RETAIL PROPERTY MARKET PERFORMANCE OF CITIES:

An Investigation of the Relationships between Spatial Configuration of Consumer Movement and Changes in Retail Stock and Value in Leeds, Newcastle and York

A A ADEBAYO

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ADEJIMI ALLI ADEBAYO

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Abstracts

The influence of consumer activities on the performance of retail locations and retail property market in cities can be critical. This is because where and how retail consumers choose to transact influences the locational performance of retail property markets in cities. This study investigates relationships between consumer movement and the performance of retail property markets (RPM) between 2010 and 2017 in York, Leeds and Newcastle. The study adopts the spatial configuration (street segment) analysis technique to compute consumer movement patterns (CMP) on the sampled cities' layouts using DepthMapX to obtain the CMP variables; specifically, integration, choice and NACH metrics. The RPM data were sourced from valuation summary lists belonging to the VOA dataset and analysed using MS Access and MS Excel to obtain RPM variables, namely, changes in retail rental value and changes in retail stock across locations. The study investigates the spatial and statistical relationships between the CMP and RPM variables of cities at mesoscales and macroscales using QGIS and SPSS tools, respectively. The spatial investigations visualise locational relationships between changes in RPM variables and the spatial accessibility index of the CMP variables. The statistical analyses adopted Spearman-rho coefficients to investigate the rank correlation between the RPM and CMP variables. Further statistical (multiple regression) analysis were undertaken to estimate the locational performance of the RPM (dependent variable) using the CMP (independent variables) across all the estimable city layouts. Findings show that there are significant relationships between changes in retail rental value and all the CMP variables at York mesoscale, Leeds mesoscale and Newcastle macroscale. The results indicate that the relationship between configured consumer movement and changes in retail rental value are influenced by scale and city characteristics. The research is the first to estimate the location performance of commercial property by way of spatial configuration analysis. The research outputs are useful tools for retail property market actors to make locational decisions on investments, occupation, development and the strategic management of urban retail space. The study recommends further studies on the prospects of spatial configuration analysis and other methods in estimating the future performance of the commercial property market for optimum utilisation and the management of urban resources.

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Author's Declaration

I declare that this research has not been submitted for another award and that it is all my own work. I can confirm that the work acknowledges the works and views of others and has attained ethical approval. Approval has been sought and granted by the Faculty Ethics Committee.

Aspects of this research work have been published in journals and presented at conferences.

Published and presented works from this research include:

Adebayo A., Greenhalgh P., Muldoon Smith, K (2019) 'Investigating retail property market dynamics through spatial accessibility measures,' *Journal of European Real Estate Research,* Vol. 12 No. 2, pp. 155-172 (Appendix F)

Adebayo, A., Greenhalgh P., & Muldoon-Smith K., (2019) '*Investigating retail space performance through spatial configuration of consumer movement: A Comparison of York and Leeds'*. 12th Space Syntax Symposium (SSS). Beijing, China, July 2019 (See Appendix F)

Adebayo, A. (2018) '*Map as real estate tool: How data classification deceives'*. Annual Conference of Faculty of Engineering and Environment 2018. University of Northumbria Newcastle, June 21.

Adebayo A., Greenhalgh P., Muldoon Smith, K (2017) A taxonomy of data and software tools for geo-spatial analysis of town and city centre retail space, *The Journal of Association of Chief Estate Surveyors and Property Managers in Public Sector*. The Terrier. Autumn, 2017 pages 47-50

Adebayo, A. (2017) '*Using rental value and spatial configuration metric models as indicators of retail performance: A Decision tool for urban actors'*, Oxford Retail Future Conference, Said Business School, Oxford University Oxfordshire UK. December 12.

Adebayo A., Greenhalgh P., & Muldoon-Smith K. (2017) '*Exploring datasets needed for configuration of retail space performance analysis'*. Annual Conference of Faculty of Engineering and Environment 2017. University of Northumbria Newcastle, June 15.

