Exploring evidence of spatial economic agglomeration in Ekurhuleni Metropolitan Municipality, Gauteng, South Africa

Koech Cheruiyot

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Abstract

Since Marshall's (1890) work on industrial districts in 19^{th} century England, agglomeration economies are credited for providing the needed catalytic role to economic growth and development. It does this by allowing critical masses, where knowledge spillovers among firms; labour market pooling; and sharing of industry-specific non-traded inputs, prosper. This research employs advanced spatial statistical approaches to analyse the spatial locations and economic sectors data of about 14,000 firms in Ekurhuleni Metropolitan Municipality, a major sub-regional economy in Gauteng economic metropolis and in South Africa. It attempts to answer the following questions; Is there evidence of spatial sectoral clusters, and if present, which kind of spatial economic clusters are they? What is the footprint of these spatial business clusters? The results of four selected industrial clusters show evidence of varying global and localised agglomeration. Localised agglomeration was established to be statistically significant as well. This research complements existing research in suggesting policies that ensure economic growth and development of the regional economy benefits from agglomeration economies.

Keywords: Spatial agglomeration, exploratory spatial data analysis (ESDA), Ekurhuleni metro, South Africa

JEL: R12, O4, R3, O18

1 Introduction

The study of economics of agglomerations either focusing on commercial/industrial districts within cities, industrial clusters at the regional level, or the existence of imbalance between regions/countries can be traced to Marshall's (1890) work relating to industrial districts in 19^{th} century England (Fujita & Thisse, 2002). Regardless of the geographical focus one is studying, agglomeration economies,

*Senior Researcher. Gauteng City-Region Observatory, Private Bag 3, Wits 2050, Johannesburg, South Africa. Email: Kenneth.koech@gmail.com

primarily in the form of knowledge spillovers among firms; labour market pooling; and sharing of industry-specific non-traded inputs, provide the needed catalytic role to economic growth and development. Witnessed as external economies, agglomeration economies comprise of localization and urbanization economies that transmit positive externalities to either similar or dissimilar firms that geographically concentrate or co-locate in particular areas. Localization economies accrue to firms of the similar industrial sector (Hoover, 1948; Aoyama, et al. 2011; Marshall 1890). Urbanization economies (also Jacobian externalities after Jacob, 1969) refer to the advantage enjoyed by diverse firms when they co-locate in a large urban area, with large and heterogeneous markets. In the literature, several theoretical and empirical studies can be found focusing in developed and some developing countries. In South Africa, limited empirical studies have focused at the sub-national regions – either provinces or cities (Pisa, et al., 2015; vom Hofe & Cheruiyot, 2018; Krugell & Rankin 2012; Naudé & Krugell 2006; Pillay & Geyer 2016; Fedderke & Wollnik, 2007).

This research complements existing research by focusing on a large and detail dataset (to the point of individual geocode). The research employs exploratory spatial data analysis (ESDA) and spatial statistical approaches to analyse the spatial locations and economic sectors data of about 14,000 firms obtained from triangulation of various data sources in Ekurhuleni Metropolitan Municipality (EMM), a major sub-regional economy in Gauteng and in South Africa. It attempts to answer the following questions – is there evidence of spatial business clusters, and if present, which kind of spatial sectoral clusters are they? What is the footprint of these spatial sectoral clusters? The paper, thus, proceeds to explore agglomeration, using the number of firms per square kilometre, independent of firm sizes (Duranton & Overman, 2005; Pillay & Geyer, 2016). It suggests policies needed for economic growth and development of the regional economy emanating from agglomeration economies.

The need to proceed using the number of firms per square kilometre was necessitated by lack of firm data on measureable indicators such as the number of employees as is commonly used. We tested for scale and aggregation issues (using one kilometre square grid and 0.5-kilometre square grid) and found broad consistency of the results (Duranton & Overman, 2005). The choice of one square kilometre was more appealing as it is commonly used and easy to interpret the results. Given the spatial focus of the paper, we needed to obtain both the global and local patterns of agglomeration knowing well, as suggested by Guillain and Gallo (2010, p. 965), that it is possible to "identify the location of agglomerations and their borders in a discrete-space approach as in a continuous-space approach". Beyond this exploratory (baseline) research, the database would continue to be built to allow further analysis in the future.

The paper is structured as follows. After the introduction, the second section reviews related literature focusing on economics of agglomeration and measures of agglomeration economies. Section three sheds light on the economic significance of EMM to Gauteng city-region and the country, while section four focuses on methods and data employed in the paper. Section five presents results based on descriptive mapping, kernel density mapping, global and local evidence of

agglomeration. The last section concludes the paper.

2 Literature review

2.1 Economics of agglomeration

Fujita and Thisse (2002) note that economics of agglomeration's geographical focus is exploring the formation of commercial districts within cities, industrial clusters at the regional level, and the existence of imbalance between regions. Firms of the same industrial sector or from different industrial sectors geographically concentrate or co-locate to take advantage of agglomeration economies: knowledge spillovers among firms; labour market pooling; and sharing of industry-specific non-traded inputs (Marshall, 1890). The first two agglomeration economies are external to the firms and are what Hoover (1948) called economies of localization and economies of urbanization, respectively. Hoover (1948) identified the third Marshall's (1890) agglomeration economies above as internal to firms and called it internal returns to scale. Internationally, there is a long list of theoretical and empirical studies on the agglomeration phenomenon (see Fujita & Thisse (2002) for a theoretical survey; Rosenthal & Strange (2004) and Duranton & Kerr (2015) for an empirical survey).

In South Africa, academic work on clusters or agglomeration is limited. Pisa, et al. (2015) undertook cluster analysis in the South Africa's North West Province (NWP), a rich platinum and gold mining region that is highly specialised and dependent on a few sectors. Employing structural path analysis and Power-of-Pull methods, they identified 10 industrial clusters that offer the greatest economy-wide benefits, while also creating opportunities for cross-sectoral collaboration. Vom Hofe and Cheruiyot (2018), while employing principal component analysis on Gauteng's Social Accounting Matrix, showed evidence of a few, but critical masses of economic clusters in Gauteng's regional economy. Their analysis led to the identification of six distinctive industrial clusters as follows: Service and Trade; Food Products; Metal Products; Chemical Products and Petroleum; Building and Metal Products; and Light Manufacturing Products. Rogerson (1998) used UNISA's Bureau of Market Research data and found that Gauteng province dominated agglomeration activities in the high-technology clusters – with locations such as Johannesburg, Boksburg and Kempton Park emerging as the largest foci of high-technology manufacturing (Rogerson, 1998, p. 889).

Other studies have found evidence that different South African cities are agglomeration hot spots, that is, are places that offer urban diversity, industry specialisation, dynamism and inclusivity, opportunities to migrants, as well as hosting growing industries such as finance, business and consumer services, and high-level professional and technical occupations, etc. (Krugell & Rankin, 2012; Naudé & Krugell, 2006;Turok, 2011). As such, these cities (e.g. Johannesburg, Tshwane, and Cape Town) have experienced significant growth. All the above South African research focused on the sub-regional levels and were

aspatial – they did not spatially allocate the identified clusters or evidence of agglomeration economies in the respective study areas.

