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*Working Paper Series*

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2012/01

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Naudé *et al*. (2009) present an exploration into economic vulnerability from a sub-national, district-level perspective. Their paper is an important and timely contribution because it recognises the heterogeneous nature of vulnerability across areas within a country. However, their analysis is aspatial because they do not explicitly account for the relative locations of or the potential for spillovers between contiguous areas. This paper extends the work of Naudé *et al*. (2009) by i) augmenting their model to take account of spatial contiguity, ii) comparing spatial and aspatial *local vulnerability index* estimates to illustrate the presence and importance of spatial spillovers between contiguous areas, and iii) enhancing their methodology on the *vulnerability intervention index* to present results which highlight areas that are performing better and worse than expected. Application of these methods to South African Magisterial District level data reveals a widening urban-rural vulnerability divide.

**Keywords:** Vulnerability; South Africa

**JEL Classification:** R1; O1

**Acknowledgments**: The authors would like to thank Paul Dunne, Peter Howells and Gail Pacheco for helpful comments on earlier drafts. All errors remain the authors' responsibility.

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## 1. **Introduction**

Economic vulnerability is a multidimensional, multi-faceted concept. Its (re-)definition and (re-)measurement are not new areas of academic interest, but recently there has been a shift in thinking about economic vulnerability associated with the belief that the alleviation of poverty is a prerequisite for the achievement of development goals. In this journal, Naudé, McGillivray and Rossouw (2009) (hereafter NMR) highlighted that most previous measures of vulnerability are potentially biased because they exclude environmental and/or geographical factors. Moreover, they recognised that the growing vulnerability literature has a focus at either the national or household level, which led them to emphasise the need for a characterisation and measurement of vulnerability at the sub-national, area level. They attempted to fill these gaps in the literature by:

i) advocating a method of sub-national vulnerability measurement through the construction of a *Local Vulnerability Index* that includes environmental and geographical factors as integral components and
ii) conditioning their *Local Vulnerability Index* on income per capita to yield a *Vulnerability Intervention Index*.

Though the augmentation of models to include variables pertaining to environmental and geographical factors is significant, a crucial aspect that was not integrated into their analysis is the potential influence on vulnerability of spillovers between areas. Anything that is observed to have a spatial dimension also has the potential to encounter spatial spillovers.[i] Spatial spillovers are features whereby the attributes of an area are influenced by the attributes in nearby or contiguous areas. The *relative* location of an area may be important when considering vulnerability because the population and policy-makers of that area may compare it to other areas that they are most familiar with, and these areas are often ones that are contiguous or close by. An individual's perception of being in poverty, and the importance and selection of alleviating policy, may be a relative concept.

This paper augments the methodology of *NMR* by i) expanding their principal components model to take account of spatial contiguity, that is the physical contact of an area's geographical boundary by another area, ii) comparing spatial and aspatial *Local*

*Vulnerability Indices* to illustrate the importance of spatial spillovers between areas, and iii) extending their *Vulnerability Intervention Index* method and subsequently presenting results which highlight areas that are performing better and worse than expected. Application of these augmented economic vulnerability indices to the same data used by NMR (South African Magisterial District level data) provides us with a platform by which we can compare our results to those generated by NMR and draw conclusions which suggests that the inclusion of a spatial dimension is crucial in ascertaining location-specific economic vulnerability. Not appreciating the impacts of spatial spillovers will potentially bias results and lead to incorrect policy recommendations.

This paper is structured as follows: the next section reviews the literature on vulnerability and critically reviews the content and approach of *NMR*. Section 3 argues that a sub-national perspective on vulnerability should take explicit account of relative location. Section 4 describes the data. Section 5 details augmentations and new results of NMR's model that incorporate spatial and aspatial Local Vulnerability and Vulnerability Intervention Indices. Section 6 provides conclusions.

## 2. Literature review

*Vulnerability origins and the spatial scale of analysis*

The origins of vulnerability transcend the geographical, economic and political. Primary concerns associated with negative events are their impacts on productivity growth, development potential and the extent to which they alter vulnerability (Guillaumont, 2004).[ii] However, before vulnerability can be accurately measured, attention needs to be focused on where potential shocks may arise. Three basic channels of origin can be identified: (i) environmental or natural shocks, such as natural disasters; (ii) other external shocks (trade and exchange related), such as slumps in external demand, and (iii) other (non-environmental) internal shocks, such as political instability (Guillaumont, 2004).

Once the origins of vulnerability have been identified the next stage in any vulnerability empirical analysis is to decide on the appropriate spatial scale. Literature pertaining to the study of vulnerability has focused on three levels of analysis: household, regional and national. A large majority of this literature is devoted to measuring the relative vulnerability of a country.[iii] Turvey (2007) advocates the need for place-specific vulnerability indices and constructed a Composite Vulnerability Index for 100 developing countries out of four sub-indices: a coastal index, a peripherality index, an urbanisation index and a vulnerability to natural disasters index. She argued that if the measurement of vulnerability excludes a geographical component then the construction of vulnerability profiles might be useless for framing development policy and evaluating developing countries.[iv]

Although the majority of analysis has focused on the country-level spatial scale, there are a growing number of articles that examine vulnerability at the household level. For instance, Bird and Prowse (2008) investigated the vulnerability of households in Zimbabwe and found that if official donors did not intervene then the poor and very poor were likely to be driven into long-term chronic poverty and such chronic poverty would be extremely difficult if not impossible to reverse. Gaiha and Imai (2008) also argued that idiosyncratic shocks (e.g. unemployment or illness) were the primary cause of Indian rural households' vulnerability, although poverty and aggregate risks (weather and crops) were also important contributory factors; the last of these is clearly a geographical issue.[v]

Not a lot of attention has been given to the vulnerability of regions within a country. Hulme *et al*. (2001) linked poverty to the vulnerability of specific regions and Kanbur and Venables (2005) showed that not only is spatial inequality between regions on the increase but that it will ultimately cause an overall increase in the inequality of specific countries. Similarly, Ivaschenko and Mete (2008) presented evidence of poverty traps and argued that higher levels of poverty in a region appear to reduce radically the chance of a household emerging out of poverty, and that living in a region with a slow economic growth weakens the odds of a household exiting poverty and increases its risk of slipping into poverty.[vi]

*Naudé, McGillivray and Rossouw's (2009) contribution*

Much development literature still relies on income per capita measures as an indication of development and vulnerability. NMR underscore the shortcomings of focusing only on incomes when assessing vulnerability by stating that "equal incomes do not translate into equal outcomes for all ... (and) different people are faced with different environments for translating income gains into non□income wellbeing gains" (p. 4). An important, though not new, contribution of their study was to emphasise that vulnerability is a multidimensional phenomenon that requires and deserves a multidimensional analysis. It is uplifting to see this underlying multidimensional theoretical perspective being adopted empirically in their subsequent analysis. They constructed a composite index of local vulnerability using principal component analysis (PCA).[vii] The execution of PCA[viii] is thought to reveal the internal structure of the data with each component being ranked in accordance with its importance to the multidimensional phenomena, and with the first component known to capture most of the data's variability.

In line with theoretically-driven multidimensional considerations, NMR proposed the construction of a Local Vulnerability Index (*LVI*) based on ten different and distinct domains,[ix] which are constructed from sub-domains stated in brackets:

1. *Size of local economy* (GDP, population size, population density, urbanisation rate)
2. *International trade capacity* (ratio of exports and imports to local GDP, export diversification)
3. *Development* (HDI, percentage of local population in poverty, unemployment rate)
4. *Demography and health* (incidence of HIV/AIDS, population growth rate)
5. *Environment* (percent degraded land, proportion of forest-covered land and water-bodies, wetlands and rainfall)
6. *Financial system* (number of people per bank branch, ratio of the percentage share of the country's financial sector in a particular area).
7. *Structure of the local economy* (share of primary production in total production)
8. *Peripherality* (distance from the market)
9. *Income volatility* (standard deviation of GDP growth)
10. *Governance* (per capita capital budget expenditure)

It should be emphasised that NMR include both geographical and environmental indicators, which they strongly and correctly suggest are important for economic vulnerability measurement. They applied the following structured method to a data set detailed in our Section 4. Initially, PCAs were run on each of the individual domains that had more than one sub-domain (i.e. domains 1-6). Although it would be possible to appoint different weights to each subsequent component, this would require an appropriate selection of weights. Instead, the principal components of each of the individual domains PCA's results were selected and pooled into a data set that already contained the non-multidimensional individual domains (i.e. domains 7-10). Then a second PCA was estimated on these data and the principal component again chosen for subsequent interpretation; the result is a single principal component used to represent their multidimensional *LVI* from which district ranks and area comparisons can be made. Note that each of NMR's domains are aspatial by construction: each area's estimate does not explicitly consider what is happening in an area's neighbouring areas.

NMR also propose the construction of a Vulnerability Intervention Index (*VII*) that is designed to reflect the vulnerability associated with per capita income, such that:

$$LVI_i = \alpha + \beta Y_i + \mu_i \qquad i = 1, \ldots, 354 \qquad (1)$$

where $\alpha$ is an intercept, $\beta$ is a slope coefficient, $Y$ is per capita income of magisterial district $i$ and $\mu$ is the well-behaved error term. If $\beta$ is equal to one then any change in the *LVI* is a proportional response to the corresponding change in income per capita. Assuming that there are no scale returns disparity issues across areas, estimation of equation (1) leads to a vector of residuals, one for each area, where each individual residual represents the deviation between the actual and the predicted *LVI* based on per capita income. NMR examined the absolute values of these residuals to identify areas which deviate strongly from the average and found that although the *VII* was highly correlated with per capita income (with greater income per capita being associated with lower vulnerability) it was far from being equal to unity; this led them to believe that there were reasons other than achieved incomes that drive vulnerability levels.[x] As far as policy formation is concerned, this belief is in line with the suggestion that any policies aimed at reducing area-level vulnerability should not rely solely on increasing incomes.

