclusion

The purpose of this paper was to determine whether or not suburbanization of employment and population is taking place in South Africa's cities, and how substantial the degree of desegregation is.

Suburbanization was measured by calculating and estimating the density gradient of population and employment, and estimating cubic-spline functions for population and employment density. It was found that the population density gradients for South Africa's cities are quite small in absolute value, indicating a relatively flat population distribution across the cities. This could be a legacy of South Africa's apartheid city planning. In most – but not all – cases, the density gradient of population was negative, which indicated that population density (proportion) is slowly declining from the city centre with distance. The possible exceptions identified were Cape Town, Ekurhuleni, and the City of Johannesburg, where population density has been increasing away from the city centre. Comparisons of the value of the density gradient over time were in all cases, except for Ekurhuleni, indicative of suburbanization taking place between 1996 and 2001.

In comparison with the suburbanization of population, the absolute values of the employment density gradients in South Africa's cities were found to be significantly larger in size than the population density gradients. Thus, employment is less flatly distributed than the population. The size of the coefficient is largest in the cases of Cape Town and Tshwane, which are, respectively, the legislative and administrative capitals of South Africa, with substantial public sector employment located in the central city areas. The results from a cubic-spline density function estimation of population and employment proportions were found to be consistent with the results from the density gradients in that, on average, they show that density in South African cities is highest near the central city areas (but not the actual city centre) and decline from there on; and also that density away from city centres has increased. Furthermore, it was found that the relationship between employment densities and distance across South African cities has remained constant during the selected period whilst, on average, there has been a slight increase in population density further away from the city centres.

The determinants of suburbanization were investigated with a varying parameter regression model. It was found, consistent with expectations and results elsewhere in the literature, that, as per capita income of the population rises, density in the central city areas will decrease. The impact of employment growth on suburbanization was found to be statistically insignificant, which was taken to imply that population settlement does not necessarily follow jobs.

Finally, given that population, but not employment, seems to be suburbanizing in South Africa, it was asked whether or not there is evidence of substantial residential desegregation. To measure the extent of residential desegregation, an index of segregation was calculated for each of the cities. This indicated that there have, indeed, been decreases in segregation in South Africa's metropolitan cities since 1996, but that these are relatively small. It also indicated that the largest declines are taking place in the former white group areas, which could suggest that the formerly spatially excluded black population is slowly moving into former white areas, which are also closer to where economic activities are located. The relatively slow pace of desegregation might imply a lack of residential mobility. This could conceivably contribute to the potential for a spatial mismatch in the urban labour market. Given that the weight of evidence in this paper suggests that the population in South African cities is suburbanizing faster than employment opportunities, and that residential desegregation is relatively slow, further research on the possibility that a spatial mismatch is contributing to high black unemployment is warranted.

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