Adebayo A., & Greenhalgh P. (2017) '*Examining how data utilised as segment lines in space syntax measurements influence configuration outputs: A test for Ordnance Survey MasterMap datasets of York city*'. Postgraduate Research Society Conference, Northumbria University Newcastle. April, 2017

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Glossary

Change period:	A seven-year period between 2010 and 2017.
Choice metrics:	One of the spatial configuration metric outputs. It represents through-movement metrics. (See CMP).
Choropleth map:	Thematic shaded maps revealing extent of spatial accessibility index or degree of changes in retail property market variables.
City:	Urban area including town.
CMP:	Consumer movement pattern. It is spatial configuration metric outputs comprising both spatial outputs and assigned syntactic values that allows geo-visualisation and statistical analysis with retail property market variables. There are three (3) configured metric outputs, namely, integration, choice and NACH metrics.
Computed changes:	Performance of RPM variables within the change period.
DepthMapX:	Software tool for conducting spatial configuration analysis.
Estimable layouts:	City spatial layouts (macroscale or mesoscale) that have all the CMP variables showing significance relationship with RPM variables.
Estimable variable:	Retail property market variables that have all the consumer movement pattern variables having significance relationship.
Existing Changes:	Please see observed changes.
Integration metrics:	One of the spatial configuration metric outputs. It represents to-movement metrics.
Locational changes:	Changes in the retail property market that are computed within delineated locations of spatial layouts.
Macroscale**:**	City wide scale having a 10km radius from the selected centre point of a city.

Mesoscale: Spatial extent of the city centre for any city, having a radius of not more than 2 km from a selected centre point.

Microscale: Neighbourhood extent within a city having a collection of a few streets that are far less than a 2km radius from selected centre points. Analysis at microscale has not been undertaken in this research but has been recommended for future researches.

NACH metrics: Normalised choice metrics. It represents through-movement metrics

Observed changes: Locational differences of retail property market variables between 2010 and 2017. It is the same as existing changes.

Overall changes: Changes in the retail property market that are computed across the macroscale of the sampled cities.

Property market systems: An indication of retail market characteristics at cities. It shows the degree of retail market competitiveness within a city. It indicates monopoly or perfection as regards the retail market on cities.

Retail cluster: Total number of retail addresses (retail units) within a delineated retail location. It is a subset of retail stock variable and has a strong relationship with retail floor space.

Retail floor space: Retail stock variable. Represents the total net floor space of retail spaces within and across delineated retail locations. It exhibits a strong relationship with retail cluster.

Retail rental value: Variable measure of £ per square metres of retail space. It indicates the demand-side of the retail property market on cities.

Retail Stock: The total count for retail floor space (or retail cluster). It denotes the supply-side of the retail property market.

Road centre line: Underlying street network data obtained from Ordnance Survey.

RPM: Retail Property Market. Consists of retail rental value variables, retail floor space and retail cluster. RPM performance implies changes in the aforementioned variables between the computed change periods.

Sampled city: Study area or investigated city. Three cities, namely, York, Leeds and Newcastle have been investigated in this research. (See spatial layout).

Spatial configuration: Technique based on space syntax theory that measure spatial (connectivity) properties of street segments by assigning syntactic values to all the analysed street segments.

Spatial layout: Global scale street network with a definitive boundary. It can be a city wide network (macroscale) or city centre network (for example, mesoscale). Six (6) sampled spatial layouts (namely, York mesoscale, York macroscale, Leeds mesoscale, Leeds macroscale, Newcastle mesoscale and Newcastle macroscale) have been investigated in this research. (See sampled cities).

Spatial relationship: Visualisation of one-to-one locational relationships between CMP and RPM variables. It is synonymous of a visual relationship.

SPSS tool: Statistical Package for Social Sciences tool. Adopted primarily in conducting statistical relationships between variables.

Statistical relationship: Quantification of relationships between variables to establish the significance of a relationship.

Street Segment: Smallest unit of link within a spatial layout. Connecting a street segment from a street network or spatial layout.

Street network: Synonymous of spatial layout.

Syntactic Values: Assigned numbers revealing the weight index of spatial configuration outputs on street segments. It reveals the metric index of integration, choice, NACH and any other investigated spatial configured variables.

Visual relationship: See spatial relationship.

To-movement: Integration metrics output of spatial configuration analysis.

Through-movement: Choice and NACH metrics outputs of spatial configuration analysis

VOA data: Valuation Office Agency data. The data is a valuation summary list of all non-residential property in England and Wales. It contains raw data on market rent value, floor space, addresses and other relevant data adopted in this research. The 2010 and 2017 data are publicly available. The 2010 and 2017 data represent market values for 2008 and 2015, respectively.

Chapter One

Introduction

1.0 Introduction

This chapter introduces the research thesis. It presents an overview of the research while revealing the background, objectives and reasons why it was undertaken. The chapter also contains the research's problem statements, key limitations of the study, structure of the thesis as well as the philosophical position adopted by the researcher.