## 3. Towards a spatial perspective

As each of NMR's domains are aspatial by construction, their *LVI* and *VII* measures are also aspatial: using the above methods implicitly assumes that relative location is not important. However, the literature emphasises that of crucial importance for vulnerability assessments is the relative location of an area. For instance, Chauvet and Collier (2005) stressed the importance of spatial spillover effects from fragile neighbouring countries and calculated that the negative effects of having fragile neighbours average 1.6 per cent of GDP per annum. Tondl and Vuksic (2003) emphasised the importance of contiguity and spatial dependence at the regional scale by showing that a region's growth is significantly more likely to be higher if it is a neighbour of another high growth region. They estimated that about a fifth of a region's growth is determined by that of surrounding regions. Similarly, Florax and van der Vlist (2003) suggested that it is necessary to include 'neighbourhood' effects in explaining the spatial distribution of indicators related to wages, crime, health and schooling.

Empirical investigations into vulnerability issues will be inefficient if account has not been taken of spatial spillovers. Spatial autocorrelation, that is the degree of dependency among observations in a geographic space, will be an important consideration in any modelling procedure if there are processes operating across space, as exemplified when adjacent observations are not independent of each other. *NMR* are not alone in the lack of recognition of the importance of relative location and spatial autocorrelation. For instance, although Bird *et al*. (2007) emphasise that a location's attributes have a significant influence on poverty traps, it is not simply the attributes of the location in isolation that are important but also the attributes of an area's relative location. A better understanding of how area-specific attributes contribute to the creation and sustainability of place-specific vulnerability is prudent, but it may be superior to improve contemporaneously our understanding of how one area contributes to another area's vulnerability.

One of the clearest expositions of the reasons why spatial autocorrelation in socioeconomic variables can occur has been provided by Voss *et al*. (2006) who emphasised the importance of, amongst other things, *feedback*, *grouping forces* and *grouping responses*. These can be positive or negative and could result in some areas being vulnerability black-spots.

There is the potential for *feedback* forces to influence individuals and households' preferences and activities, willingness to accept greater vulnerability and activities to reduce vulnerability. *Ceteris paribus*, the smaller the spatial scale of analysis then the higher the likelihood and frequency of contact between individuals and the greater the potential feedback between individuals and between policy makers, and often between individuals and policy-makers. Greater similarity in socioeconomic measures and conditions will mean less justification for individuals to perceive that they are relatively more vulnerable. For reasons related to the adoption/diffusion theory (Rodgers, 1962) and the agent interaction theory (Irwin and Bockstael, 2004), we should expect there to be the potential for spatial spillovers in underlying vulnerability dimensions with a positive correlation in dimensions between contiguous areas. For instance, unemployment rates tends to have some degree of imitation across areas correlated with, for example, similarities in the cultural acceptance of being unemployed. Individuals might incorrectly associate unemployment benefits or social grants received for children with more leisure time or freedom from not working and therefore follow suit. This could ultimately increase the vulnerability of the area or group of areas.

Geographically proximate districts with similar socioeconomic attributes and vulnerability dimensions are more conducive to *grouping forces*, such as the formulation of parallel policy initiatives. The clustering of underlying vulnerability dimensions across space might be due to a number of reasons including policy that has been applied to groups of areas or socioeconomic issues that lead to spatial clustering (e.g. high house prices force low income people into other areas, seaports attract international trading activities, etc.). In South Africa, as in various developing countries, there is a serious problem with informal (slum) settlements. Informal settlements are the illegal and unauthorised occupation of private or government owned land and consist of dwellings usually made out of corrugated metal. Typically these informal settlements found on the periphery of large urban areas are established by unemployed, impoverished, illiterate, homeless or illegal migrants who may respond in similar ways to policies due to their socioeconomic circumstances.

Alternatively *grouping responses* can occur where the application of policy is reacted to in similar ways, often due to the spatial clustering of similar socioeconomically characterised individuals. As the people occupying informal settlements share the same plight they tend to assemble and demand ownership of the occupied land as well as the installation of water and refuge systems. If they do not receive what they demand then protests can be organised which may cause damage not only to the reputation of the area but also to public property such as schools, libraries, etc. Such demonstrations could greatly increase the vulnerability of a specific area and its neighbours.

Sub-indices used for the construction of vulnerability indices are particularly likely to possess a spatial dimension. For instance, the size of the local economy domain is based on GDP, population size, population density and urbanisation rate, factors which are likely to have high (low) values in areas that are contiguous to areas also with high (low) values. As a result two important considerations arise: first, if the spatial evolution of socioeconomic attributes is by accident, fate or otherwise, then recognition of such spatial patterns when formulating policy could improve the effectiveness of the policy; second, application of policy designed to alleviated vulnerability should not be focused on one area without contemporaneously and explicitly considering similarities across neighbouring areas. This perspective is supported by Chauvet *et al*. (2007) who argue that since failing regions impose a large cost on their neighbours it is not only required but also justified to have cross-region intervention in decision-making processes.

Policy directed towards reducing vulnerability needs to have a spatial dimension, and can be articulated into two simple groups. First, areas may suffer higher levels of vulnerability because they are distinctly different from other areas, including those areas, which are contiguous. In this case the policy would need to be area-specific and designed to improve the vulnerability of the area in isolation. Second, areas may suffer higher levels of vulnerability *because* they are influenced by spatial spillovers. In this case the appropriate policy would need to be targeted towards not simply the specific area but also the group of contiguous areas.[xi]

In summary, a lack of appreciation of the spatial autocorrelation that is present in sub-domains may result in the under-specification of a model and inefficient vulnerability estimates. Modelling under-specifications and inefficient vulnerability estimates can result in sub-optimal and inappropriate policy formation.

## 4. Data

NMR applied their methodology to South African data. To illustrate the strengths of our methodological developments we apply them to the same data set, which was acquired for all of South Africa's magisterial districts over the period 1996 to 2006.

South Africa is classified as a middle-income country, with a GDP per capita of approximately US$ 5750, an overall GDP of US$ 211.2 billion and an estimated population of over 49 million. She experienced exceptionally high inflows of foreign capital and foreign direct investment after 2003 which assisted in speeding up the process of employment creation; for instance, during the year ending 2005, approximately 540,000 jobs were created. Unemployment remains severe in spite of a considerable drive for further job creation and poverty reduction. In 2008, the OECD's economic assessment (2008, p.1) stated that South Africa is seen as a "*….stable, modern state,* (and) *in many ways* (is) *a model for the rest of the African continent*" but "*there have also been notable weaknesses in* (its) *economic record to date, especially as regards to unemployment, inequality and poverty…HIV/AIDS and crime*". This report views South Africa not as a vulnerable state in the traditional sense but it does recognise the role its strong institutions played in bringing about this result. In the absence of these institutions South Africa could be rendered vulnerable as it is plagued by high unemployment, widening inequality, poverty, AIDS related deaths and a rapid increase in the crime rate. Demombynes and Özler (2005) argued that a direct link exists between this crime rate and the degree of local inequality thereby reinforcing the general consensus of institutions responsibility for implementing policies to eradicate poverty and inequality.[xii]

The Accelerated and Shared Growth Initiative for South Africa (AsgiSA) was formally launched in 2006 to help the South African Government halve poverty and unemployment by 2015. AsgiSA concluded that in order to achieve these social objectives South Africa would need to keep growing at a rate of 5 per cent per annum until 2015 and there should be a concurrent reduction of deficiencies in state organisations, capacity and leadership. AsgiSA launched *Project Consolidate* which was designed to address the skills problems of local government and service delivery. Skills interventions include the deployment of experienced professionals and managers to local governments to improve project development implementation and maintenance capabilities. In 2010, the New Economic Growth Path was introduced with its focal point being the creation of five million jobs by 2020. This target is said to be achievable by focusing on two key variables: the rate of economic growth and the employment intensity of that growth.[xiii]

To conduct the empirical analysis, data were compiled from various sources, as shown in Table 1. The spatial scale of our analysis is the same as NMR and is based on the analysis of 354 magisterial districts.

{Table 1 about here}

Socio-economic variables have a spatial dimension. One way of examining spatial patterns is to exploit the spatial nature of a data set by constructing maps and estimating Moran's *I* statistics. Consider Figure 1 which shows a map of rates of poverty expressed as standard deviations away from the sample mean.[xiv] It illustrates that poverty rates in South Africa have a spatial dimension. There is an East-West split with western (eastern) parts having relatively low (high) rates of poverty. Poverty rates are relatively low throughout the Western and Northern Capes and are relatively high in the North West and in the Free State. Generalisations are more difficult for Limpopo, Kwa-Zulu Natal, Mpumalanga and the Eastern Cape because of their relatively large variation in poverty rates. Urban areas appear to have relatively low rates of poverty, specifically Johannesburg, Durban, Cape Town, East London, Port Shepstone and Richard's Bay. Visual inspection suggests that areas with high (low) rates of poverty are more likely to be contiguous to areas that also have high (low) rates of poverty, at least at this spatial scale.

{Figure 1 about here}

Moran's *I* values are produced to test statistically for spatial clustering, i.e. similar values of a variable being present across areas that are located relatively close to each other. Typically a Moran's *I* value is obtained via the Moran scatter plot, which in this case plots poverty rates on the horizontal axis and its (queen-contiguity) spatial lag on the vertical axis, as shown in Figure 2.[xv] The upper right quadrant of the Moran's *I* scatter plot shows those areas with above average poverty values which share boundaries with neighbouring areas that also have above average poverty values (high-high). The bottom left quadrant highlights areas with below average poverty which have neighbouring areas that also have below average poverty values (low-low). The bottom right quadrant displays areas with above average poverty surrounded by areas that have below average poverty (high-low) and the upper left quadrant shows the opposite (low-high). The slope of the line through these points expresses the global Moran's I value (Anselin, 1996). The Moran's *I* value of 0.641, which is statistically significant at the 1% level, leads us to reject the null hypothesis that there is no spatial clustering. Hence, the visual interpretations of Figure 1 are supported with the quantitative results of Figure 2 and leads us to believe that spatial autocorrelation in socioeconomic variables may be important in the construction of vulnerability indices.

