# Non-Economic Quality of Life and Population Density in South-Africa

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**Abstract**

The purpose of this study is to investigate the relationship between population density and non-economic quality of life. Popular opinion has generally been that population density can be seen as beneficial for economic growth, as it allows for greater productivity, greater incomes and can be translated into higher levels of quality of life. Recently though, growing evidence tends to suggest the exact opposite in that increases in productivity and incomes are not translated into better quality of life. As economic or income variables have always played a significant role in this research, questions regarding the relationship between population density and non-economic quality of life has largely remained unanswered. In this light, the paper utilises a panel data set on the eight metropolitan cities in South Africa for the period 1996 to 2014 to determine the relationship between population density and non-economic quality of life in the South African context. In the analyses we make use of panel estimation techniques which allows us to compare changes in this relationship over time as well as adding a spatial dimension to the results. This paper contributes to the literature by firstly studying the aforementioned relationship over time and secondly conducting the analyses at a sub-national level in a developing country. Our results show that there is a significant and negative relationship between population density and non-economic quality of life. Based on our findings policy measures to encourage urbanisation should not be supported if the ultimate outcome is to increase non-economic quality of life.

**Key words:** Quality of life, Population density, Urbanisation, South Africa, Panel data

**JEL classification codes**: O15, O18, O55, R11, R00, C01, C33, C43

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# 1 Introduction

The main purpose of this study is to provide insights regarding the relationship between non-economic quality of life and population density for regions designated at a sub-national level. The foundation of this study comes from Paul Krugman's (1998) work in that he found large regional inequalities in growth and development within countries and, that often, there were also an associated tendency for populations to concentrate in a few densely populated regions. His findings are important since they allude to a relationship between regions experiencing both more economic activities, i.e. higher economic growth and higher population density. Krugman (1998) argued that there is a tug of war between forces that tend to promote geographical concentration of both economic activity and population and those that tend to oppose it – between *centripetal*[1] and *centrifugal*[2] forces (Krugman 1998).

Buch, Hamann, Niebuhr and Rossen (2014), recapitulate Krugman's theory by stating that the density of a region's population could be influenced by said region's characteristics as it could act both as a repellent or an attraction to within country migration. They divide these characteristics into two distinctive groups: (i) labour market conditions representing unemployment levels and market wages and (ii) amenities representing the natural beauty, consumer facilities and the level of access to public goods.

At first glance, population concentration in a specific urban area seems like a very positive step to achieving not only higher economic growth, as newly developed political and economic structures will attract further investment leading to higher demand for labour, but also in achieving a higher quality of life for those residents within this now increasingly dense populated urban area. The problem however, is that internal and external migrants will also be attracted by the higher quality of life in these urban areas and might generate with their presence unemployment which could lead to increasing poverty levels, environmental decay and in many developing countries, the inception of slum areas, increased violence through riots and rising crime levels. Thereby, vis-á-vis decreasing quality of life in this now highly dense populated urban area (Bloom et al. 2008).

South Africa is classified as a middle income country with a Gross National Income (GNI) of $6800 (current US$) for the year 2014 (IHS Regional Economic Explorer 2014). The country's Human Development Index (HDI) was 0.63 pointing to medium development achievements and the Gini coefficient 0.64 – which indicates large income inequality. Of its total population (53,781,908 million) a staggering 45.4 per cent was deemed to fall below the upper poverty line[3]. What is even more problematic is that 40 per cent of South Africa's total

[1] Centripetal are the three classic Marshallian sources of external economies; market size effects, thick labour markets and pure external economies.

[2] Centrifugal forces include immobile factors, land rents and pure external diseconomies.

[3] To see the formal definition of South Africa's upper poverty line please visit Statistics South Africa at www.statssa.gov.za/publications/Report-03-10-06/Report-03-10-06March2014.pdf

population and 31.3 per cent of those perceived as poor were located in only eight large urban areas classified as metropolitan cities[4]. On the whole, this might not seem like such a big problem, unfortunately, these eight highly dense populated metropolitan cities only cover 2 per cent ($km^2$) of South Africa's total land mass (IHS Regional Economic Explorer 2014). Figure 1 provides a visual of the exact locations and relative land area of these eight metropolitan cities.

This highly unequal distribution and clustering of people in these eight urban metropolitan cities provide us with a unique case study to test the influence of urbanisation, through population density, on quality of life.

In a study conducted by McGillivray and Shorrocks (2005) they alluded to the fact that social science research was on a path of consistent change as it increasingly recognised that quality of life was a multidimensional concept and that the importance of non-income dimensions for quality of life achievement had been acknowledged. Non-economic or non-monetary measures of quality of life has ever since dominated the discussion on the meaning of quality of life.

One might ask what, if any, comparative advantage does measuring quality of life in terms of non-economic indicators (instead of economic measures) hold? Non-economic measures of quality of life can be seen as being more useful than economic measures when a medium or long-run evaluation is required, because these type of measures more directly address the outcomes of policy for the development of human life in as much that people are seen as 'the ends rather than the means' or inputs to these policies. Given that non-economic measures are slower to react and more expensive to obtain than economic data, they have the additional benefit of being adaptable to disaggregation, making them instructive for distributional impacts of policy changes (World Bank, 2001).

In this study, we will utilise a method made famous by McGillivray (2005) and subsequently used by Rossouw and Naudé (2008), Naudé, Krugell and Rossouw (2009), Rossouw and Pacheco (2012) and Pacheco, Rossouw and Lewer (2013) to construct an index for South Africa that measures non-economic quality of life on a sub-national level as measured by its eight metropolitan cities and to determine what relationship (if any) exists between non-economic quality of life and population density. This study fills the gaps and contributes to the literature in the following ways: (i) it is the first study of its kind (to the knowledge of the authors) that investigates the relationship between *objectively* measured non-economic quality of life and population density; (ii) it is the first study to investigate the abovementioned relationship on a sub-national level; (iii) it utilises panel data modelling techniques, not previously used in this type of research, which controls for unobserved heterogeneity; (iv) the usage of panel data has the additional advantage that by testing for endogeneity that spreads from simultaneity, the causal relationship between population density and non-economic quality of life can be determined and (v) this study is conducted in a developing country whereas the other studies (for example Fassio et al. 2013; Glaeser and Shapiro 2001; Glaeser 2012; Walton et al. 2008) were conducted

[4] City of Cape Town, EThekwini, Ekurhuleni, City of Johannesburg, Nelson Mandela Bay, City of Tshwane, Mangaung and Buffalo city.

in developed countries. We will achieve these aims by discussing the different ideologies behind economic and non-economic quality of life, constructing our index and running panel data regression analysis.

The rest of the paper is structured as follows. The next section explores the literature regarding population density and quality of life. Section 3 contains the outline of the methodology used whereas section 4, describes the data and empirical model. The results and analysis will follow in section 5, whilst the paper will conclude in section 6.

# 2 Literature review

In this section we will briefly provide an overview of various literature we deem influential to our study. It provides a solid foundation for the study and will encompass population density, quality of life and consequently, non-economic quality of life as we interpret it. As indicated in the introduction section we perceive this study to be the first focusing on the specific relationship between objectively measured non-economic quality of life and population density. In saying this, we will however conclude this section by discussing various studies that share in our area of research and use them as a reference point to illustrate the gaps in the literature that we maintain will be filled by our current study.