A paper with a spatial focus like the current one is that of Pillay and Geyer (2016), who used aerial photography, zoning and cadastral data as well as field survey, to show evidence of business clusters along one of the transport corridors in Gauteng. Pillay and Geyer (2016) employed a distributional directional analysis tool (part of ESRI's ArcGIS software's spatial statistical analysis) to measure the geographic distribution of the data, thus visual interpretation of how business areas along the M1-N3-N1 corridor between Johannesburg-Germiston and Pretoria have densified from 2003-2012. Finally, a triangulation survey[1] of the number of business revealed several and different business clustering across the A1-A15 business clustering zones (see, Pillay & Geyer, 2016, pp. 349-352 for complete description of the methodology and the different identified clusters).

This paper complements existing research by analysing spatial economic agglomeration in the EMM. Beyond Pillay and Geyer's (2016), the present paper employs advanced spatial statistical techniques, including ESDA, kernel density analysis, global Moran's I and Anselin's (1995) LISA tests. These techniques were implemented in ArcGIS and GeoDa. In doing so, the present paper not only identify both global and local spatial economic agglomeration through spatial dependence, but also its statistical significance. This was possible since point data (captured at individual firm's geocode) used in the analysis was large and detail enough. Often spatial agglomeration is underestimated when data is only available at some defined discrete space that only allows aspatial analysis as the only option (Guillain and Gallo 2010).

2.2 Measuring agglomeration

There has been continuous search of better techniques for measuring geographic concentration of economic activities or agglomeration (also cluster) over the years. Earlier techniques employed aspatial techniques and were essentially measuring geographic concentration of economic activities across some defined spatial scale and treating spatial units independently. Guillain and Gallo (2010) warn that such aspatial techniques, by ignoring spatial dependence across geographical units, potentially underestimate existing spatial agglomeration. They suggest that an appropriate empirical technique must capture two dimensions of agglomeration; "concentration in one spatial unit but also the spatial distribution of these units in the study area" (Guillain & Gallo 2010, p. 3). Such techniques must measure the global and local spatial patterns of agglomeration, while allowing for spatial dependence across geographical units.

Several global indices are available for measuring spatial concentration of activities. These include spatial concentration ratio, the spatial Hirschmann-Herfindhal index, the locational Gini coefficients (Krugman, 1991), the Ellison

[1] This was achieved by triangulation where, first, Google Maps' Street View option was used to identify business types in the different study areas, and second, driving to the different business areas to capture outstanding businesses.

and Glaeser (1997) concentration index. This paper does not attempt to review all indices used in measuring spatial distribution of economic activities due to limited space. [2] As suggested by Duranton and Overman (2005, p. 1079) an ideal test of localization should rely on a measure which "(i) is comparable across industries; (ii) controls for the overall agglomeration of manufacturing; (iii) controls for industrial concentration; (iv) is unbiased with respect to scale and aggregation... (v) give an indication of the significance of the results". This paper focuses on global Moran's I and LISA (Anselin, 1995) that – while incorporating spatial distribution and dependence in the data within defined spatial units – allow for accurate spatial identification (i.e., where firms are located) and statistical significance testing of agglomerations (Guillain & Gallo, 2010; O'Donoghue & Gleave 2004; Duranton & Overman 2005).

3 Economic significance of Ekurhuleni Metro to Gauteng city-region and the country

As one of the three metropolitan municipalities located in South Africa's largest agglomeration (i.e. Gauteng), EMM covers 197,500 hectares partitioned into six management (also economic) regions namely Regions A-F. With each region comprising of several industrial areas, Region A has the largest amount of industrial space (3,370.97 hectares), while Region C has the least amount of industrial space (167.17 hectares). This is not surprising considering the fact that Region A is comprised of O.R. Tambo International Airport as well as industrial and logistic areas such as Jet Park, Boksburg and Germiston (see Figure 1).

Ekurhuleni metro (EMM) is the industrial backbone of Gauteng province, Gauteng province itself the economic heartland of the country contributing about a third of national GDP (EasyData, 2019). Table 1 shows the size and the contribution of EMM to the provincial and the national economies. The table shows that EMM, as a key player in the province as well as nationally, contributes close to a quarter (23.3%) and close to a tenth (8.1%) to provincial and national GVA output, respectively. EMM's contribution to secondary sector is higher and is followed by tertiary and primary sector to both provincial and national economies. In terms of employment and compensation, EMM's contributions mirror its contribution to GVA. For instance, it contributes 25% to the provincial and 8.3% to the national total employment. Its share of provincial and national total real compensation is 23% and 9%, respectively.

Table 2 shows the contribution of each of the EMM's economic regions to the metro's economy. As expected, Region A – comprising of Kempton Park, Germiston, and Boksburg – contributes more to the metro economy than other regions (see Table 3 as well). Assuming that Germiston and Edenvale contribute equally and thus we can split their contributions, the contribution of Region A,

[2] For a complete review of various indices of measuring spatial distribution of economic activities across the world, see Holmes & Stevens (2004), Combes & Overman (2004), Fujita, Henderson & Mori (2004), Guillain & Gallo, 2010, pp. 5-7; Ellison and Glaeser concentration index, see Lafourcade & Mion,2007, pp. 3-5).

comprising of Kempton Park, Germiston, and Boksburg, will increase to a third (33.8%) of the EMM's economy.

Figure 2 shows the GVA contribution of different sectors to EMM's economy. The figure shows that manufacturing, wholesale and retail trade, and finance and business support services are important contributors to economic growth in the municipality. Mining and agricultural sector contributes the least to EMM economy. With the highest annual average growth rates (2010-2017), mining (3.61%), trade (3.04%), finance (3.30%), construction (2.25%), and community services (2.46%) are expected to drive EMM's economy going forward. The overall GVA growth rate has averaged 2.26% over 2010-2017 period.

4 Data and methods

4.1 Data

The data used in the paper comprises of the number of firms obtained from EMM's GIS Corporate zoning and billing register. The billing register metafile comprised of several zonal classifications with almost 600,000 records. After carefully cleaning the records of duplications, vacant lots, etc. and limiting the records to industrial and business classifications, a total of close to 14,000 firms was obtained. The firms' names have been anonymised in the research. Using the economic sectors that was part of the metafile, respective SIC codes were assigned. At this point, the list contained key details as firm's name, physical address, suburb, region, economic sector, and SIC codes. Subsequent work will focus on adding employment details to the database. Finally, using above details all firms were assigned geocodes in ESRI website using address geocoding tool.

4.2 Analytical techniques

Given the point data collected above had no measurable attribute, for instance, the number of employees, the analysis had to proxy firm concertation by creating a fishnet of one kilometre square for the study area and merging it to point data on geocoded firms' location. By doing this, it was possible to find firms density – number of firms falling in each kilometre square. Since the study area is under the management of one municipal government, zoning and planning restrictions are ubiquitous, thus we expect the behaviour of firms vis-à-vis regulatory frameworks to be singly as a response to business acumen.

The resultant shape file with a density of firms was analysed in ArcGIS and Geoda. These softwares' mapping clusters tools allow visualization of the cluster locations and extent (ESRI, 2019a). The analysis proceeded in three steps. In the first step, we use kernel density analysis in ArcGIS to explore hot and cold spots. Secondly, we run global Moran's I to test for overall agglomeration, and thirdly, we employ LISA to test for localised agglomeration. The latter also allowed for statistical significance testing. We strengthen results of localised agglomeration with location analysis (using location quotient), albeit at a higher

level of aggregation based on economic regions defined by EasyData (2019).