{Figure 2 about here}

## 5. Methodological extensions and applications

This section presents two major augmentations of NMR's methodology which are based on the following underlying concerns. First, although their *LVI* includes both environmental and geographical indicators, it is aspatial in nature as each area's estimate does not explicitly consider what is happening in it neighbouring areas. Hence, they do not take into account explicitly the possible effects of spatial spillovers and they treat all areas as though they were unconnected islands; this is extremely unlikely if there are important spillovers from one area on to its surroundings.

Second, they categorise districts into nine groups and subsequently convert them into a 9-point index, where members of group 1 have a value of 1, group 2 have a value of 2, etc. Categorisation into groups can be problematic and misleading if gaps between groups are arbitrary; for instance an area with a very low value that is part of group 4 might actually be closer to a high value member in group 5 than a high value member in group 4. This is similar to the criticism made by Baliamoune-Lutz and McGillivray (2008) on the World Bank's CPIA.

Put simply, we augment the work of NMR by addressing these two areas. First we construct a spatial *LVI* through the inclusion of queen-contiguity spatially-weighted sub-domains, and second by retaining the final principal component value as determined by the *LVI* for each area in order to sustain a quantitative indicator of disparity between district *i* and *j* that is not affected by group categorisation.

*Augmentations of the LVI and VII*

In contrast to NMR, we apply the following structured method:

1. Begin with exactly the same original data and variables as NMR.
2. Replicate the estimates of NMR. This will generate a set of aspatial results that are not categorised using the 9-point index.
3. Append original data to each area within a Magisterial Districts shapefile
4. Construct a spatial weight matrix that will permit the formation of new variables to capture spatial spillovers. This part of the process can use weights selected purely on theory, purely on statistical strength, or on a combination of these two extremes. We commenced this process by weighting data for area *i* by the corresponding values of the same variable in areas that are contiguous to area *i* – these are called queen-contiguous weights. We constructed a series of other spatial weights, including rook, second-order queen and various distance weight matrices and then compared the results. We identified no qualitative differences across the final sets of empirical results and so decided to retain the queen-contiguity weight matrix throughout.
5. Estimate PCAs for each of the individual domains listed 1-10 in Section 2. Note that all individual domains will have double their original number of variables: the original variables and their queen-contiguous spatially-weighted equivalents.

6. Retain and pool all individual domain PCA's principal components.
7. Estimate a second PCA across these individual domain principal components and retain the principal component for interpretation. We retain the final principal component raw values for each managerial district in order to sustain a clear quantitative indicator of disparity between area *i* and *j*. This is contrary to NMR who instead categorised districts into nine groups.

The result is two principal components: one that will represent the multidimensional *LVI* from NMR's aspatial perspective, and one that will represent the multidimensional *LVI* from a spatial perspective, which we denote *sLVI*.

8. Reconstruct NMR's *VII* to reflect vulnerability associated with per capita income. Estimating $LVI_i = \alpha + \beta Y_i + \mu_i (i = 1, ..., 354)$ to replicate NMRs results and estimate $sLVI_i = \alpha + \beta Y_i + \mu_i$ to capture the spatial equivalent set.
9. Save the vectors of residuals which represent the deviations between the actual and the predicted values for *LVI* and *sLVI* respectively.
10. Interpret the absolute values of these sets of residuals and identify which areas deviate strongly from predicted.

It is emphasising that this retention and subsequent analysis of the residuals is a clear extension of the methodology employed by NMR, as they take the *absolute* residual values as an indication of the level of vulnerability of an area. Collating absolute values will muddle areas into a vulnerability intervention index irrespective of whether they were performing much better (a *good* form of vulnerability) or much worse (a *bad* form of vulnerability) than expected under the fitted model. Good (and bad) forms of vulnerability may be the result of appropriate (and inappropriate) policy; for instance, some areas may have been influenced by beneficial policy or naturally occurring economic phenomena (such as urbanisation and localisation economies) that make areas perform better than would be expected otherwise, while the absence of appropriate policy (or the application of inappropriate policy) may result in the deterioration of other areas.

*Results of LVI and sLVI estimations*

Figures 3 and 4 present Local Indication of Spatial Association (LISA) maps based on the results of *LVI* and *sLVI* estimations. LISA maps are special choropleth maps that highlight those locations with a significant local Moran statistic classified by type of spatial correlation (Anselin, 1995). They highlight areas with high (low) vulnerability that are surrounded by areas with relatively high (low) vulnerability; LISA maps can also highlight areas with high (low) vulnerability that are surrounded by areas with relatively low (high) vulnerability. Through visual inspection it becomes clear that an appreciation of the influence of contiguity effects will affect *LVI* estimates.

{Figure 3 about here}

{Figure 4 about here}

Several observations obtainable from comparing Figures 3 and 4 are worth highlighting. First, magisterial districts within and surrounding Cape Town, Durban and Johannesburg are least locally vulnerable. This emphasises a large urban / rural disparity vulnerability effect. The same pattern is not identifiable for other urban areas, with the only exception being Umtata. Taken together, the results suggest that Umtata is an area that is doing relatively well in comparison to its hinterland (see Figure 3) but it is at risk because its hinterland is performing relatively poorly and spatial spillovers might deteriorate the extent of vulnerability within this conurbation (see Figure 4). Umtata's extent of vulnerability could be the result of policies that have been directed at this large conurbation without concern for its surrounding hinterland.

Second, Figure 4 suggests that the greater hinterland of the three main urban areas of Cape Town, Durban and Johannesburg are much less vulnerable than Figure 3 indicates. This is illustrated by the significant spillovers between contiguous districts which, in these cases, appear to diminish vulnerability. Such a contagion issue will be related to either spatial feedback, grouping or response forces. Of particular interest are the magisterial districts of Heidelberg and Bronkhorstspruit which are low-highs according to Figure 3 and high-highs according to Figure 4; these differences are due to the spatial spillovers between contiguous districts and without these spatial spillovers it is likely that these two districts would be much more vulnerable. An alternative perspective is that individuals are being marginalised in and around Johannesburg and are being forced out of relatively affluent areas and clustered into these two relatively poorly performing districts. Thus, policy geared towards diminishing the vulnerability of people in Heidelberg and Bronkhorstspruit should be both district specific (as highlighted in Figure 3) and take account of spatial spillovers (as highlighted in Figure 4).[xvi]

Third, there are also important differences between Figures 3 and 4, which reflect differences in estimates obtained that result from the inclusion of spatially-weighted sub-domains. The results presented in Figure 3 suggest that there are magisterial districts that suffer high levels of vulnerability, but the results presented in Figure 4 illustrate that this is not an attribute that stops at areas' borders. Instead the most vulnerable areas are clustered and contiguous in several areas. Of most concern are i) magisterial districts occupying the area to the south of Swaziland and which continues, mainly inland, down to Ladysmith, ii) much of the eastern part of the Eastern Cape to the south of Lesotho, and iii) a large, central part of the Northern Cape. The extent of vulnerability is not fully emphasised in Figure 3; the reason why this spatial perspective is so important is because any attempts by policy makers to alleviate vulnerability in these areas need to take a larger spatial perspective and explicitly consider large swathes of districts in their policy formations rather than simply considering the circumstances within specific districts in isolation.

When account of spatial spillovers in vulnerability sub-domains are explicitly considered in the estimation process the rankings of districts can differ substantially from estimates where account of spatial spillovers is excluded. Table 2 presents the *sLVI* estimates of the top and bottom 20 magisterial districts and each of these districts' ranks that have been replicated using the (non-spatial) *LVI*. Although there are some districts where the rank is unaffected, such as Nelspruit (rank=1) and Soweto (rank=354), the estimates of the ranks of many other districts do alter substantially; for instance, Rustenburg's rank improves from 228$^{th}$ to 18$^{th}$ after taking into account spatial spillovers, while Simonstown's rank falls from 62$^{nd}$ to 350$^{th}$.[xvii]

{Table 2 about here}

*Results of VII and sVII estimations*

Residual estimates are presented for the top and bottom 20 districts in Table 3 and Figures 5 and 6 provide visual support. Table 3 highlights the importance of accounting for spatial spillovers in *VII* estimates; although the top three districts (Johannesburg, Soweto and Durban) only switch places when the *VII* and *sVII* estimates are compared, many of the ranks of the other districts detailed do change rank substantially.

{Table 3 about here}

{Figure 5 about here}

{Figure 6 about here}

Several observations can be made when interpreting Table 3 together with Figures 5 and 6. First the association of urbanisation and vulnerability alleviation, perhaps associated with agglomeration economies etc., around Johannesburg, Cape Town, Durban, Richard's Bay and Hluhluwe is much clearer from the visual examination of Figure 6, where the residuals are the result of an equation that explicitly considered spatial spillovers. Many economic geographers would expect this result.