1.1 Background of the study

The retail property market is constantly adapting to the continuous demands of retailers, which are influenced primarily by consumer demand for retail goods and services. Retail consumers play significant roles in shaping retail location performance. This is because where and how consumers choose to shop determines retail location viability, which in turn influences demand (rental value) and supply (stock) of retail property within a given built environment. The retail property market performance of a city is measurable by means of locational changes in market variables between two or more dates, where noticeable (market) changes of variables may have occurred. Changes in retail property market variables, such as rental value, floor area (stock), retailer cluster, retailers' turnover, vacancy rates, tenant mix among others, can signal the locational performance of retail property within a given city (Wrigley et al., 2002; Adebayo et al., 2019a; Greenhalgh, 2020). The relationship between retail location performance and consumer movement across cities is the focal point of this research.

Cities are built environments made up of connected streets. The way these streets are laid out influences human (consumer) movement, concentration of footfall and the accessibility index of locations (Jiang and Jia, 2011; Shen and Karimi, 2016; Adebayo et al., 2019a; 2019b). Increasing numbers of studies (Alonso, 1964; Batty, 1989; Litman, 2003; Taylor et al., 2006; Matthews and Turnbull, 2007; Halden, 2011; Hillier et al., 2012; Levison and Huang, 2012; Netzel, 2013), have explored the connectivity of streets, along with accessibility and urban land value using different approaches. These studies have established that there are correlations between spatial accessibility, human movement and urban land value. However, little is known about *how spatial accessibility (consumer movement) index correlates with changes in retail rental value and stock (retail property market performance) across different locations*. This knowledge gap has hindered the practical application of the established relationships between spatial accessibility and urban land value.

The challenges facing retail property markets in UK are common to many cities. These challenges include increasing store closures, declining high streets, increasing vacancy and void periods, low absorption rates (of retail space), increasing tenant incentives, reduction in net effective rents and many other unfavourable market conditions (Deloitte, 2013; 2017; 2018). These aforementioned characteristics (challenges) are not the problem per se, the main problem rests on the volatility and unpredictable nature of the leading cause of these unfavourable market conditions; that is, consumers and their behaviour. *Retail consumers are unpredictable despite having a huge influence on retail property markets* (Andreasen, 1984; Pickett-Baker and Ozaki, 2008; Hackett and Foxall, 2010). It should be mentioned that changes in consumer shopping behaviours are altering the economic and physical structures of retailing in the UK (Hackett and Foxall, 2010; Greenhalgh, 2020).

The contemporary conditions of retail property markets in many cities have been shaped by changes in consumer shopping behaviour, many of whom now prefer online shopping (for certain products) than purchasing from traditional bricks and mortar (physical retailing) (Sangjae and Hyunchul, 2010; Deloitte, 2018). Concomitantly, the need to transact business within physical retail spaces is decreasing and consequently, is making many retail spaces (stores) redundant (Alwitt and Donley, 1997; Spillier and Lohse, 1997; Sangjae, 2003; Haugen, 2007). The recent study conducted by Greenhalgh et al. (2020), shows that the UK is in excess of more than 30% retail space. This suggests both problems and opportunities for repurposing, reinvestment and the redevelopment of urban retail spaces.

Therefore, it is important for retail market actors including retailers, landlords and local planners to understand the relationship between retail consumers' movements and retail location performance in order to make reasonable decisions on the use and management of urban retail spaces. Whilst the importance of consumer movement on the success and performance of retail locations is not in doubt, assessment and understanding of consumer spatial behaviour across wide urban retail spaces can be challenging due to retail consumers volatility (Wang et al., 2014; Omar and Goldblatt, 2016). This is because consumer behaviours vary and depend on many inconstant variables, including, consumer income, social class, age range, emotion, taste and style, culture, consumer needs and preferences among others (Andreasen, 1984; Spillier and Lohse, 1997; Wrigley et al., 2002; Sangjae, 2003; Sangjae and Hyunchul, 2010). In other words, the volatility of consumer variables makes it extremely difficult to generalise consumer behaviours to guide decisions of retail property market actors to tackle the current challenges and prepare for the future ones. Earlier studies (Christaller, 1933; Batty, 1978; Borgers and Timmermans, 1986; Leeuwen and Rietveld, 2010; Shephard and Thomas, 2012; Helm et al., 2015), that have investigated consumer spatial behaviour across cities, have done so, relying on observational and physiological methods. These methods are detailed but limited in coverage (scope), which often limits its practical applications (Wang et al., 2014).