## 2.1 Population density

In 1999, Gallup and Sachs used a geographic information system (GIS) to make three observations regarding population density. First, the relationship between population density and income level is much more complicated than originally thought. Regions with high population density were found to be both rich (Western Europe) and poor (China, India and Indonesia), and regions with low population density were found to be both rich (New Zealand and Australia) and poor (the Sahel[5] of Africa) as well. On a cross-country basis, a weak but positive correlation between population density and gross domestic product (GDP) per capita were found[6].

Second, the great Eurasian landmass has a higher population density than any of the other continents. Third, the coastlines and areas connected to the coast by navigable waters have a higher population density than the hinterlands (regions more than 100 km from the coast or an ocean-navigable waterway) (Gallup and Sachs 1999). As was pointed out by Gallup and Sachs (1999), the level of population density across various regions is problematic in the following two senses: first, there are massive human populations in regions seen as being quite disadvantaged for modern economic growth. Throughout history there has been one inclination for human population densities to rise

[5]Sahel is the semiarid region of western and north-central Africa extending from Senegal eastward to the Sudan.

[6]For the universe of 150 countries with population greater than 1 million, the correlation between population density (population per$km^2$) and GDP per capita in 1995 is 0.32.

in areas favourable for growth, so that coastal regions indeed do have higher levels of population density than hinterlands. Second, the more remote regions are currently experiencing higher population growth, mainly because population growth is negatively related to per capita income, and especially inversely related to a mother's education and the market value of a mother's time[7]. Thus, the level of population density in problematic regions is rising.

As a result of the mismatch of economic growth and population growth trends, there is a mass migration of populations from the hinterland and surrounding areas to the coastal regions. The majority of migratory movements are within poor countries, leading to unprecedented inflows of population into urban areas and the rise of mega-cities (metropolitans) in developing countries.

History teaches us that there has definitely been an influx of population into urban cities although the last several decades has seen a complete reverse of the aforementioned especially in industrialised countries (Glaeser and Gottlieb 2006). During the 1990s, however, there has been what is coined as an '*urban resurgence*' but interestingly enough, this reversed trend is not representative of all urban areas. Whether a specific urban area is considered to grow or contract all depends on the amount of internal migrants it attracts. It was found by Buch et al. (2014) that even though labour market conditions are seen as a primary attraction tool, it was also the quality of life of an urban city which influenced residents' choice of where to stay. They highlighted that positive domains of quality of life such as amenities (recreational facilities), climate and accessibility to public goods played a significant role but that one should also take into account the negative domains of quality of life (disamenities) such as crime rate, $CO_2$ emissions etc. as these decreased the attractiveness of the urban cities.

Bloom et al. (2008) warned that high population density has caused major air, water and land pollution and that there is a massive increase in slum population in and around urban areas. These increasing populations living in deplorable circumstances give rise to economic and social instability in these 'a- uent' areas.

From the above discussions, it can be seen that internal migration to specific urban areas driven by the promise of higher economic quality of life as measured by more employment opportunities and/or higher compensation causes a significant increase in those regions' population densities. These higher population density regions could possibly give rise to lower non-economic quality of life through various disamenities.

## 2.2 Quality of life

Rahman, Mittelhammer and Wandschneider (2003:1) stated: "*Given that improving quality of life is a common aim of international development, the long-*

[7] In an urban setting, children are net economic costs: they are likely to attend school rather than contribute to household production, and because of urban mortality, are much less reliable as social security for aged parents. Moreover, the opportunity costs of raising children are much higher, especially if women are part of the urban labour force.

*term future of humanity lies in a better understanding of factors that may have had or will have an impact on the quality of life*".

Since the 1970s, there has been countless studies done to determine not just what quality of life entails but also more importantly how does this translate to real world development. The field of economics and quality of life research has gone through numerous growth spurts (see Sumner (2003) for a comprehensive study) and it is accepted that quality of life is a multidimensional concept which does not merely encapsulate economic domains (GDP per capita) but also non-economic domains (amenities, environment, crime etc.).

When reading the important works done by Sen (1984; 1996) and Griffin (1986; 1991) it is clear that the state of a person, their abilities as well their core prudential values are what enables a human life to 'go well'. This implies that there is some subjective aspect to determining quality of life. Rojas (2003) stated that subjective quality of life refers to the well-being as professed by a specific individual. It is based on a declaration made by an individual and can be seen as a measure that incorporates all life events, aspirations, achievements, failures and emotions. This clearly aligns with Sen and Griffin's philosophy regarding a 'good' human life. Whilst acknowledging this, there is also economic quality of life sometimes referred to as objective quality of life that needs to be addressed.

Economists have come a long way since simply utilising GDP per capita as a measure for quality of life, as they acknowledge this could provide a warped picture of a country's ability to translate its income into better health, longevity, social amenities etc. However, economists do still prefer to rely on objective measures as it is seen as tangible, easily quantifiable and not very dear. Many researchers have developed theories and indices through which to capture the essence of objective quality of life and to measure across time how these changes impact peoples' life. If one was to focus on the study of quality of life within the field of economics, it is important to note the works done by Towsend (1979), Erikson, Hansen, Ringen and UUsitalo (1987) and certainly Erikson (1993) through which they showed that quality of life is an economic good and should be treated as a multidimensional concept and not purely linked to monetary variables such as GDP per capita.

In 2007, Lambiri, Biagi and Royuela sited that there are two main reasons driving an unrelinquishing interest in studying quality of life within the field of economics: (i) the use of quality of life measures to be used as a political tool; meaning that if one can measure across specific regions and make comparisons then it becomes increasingly beneficial to influence policy change and (ii) quality of life is increasingly influencing the location choices of the population at large.

Many researchers have depicted theories and/or proposed measures for economic or objective quality of life. The main contributors in this field has been the Human Development Index (HDI) which was first introduced in the 1990 Human Development Report, Calvert-Henderson Index (Flynn 2000), Morris' Physical Quality of Life Index (1979) and Osberg and Sharpe's Index of Economic Well-Being (2000). In ground breaking work done by McGillivray (1991), McGillivray and White (1993) and Cahill (2005) a positive correlation was found between the HDI and Gross National Product (GNP) per capita. This suggested that the HDI was completely 'redundant' in capturing non-economic quality of life (which was its initial goal) as the economic component still dominated. To an extent this positive relationship between HDI and per capita income was due to the fact that per capita income is one component of the HDI – the other two being literacy rate and life expectancy measured in total years. Thus, given that the HDI, and by implication most other development index statistics, is not an exclusive indicator of non-economic quality of life as it contains per capita income, a new non-economic quality of life index had to be constructed. This index must not contain income or any other economic aspects of quality of life.

As was stated by Veenhoven (1996: 2) "*The key aim of Social Indicators Research is to create an all-inclusive measure of quality of life in countries that is akin to Gross National Product in Economic Indicator Research*".

Therefore, this study ascertains that the problem with non-economic quality of life indices so far has been that they are either (i) subjective by nature or (ii) objective but contains an income measure of some sort. This impedes any study that makes use of contemporary non-economic quality of life measures since the impact of income on the proposed results must be eliminated (Diener and Diener 1995).

In 2005 McGillivray proposed a method through which the effect of per capita income could be eliminated from an objective quality of life measure. This would mean that you could measure quality of life by making use of objective indicators, then by taking out the income effect you would be left with a true objective non-economic quality of life measure. This could then be used to see whether countries, regions or cities were able to translate their income levels into better health, longevity, social amenities etc., thereby increasing their population's quality of life. McGillivray's (2005) methodology has been subsequently utilised by Rossouw and Naudé (2008), Naudé, Krugell and Rossouw (2009), Rossouw and Pacheco (2012) and Pacheco, Rossouw and Lewer (2013) and is also used in this study. This methodology will be discussed in greater detail in section three.