Second although Figures 5 and 6 highlight large areas of central South Africa in white, therefore suggesting that the areas are not performing substantially different than expected given their GDP per capita level, and the Northern and Western Capes have much worse vulnerability rates than we would expect given their GDP per capital levels, the area of greatest disparity between the *VII* and *sVII* estimates are in the province of Limpopo. The *sVII* perspective suggests that Limpopo is an area that deserves much more policy focus as spatial spillovers are resulting in much deeper vulnerability than one would otherwise expect. Policy directed towards individual magisterial districts in isolation within Limpopo will probably be relatively inefficient as the province requires a more holistic policy approach which explicitly accounts for spatial spillovers

Third, the values of the *VII* shown in Table 3 do not have a large spread: the value for the 15$^{th}$ highest spatially-ranked district (Bloemfontein) is equal to 1.88 whereas the value for the bottom spatially-ranked district (Pelgrimsrus) is equal to -1.34. This is in contrast to the top 14 spatially-ranked districts, which vary between 6.47 (Johannesburg, 1$^{st}$) and 2.05 (Cape Town, 14$^{th}$). Further examination of this data is carried out using the multivariate Moran scatterplot, as show in Figure 7, which presents the *sVII* estimates on the horizontal axis and the *sLVI* on the vertical axis. Initial execution of this technique reveals a strong, statistically significant Moran's *I* value of 0.616, but the exclusion of these top 14 ranked areas reveals a much shallower Moran's *I* value of 0.104. Although this latter value is still statistically significant, it becomes clear that a substantial part of the spatial correlation between *sVII* and *sLVI* is due to a large conurbation effect.

{Figure 7 about here}

The large conurbation effect reflects the fact that those areas that are wealthier also have better vulnerability values. Such attributes could be due to the benefits of agglomeration, typically associated with urbanisation and location economies, but may also be due to national policies that are geared towards improving the lives of urban-dwellers rather than their rural counterparts. This is in line with Friedmann (1963), Alonso (1968) and Yang (1999) who found that regional policies are biased in that they are likely to reflect the development of the urban areas as they are seem to have the most potential for development but ultimately cause greater spatial inequality. Little (2009) found that government policy needs to change in order to rectify the geographical imbalances in both recorded and hidden unemployment in urban and rural areas. Etherington and Jones (2009) argued that the policies implemented for city-regions emphasise, and have the potential to increase, rather than resolve, uneven development and socio-spatial inequalities.

*Spatial lag and spatial error models*

There is an alternative method of generating estimates of *sVII* using spatial econometrics. The first stage is to estimate a standard OLS estimate of $LVI_i = \alpha + \beta Y_i + \mu_i$ ($i = 1, \ldots, 354$) and to incorporate a spatial weights matrix to permit the diagnosis of spatial dependence. This can be carried out using the *GeoDa* freeware, as employed above to generate spatial weights. Application of the OLS procedure yields results presented in Table 4.

{Table 4 about here}

Several values presented in Table 4 are worth emphasising. First, the GDP value is greater than unity, suggesting that a one unity increase in GDP will result in a larger than one unit increase in the *LVI*. This would lead to the conclusion that, on average, GDP has a stronger than proportional effect on the *LVI* thereby emphasising that GDP is vital to the alleviation of vulnerability. That GDP is important for the *LVI* is not surprising, but this very strongly emphasises the importance of policies designed to stimulate the economy of South Africa so that they can “grow out of vulnerability”. Although this result is based on the multidimensional PCA estimation of the LVI, the result does not support a multidimensional policy alleviation perspective.

Second, the Moran’s *I* statistic indicates that there is strong spatial autocorrelation in the errors. This implies that an area’s *LVI* value is very strongly and positively associated with its contiguous areas’ *LVI* values, and that policies to reduce vulnerability should not target areas in isolation; policy-makers should examine the cause and consequences of spatial spillovers that contribute to an area’s vulnerability.

Third, the Lagrange multiplier and robust Lagrange multiplier statistics indicate that the preferred spatial econometric model is the spatial error model, although this is by no means definite. If there were strong theoretical reasoning to believe that the errors of an OLS regression would be spatially autocorrelated, then the appropriate technique is to estimate a spatial error model, which in our case is specified as follows:

$$LVI_i = \alpha + \beta Y_i + \mu_i \tag{2}$$

where

$$\mu_i = \rho W u_i + \varepsilon_i \tag{3}$$

in which $\rho$ represents the spatial error parameter to be estimated, $W$ represents our spatial queen-weights matrix such that $Wu$ captures the spatial lags of the model’s disturbance term, $u$, and $\varepsilon$ represents the independently distributed error term. Under this specification spatial autocorrelation of the *LVI* is the result of exogenous influences captured in the error term and not directly from the GDP explanatory variable. Selection of the spatial error model tends to be due to the list of explanatory variables excluding a variable that may have otherwise captured the spatial autocorrelation of the *LVI*.

The results of the spatial error model are also presented Table 4. The spatial error results are noticeably different from the OLS results in the following ways. First, Lambda is positive and strongly statistically significant. This indicates that the spatial component in the error term is capturing some positive spatial autocorrelation, again suggesting spatial spillovers between contiguous areas are important in influencing an area's economic vulnerability.

Second, inclusion of Lambda strongly affects the coefficient of GDP. Interpretations of this effect can be numerous. One option is that the OLS coefficient for GDP included both the effects of GDP on *LVI* and the spatial spillover component, and that entering the spatial spillover effect separately reveals the effect of GDP on *LVI* once we hold the spatial spillover effect constant. Contrary to the OLS results, the magnitude of the GDP coefficient is now less than unity, suggesting that a one unit increase in GDP will result in a smaller than one unit increase in the *LVI*. Now this leads to the conclusion that, on average, GDP has a smaller than proportional effect on the *LVI*, thereby emphasising that although GDP is important in the alleviation of vulnerability the economy needs to grow substantially more to achieve a measured reduction in vulnerability than was suggested in the OLS results.

Third, although the proportion of the variation of the *LVI* that is now explained by the model has increased substantially from 0.36 to over 0.7, there is still evidence of spatial dependence as indicated by the likelihood ratio test.

As the Lagrange multiplier tests were not conclusive about whether the model should be estimated with either a spatial error or a spatial lag, it is worth complementing the spatial error results with the spatial lag results. The spatial lag model captures spatial autocorrelation as an explanatory variable, which in our case will take the following form:

$$LVI_i = \alpha + \lambda WLVI_i + \beta Y_i + \mu_i \tag{4}$$

In our formulation, *WLVI* is the queen-contiguous spatially-weighted average of the dependent variable for area $i$ and $\lambda$ is the spatial lag parameter to be estimated.

Although the results of the spatial error and spatial lag models originate from different theoretical concerns for the origins of spatial spillovers, our results for the spatial lag and spatial error models effectively corroborate each other: the magnitude of the impact of GDP on the *LVI* is positive and around 0.8, therefore GDP does *not* have a more than proportional effect on *LVI*. Therefore, there may be important roles in vulnerability alleviation associated with factors other than stimulating GDP.

The residuals of the three models whose results are presented in Table 4 were retained, as before, to identify the top and bottom ranked areas and are presented in Table 5. A number of important issues that corroborate our previous results can be made.

First, the most consistent set of results are identifiable for the top seven regions. All three model estimates suggest that Cape is the least vulnerable. All three models suggest that the next six areas are consistently in the top 15 area for low amounts of vulnerability. These results hold when the spatial and aspatial perspectives are accounted for, but this time using the spatial error and spatial lag models. Also of note is how the magnitudes of the residual values are relatively stable, large and positive for these seven areas.

Second, there is substantial rank switching at the bottom end between the aspatial and spatial models. For instance, out of the bottom 20 in the OLS, only six remain in the bottom 20 using either of the spatial models. Also noticeable is that there is substantial rank switching at the top end between the aspatial and spatial models. For instance, ignoring the top seven, out of the next 13 in the OLS results, only two remain in the top 20 using either of the spatial models. Taken together these results indicate that the method of analysis is important when identifying the relative vulnerability position of areas.

Third, when the magnitude of the difference in the residual values are observed, it appears that the gaps in vulnerability are much smaller between areas that do not make up the top seven, which are areas that are very urban. This highlights the importance of the urban-rural divide in vulnerability terms, and that the beneficial effects of urbanisation on vulnerability do not reach far into rural areas to alleviate vulnerability.

{Table 5 about here}

## 6. Conclusion

This paper emphasises the need for recognition of the spillovers in economic vulnerability that may be present within a country at a sub-national, area level. Vulnerability indicators must take into account spatial spillovers if they are economically significant. This paper attempts to fill a gap left in the literature by augmenting and expanding on index methods presented in Naudé *et al.*'s (2009) important and timely contribution. Application of the extensions to South African Magisterial District data illustrates the presence and importance of spatial spillovers in shaping local vulnerability. It is argued that account of spatial spillovers is an important issue if full and accurate vulnerability indices are to be identified.

Our results illustrate a clear urban-rural vulnerability divide and the need for appropriate policy. If policies are going to be focused on improving vulnerability then policy-makers must decide whether to invest in urban areas, where economic growth and development are typically at their greatest and where a vast majority of a country's population resides, or across whole swathes of countryside and achieve a more holistic reduction in vulnerability. Governments should be aware that if they choose the wrong policy then they may accentuate the problem and it would appear that their policies have failed.