Moran's I measures the overall spatial autocorrelation (i.e. the correlation of adjacent observations across space) of the data being analysed and aids in finding patterns. Like other correlation coefficients its value ranges from -1 to 1, with -1 being perfect clustering of dissimilar values, 0 is no autocorrelation, and +1 indicates perfect clustering of similar values (Anselin, 1995). It is calculated using below equation.

$$I = \frac{\Sigma_i \Sigma_j \mathrm{w}_{ij} \mathrm{z}_i . \mathrm{z}_j / \mathrm{S}_0}{\Sigma_i z_i^2 / n} \tag{1}$$

Where $z_i = y_i - \bar{y}$, where $\bar{y}$ is the mean of the variable, y representing the observations under study, W_{ij} is the spatial weight between feature i and j, and S_o is the sum of all elements in the spatial weights matrix ($S_o = \sum_i \sum_j w_{ij}$) (the paper uses k-nearest neighbours with the number of neighbours set at 8).

Anselin's LISA needed to test for localized agglomeration is calculated using below equation.

$$L_i = z_i \sum_j^n w_{i,j} z_j \tag{2}$$

Where, analogous to global Moran's I, the observations z_i $z_j$are deviatins from the mean, and the summation over j is such that only neighbouring values j, subsets of J_j are included. Often w_{ij} is standardised for easy interpretation as well as w_{ij} (Anselin, 1995).

5 Results and discussions

5.1 Descriptive analysis

Preliminary analysis focuses on the distribution of firms based on their primary and secondary SIC codes. With most SIC codes represented, few SIC codes stand out. For instance, of the 13,973 geocoded firms (see Table 3), SIC3 (manufacturing), SIC8 (finance and business services), and SIC61 (wholesale and retail trade) accounted for 37.6%, 24.4%, and 25.6%, respectively. Transport and storage (SIC71) follows at a distance with 4.8%. The secondary SIC code in SIC3 is SIC35 (manufacture of metals, machinery, and equipment) that itself account for 14.4% of the 13,973 geocoded firms. Spatial statistical analysis is based on SICs 3, 35, 8, and 71.

Figure 3 shows the distribution of selected firms in EMM. It is visible that manufacturing is predominantly in Region A, and north of Region F, south of Region B, west and south to south east of Region D. Some manufacturing is also visible in the south east of Region E. The further away from Region A, the less the number of manufacturing activity. Overall, these results support the industrial role of the municipality both provincially (in Gauteng) and nationally. Figure 3 shows that the distributional pattern of metal, machinery, and equipment sub-sector firms is similar to Figure 3, except less dense.

Figure 3 shows further that Region A has more number of finance and business services firms. Regions F and D follow with the highest number of firms.

Away from these areas, the number of firms decline towards the outer parts of EMM. These results indicate that most of the finance and business firms are concentrated in the core of the metro. The distribution of transport and storage firms is more concentrated around airports (i.e. O.R. Tambo International airport, Rand Airport, and Brakpan and Springs airfields and their surroundings).

5.2 Kernel density mapping

Kernel density mapping produced using kernel density tool in ArcGIS aids in smoothing out the information represented by a collection of points in a way that is more visually pleasing and understandable. This is necessary when the points cover large areas of the map (ESRI, 2019b). Figure 4 shows that more of the manufacturing firms are concentrated more evenly across Region A, in the south of Region B (near Kempton Park), and in several towns, including Boksburg, Alrode, and Alberton, and Vosloorous. The concentration of metal, machinery, and equipment firms, while it follows the same pattern as aggregated manufacturing firms, have some particularities. For instance, while aggregated manufacturing firms show a dense concentration around Springs Airfield, the concentration of metal, machinery, and equipment firms is barely visible around the same area. The dense concentration of aggregated manufacturing firms in the north of Region B is similarly barely visible regarding metal, machinery, and equipment firms.

Finance and business services firms are predominantly in Kempton Park, and located along EMM's boundary with City of Johannesburg (i.e. western boundary of the Ekurhuleni metro). The cores of the various regions seem to have a concentrated number of finance and business services firms. Transport and storage firms are predominantly in Kempton Park, Boksburg, near Rand Airport as well as Brakpan and Springfield Airfields, etc.

5.3 Global measures of agglomeration

Figures 5a-5d show global spatial autocorrelation of the selected industrial sectors. All the Moran's Iscatter plots show statistically significant global spatial autocorrelation, with manufacturing (SIC3) more autocorrelated (Moran's $I = 0.196802$), followed by manufacture of metal, machinery and equipment (SIC35, Moran's $I = 0.177295$), finance and business services (SIC8, Moran's $I = 0.157276$), and transport and storage (SIC71, Moran's $I = 0.0925195$).

5.4 Local measures of agglomeration

Figures 6a- 9a show local spatial association of the selected industrial sectors. These figures show local spatial association, where different pockets of associations show either spatial clustering (i.e. high number of firms surrounded by high number of firms and low number of firms surrounded by low number of firms) or spatial outliers (i.e. high number of firms surrounded by low number

of firms, and low number of firms surrounded by high). The statistical significance of these spatial associations are shown in Figures 6b- 9b, respectively. Figure 6a shows that spatial clustering of higher number of manufacturing firms is found in several locations, including areas around Edenvale, Kempton Park, Alrode, and Alberton. Spatial outliers in Figure 6a border the spatial clusters of the higher number of manufacturing firms. The closeness of spatial clusters and spatial outliers imply that the distribution of manufacturing firms (SIC3) depicts spikes and subsequent decay of the number of manufacturing firms as one moves away from the evident spatial clusters. Figure 6b shows that the preceding spatial associations are statistically significantly at p-values ranging between 0.0001 and 0.05.

The local evidence of agglomeration in this paper is sufficiently supported by the calculation of simple location quotients to reflect a measure of relative concentration. In this paper, it is used to quantify the concentration of a particular industry in a given region (i.e., EMM's economic Regions A-F) as compared to the Gauteng province and Ekurhuleni metro. In this manner, it captures localisation economies (part of agglomeration economies, the other being urbanization economies) associated with local specialisation.

In terms of broad manufacturing (SIC 3), all the EMM's economic regions have location quotients more than one, except two (i.e. Germiston/Edenvale and Springs). The same picture is reflected in the manufacture of metal, machinery, and equipments (SIC35). The major difference is the higher location quotient of 1.59 (Benoni) for manufacture of metal, machinery, and equipments, compared to the highest location quotient of 1.38 (Kempton Park) for broad manufacturing. At the metro level, Kempton Park (1.19) and Benoni (1.08) have location quotients more than one, meaning that there is a higher concentration of manufacturing firms (SIC3) in Kempton Park compared to the other regions. Still in manufacture of metal, machinery, and equipments (SIC35), Benoni (1.35) and Kempton Park (1.16) are the only regions with location quotients more than one. These results coincide with Rogerson's (1998), who used both the numbers of establishments and estimated total employment, and found that the highest cluster of high-technology production, including manufacture of electrical and industrial machinery, was found in Boksburg, Kempton Park, Germiston (part of EMM), etc. compared to the rest of the country.