## 2.3 Relationship between population density and quality of life

This section will be used to identify the caveats in the literature pertaining to the relationship between population density and quality of life. From the discussion to follow, it can be seen that studies either focus on (i) subjective quality of life as their measure, (ii) where objective indicators are used, income in some form or another is included thereby rendering their measure 'redundant' and (iii) the impact on major metropolitan areas in developing countries have been neglected.

Carnahan, Gove and Galle (1974) studied the supposition that higher population densities were responsible for a decrease in subjective quality of life as was measured by a rise in pathological behaviour. They drew conclusions based on US data for the years 1940 to 1970, on both national and regional level across ethnicity lines and concluded that there was no clear relationship to prove the abovementioned hypothesis. Contradicting this finding, Cramer, Torgersen and Kringlen (2004) in a study that investigated 3590 individuals between the age of 18 and 65 that were registered in the National Population Register for Oslo in 1994 determined lower population density has a positive effect on subjective quality of life.

To test their hypothesis regarding the influence of population density on subjective quality of life, Fassio, Rollero and De Piccolli (2013) studied 344 adults living in Piedmont (North-West Italy) between the ages of 18 and 88. More specifically, they postulated that people living in areas with a higher population density should enjoy higher physical health but should experience lower quality of life in the following three domains; (i) psychological health, (ii) relational and (iii) environmental quality of life. They concluded by accepting their hypothesis in that people did indeed experience lower quality of life in the aforementioned three domains if they resided in areas with higher population density. They marked that their findings were in line with Cramer et al.'s (2004) study in that lower population density does increase subjective quality of life (through higher number of friends and a reduction in negative life events).

When it comes to smaller residential areas or neighbourhoods, the relationship between population density and quality of life is not as clear cut. Walton, Murray and Thomas (2008) tested the aforementioned by making use of various sizes of neighbourhoods in Auckland, New Zealand. The purpose was to see whether there was any effect on perceived environmental[8] quality of life (one of the main four domains). The study was conducted by the completion of surveys which were mailed out to participants. Unfortunately, the authors had a very low response rate of 26 per cent (1998 surveys were posted) but they concluded that population density had no significant effect on residential satisfaction, environmental quality of life nor affected the intention/desire to relocate. Walton et al.(2008) concluded that they did not support Cramer et al.'s (2004) finding of higher population density translating into more negative life events and a decrease in perceived neighbourhood quality.

Glaeser and Shapiro (2001) as well as Glaeser (2012) used US data to investigate the impact of population density on urban migration which directly impacts on the region's quality of life. They found that there was no one suitable answer; positive agglomeration effects (increasing returns to scale) due to high population density was observed but there were also negative effects for example congestion costs – this could be argued to translate into lower subjective quality of life.

In the following section, we attempt to fill these caveats by (i) constructing an objective non-economic quality of life measure which eliminates the effect of income, (ii) applying this measure to a sub-national level by investigating South Africa's highest populated areas (its eight metropolitan cities) and (iii) provide an insight to the relationship between these two indicators. We do this by using

[8] Due to a lack of environmental variables in our data set we were unable to test the effect of environmental factors on non-economic quality of life, though this is a very important matter that should be addressed in future research.

data that is freely available so as to encourage other comparative sub-national studies.

# 3 Approach

As this study incorporated quite a few techniques, this section is structured as follows; we begin by discussing the proposed method for the creation of our objectively measured true non-economic quality of life (TNEQoL) index. This will be followed by the introduction of i) the general function for testing the relationship between our objectively measured TNEQoL index and population density and ii) a description of the panel data estimation techniques used. This section will conclude with a discussion regarding the validation of our composite index as well as various tests which will be used for robustness of results purposes.

## 3.1 Methodology followed for the composite TNEQoL index

In constructing our TNEQoL index for South Africa's eight metropolitan cities, we follow the method first proposed by McGillivray (2005) where he stated that one could distinguish between economic and non-economic quality of life by extraction, through principal component analysis (PCA), the maximum possible information from various standard national non-economic quality of life indicators[9]. When applied in this context, non-economic quality of life indicators refers to those indicators other than direct measures of income. The variation not accounted for by per capita income was defined as $\mu_i$, and was defined as the residual yielded by cross-country regression of the extraction on the natural log of Purchasing Power Parity (PPP) GDP per capita. Thus, $\mu_i$ can be interpreted as a measure of non-economic quality of life as it measures quality of life achieved independently of income.

Subsequently, this methodology has been utilised by Rossouw and Naudé (2008) where two separate non-economic quality of life indices were constructed on a sub-national level for South Africa's 354 magisterial districts for 1996-2004, Naudé, Krugell and Rossouw (2009) where a non-economic quality of life measure was constructed for South Africa's then six metropolitan areas spanning the years 2001-2004, Rossouw and Pacheco (2012) where two non-economic quality of life indices were constructed on a regional level for New Zealand covering the period 1986-2006 and Pacheco, Rossouw and Lewer (2013) where two non-economic quality of life indices were applied in conjunction with other independent welfare measures to an extended gravity model of immigration for 16

[9] McGillivray (2005) uses a method explained in the Handbook on Constructing Composite Indicators (OECD 2008) to construct the initial composite index of non-economic quality of life, to be used in further analyses, by applying PCA and saving the first extracted principal component which represents a weighted summary index of the original indicators.

Organization for Economic Cooperation and Development (OECD) destination countries for the period 1991 to 2000.

Thus, following this acclaimed method, we first make use of PCA in order to obtain a single composite non-economic quality of life index. Second, we take this composite summary index and run a regression against the natural log of per capita income. Lastly, we save the residual, $\mu_i$ from this regression and interpret it as what we coin objectively measured *true non-economic quality of life* (TNEQoL), as this residual contains the variation in the regression not explained by per capita income.

The regression that we run on the composite summary index against the natural log of per capita income can be expressed as follows:

$$Q_{it} = \alpha + \beta \ln y_{it} + \mu_{it} \tag{1}$$

Where $Q_{it}$ is the composite summary index of non-economic quality of life in metropolitan area $i$ in period $t$ (t= 1996 to 2014); and $ln\ y_{it}$ is the natural log of per capita income in metropolitan area $i$ in period $t$, with $\mu_{it}$ the residual term. This residual term is the indicator we utilise to identify and specify our objectively measured true non-economic quality of life index.

To test the validity of the newly constructed TNEQoL index we correlate it with other single indicators for non-economic quality of life available from the data set. If our composite index is correlated to these single indicators, it is assumed that it is a valid measure of objective, true non-economic quality of life. These results will be discussed in section 5.2. The reader should note here, that concurrent with the construction of our own index of objectively measured true non-economic quality of life we also construct a second composite index based on the variables used by McGillivray (2005), which includes life expectancy at birth, adult literacy rate and the school enrolment rate. The McGillivray index is purely constructed for the purpose of testing the robustness of our regression results. We also run all regression against adult literacy rate (dependent variable) as an additional robustness test. These supplementary tests and regression results can be found in appendix A.