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**Figure 1: Poverty map**

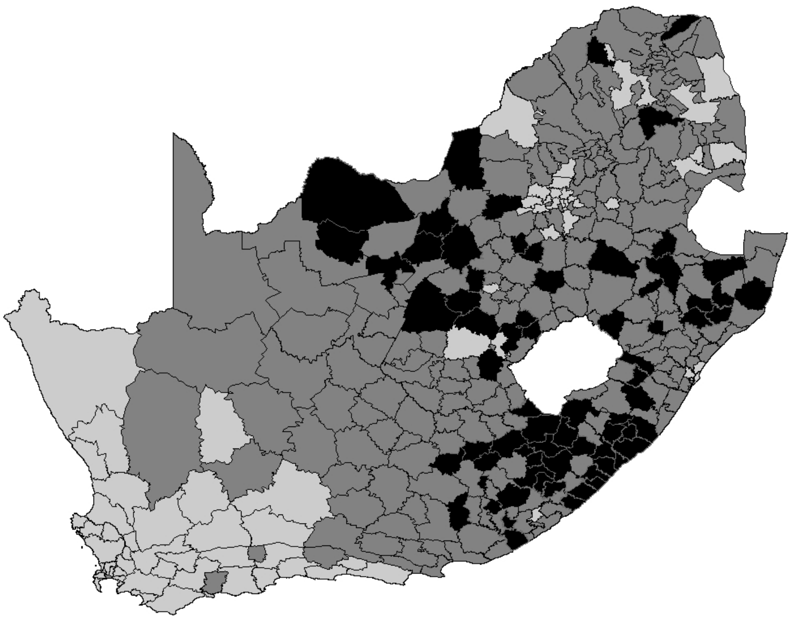

**Figure 2: Moran's I of poverty (Moran's I = 0.6410)**

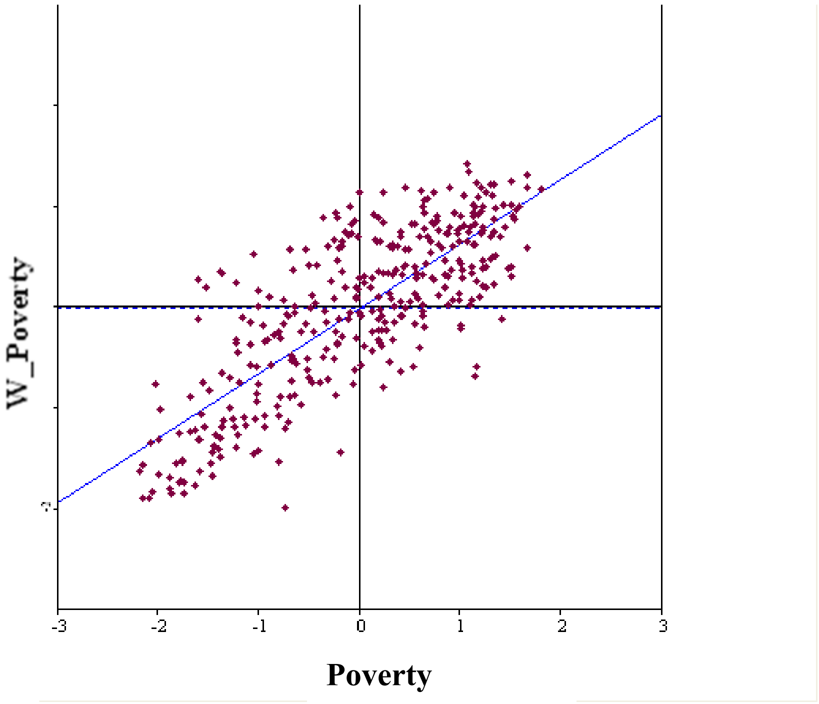

**Figure 3: LISA map of *LVI* estimates**

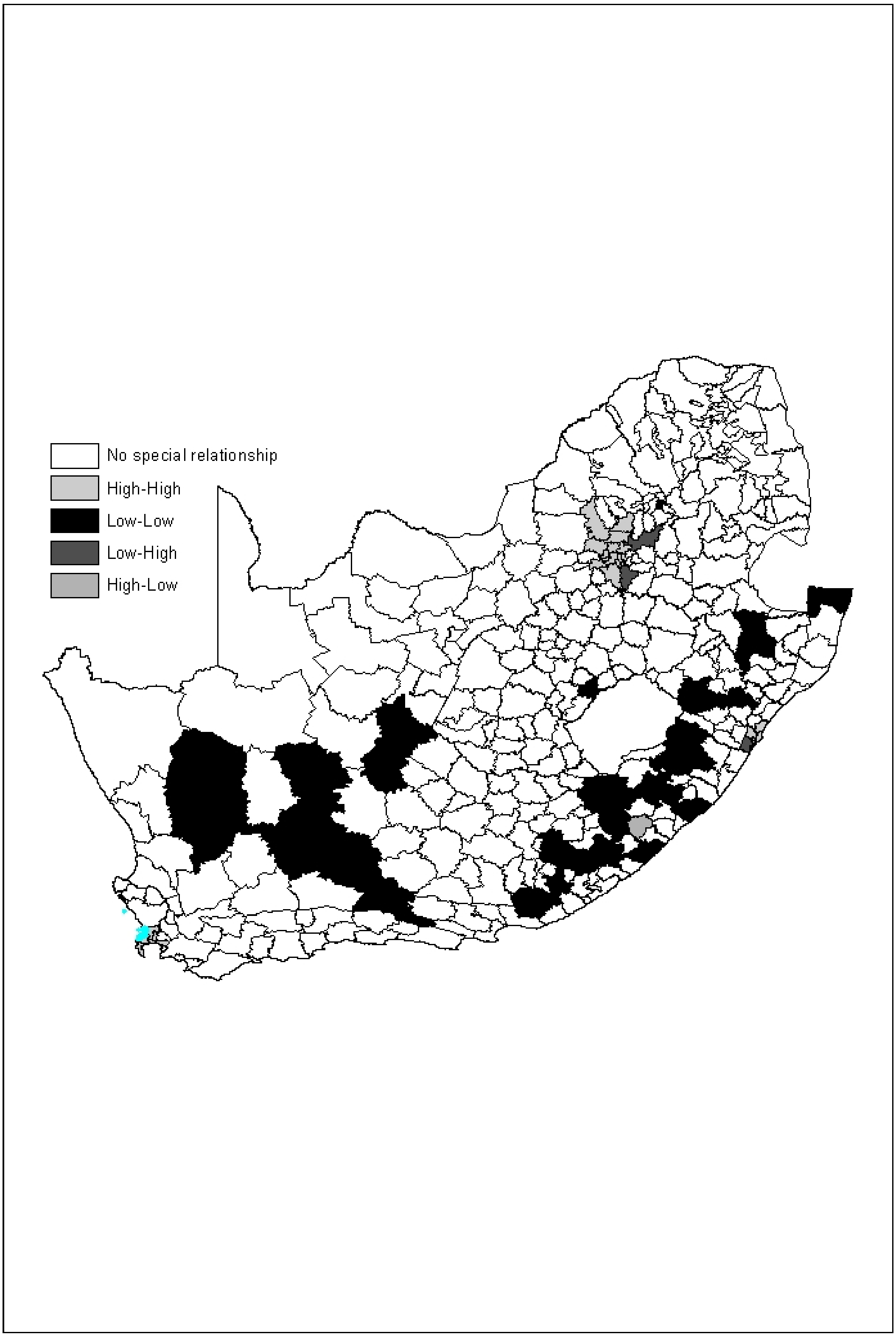

**Figure 4: LISA map of *sLVI* estimates**

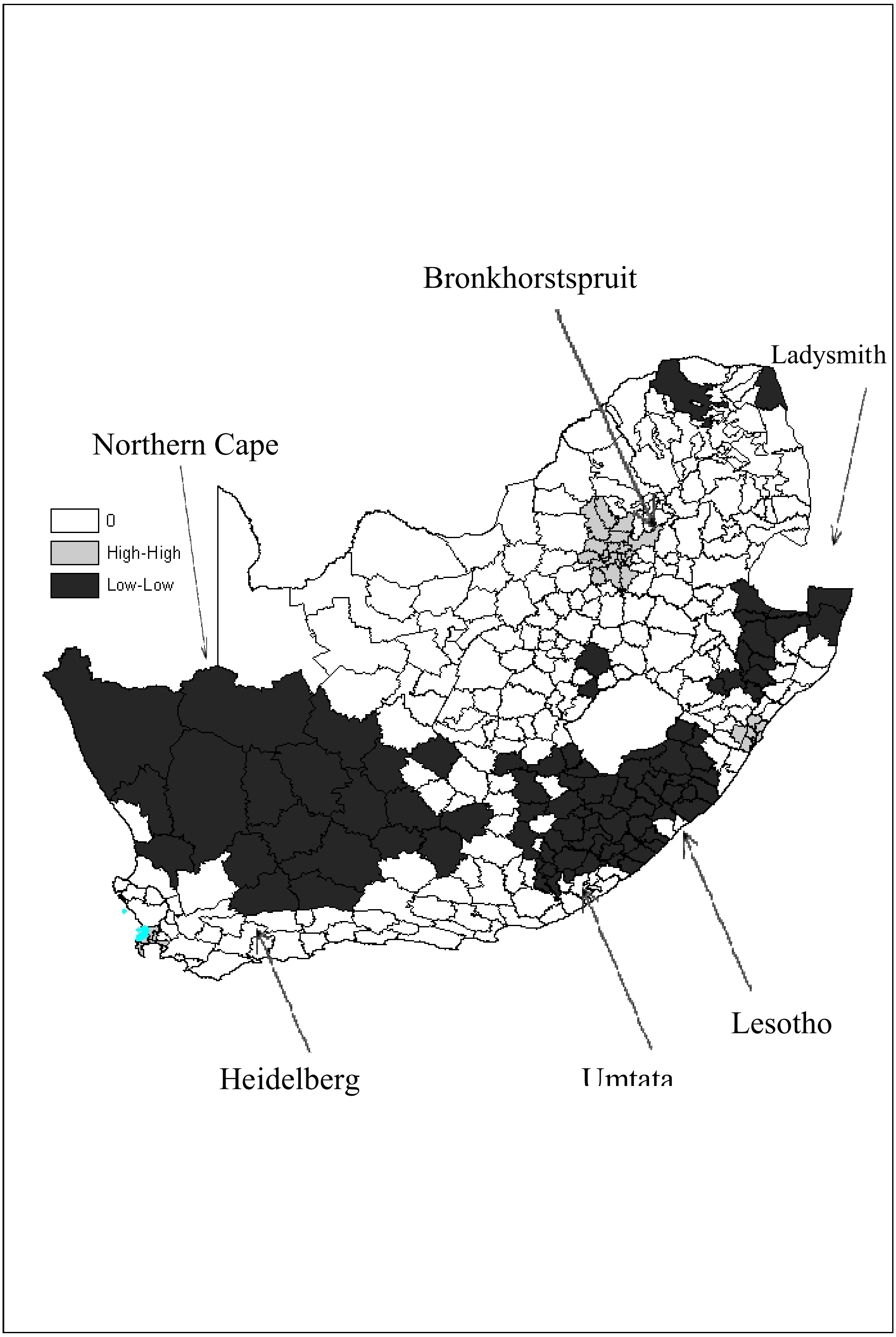

**Figure 5: LISA map of *VII* estimates**

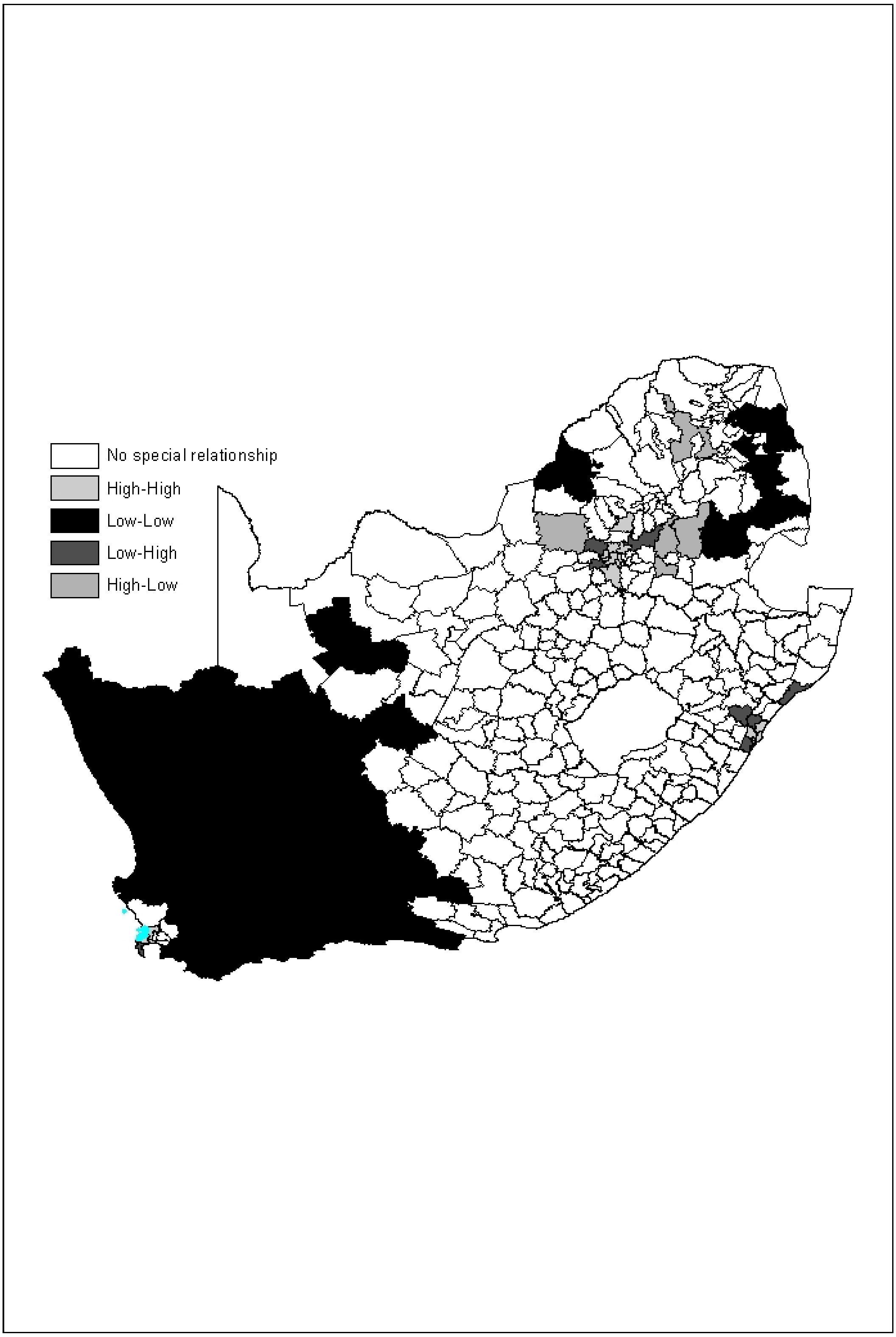

**Figure 6: LISA map of *sVII* estimates**

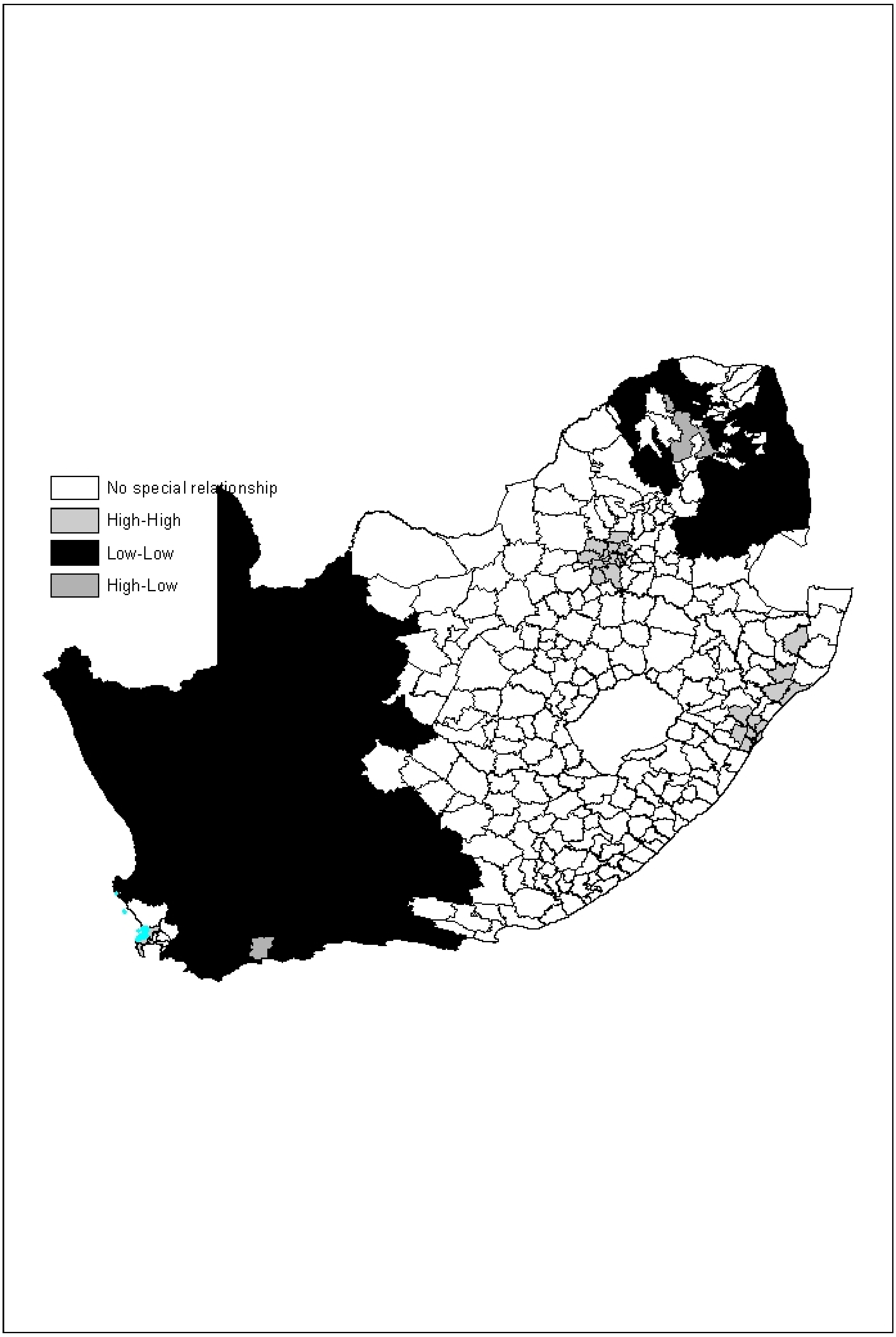

**Figure 7: Multivariate Moran scatterplot**

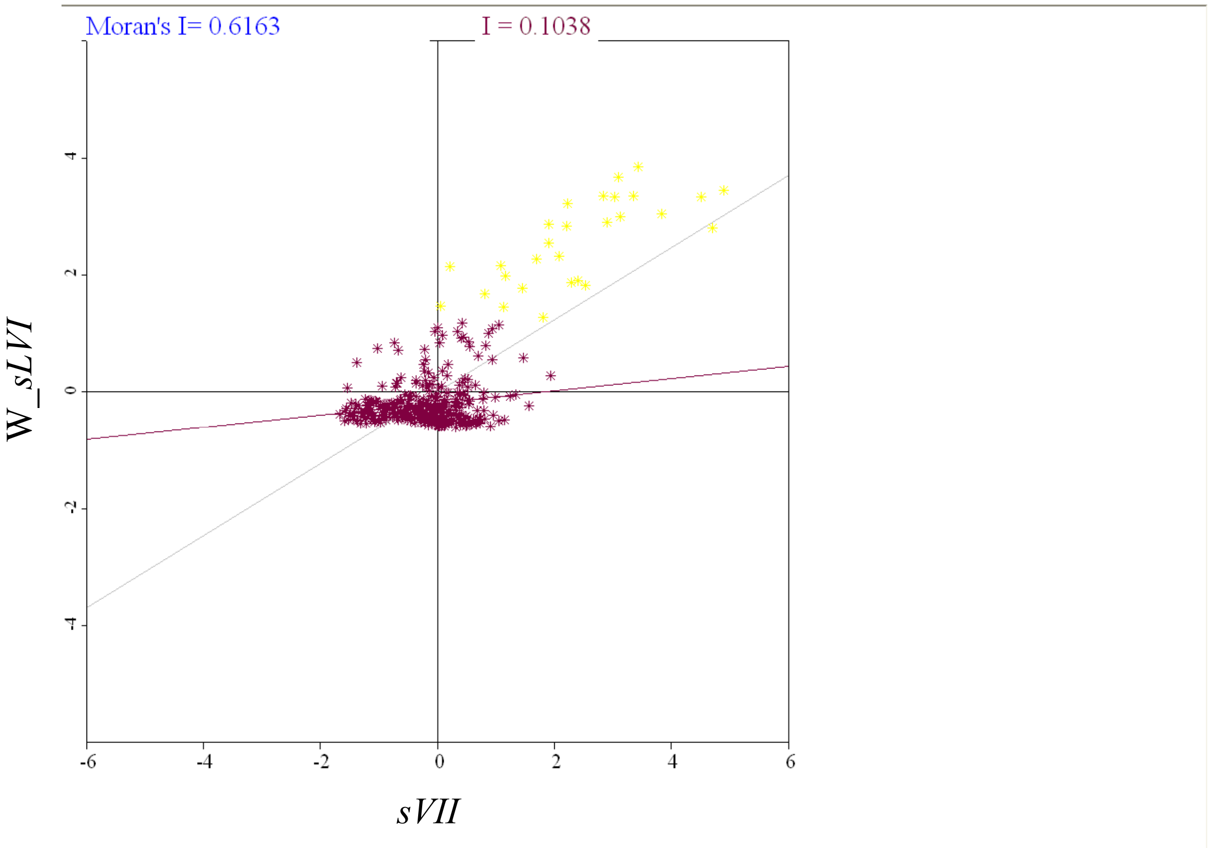

**Table 1: Data description**

| Variable | Source | Mean | Standard deviation | Maximum | Minimum |
|---|---|---|---|---|---|
| GDP | Global Insight | 30,121,387 | 95,229,631 | 119,612,638 | 24,409 |
| Total population | Global Insight | 127408 | 157519.5 | 1139848 | 3866 |
| Population density | Global Insight | 255.51 | 935.82 | 9707.23 | 0.351 |
| Urbanisation rate (%) | Global Insight | 0.52 | 0.335 | 1 | 0 |
| Proportion of primary production | Global Insight | 0.22 | 0.185 | 0.91 | 0.0006 |
| Exports as (%) of GDP | Global Insight | 0.06 | 0.189 | 2.76 | 0 |
| Imports as (%) of GDP | Global Insight | 0.051 | 0.188 | 2.87 | 0 |
| Diversity in exports | Matthee and Naudé (2007) | 0.67 | 0.284 | 1.89 | 0.14 |
| Distance from closest hub/market | Matthee and Naudé (2007) | 226.11 | 131.46 | 684.76 | 0 |
| HDI | Global Insight | 0.52 | 0.094 | 0.83 | 0.28 |
| Number of people in poverty as % of total population | Global Insight | 0.51 | 0.206 | 0.97 | 0.062 |
| Unemployment rate (%) | Global Insight | 0.4 | 0.191 | 0.9 | 0.03 |
| Volatility in income | Global Insight | 0.03 | 0.009 | 0.07 | 0.012 |
| Total people HIV+ | Quantec Easydata | 11285 | 15002.7 | 126479 | 1 |
| Population growth rate (%) | Global Insight | 0.011 | 0.004 | 0.04 | -0.003 |
| Per capita capital budget expenditure (R'000) | Statistics South Africa | 388.28 | 1217.06 | 26761.86 | 2.68 |
| Degraded land (%) of total area | Global Insight | 0.07 | 0.12 | 0.68 | 0.000003 |