Figure 7a shows the spatial clustering of the number of manufacture of metals, machinery, and equipments (SIC35). Compared to Figure 6a, Figure 7a shows a close similarity of spatial association. Notable in Figure 7a, that is different from Figure 6a, is the location of spatial outliers (high-low) in the northern parts of Region B and parts of Regions C, D, and E. Figure 7b shows that the preceding spatial associations are statistically significantly at p-values ranging between 0.0001 and 0.05.

Figure 8a shows the spatial association in the finance and business services sector (SIC8). It shows a more widespread distribution of firms compared to Figures 6a and 7a. While locations running south from Kempton Park through to Alrode in the western side of the metro show spatial clustering, new areas such as Geluksdal in Region E, areas near Springs and Brakpan Airfields – the

latter two areas in Region D – show spatial clustering as well. The statistical significance of these spatial associations (p-values) range from 0.0001 and 0.05 (Figure 8b). These results seem to support results of location analysis. The finance and business services sector in EMM is less concentrated at the province level – only one region (Alberton) has location quotient of 1.07. A regional-level (in-metro) comparison shows that in terms of finance and business services, the four regions with location quotients more than one are Alberton, Germiston/Edenvale, Nigel, and Brakpan. These regions do have higher concentration of finance and business services firms than the other regions at the metro level.

Figures 9a and 9b show the spatial association and the respective statistical significance of spatial associations of transport and storage firms. Figure 9a shows a limited spatial clustering of high number of transport and storage firms in Kempton Park, Boksburg, near Brakpan Airfield, etc. A spread of spatial outliers (high-low) is visible in the outer parts of Regions B, D, and E. These results are broadly supported by location quotient analysis, where five out of eight of EMM's economic regions have location quotients more than one. These include, Kempton Park (in Region A) with the highest location quotient of 2.11, it is followed at a distance by Region C's Benoni (1.33), Region D's Brakpan (1.04), Region A's Boksburg (1.04), and Germiston/Edenvale (1.03). These location quotient results show the dominance of Region A's hold on transport and storage size of employment in the province. Within EMM, Kempton Park is the only economic region with a location quotient more than one - thus it has more concentration of transport and storage firms than other regions in the metro.

6 Conclusion

One of the key motivations for the work reported in this paper was to learn about the nature of the agglomerative forces that operate in EMM, particularly to assist policy-makers considering proposals to encourage further agglomeration economies or to develop new agglomeration sites. Agglomeration economies, be it localization economies (benefits firms belonging in the same industrial sector) or urbanization economies (benefits firms belonging in different industrial sectors) allow firms to share knowledge, labour, and other industry-specific non-traded inputs.

Focusing on the following questions – Is there evidence of spatial sectoral clusters, and if present, which kind of spatial economic clusters are they? What is the footprint of these spatial business clusters? – this paper's results (based on geocoded point firm data) have shown the presence of statistically significant concentration of firms in EMM. Descriptive mapping shows that Region A, comprising of Kempton Park, Germiston, and Boksburg, dominates EMM's industrial economy. Kernel density mapping aided in improving visualization of where the different selected firms in EMM are concentrated.

Statistical evidence of overall and localization spatial agglomeration was evident from global and localisation spatial autocorrelations. As expected, broad

manufacturing (SIC3) was more clustered, followed by manufacture of metal, machinery and equipment (SIC35), finance and business services (SIC8), and transport and storage (SIC71). Anselin's LISA maps (i.e. cluster and significance maps) showed (localised) footprint and statistical significance of the identified spatial clusters. As observed in Figures 6a/b-9a/b, the localised agglomeration of the selected industrial firms vary. Nonetheless, Region A and its surroundings dominates other regions. The footprint of local agglomeration was partly supported by calculated location quotients of unemployment data (newly calculated by the author as well as Rogerson (1998)).

These results are useful in helping EMM to know the spatial footprint of what type of cluster so as to devise policies to encourage further agglomeration in areas where (statistically significant) agglomeration exists or to encourage potential agglomeration economies in other areas. Policies that enhance existing agglomeration economies or develop new agglomeration economies could either be cluster-specific (objective is to encourage the emergence or development of a distinct cluster) or cluster-informed strategies (with objective to improve implementation of individual (or isolated) development initiatives). Specific policy mechanisms may include provision of general business assistance, network brokering, technology transfer, information provision, training opportunities, hard (e.g. roads) and social infrastructure (e.g. employee transport) subsidies, etc. (vom Hofe and Cheruiyot 2018, p. 97).

Given that the evidence based on location quotient was at a lower resolution (i.e. main places across the country, including aggregated economic regions in EMM), there is need to develop the firm-level data to include variables such as number of employees (possible from Department of Labour's Unemployed Insurance Fund UIF data) in future work. The use of built area as contained erfs' description in valuation roll could also easily used as a proxy for density as suggested by one of the reviewers. This will incorporate firms' sizes, etc. towards a deeper understanding of spatial agglomeration in EMM and beyond. There is also a need to explore the relevance of economic development corridor development policies that are being advanced by the various spheres of government given the evidence put forward by this research.

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Table 1. Contribution of EMM to Gauteng and national economies, 2017

	Value concept	% contribution to Gauteng	% contribution to South Africa
Real GVA at basic prices (R millions constant 2010 prices)			
Total	231,499	23.3	8.1
Primary	6,912	21.5	2.2
Secondary	56 158	26.5	10.1
Tertiary	168 430	22.5	8.5
Employment			
Total Employment (Number)	1,326,663	25	8.3
Formal- Skilled Employment (Number)	282,436	24	9.3
Formal, Semi-skilled Employment (Number)	477,163	24.8	8.6
Formal, Low- skilled Employment (Number)	267,414	28.2	8.2
Informal Employment (Number)	299,650	24	7.4
(Real) Compensation (R million constant 2010 prices)			
Total	136,137	23	9
Formal, skilled	55,581	20	8.5
Formal, semi-skilled	54,231	24.1	9
Formal, low skilled	19,619	31.7	10.9
Informal	6,707	24.8	8.5
Gross fixed capital formation (R million constant 2010 prices)			
Total	48,745	23.9	7.9
Primary	1,614	20.6	2.2
Secondary	15,145	25	8.7
Tertiary	31,985	23.6	8.7

Source: EasyData (2019)

Table 2. Percentage contribution of regions to EMM economy in 2017

Economic Region (main place names)	Planning Region	Value concept[a]	% contribution to Ekurhuleni metro economy
Kempton Park	Region A	60,679	26.2
Germiston/Edenvale	Region A/B[b]	35,173	15.2
Boksburg	Region A	19,728	8.5
Benoni	Region C	34,049	14.7
Brakpan	Region D	17,809	7.7
Alberton	Region F	45,026	19.4
Springs	Region D	14,172	6.1
Nigel	Region E	4,863	2.1

Source: EasyData (2019)