## 3.2 The model

As the main purpose of this paper is to determine the relationship between objectively measured true non-economic quality of life and population density for South Africa's eight metropolitan cities, the above compilation of the TNEQoL index was considered step 1. After the compilation of our index, the following general function was estimated in order to analyse this relationship, which is then seen as step 2:

$$TNEQoL_{it} = \beta_1 Log(PD)_{it} + \beta_k X_{it} + \mu_{it} \tag{2}$$

Where $TNEQoL_{it}$ is the dependent variable (DV), with $i$ being the entity (metropolitan city) and $t$ being time (1996-2014). With $\beta_1$ the estimated coefficient of the population density variable of each metropolitan city and $X_{it}$ is a vector of control variables that includes time variant demographic and socio-economic variables at the metropolitan city level, $\beta_k$ is the estimated coefficients for the control variables and $\mu_{it}$ is the error term.

To estimate the specified model in equation (2) panel data analysis was utilised. Panel data estimation has the advantage over cross sectional analysis in that it controls for endogeneity arising from *unobserved heterogeneity*[10] *(omitted variable bias)*, which is often present in the estimation of quality of life regressions (Baltagi 2008). Through using panel data techniques the time dimension within the metropolitan cities is exploited while controlling for the unobserved time-invariant individual heterogeneity of the metropolitan cities. Consequently, both Random Effects (RE) and Fixed Effects (FE) models[11] were estimated for the dependent variable. The Hausman test revealed the FE method to be the most appropriate technique to estimate the specified model. Thus, we report on both the RE and FE results but only interpret those results obtained by the FE regression.[12] The findings from this part of the analysis are presented in section 5. 2.

Although the problem associated with endogeneity arising from *unobserved heterogeneity* might be addressed by panel data analysis, the endogeneity that results from *simultaneity (reverse causality)* still needs attention. Simultaneity can be solved by using the Instrumental Variable Regression (IVR) method in which a variable to instrument the endogenous variable is introduced (Husain, Dutta and Chowdhary 2014). Since population density has the potential to suffer from simultaneity (Rosen 1979) in regards to non-economic quality of life, implying that higher levels of non-economic quality of life can lead to increased population density, we used IVR with two stage least squares (2SLS) estimation to address this problem. To find an adequate instrument, thus a variable that is exogenous, that is uncorrelated with the error term of the estimated regression equation, and sufficiently strongly correlated with the endogenous variable was a challenge and the options of variables to instrument population density were limited. We considered multiple options in our pursuit to find the best available instrumental variable for our study. Following the work done by Iverson and Cook (2000)[13], in which they used the number of households as a proxy for pop-

[10]Heterogeneity is the likelihood that there are important independent variables that are not included in a regression model but which are correlated with the dependent variable.

[11]Panel data analysis can be divided into FE and RE methods. The FE method is designed to study the causes of changes within an entity such as a metropolitan city. The model estimates change in the dependent variable from changes in the independent variables (within group variation) and removes estimates of any variables that are time invariant being either observed or unobserved. In this manner the FE model, in particular, deals with unobserved heterogeneity. The main limitation of the FE method is that it can only incorporate the effect of variables that change over time, such as population density or the GDP per region, and not variables that are time invariant. Time invariant variables, however, can be estimated using RE techniques, as it uses both within group and between group variation.

[12]We ran diagnostic tests for homoscedasticity and autocorrelation. To address heteroscedasticity, we made use of robust standard error estimations. No autocorrelation was detected. To test for multicollinearity we correlated all independent variables and found no correlation of more than 0.3.

[13]The relationship between population density and number of households in a geographical

ulation density we selected the variable '*number of households per metropolitan city*' as our instrument. Since we used the natural log of population density in our original estimated regression we also transform the '*number of households*' variable in the same manner. We found that the '*number of households*' variable was strongly correlated with the population density variable ($r = 0.90$) and, not the optimal uncorrelated relationship, but weakly correlated with the TNEQoL index ($r =$-0.19).

We once again remind the reader, that we tested the robustness of our results by running all regressions using the McGillivray (2005) constructed composite index and adult literacy rate as dependent variables (see these results in appendix A). We compare the results to those obtained from our own TNEQoL index. In the event of these results being similar we accept our results to be robust.

# 4 Data and variables

The data used for the analyses were obtained from IHS' Regional Economic Focus (REF) (see http://www.ihsglobalinsight.co.za) and is from their Regional eXplorer (ReX) database. ReX is compiled by combining various sources of subnational information from for example; Statistics South Africa, South African Reserve Bank, South African Revenue Service, Council for Scientific and Industrial Research etc.

## 4.1 Data

South Africa is compiled out of areas known as municipalities. These municipalities can be divided into three distinct groups namely; local municipalities, district municipalities and metropolitan municipalities. The demarcation of these municipality boundaries were changed by the Municipal Demarcation Board of South Africa (MDB) (MDB, 2016) three times since and including the year 2000 (the demarcation were also changed in 2006 and 2011) which could make the analysis of municipal data over time challenging. A unique feature of the ReX database is the inclusion of these changes in the demarcation of municipalities and its ability to adjust the data accordingly. This study uses a data set which has been adjusted for the 2011 demarcation boundary changes, thereby ensuring data for different years are directly comparable on a geographical basis. According to the 2011 boundary demarcations there were 226 local-, 44 district- and eight metropolitan municipalities. These eight metropolitan municipalities are the focus of our research and we compiled a panel data set for these municipalities by appending data for the years 1996 to 2014. It is a balanced panel data set with a total number of 152 observations.

region was also highlighted in among other Beckmann (1969), Cardillo, et al. (2004) and Carlino and Mills (1987).

## 4.2 Variables included in the TNEQoL Index

As discussed in section 3.1 we construct an objectively measured true non-economic quality of life index and we interpret this as such since it is independent of per capita income (economic quality of life). Through the selection of variables in compiling this index, we were led by McGillivray (2005) and then Naudé, Krugell and Rossouw (2009), as they modified McGillivray's model to reflect the qualities representative of South Africa. We therefore included the ratio of the population over the age of 75 years as a sign of longevity and thus a suitable proxy for life expectancy, adult literacy rate and a variable coined 'equal', which is defined as '1 − the Gini coefficient'. The Gini coefficient is a measure of income distribution for a country's residents. The number ranges between zero and one, with zero representing perfect equality and one perfect inequality. As regards to our variable 'equal' (1-the Gini coefficient) a value of zero implies perfect inequality and one perfect equality. The selection of this last measure (equal) reflects the importance of income distribution's effect on quality of life (Kanbur and Venables 2005). South Africa is classified as the fourth most unequal country in terms of income distribution, therefore the 'equal' variable is a very relevant indicator to be included in any South African specific non-economic quality of life study.

Table 1 shows the descriptions, sources and descriptive statistics across the eight metropolitan cities for the selected variables included in our TNEQoL index. As an added measure, to test the validity of our TNEQoL index we correlate it with other single standard measures of non-economic quality of life. Selecting these standard indicators proved to be somewhat problematic since we were left with a limited number of variables pertaining to non-economic quality of life available in the data set, as many of these indicators were already part of the composite index. The single standard measures available for this purpose were HIV (proxy for health), the proportion of the population with no-schooling (an education measure) and the proportion of households that reside in formal housing (a measure of type of housing).