| Total land cover $km^2$ (forest, waterbodies and wetlands) | Global Insight | 39.95 | 86.69 | 742.77 | 0.015 |
| Average rainfall (annual mm) | Global Insight | 639 | 316.90 | 2912.57 | 25.9 |
| No. of population per bank branch | Naudé *et al.* (2008) | 83643 | 95164.64 | 690504 | 4369 |
| Relationship between (%) of SA's financial services and (%) of SA's population | Global Insight | 0.10 | 0.07 | 0.4 | 0.004 |

**Table 2: LVI top and bottom 20 areas**

| Area | LVI | Rank with spatial weights | Rank without spatial weights |
|---|---|---|---|
| Nelspruit | -1.736 | 1 | 1 |
| Lower Umfolozi | -1.651 | 2 | 20 |
| Thabazimbi | -1.613 | 3 | 2 |
| Middelburg | -1.559 | 4 | 17 |
| Phalaborwa | -1.425 | 5 | 3 |
| Pietersburg | -1.391 | 6 | 6 |
| Mmabatho | -1.378 | 7 | 26 |
| Umtata | -1.337 | 8 | 63 |
| Kimberley | -1.284 | 9 | 95 |
| Worcester | -1.276 | 10 | 21 |
| Postmasburg | -1.226 | 11 | 23 |
| Highveld Ridge | -1.224 | 12 | 48 |
| Witbank | -1.214 | 13 | 78 |
| Rustenburg | -1.200 | 14 | 218 |
| Soutpansberg | -1.194 | 15 | 7 |
| Namaqualand | -1.183 | 16 | 16 |
| Thohoyandou | -1.174 | 17 | 106 |
| Bloemfontein | -1.158 | 18 | 228 |
| Gordonia | -1.148 | 19 | 40 |
| Letaba | -1.104 | 20 | 5 |
| | | | |
| Bellville | 1.523 | 335 | 261 |
| Cape | 1.613 | 336 | 339 |
| Westonaria | 2.162 | 337 | 176 |
| Umbumbulu | 2.218 | 338 | 235 |
| Soshanguve | 2.270 | 339 | 348 |
| Inanda | 2.431 | 340 | 347 |
| Alberton | 2.570 | 341 | 343 |
| Roodepoort | 2.659 | 342 | 292 |
| Kempton Park | 2.684 | 343 | 337 |
| Germiston | 2.790 | 344 | 230 |
| Durban | 3.070 | 345 | 349 |
| Randburg | 3.162 | 346 | 342 |
| Wynberg | 3.224 | 347 | 344 |
| Chatsworth | 3.775 | 348 | 341 |
| Johannesburg | 3.883 | 349 | 353 |
| Simonstown | 3.911 | 350 | 62 |
| Goodwood | 3.943 | 351 | 346 |
| Mitchellsplain | 3.979 | 352 | 352 |
| Umlazi | 4.736 | 353 | 351 |
| Soweto | 5.935 | 354 | 354 |

**Table 3: VII top and bottom 20 areas**

| Area | VII | Rank with spatial weights | Rank without spatial weights |
|---|---|---|---|
| Johannesburg | 6.473208 | 1 | 3 |
| Soweto | 5.713385 | 2 | 1 |
| Durban | 5.31242 | 3 | 2 |