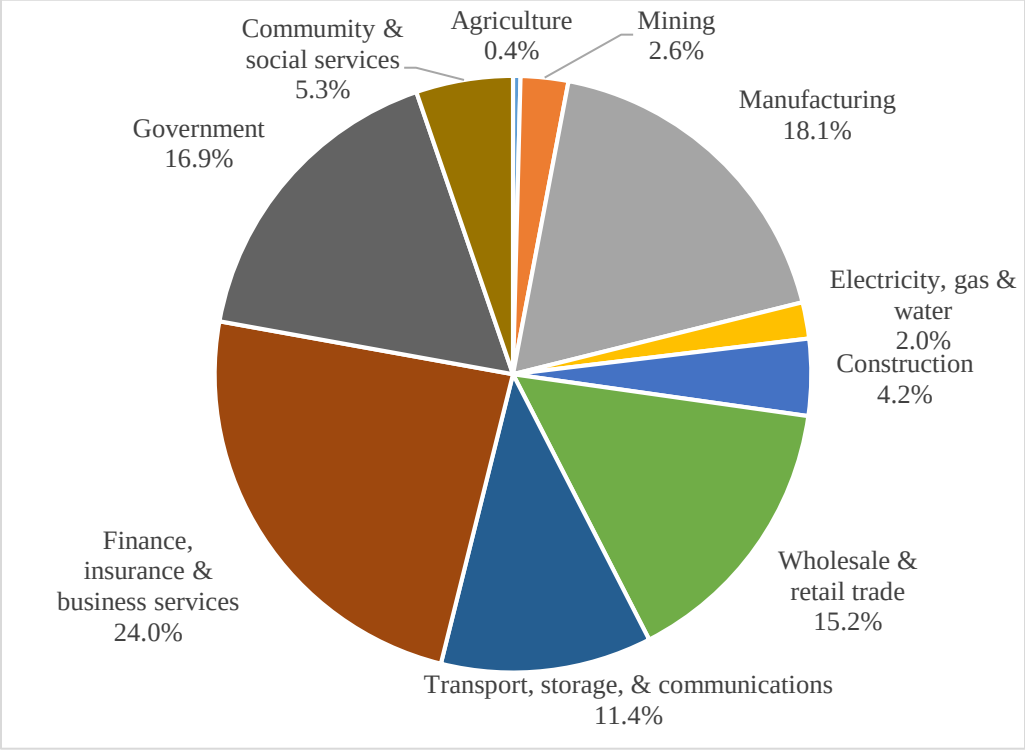
Note: a - Real Gross value added at basic prices in R millions constant 2010 prices; b - EasyData (2019) aggregated data for Germiston (Region A) and Edenvale (Region B).

Table 3. Distribution of firms per SIC codes in EMM's six economic regions

Sector (SIC code)	Economic regions													
	A		B		C		D		E		F		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Agriculture-related (1)	97	46,0%	17	8,1%	40	19,0%	22	10,4%	12	5,7%	23	10,9%	211	1,5%
Mining-related (2)	43	68,3%	0	0,0%	6	9,5%	4	6,3%	1	1,6%	9	14,3%	63	0,5%
Manufacturing (3)	3,224	61,4%	279	5,3%	519	9,9%	360	6,9%	153	2,9%	718	13,7%	5,253	37,6%
Electricity, water, & gas (4)	41	62,1%	4	6,1%	3	4,5%	5	7,6%	3	4,5%	10	15,2%	66	0,5%
Construction (5)	134	59,6%	19	8,4%	17	7,6%	11	4,9%	7	3,1%	37	16,4%	225	1,6%
Wholesale & retail trade, catering & accommodation (6)	1,655	46,2%	173	4,8%	492	13,7%	806	22,5%	223	6,2%	234	6,5%	35,83	25,6%
Transport and storage (7)	434	64,1%	19	2,8%	95	14,0%	36	5,3%	24	3,5%	69	10,2%	677	4,8%
Finance and business services (8)	1,657	48,6%	409	12,0%	411	12,1%	478	14,0%	86	2,5%	366	10,7%	3,407	24,4%
General government (9)	254	52,0%	29	5,9%	67	13,7%	64	13,1%	29	5,9%	45	9,2%	488	3,5%
Total	7,539	54,0%	949	6,8%	1,650	11,8%	1,786	12,8%	538	3,9%	1,511	10,8%	13,973	100%

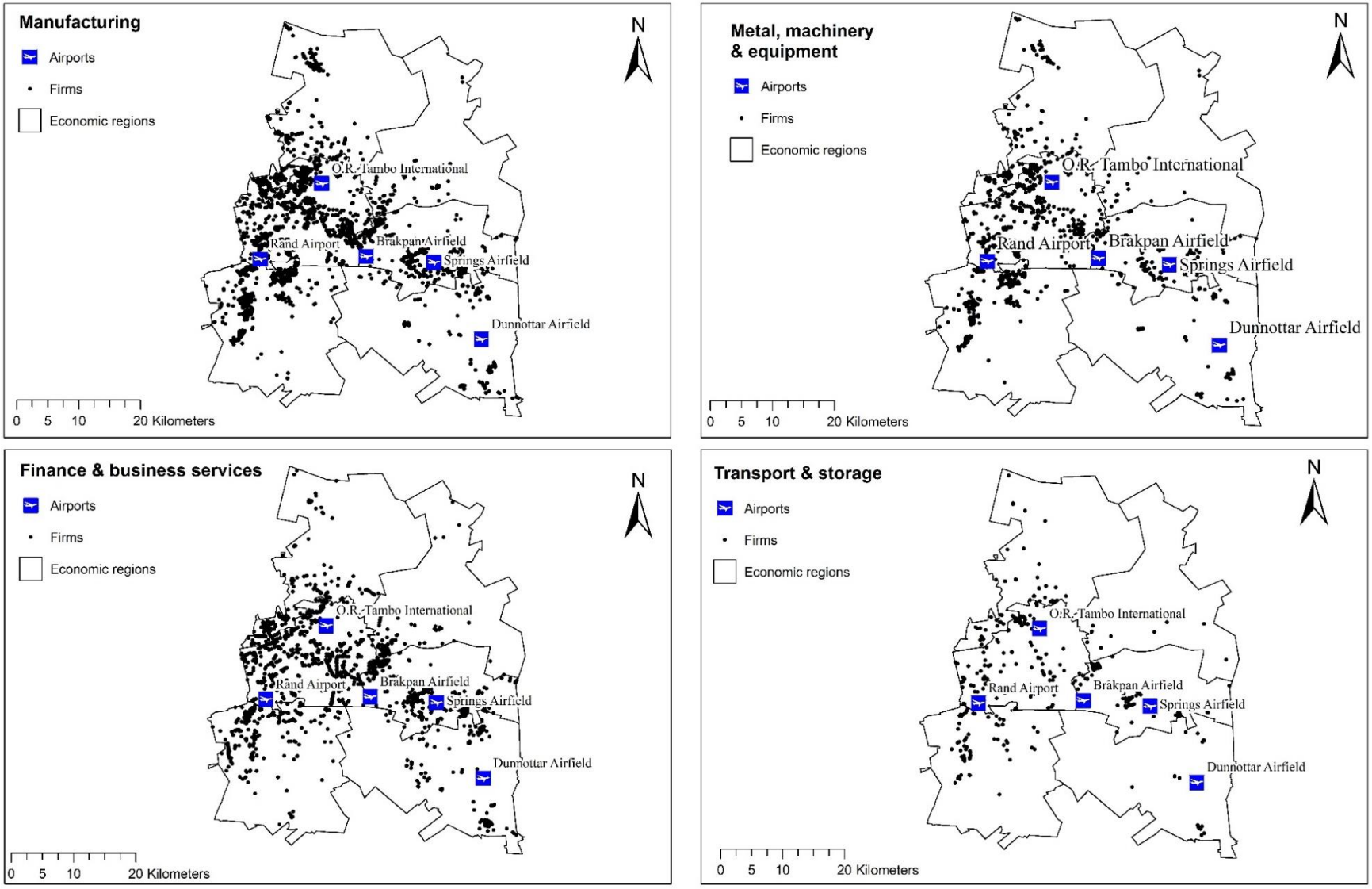
Figure 1. The location of Ekurhuleni metro in Gauteng and South Africa