## 4.3 Control variables

The variables included in the regression analysis as specified in equation (2) was gleamed from various development and quality of life literature (see section 2.3) as well as the availability of data. Table 2 provides a summary as regards to the description, source, means, distributions and the minimum and maximum values covering the period 1996 to 2014 for the selected independent variables used in the regression analysis as specified in equation (2) (see section 3.1)

We transformed population density (our variable of interest) by using its natural log so as to improve the distribution of the variable and to improve the fit of the model. The control variables included in the regression are: the natural log of GDP, the Gini coefficient (Kanbur and Venables 2005), the standardised crime index (see Carnahan, Gove and Galle 1974), the HIV rate (see Worthington and Krentz 2005 and Ellis, Smit, and Laubscher 2006), the poverty rate (see Diener and Diener 1995), the unemployment rate, the proportion of people that successfully completed matric (highest level of high school) and the proportion of people residing in formal housing (see Zakerhaghighi, Khanian and Gheitarani 2015 and Richards, O'Leary and Mutsonziwa 2007). We ran all diagnostic tests and found an absence of multicollinearity and autocorrelation. In order to address heteroscedasticity, we made use of robust standard error estimations

# 5 Results

## 5.1 Principal Component Analysis

In order to compile our composite non-economic quality of life index, PCA was applied and the first principal component extracted:

$$Q = a_1 Life\ expectancy + a_1 Adult\ literacy\ rate + a_1 1 - Gini\ coefficient \quad (3)$$

Where $Q$ (the first extracted principal component) represents the non-economic quality of life index as determined by the specified proxies and $a_1$ represents the factor loading for the $1^{st}$ principal component and the $n_{th}$ variable.

The standard method when applying PCA in constructing composite indices is to use the factor loadings ($a_1$) of the indicators on the first extracted component to weight the index (Klasen 2000). For the $Q$ index from equation (3), it was found that the first extracted component explained 57 per cent (Eigenvalue = 1.59) of the variance in the data. It is deemed an acceptable level of explained variance, especially if we take into consideration other comparative studies such as Vyas and Kumaranayake (2006); Rossouw and Naudé (2008); Naudé et al. (2009) and Rossouw and Pacheco (2012).

After the $Q$ index was constructed based on the first extracted component, the regression against the natural log of per capita income was conducted:

$$Q_{it} = \alpha + \beta \ln y_{it} + \mu_{it} \quad (4)$$

The residual term derived from equation (4) is now that which we coin as objectively measured *true non-economic quality of life* (TNEQoL) as it reflects quality of life independently achieved from income.

In order to test the validity of our derived residual, TNEQoL, we correlate it with the other standard single measures for non-economic quality of life namely HIV, proportion of people with no-schooling and formal housing as explained in section 4.2. As can be seen from table 3, we found that the standard single measures for non-economic quality of life were statistically significantly correlated to our composite index with the expected signs of correlation. In light of these results we are confident that our newly constructed index is a valid reflection of objectively measured true non-economic quality of life in South Africa.

In table 4 we report the rankings of South Africa's eight metropolitan cities according to the TNEQoL. As an added measure we compare our measure with two other well-known economic measures of quality of life, HDI and per capita income for each of these metropolitan cities.

What is interesting to note from the above table is that our objectively measured TNEQoL indicator as well as the other two economic quality of life measures tend to group metropolitan cities in the middle ranking similar. However, this is not the case for cities with extreme rankings as can be seen in the difference computed between the income per capita and the TNEQoL rank order (column 6). Cities with relatively high (City of Johannesburg, the City of Tshwane and Ekurhuleni) and low levels of per capita income (Nelson Mandela Bay) are ranked in reversed order when compared to the TNEQoL rankings. The big difference in the ranking order of the City of Johannesburg (2-7=-5), the City of Tshwane (1-6=-5) and Ekurhuleni (4-8=-4) shows that these cities do not translate high levels of per capita income into high levels of non-economic quality of life (the difference in ranking orders are high and negative). This clearly confirms what we already know from the theory in that, economic quality of life does not necessarily *translate into* non-economic quality of life. Furthermore, these results ratify the importance of measuring non-economic quality of life independent from income, as only then can we get a true measure of the impact of policy.

One should note that although the average income per capita might be relatively high in these cities it gives no indication of the distribution of income. Cities such as Johannesburg and Tshwane have areas with very high income earners, but also slum areas in which poverty is rife. In Johannesburg 19 per cent and in Tshwane 20 per cent of their residents stay in informal housing characteristic of slum areas (IHS Regional Economic Explorer 2014). In these slum areas people have limited access to water, electricity, plumbing, food and work (Davis 2003). These factors contribute to lower levels of non-economic quality of life. Furthermore, as has been shown in the literature (Clark and Kahn 1988), higher population density, which is positively correlated to per capita income, also have drawbacks other than large slum areas, such as pollution, crime, congestion, noise, stressful commutes and expensive housing (disamenities).

## 5.2 Regression analysis

We ran all regressions using both RE and FE methods and in order to determine the preferred method of estimation we used the Hausman test as a signal. The null hypothesis of the Hausman test stating that the difference in coefficients is not systematic was rejected (*chi-square (9)* = 232.24, $p$=0.00), indicating that the FE estimation is the preferred method. We report the RE, FE and the FE with standardised coefficients in table 5, although we only interpret the FE and the FE with standardised coefficients.

Assuming endogeneity in the model we tested the hypothesis that population density is exogenous with the null hypothesis stating that an OLS estimator of the same equation as an IVR would yield consistent estimates. A rejection of the null hypothesis indicates that the endogenous regressors' effects on the estimates are meaningful, and instrumental variable techniques are required.

After conducting the IVR and running the post estimation tests the Davidson-MacKinnon test of exogeneity indicated that the null hypothesis could not be rejected (*P-value* = 0.20) and therefore we conclude that population density is not endogenous. In order to test the strength of the instrument, we used the Cragg-Donald Wald F statistic (397.826) which was greater than the Stock Yogo's weak ID critical value at 10 per cent[14] of 16.38. This allowed us to conclude that the instrument is strong and valid. Based on these test results, we determined that simultaneity was not present in the model and therefore we interpreted the results of the FE without considering the IVR (2SLS) results, however the estimation results of the IVR (2SLS) pertaining to TNEQoL are reported in table 5.

According to the reported FE estimation results (table 5), population density (our variable of interest) is negatively related to TNEQoL and statistically significant at the 0.1 per cent level. We also tested a quadratic relationship between population density and TNEQoL, but found it to be statistically not significant in this sample and thus we refrained from including this in the final estimation.

Our results are in line with those of Fassio, Rollero and De Piccolli (2013), Glaeser and Shapiro (2001), Glaeser (2012) and Walton, Murray and Thomas (2008) that studied the related topic of the effect of population density on subjectively measured quality of life and found a negative relationship, but our results contradict the findings of Cramer, Torgersen and Kringlen (2004). The FE estimation results indicate that population density has an elasticity of -0.68 suggesting that a 1 per cent increase in population density will on average, *ceteris paribus*, result in 0.0068 units decrease in the level of non-economic quality of life. Seeing that non-economic quality of life is measured on a scale from zero to one, it is a significant influence. Furthermore, considering the standardised coefficient estimations of the FE model we find that the natural log of population density, compared to the other independent variables, has the largest coefficient (-3.156), though one must remember that this variable is transformed and not population density in itself. This implies, that one cannot ignore the impact of population density on non-economic quality of life.