Conversely, one unifying element as regards consumers, irrespective of the diverging variables, is that they will continue to navigate physical retail spaces via street networks to effect interaction with retailers. In other words, the connectivity of streets can be analysed to have an involatile attribute of retail consumers, which can be investigated with retail property market performance (Adebayo et al., 2019a; Adebayo et al., 2019b).

This research adopts static measure of 'streets' in assessing consumer movement across the sampled cities; specifically Leeds, Newcastle and York. The research adopts scientific means, primarily spatial configuration techniques (based on space syntax theory), to compute spatial accessibility as measures of retail consumer movement across the sampled cities. Therefore, *consumer's movements were captured through analysis of street networks based on space syntax theory*. Preceding studies (Rodriguez et al., 2012; Netzell, 2013; Muldoon-Smith et al., 2015; Giannopoulou et al., 2016; Adebayo et al., 2019), that have focused on relationships analysis between spatial configuration parameters (as a measure of accessibility) and urban economic variables, such as rental value and stock, have shown variations in the types of relationships between the investigated variables across different cities.

This research investigates these inconsistencies (in relationship outputs), by exploring relationships between variables across different locations. *The research contends that should significant relationships between configured consumer movement and the performance of the retail property market exist in a given location, then one should be able to estimate the future locational performance of that location, using the coefficients of the configured consumer* *movement index*. In doing so, consideration has been given to underlying static streets which have been used as a measure of consumer movement. *The study explores the extent of the influence of street networks (scale) on relationship analysis between retail property market performance and consumer movement*. This study sheds light on the application of spatial configuration techniques (space syntax theory) in analysing real (retail) property markets within city locations. The research contributes to the existing body of knowledge that has explored relationships between spatial accessibility and urban land values (Alonso, 1964; Song and Sohn, 2006; Rodriguez et al., 2012; Tal and Hardy, 2012; Netzell, 2013; Muldoon-Smith et al., 2015; Greenhalgh et al., 2020).

The key questions that this research answers are:

i. How has the retail property market performed across the investigated cities?

ii. How does spatial configuration analysis capture consumer movement patterns across the sampled cities (street network)?

iii. How do configured consumer movements relate to the performance of the retail property market?

iv. How do configured consumer movements estimate the performance of retail locations in cities?

1.2 Rationale and contributions of the research

The section identifies two broad reasons for undertaking the research. The first rationale is practice-led. That is, it considers the current challenges facing retail property markets that require understanding the future performance of retail space for the optimum utilisation of urban resources. The second reason is theoretical and aims to enhance the application of relatively new but relevant theory; specifically space syntax theory and spatial configuration techniques, into the study of real estate (retail property) markets. The second reason covers developing and updating existing academic theories on retail property markets while filling essential gaps in knowledge. The following subsections further discuss the two broad motives of this research.

1.2.1 Practice led Rationale: Tackling the current challenges facing the retail property market

One of the motives behind examining retail market changes through consumer actions is an attempt to address the current challenges facing the retail sector. As indicated in the preceding section, the current challenges facing the retail property market are many and require immediate action to mitigate it.

The relevance of the retail market sector to national and local economies including the social wellbeing of people cannot be overemphasised (Haugen et al., 2007; Griffiths et al., 2018). The retail sector is the largest private employer of labour in Europe and provides more than 3 million jobs in the UK (British Retail Consortium BRC, 2015; 2017). Retail also contributes more than 5% to the UK GDP, as one third of all household spending goes into this sector (Office of National Statistics ONS, 2017). The continuous changes in retail markets are of concern to many retail market stakeholders, including governments (who generates taxes from it), landlords, retailers (occupiers), Business Improvement District (BID) companies, local authorities, local planners, as well as other decision-makers (British Council of Shopping Centres (BCSC), 2007; Deloitte, 2013; 2018). That is, the economic and social interests of these market stakeholders are at risk, if necessary measures are not taken to tackle these challenges (Guy, 1998; Kim, 2001; Deloitte, 2018). As such, the influence of consumer movement and changes in retail property markets across locations should be clearer to stakeholders in guiding them on the use, management and planning of urban retail spaces. *This study analyses the relationships between consumer movement and changes in the retail property market across different locations with a view of estimating future performance of the retail market*. The researcher's view is that understanding the locational performance of retail space (through consumer and retail market variables), will enhance decision-making on retail property investment, development, taxation, occupation and better utilisation of urban spaces. The research develops the new approach of relating consumer movement and existing recorded changes in retail markets in cities that has both practical and theoretical implications for commercial property markets decision-making. The following subsection discusses the theoretical motivations of this research.