Figure 2. Contribution of different economic sectors to EMM economy



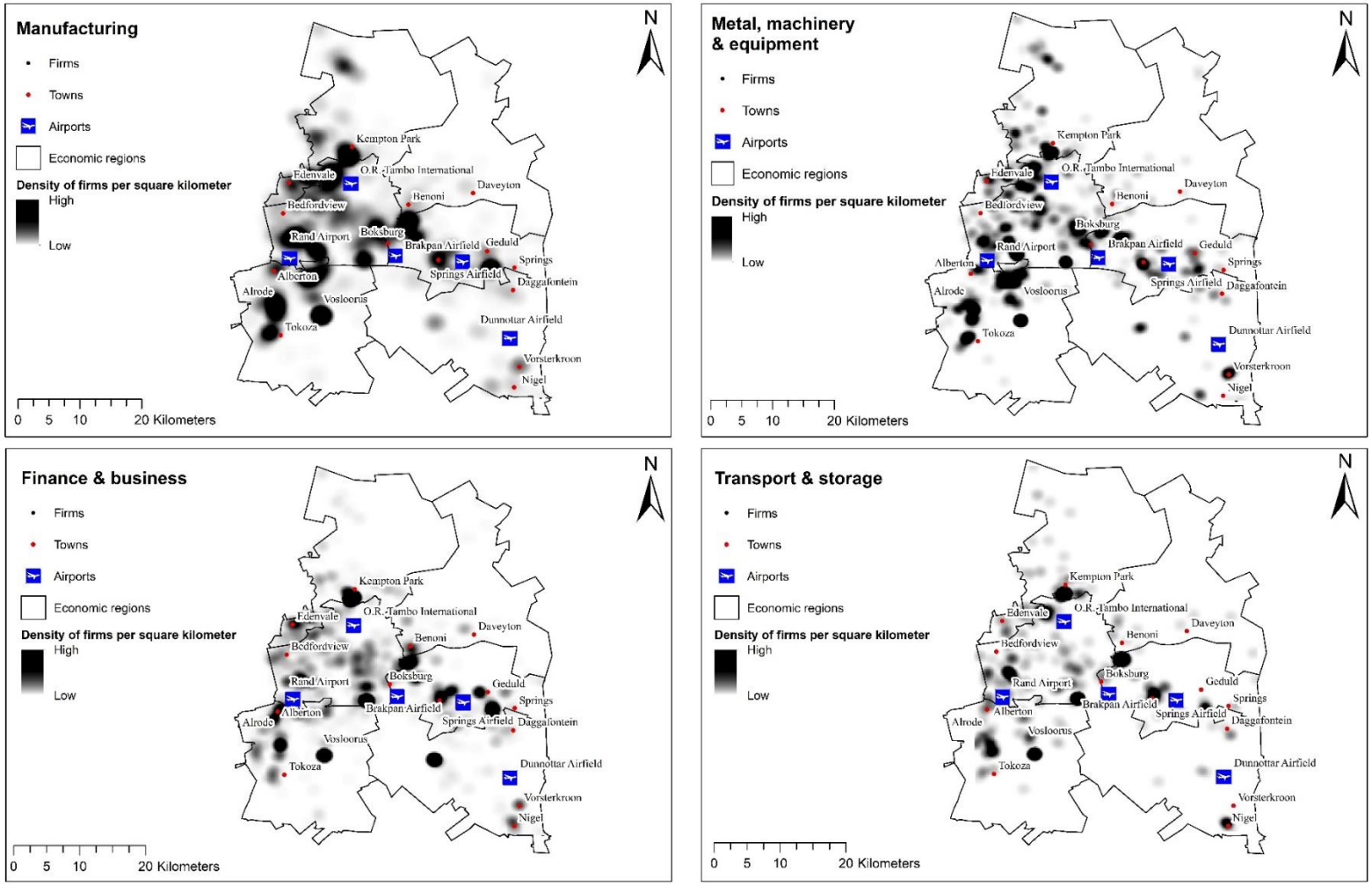
Source: EasyData (2019)

Figure 3. Distribution of selected industrial firms



Data Source: Ekurhuleni Metro Corporate GIS

Figure 4



Data Source: Ekurhuleni Metro Corporate GIS

Figure 5

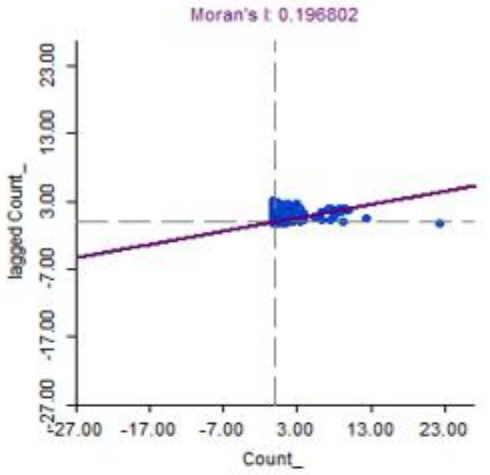


Figure 5a: Global Moran's *I* for manufacturing (SIC3)

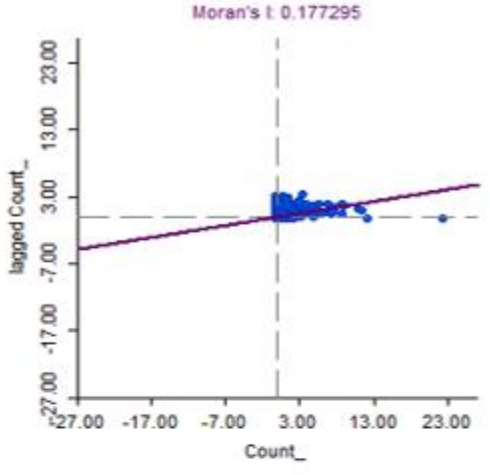


Figure 5b: Global Moran's *I* for metal, manufacturing, and equipment (SIC35)

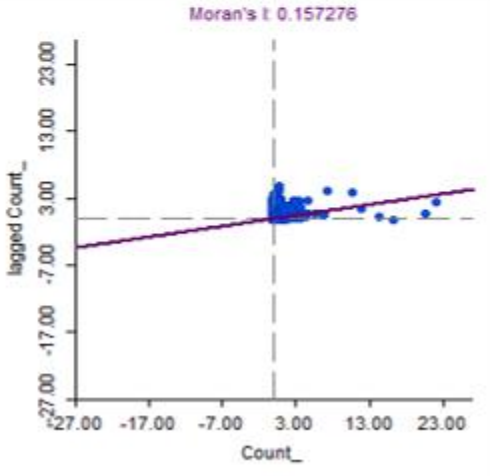


Figure 5c: Global Moran's *I* for finance and business services (SIC8)