More important than the unit number effect of population density on non-economic quality of life is the fact that the relationship is negative. This infers that as population density increases, a negative impact on non-economic quality of life for the residents in metropolitan cities in South Africa will be experienced and agrees with the findings in the literature on the relationship between subjective measures of quality of life and population density (Cramer et al. 2004; Fassio, Rollero and De Piccolli 2013; Glaeser and Shapiro 2001; Glaeser 2012; Walton, Murray and Thomas 2008). Non-economic quality of life indicators such as education, health, service delivery, the availability of formal housing and pollution therefore are negatively affected by increased population density and outweighs any positive effects of agglomeration such as increasing returns to scale, access to better employment opportunities, wider range of goods and

[14] Accepted level of distortion.

services or increased recreational/educational services.

These aforementioned conclusions are supported by Winsborough (1965) as he alluded to the negative social consequences from higher than desired population density. Winsborough (1965) investigated the effects of an increasing population density in 75 Community Areas in Chicago and found that the well-being of the population was deleteriously affected seeing as the infant mortality rate; tuberculosis infection rate; overall public assistance rate and public assistance rate to persons younger than 18 years of age were all positively correlated; i.e. the higher population density, the higher these rates. Lastly, Sirgy (2012) investigated the residential population quality of life and found that there was a negative relationship between quality of life and population density as higher population density gave rise to more negative life events being experienced; i.e. higher criminal as well as non-criminal activities.

Based on the results of the endogeneity test there exists no reversed causality between population density and non-economic quality of life, thus there is no *feedback effect* and in this model we can assume that the causality flows from population density to non-economic quality of life. The causality between population density and non-economic quality of life has not previously been tested and these results contribute to the exiting literature as it improves our understanding of this unique relationship. These findings are highly applicable to any future policy intervention directed at improving non-economic quality of life for people in metropolitan cities. We can now state with confidence that population density itself should be targeted as lower levels will improve other domains necessary for sustaining better non-economic quality of life. These could include easier access to health and educational infrastructure through lower competition for these vital amenities, decreasing levels of pollution, congestion and a lower crime rate.

As regards to the control variables: the natural log of GDP, Gini coefficient, crime rate, HIV prevalence rate, poverty rate, unemployment rate, and the formal housing rate were all statistically significant at either the 0.1 per cent or 1 per cent level with the expected signs. Education rate (proportion of people with grade 12) was statistically significant at the 5 per cent level according to the results of the FE model Interestingly here, it revealed a negative sign. This indicates that if a higher proportion of all people have matric (grade 12 which is the highest level of high school education in South Africa) non-economic quality of life will decrease. This might reflect the lack of employment opportunities for people who have matric, which might include a big proportion of the youth. According to the expanded definition, the unemployment rate for the youth (younger than 25) is at 63.1 per cent, thereby making South Africa one of the countries with the highest rate of youth unemployment (StatsSA, 2015). The high rate of unemployment contributes too much of the social tension and anguish experienced in South Africa, especially amongst the youth. Previous research conducted by Greyling and Tregenna (2016) and Greyling (2015) found similar results related to the South African scenario with education either being statistically insignificant or negatively related to quality of life in South Africa. One could argue that people with only a grade 12 education level does not have the relevant skillset to ensure them employment, therefore it is likely that they stay at home in less than desirable surroundings. Increasing employment opportunities should be high on the policy agenda of South Africa.

The impact of GDP on non-economic quality of life is not surprising as without higher levels of production of goods and services, which in turn leads to higher levels of employment, higher levels of income, greater access to better housing, health and education and services, there can be no extra monetary resources to accomplish the aforementioned benefits.

From the standardised estimation results of the FE model it seems that the Gini coefficient - and the HIV variables, relative to the other independent variables have the largest coefficients (-.353 and 0.342, respectively), not considering the natural logged variables (population density and GDP). This indicates that these variables are important factors in examining non-economic quality of life for people residing in South Africa's metropolitan cities. These two variables are very distinct to the South African scenario. The importance of the Gini coefficient emphasises the important role an unequal distribution of income plays on peoples' non-economic quality of life. According to Rowlingson (2011) income inequality is detrimental to the economy as it creates both social and health related problems. People are ranked according to a hierarchical system coupled to their level of income and this in turn creates pressure manifesting as stress and anxiety to the 'have nots'. This is in stark contrast to previous believes in that income inequality does not act as an incentive to work harder but rather discourages people from seeking employment and thereby decreasing their perceived quality of life.

These results also emphasise the unique role of HIV in South Africa, because of its high prevalence rate. HIV and AIDS has a synergistic relationship with Tuberculosis, maternal- and child- morbidity and mortality rates. Globally, South Africa has the largest number of people living with HIV and AIDS, with approximately 6.4 million (12.8 per cent of total population) infected with the disease in 2015 (StatsSA 2015). HIV does not only affect the non-economic quality of life of the people suffering from HIV but also their wider support system consisting out of family, friends and health professionals. The limited life expectancy of HIV sufferers has dire consequences for households. If the parents pass away the households are often headed by children with limited access to income, health or education services.

# 6 Conclusions and recommendations

The main aims of this paper have been to i) develop a composite index to measure non-economic quality of life within the eight metropolitan areas in South Africa and ii) to estimate the relationship between this measure of non-economic quality of life and population density.

The importance of this study lies in understanding that quality of life is a multidimensional concept encompassing both economic and non-economic components. If policy makers on behalf of the people are driven by the achievement of a higher standard of living and well-being, understanding and analysing the determinants of quality of life over a population, society or region seems a necessary condition to understand human behaviour.

Worldwide the phenomenon of 'urban resurgence' is taking place which shows that many urban areas are experiencing a massive influx of internal migrants (Glaeser and Gottlieb 2006). This higher population density can be seen as beneficial for growth, as it allows specialisation, increasing returns to scale and positive externalities. This will ultimately lead to greater productivity, greater incomes and higher levels of quality of life. Whilst acknowledging the advantages of population density, new evidence tends to suggest that increasing returns to scale is not always the outcome or result of higher population densities. More importantly, increases in productivity and therefore higher incomes are not always translated into better quality of life as this phenomenon can create various disamenities (Glaeser and Gottlieb 2006).

Most of the research to date pertaining to the relationship between quality of life and population density have been (i) subjective in nature or (ii) objective but in these studies a measure of income was included and we know because of the work done by McGillivray (1991) that any of these quality of life measures is deemed 'redundant' as the income component will dominate. Research has also mainly focused on relatively small samples, not on a wider sub-national level and these studies were conducted primarily in developed countries.

In this study, our main contributions have been to (i) construct an index for South Africa's eight metropolitan cities that objectively measures non-economic quality of life (see McGillivray, 2005); (ii) to investigate the relationship between non-economic quality of life and population density on this sub-national level; (iii) utilise panel data modelling techniques, not previously used in this area of research, which controls for unobserved heterogeneity; (iv) utilise panel data as it has the additional advantage that by testing for endogeneity that spreads from simultaneity the causal relationship between population density and non-economic quality of life can be determined and lastly (v) conduct research on the aforementioned relationship in a developing country (South Africa) since the majority of studies found were conducted in developed countries. We found the following:

When we investigated non-economic quality of life as a whole we found that our composite index ranked the eight metropolitan cities different than those obtained from the HDI and GDP per capita measures. Metropolitans with relatively high levels of economic quality of life such as the City of Johannesburg's and the City of Tshwane's ranking changed compared to those obtained through our objectively measured TNEQoL index. The City of Johannesburg and the City of Tshwane were found to be almost at the bottom according to our non-economic quality of life rankings. This indicated that economic quality of life does not necessarily translate into non-economic quality of life. Evidence of this can be seen in both the Cities of Johannesburg and Tshwane which have large slum areas and high poverty rates. In the City of Johannesburg 19 per cent and in the City of Tshwane 20 per cent of their residents stay in informal housing which is characteristic of slum populations (IHS Regional Economic Explorer 2014). In these slum areas people have limited access to water, electricity, plumbing, food and employment opportunities (Davis 2003). These factors all contribute to lower levels of non-economic quality of life.