| Pretoria | 4.95736 | 4 | 13 |
| Mitchellsplain | 4.489239 | 5 | 10 |
| Umlazi | 4.087025 | 6 | 4 |
| Port Elizabeth | 3.997531 | 7 | 18 |
| Inanda | 2.757484 | 8 | 12 |
| Pietermaritzburg | 2.725692 | 9 | 26 |
| Soshanguve | 2.34368 | 10 | 21 |
| Pinetown | 2.342031 | 11 | 14 |
| Wynberg | 2.328639 | 12 | 8 |
| Goodwood | 2.200749 | 13 | 6 |
| Cape | 2.049173 | 14 | 16 |
| Bloemfontein | 1.883006 | 15 | 34 |
| Randburg | 1.8787 | 16 | 9 |
| Lower Umfolozi | 1.75404 | 17 | 23 |
| Rustenburg | 1.749878 | 18 | 50 |
| Vanderbijlpark | 1.641831 | 19 | 37 |
| Welkom | 1.622162 | 20 | 27 |
| | | | |
| Moorreesburg | -1.00684 | 335 | 333 |
| Vredendal | -1.00964 | 336 | 340 |
| Victoria-West | -1.03966 | 337 | 308 |
| Malmesbury | -1.04856 | 338 | 309 |
| Namaqualand | -1.05074 | 339 | 349 |
| Kriel | -1.06366 | 340 | 266 |
| Piketberg | -1.07277 | 341 | 344 |
| Clanwilliam | -1.07702 | 342 | 345 |
| Uniondale | -1.08923 | 343 | 334 |
| Belfast | -1.12213 | 344 | 338 |
| Carolina | -1.12493 | 345 | 322 |
| Bochum | -1.14423 | 346 | 342 |
| Van Rhynsdorp | -1.15468 | 347 | 353 |
| Bronkhorstspruit | -1.15722 | 348 | 157 |
| Waterval Boven | -1.16347 | 349 | 352 |
| Bredasdorp | -1.18536 | 350 | 351 |
| Caledon | -1.24729 | 351 | 350 |
| Ladismith | -1.24927 | 352 | 347 |
| Joubertina | -1.3033 | 353 | 348 |
| Pelgrimsrus | -1.34627 | 354 | 346 |

**Table 4: Spatial econometrics**

| | OLS | Spatial error | Spatial lag |
|---|---|---|---|
| *N* | 354 | 354 | 354 |
| GDP | 1.121***<br>(0.079) | 0.858***<br>(0.060) | 0.752***<br>(0.061) |
| Lambda | | 0.794***<br>(0.037) | |
| Spatial lag | | | 0.688***<br>(0.036) |
| Constant | -1.582<br>(0.079) | -0.019<br>0.251 | -0.013<br>(0.054) |
| Moran's *I* (error) | 0.577*** | | |
| Lagrange Multiplier (lag) | 293.406*** | | |
| Robust LM (lag | 19.486*** | | |
| Lagrange Multiplier (error) | 311.063*** | | |
| Robust LM (error) | 37.143 | | |
| Likelihood ratio test for spatial dependence | | 240.626*** | 227.674*** |
| Breusch-Pagan | 2.090 | 0.011 | 1.060 |
| Log-likelihood | -642.191 | -521.878 | -528.354 |
| $R^2$ | 0.362 | 0.726 | 0.701 |