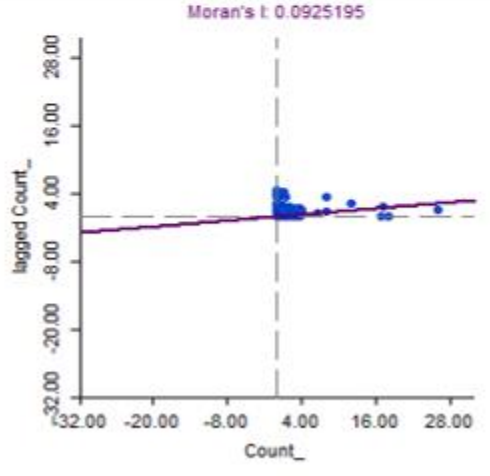


Figure 5d: Global Moran's *I* for transport and storage (SIC71)

Figure 6

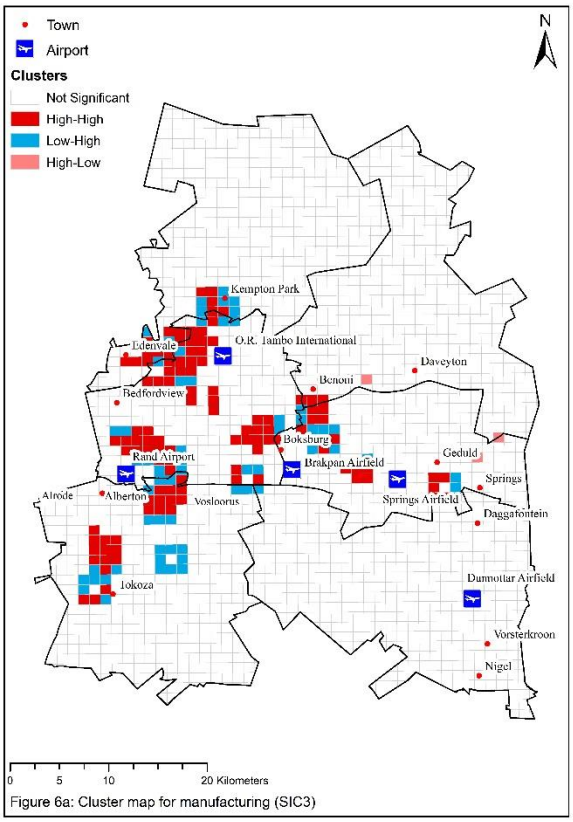


Figure 6a: Cluster map for manufacturing (SIC3)

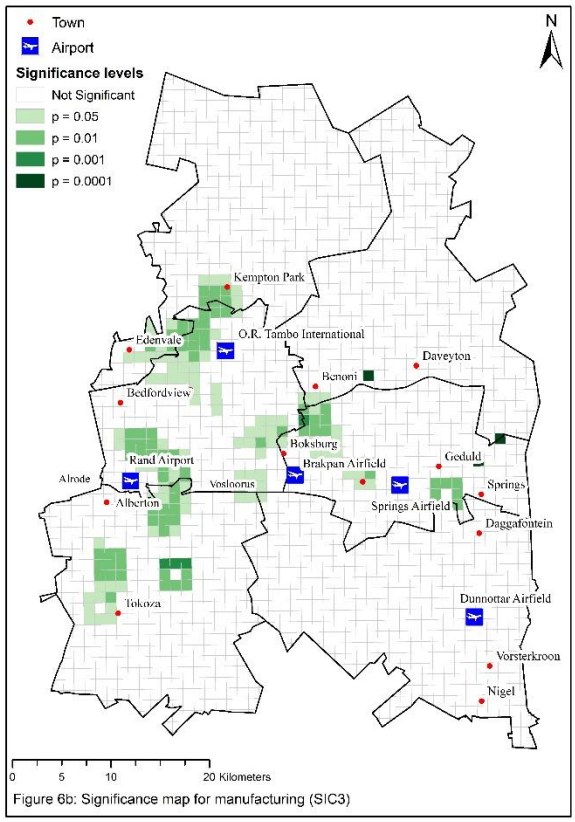


Figure 6b: Significance map for manufacturing (SIC3)

Figure 7

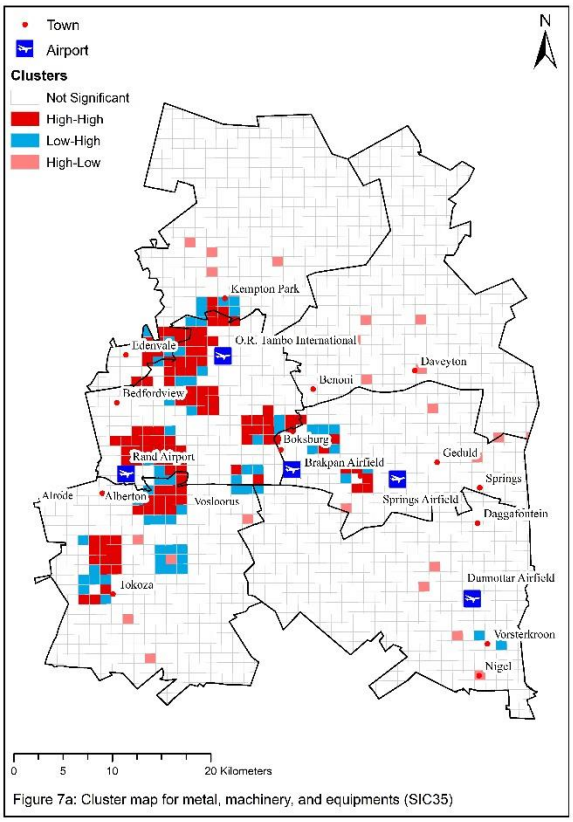


Figure 7a: Cluster map for metal, machinery, and equipments (SIC35)

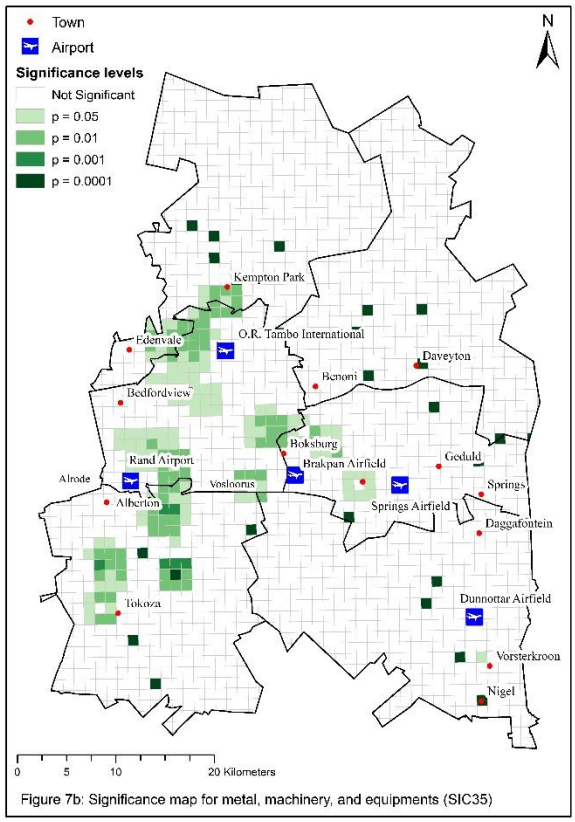


Figure 7b: Significance map for metal, machinery, and equipments (SIC35)