The regression analysis between population density and our objectively measured TNEQoL index revealed the following: first and most importantly, population density is negatively related to objective non-economic quality of life and statistically significant at the 1 per cent level. No evidence of reversed causality between population density and non-economic quality of life was found suggesting the causality flows from population density to non-economic quality of life. The causality between population density and non-economic quality of life has not previously been tested and this result contributes further to our understanding of this unique relationship. The implication of these findings strongly suggests that future policy makers have to take into account that changes to population density, as a direct result of policy changes, will have an impact on non-economic quality of life.

Second, the control variables used in our regression analysis were all statistically significant at either the 1 or 5 per cent level. The variables with the expected signs were: the natural log of GDP, Gini coefficient, crime rate, HIV prevalence rate, poverty rate, unemployment rate and the formal housing rate. From the standardised estimation results of the FE model it was found that the Gini coefficient - and the HIV variables had the largest coefficients, relative to other estimated coefficients and therefore the largest impact on South Africa's non-economic quality of life. These two variables are very distinct to the South African scenario as South Africa is classified as the fourth worst country in terms of income inequality and the country with the highest number of people living with HIV (StatsSA 2015).

Interestingly, the education rate (proportion of people with grade 12) revealed a negative relationship to non-economic quality of life This indicates that if a higher proportion of all people have matric (grade 12 which is the highest level of high school education) non-economic quality of life will decrease. We explain this with the rationale that a matric education level is not sufficient to ensure people employment, therefore it is likely that they stay at home in less than desirable surroundings and experience a lower perceived quality of life.

These findings have significant implications for policy formulation as it states in the South African Constitution that the aim of the South African Government is to improve the quality of life for all people in the country (RSA 1996). A concerted effort should be made to address the push factors that lead to internal migration thereby uplifting and developing non-urban and rural areas. Furthermore, for those people living in densely populated areas the emphasis should be on improving amenities such as better access to education, employment opportunities, health, service delivery and housing.

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**Table 1: Selected variables**

| Variable | Description | Source | Mean | Stand. dev | Min | Max |
|---|---|---|---|---|---|---|
| Over 75 years of age rate | Proportion of people over 75 years of age | Census data from StatsSA | 0.015 | 0.003 | 0.009 | 0.023 |
| Adult literacy rate | The proportion of people over the age of 15 who have a functional ability of reading and writing. | Census data from StatsSA | 0.84 | 0.06 | 0.74 | 0.92 |
| Equal | 1-Gini coefficient | Authors' own calculation based on ReX | 0.37 | 0.021 | 0.34 | 0.45 |
| HIV | HIV prevalence rate | Mortality and causes of death data from. StatsSA | 0.08 | 0.03 | 0.01 | 0.15 |
| Proportion of population with no schooling | Proportion of the population that has no schooling | Census data from StatsSA | 0.04 | 0.02 | 0.01 | 0.07 |
| Formal housing | Proportion of people residing in formal housing | Census data from StatsSA | 0.76 | 0.05 | 0.64 | 0.88 |

Source: IHS Regional Economic Explorer 2014.
Notes: Stand. dev = standard deviation.

**Table 2: Summary statistics for the independent variables**

| Variable name | Description | Source | Mean | Stand. dev | Min | Max |
|---|---|---|---|---|---|---|
| Population density | Number of people per square kilometre of land area | Census data from StatsSA | 964.53 | 707.53 | 100.41 | 2904.27 |
| GDP | Nominal GDP per metropolitan area | Gross Domestic Product Data from StatsSA | 131 million | 115 million | 108 million | 561 million |
| Gini coefficient | Distribution of income among the population | Regional Economic Focus Data from IHS | 0.63 | 0.02 | 0.55 | 0.66 |
| Crime | Standardised Crime Rate | South African Police Service data | 0.51 | 0.25 | 0 | 1.00 |
| HIV rate | HIV prevalence rate | Mortality and causes of death data from. StatsSA | 0.08 | 0.03 | 0.01 | 0.15 |
| Poverty rate | Proportion of people living under the upper bound poverty line. | Census data from StatsSA | 0.46 | 0.09 | 0.29 | 0.66 |
| Unemployment rate | Proportion of people unemployed | Census data from StatsSA | 0.23 | 0.04 | 0.14 | 0.32 |
| Education matric rate | Proportion of the population that has successfully completed matric/grade 12 | Census data from StatsSA | 0.18 | 0.03 | 0.11 | 0.23 |
| Formal housing rate | Proportion of people residing in formal housing | Census data from StatsSA | 0.76 | 0.05 | 0.64 | 0.88 |

Source: IHS Regional Economic Explorer 2014.

**Table 3: Pearson Correlation coefficients between selected indicators and TNEQoL**

| Indicators | TNEQoL | HIV | Proportion of Population with no schooling | Formal Housing |
|---|---|---|---|---|
| TNEQoL | 1.00 | | | |
| HIV | -0.35*** | 1.00 | | |
| Proportion of population with no schooling | -0.49*** | -0.35** | 1.00 | |
| Formal Housing | 0.53*** | 0.03 | -0.62*** | 1.00 |

Source: Authors' own calculation using data derived from IHS Regional Economic Explorer 2014.

Note: ***Indicates significance at 0.1 % confidence level, **indicates significance at 1 % confidence level and * indicates significance at 5 per cent confidence level.

**Table 4: Rankings according to TNEQoL Index, HDI and per capita income**

| Metropolitan city | TNEQoL | HDI | Income per capita | Income per capita (rank) – TNEQoL (rank) |
|---|---|---|---|---|
| 1. Cape Town | 0.696(1) | 0.691(1) | 41 824.74(3) | 2 |
| 2. EThekwini | 0.364(4) | 0.596(6) | 30 312.24(5) | 1 |
| 3. Ekurhuleni | 0.148(8) | 0.66(4) | 38 562.20(4) | -4 |
| 4. City of Johannesburg | 0.211(7) | 0.686(2) | 47 543.42(2) | -5 |
| 5. Nelson Mandela Bay | 0.613(2) | 0.62(5) | 29 918.82(6) | 4 |
| 6. City of Tshwane | 0.301(6) | 0.682(3) | 48 560.06(1) | -5 |
| 7. Mangaung | 0.341(5) | 0.595(7) | 29 572.63(7) | 2 |
| 8. Buffalo City | 0.387(3) | 0.591(8) | 25 552.12(8) | 5 |

Source: Authors' own calculation using data derived from IHS Regional Economic Explorer, 2014. Numbers in brackets indicate the rank of the metropolitan city according to the specific indicator.