**Table 5: Ranks of top and bottom by model**

| Area Name | OLS residual | Top OLS rank | Spatial lag residual | Top lag rank | Spatial error residual | Top error rank |
|---|---|---|---|---|---|---|
| **Cape** | **7.667395** | **1** | **5.718656** | **1** | **5.616770** | **1** |
| **Soweto** | **6.181829** | **2** | **4.046200** | **3** | **3.755192** | **3** |
| **Mitchells Plain** | **5.071464** | **3** | **2.537897** | **9** | **2.493274** | **8** |
| **Johannesburg** | **4.616083** | **4** | **2.448210** | **10** | **2.303956** | **9** |
| **Vanderbijlpark** | **4.432274** | **5** | **3.462426** | **5** | **3.148792** | **5** |
| **Umlazi** | **4.404667** | **6** | **2.013840** | **14** | **2.051522** | **12** |
| **Pietermaritzburg** | **3.887142** | **7** | **4.341789** | **2** | **4.160843** | **2** |
| Germiston | 3.560221 | 8 | 0.253805 | 113 | 0.695987 | 69 |
| Wynberg | 3.543811 | 9 | 0.193176 | 123 | -0.113391 | 172 |
| Goodwood | 3.327346 | 10 | 0.040754 | 140 | -0.325927 | 207 |
| Pretoria | 3.326061 | 11 | 2.053859 | 12 | 2.230983 | 10 |
| Benoni | 3.278169 | 12 | 1.480079 | 27 | 1.739241 | 17 |
| Alberton | 3.231379 | 13 | 1.259960 | 34 | 1.343254 | 29 |
| Durban | 3.222810 | 14 | 1.202821 | 38 | 1.076926 | 38 |
| Bellville | 3.183346 | 15 | 0.827481 | 63 | 0.447870 | 96 |
| Randburg | 3.106678 | 16 | 1.005883 | 50 | 1.141873 | 35 |
| Kuils River | 2.980157 | 17 | 0.701022 | 77 | 0.575824 | 86 |
| Umbumbulu | 2.896122 | 18 | 1.293591 | 32 | 1.309618 | 31 |
| Welkom | 2.786820 | 19 | 3.504635 | 4 | 1.959624 | 13 |
| Kempton Park | 2.725254 | 20 | 0.263465 | 111 | 0.501135 | 89 |
| | | Bottom OLS rank | | Bottom lag rank | | Bottom error rank |
| Williston | -1.615568 | 335 | -0.491418 | 233 | -0.393317 | 219 |
| Bizana | -1.685157 | 336 | -0.900947 | 304 | -0.884931 | 303 |
| Willowvale | -1.708555 | 337 | -0.476700 | 228 | -0.394206 | 220 |
| Peddie | -1.711375 | 338 | -2.025694 | 354 | -1.849968 | 353 |
| Port St Johns | -1.714403 | 339 | -0.628967 | 258 | -0.668032 | 268 |
| Ngqueleni | -1.729913 | 340 | -0.916558 | 305 | -0.882046 | 302 |
| Phalaborwa | -1.883221 | 341 | -0.741634 | 281 | -1.034943 | 319 |
| Kudumane | -1.923607 | 342 | -0.824197 | 295 | -0.778068 | 284 |
| Excelsior | -1.980283 | 343 | -1.306848 | 335 | -1.343327 | 341 |
| Kenhardt | -1.989634 | 344 | -1.256703 | 331 | -1.072313 | 326 |
| Huhudi | -2.007710 | 345 | -1.382568 | 338 | -1.206012 | 333 |
| Volksrust | -2.016398 | 346 | -0.099554 | 165 | -0.868144 | 297 |
| Mpofu | -2.017103 | 347 | -1.761701 | 353 | -1.745970 | 352 |
| Laingsburg | -2.025299 | 348 | -1.705216 | 352 | -1.476800 | 344 |
| Molteno | -2.038178 | 349 | -0.816646 | 294 | -1.044976 | 320 |
| Carnarvon | -2.104649 | 350 | -0.965756 | 312 | -0.832664 | 293 |
| Postmasburg | -2.120007 | 351 | -0.504739 | 237 | -0.487202 | 239 |
| Idutywa | -2.301529 | 352 | -1.253387 | 330 | -1.231718 | 336 |
| Herbert | -2.401343 | 353 | -1.673748 | 350 | -1.526984 | 346 |
| Elliotdale | -2.521465 | 354 | -1.246596 | 328 | -1.132202 | 330 |

## Endnotes:

i Tobler's (1970) first law of geography is that "everything is related to everything else, but near things are more related than distant things" and most geographers are aware that many if not most socio-economic variables have a spatial component.

ii For a more in-depth discussion on the empirical and conceptual viewpoints of economic vulnerability, see Briguglio (1995, 2003) and Atkins *et al*. (2000). Guillaumont (2009) suspects that there has been an upsurge in interest concerning macro vulnerability because of the unsustainability of growth episodes and contemporaneous increase in poverty rates in Africa, the Asian crisis' unveiling of emerging markets' vulnerability and the debate surrounding the construction of an appropriate vulnerability measure that can be applied for specific country groups.

iii Baliamoune-Lutz and McGillivray (2008) identify that the World Bank's Country Policy and Institutional Assessment (CPIA), under which a country is classified as being more or less vulnerable, has some severe flaws that can result in the incorrect classification of countries located close to classification boundaries. Unfortunately this has significant policy implications as CPIA ratings are used in deciding how International Development Association (IDA) assistance is allocated.

iv For further studies on country-specific vulnerability see Birkmann (2007), Easter (1998), Marchante and Ortega (2006), Mansuri and Healy (2001) and McGillivray *et al*. (2008).

v Other household level vulnerability studies include Glewwe and Hall (1998), Chaudhuri *et al.* (2002) and Kühl (2003).

vi The direction of causation should remain a moot point, although it is not explicitly addressed here. Greater income per capita should permit development that reduces vulnerability, but lower vulnerability should permit more efficient allocations of resources that should stimulate greater income per capita.

vii Advantages of the PCA technique include that i) it does not require the assumptions of correlation between variables that are due to a set of underlying latent factors (as would need to be the case when applying factor analysis) and ii) the application of PCA should permit in-depth comparison of results with NMR and permit methodological development.

viii Other approaches followed include: Glaeser *et al.* (2000) which standardised responses to various survey questions and then simply adding them together in order to derive an index of trust. Mauro (1995) uses the average of indices – such as political and labour stability, corruption, terrorism etc. – and then uses this average as a regressor in models of growth and investment across countries and to determine institutional efficiency and corruption. He deems his strategy as correct because many of these indices measure the same fundamental trend. Lubotsky and Wittenberg (2006) proposed that a regression with multiple proxies might provide better results than that of principal components.

ix The choice of using ten domains and its associated variables comes from indices compiled by the Country Policy and Institutional Assessment (CPIA), CFIP (2006), USAID (2006), Anderson (2007), Liou and Ding (2004), Briguglio (1997) and Turvey (2007). However the range of variables used differs across these studies and number from 70 to 3.

x The direction of causation should remain a moot point, although it is not explicitly addressed here. Greater income per capita should permit development that reduces vulnerability, but lower vulnerability should permit more efficient allocations of resources that should stimulate greater income per capita.

xi Friedmann (1963) argues that a country could be divided into the following development areas: (i) metropolitan development, (ii) transitional-upward, (iii) frontier regions and (iv) transitional-downward areas. Although each area has its own local development opportunities they do form a spatial system, and a country's rate of growth would be constrained if it ignores the problems of the less developed and more vulnerable transitional-downward areas. Thus any policy decisions should explicitly consider surrounding areas. Ward and Brown (2009) argue that regional policy should be directed towards low developing regions but they warn that a 'one-size-fits-all' policy is not the way to go and that policy should be changed according to the area-specific problems.

xii The spreading of HIV/AIDS is also a big concern for South Africa and McDonald and Roberts (2006) argued that the marginal impact on income per capita of a 1 per cent increase in the prevalence rate is minus 0.59 per cent.

xiii When comparing South Africa to other countries, it is interesting to note that she has a vulnerability index score placing her alongside France and Poland (Briguglio and Galea, 2003). However, NMR argued that there is exceptional variation in the degree of vulnerability across her regions with large spatial variations in economic activities and institutional qualities contributing to uneven social and economic conditions.

[xiv] To undertake these tasks we employed the GeoDa open source software. This is free software and was developed at the Spatial Analysis Lab at the University of Illinois. It can be downloaded from: https://www.geoda.uiuc.edu/.

[xv] That is any area that shares a common boundary with area *i*. Throughout this paper, a queen contiguity spatial weights matrix is employed and statistical significance of Moran's I statistics is based on the randomisation approach with 999 permutations.

[xvi] Of particular note is that the results of Calvo (2008) suggest that the urban-rural vulnerability divide in Peru was not significantly increasing over time; our results, which use annual data between 1996 and 2006, indicate that this vulnerability divide is increasing in South Africa at a time when, and explicitly after 2000, policies are focused on achieving Millennium Development Goals.

[xvii] One much highlighted issue concerning rankings is that they are highly sensitive to gaps in the underlying parameter. For instance, although the LVI estimate varies by a substantial margin of over 4 between the bottom 20 districts, the LVI value between the 20th and the 335th is only 2.5.