Figure 8

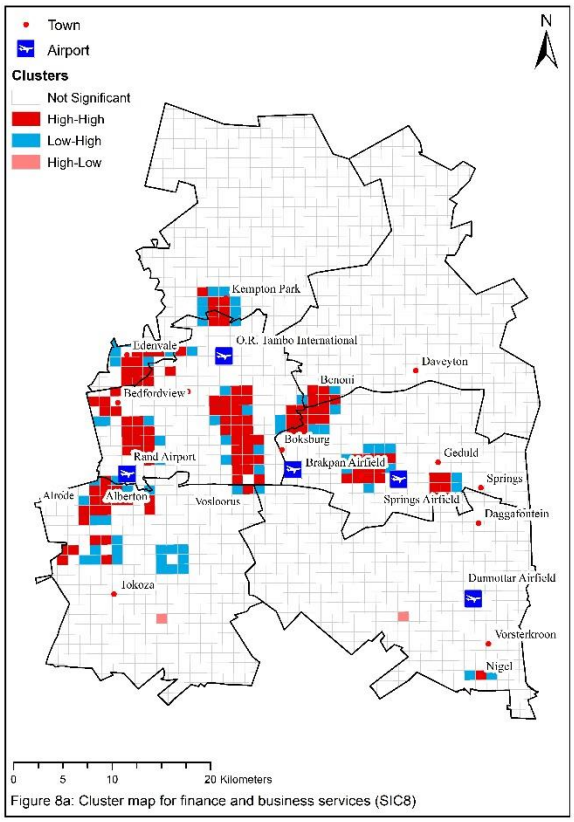


Figure 8a: Cluster map for finance and business services (SIC8)

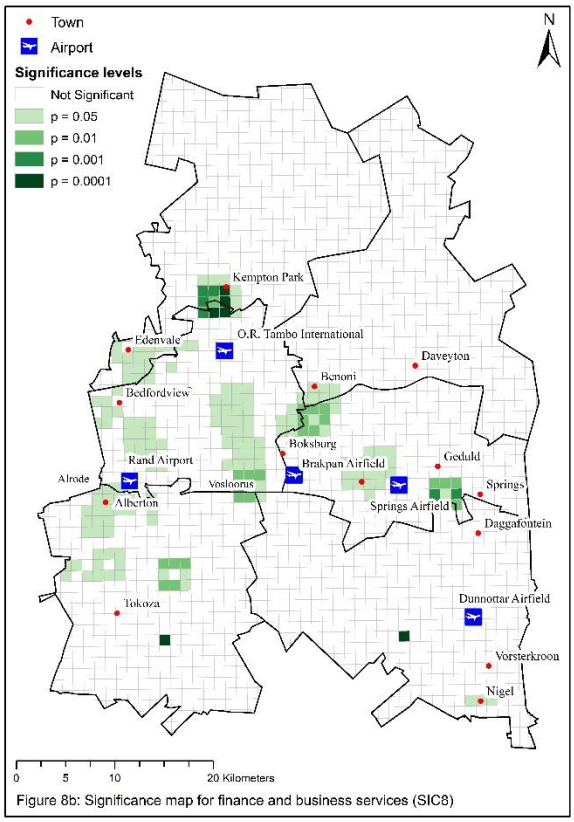


Figure 8b: Significance map for finance and business services (SIC8)

Figure 9

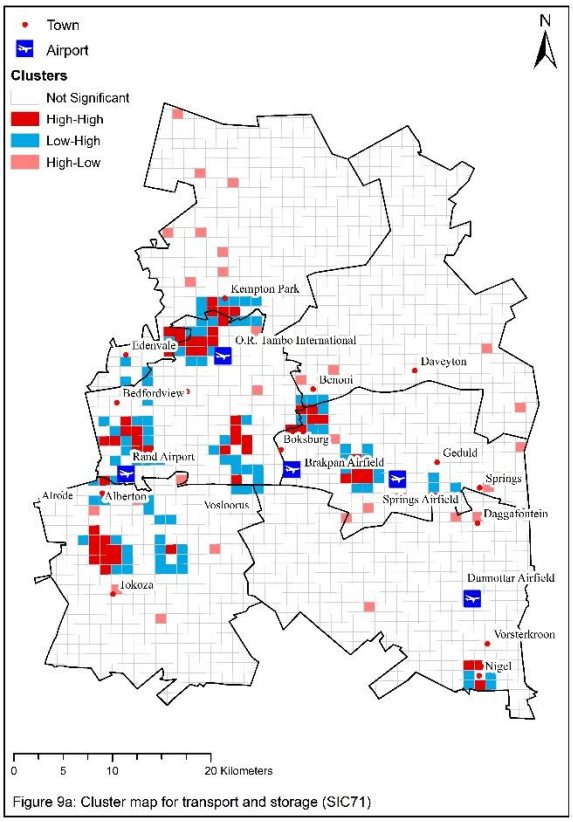


Figure 9a: Cluster map for transport and storage (SIC71)

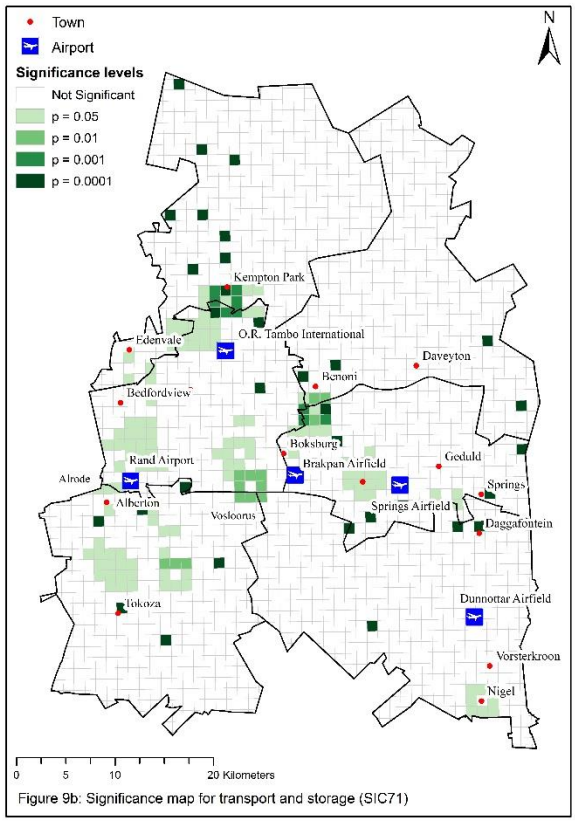


Figure 9b: Significance map for transport and storage (SIC71)