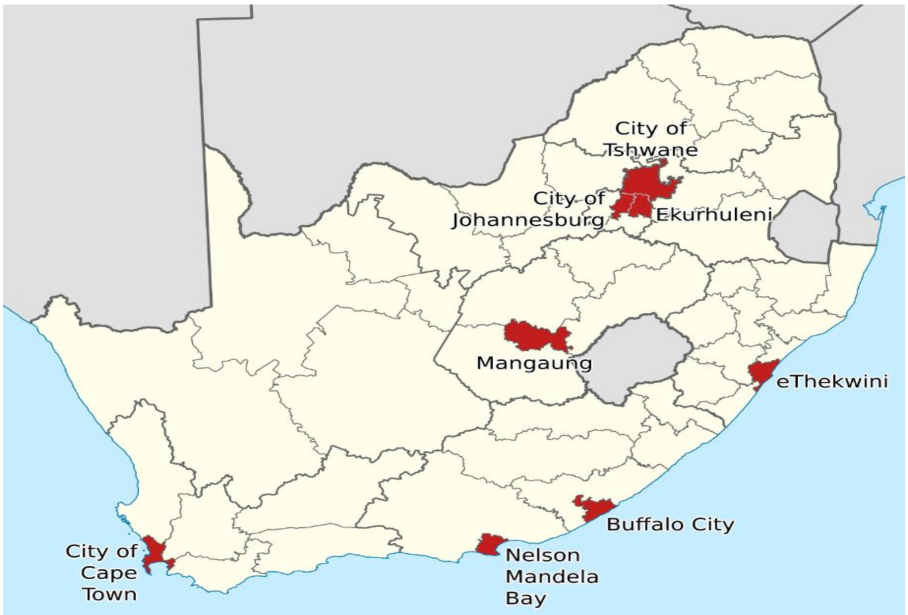
**Table 5: Estimation results with TNEQoL as the dependent variable**

| Variable | RE | FE | FE(Std) | IVR(2SLS) |
|---|---|---|---|---|
| LnPopulation density | -0.754* | -0.680*** | -3.136*** | -0.601** |
| SE | (0.03) | (0.11) | (0.49) | (0.12) |
| LnGDP | -0.182** | 0.282*** | 1.324*** | 0.253** |
| SE | (0.06) | (0.05) | (0.23) | (0.05) |
| Gini coefficient | -3.469** | -3.463*** | -0.353*** | -3.446** |
| SE | (1.08) | (0.51) | (0.05) | (0.51) |
| Crime rate | 0.069 | -0.064** | -0.119** | -0.057* |
| SE | (0.04) | (0.02) | (0.04) | (0.02) |
| HIV rate | -3.695*** | -2.072*** | -.342*** | -1.924** |
| SE | (0.77) | (0.50) | (0.08) | (0.51) |
| Poverty rate | 1.724*** | -0.653** | -.289** | -0.741** |
| SE | (0.45) | (0.20) | (0.09) | (0.21) |
| Unemployment rate | -1.230** | -0.312 | -0.056 | -0.331* |
| SE | (0.45) | (0.16) | (0.03) | (0.16) |
| Education matric rate | -2.237 | -1.539* | -.245* | -1.426* |
| SE | (1.17) | (0.63) | (0.10) | (0.64) |
| Formal housing rate | -1.372*** | 0.415** | 0.202** | 0.388** |
| | (0.23) | (0.14) | (0.07) | (0.14) |
| Constant | 7.468*** | 2.597*** | 2.83e-09 | 2.624*** |
| SE | (0.94) | (0.48) | (.01) | (0.48) |
| N | 152 | 152 | 152 | 152 |
| R-sq. within | 0.6395 | 0.8960 | 0.8960 | 0.8951 |
| F/ Wald $Chi^2$ | Chi2(9) =251.86 | F(9.135)=129.28 | F(9.135)=129.28 | Chi2(9) = 421.74 |
| Probability | 0.000 | 0.000 | 0.000 | 0.000 |

Source: Authors' own calculation using data derived from IHS Regional Economic Explorer 2014.

Note: ***Indicates significance at 0.1 % confidence level, **indicates significance at 1 % confidence level and * indicates significance at 5% confidence level using two-tailed tests. FE (std) gives the FE estimations of the standardised variables, the mean of the variables is = 0 and the standard deviation =1. Instrument – ln(number of households).

**Figure 1: Location of South Africa's eight metropolitan cities**




Source: Wikimedia commons 2016

**Appendix A**

**Testing the robustness of the estimation results**

In appendix A we include the estimation results as pertaining to Mc Gillivray's TNEQoL index based on the selection of variables used by McGillivray (2005) and adult literacy rate as dependent variables to test the robustness of our regression results in which our own TNEQoL index is the dependent variable (see section 5.2). The regression results using our own TNEQoL index, the McGillivray composite index and adult literacy rate respectively as dependent variables are very similar Therefore, we can conclude that our results are robust.

**Table 6 Estimation results for McGillivray's composite index of TNEQoL**

| Variable | FE | IVR(2SLS) |
|---|---|---|
| LnPopulation density | -0.500*** | -0.166* |
| SE | (0.13) | (0.15) |
| LnGDP | 0.189** | 0.066 |
| SE | (0.06) | (0.07) |
| Gini coefficient | -1.680** | -1.617** |
| SE | (0.61) | (0.63) |
| Crime rate | -0.124*** | -0.093** |
| SE | (0.03) | (0.03) |
| HIV_rate | -0.005 | -0.627 |
| SE | (0.60) | (0.63) |
| Poverty rate | -0.704** | -1.074** |
| SE | (0.24) | (0.26) |
| Unemployment rate | -0.938*** | -1.021** |
| SE | (0.20) | (0.20) |
| Education matric rate | -4.077*** | -3.645** |
| SE | (0.76) | (0.78) |
| Formal housing rate | 0.585*** | 0.469** |
| SE | (0.17) | (0.17) |
| Constant | 2.460 | 2.573 |
| SE | (0.57) | (0.59) |
| N | 152 | 152 |
| R-sq. within | 0.754 | 0.742 |
| F/ Wald $Chi^2$ | F(7.134)=46.04 | Chi2(9) = 10383.20 |
| Probability | 0.000 | 0.000 |

Source: Authors' own calculation using data derived from IHS Regional Economic Explorer 2014.

Note: ***Indicates significance at 0.1 % confidence level, **indicates significance at 1 % confidence level and * indicates significance at 5% confidence level using two-tailed tests. Instrument = ln (number of households).

**Table 7: Estimation results for Adult Literacy Rate as the dependent variable**

| Variable | FE | IVR(2SLS) |
|---|---|---|
| LnPopulation density | -0.083*** | -0.028* |
| SE | (0.01) | (0.02) |
| LnGDP | 0.078*** | 0.057** |
| SE | (0.01) | (0.01) |
| Gini coefficient | -0.208** | -0.197** |
| SE | (0.07) | (0.07) |
| Crime rate | -0.013*** | -0.007* |
| SE | (0.00) | (0.00) |
| HIV_rate | -0.147* | -0.045 |
| SE | (0.07) | (0.07) |
| Poverty rate | -0.109*** | -0.169** |
| SE | (0.03) | (0.03) |
| Unemployment rate | -0.039 | -0.052* |
| SE | (0.02) | (0.02) |
| Education matric rate | -0.020 | 0.050 |
| SE | (0.08) | (0.09) |
| Formal housing rate | 0.112*** | 0.093** |
| SE | (0.02) | (0.02) |
| Constant | 0.150* | 0.168* |
| SE | (0.06) | (0.06) |
| N | 152 | 152 |
| R-sq. within | 0.984 | 0.982 |
| F/ Wald $Chi^2$ | F(9.135)=935.86 | Chi2(9) = 273 |
| Probability | 0.000 | 0.000 |

Source: Authors' own calculation using data derived from IHS Regional Economic Explorer 2014.

Note: ***Indicates significance at .11 % confidence level, **indicates significance at 1 % confidence level and * indicates significance at 5% confidence level using two-tailed tests. Instrument = ln (number of households).