1.2.2. Theory-led Rationale: Filling knowledge and application gaps

There is a knowledge application gap between space syntax theory and real estate (retail property) market research. Similarly, there is a research gap around the influence of consumer movement on the performance of retail markets within cities**,** specifically, the relationships between spatial accessibility and changes in retail rental value (demand) and stock (supply) are relatively unknown (Adebayo et al., 2019a; 2019b). Previous gap in studies is principally due to the differences between the background of real estate and space syntax studies. While the latter gap generally arises because of the rigor attached to measuring and mapping consumer movement on spatial layouts, these two identified theoretical gaps contribute to the approaches adopted in this novel research.

Preliminary studies have adopted various strategies and developed models to explain changes in commercial (retail) property markets in various cities (McGough and Tsolacos, 1994; Tsolacos et al., 1998; Nanthakumara et al., 2000; Hendershott et al., 2002; Dunse et al., 2010; Liang and Wilhelmsson, 2011; Astbury & Godwin, 2014). Likewise, other related studies (Tsolacos and Mcgough, 1999; Ingrid, 2006; Greenhalgh, 2008; Nsibande and Boshoff, 2017), have also contributed to the understanding of how changes in property market performance indicators influence spatial decisions of market actors concerning the development, investment and occupation of commercial property. These preceding studies have provided insights as to how changes in retail property market variables influence the demand and supply of retail property within cities. However, *the only tangible means through which consumers will always connect and access retail property (i.e. street networks) has never been considered in the previous works*. This important gap requires exigent consideration for optimum utilisation of city (retail) space as online retailing and other factors are changing the structure of retail markets. Moreover, existing academic concepts explaining the retail property market and consumer spatial behaviours are losing relevance, principally because the changes currently facing the retail market environment are new. As such, a novel research that investigates today's realities is necessary in order to enhance use of retail space for better management of future city retail space.

Furthermore, spatial analyses of urban (retail) spaces have evolved through different stages and techniques. From the non-empirical period, retail space studies that were based on mere intuitive reasoning and observations of retailers and consumers (Gruen, 1954, 1973; Nelson, 1958; Gruen and Smith, 1960), to empirical retail space researches (Howard, 1997; Guy, 1998), that statistically investigated consumers and retail spatial variables, such as distances and densities, to computerisation using spatial software tools of urban retail (property) spaces

(Teller and Reutterer, 2008). These stages have attempted to solve germane retail (market) problems at the time. However, none of these traditional approaches can be adopted wholly to measure consumer movement behaviours, even though many of the studies (Gruen, 1954, 1973; Nelson, 1958; Gruen and Smith, 1960; Guy, 1998; Hackett and Foxall, 2010), acknowledged consumer relevance to retail markets. Computation of consumer movement on city spatial layouts can be demanding because of the differences in retail consumers' needs and other diverging variables (stated earlier). It is almost impossible to map all the retail consumer movements within a given retail space at the same time using the preceding approaches. This study explores the potential of space syntax theory in computing consumer movement.

Space syntax theory has been adopted in various aspects of urban (retail) studies including walkability, retail frontage analysis, retail crime detections and many others (Griffiths et al, 2013; Kooshari et. al., 2016; Carol et al., 2018). However, many of these studies (that have adopted space syntax theory in analysing retail space), only perceive retail property spaces as buildings and structural entities, probably because the theory is of architectural background. Hence, many of the preceding works that have applied the theory to retail spaces lack an understanding of real property attribute '*location'*. Specifically, real estate (property) market analysis is typically not based on the physical buildings and structures, but locations and other market entities that change over time (Evans, 2008; Greenhalgh and King, 2013). As such, a *fundamental understanding of location (and real estate) concepts is missing in the previous studies that have explored space syntax principles on retail space*. It can be argued that the lack of understanding of retail market (location) concepts in the previous studies have undermined the potential of space syntax ideologies in contributing to understanding the retail property market within a given spatial layout. This has made it difficult for property market professionals to comprehend the use of this highly technical but useful theory.

This research developed a means of breaking down the theory of space syntax into meaningful interpretation for real estate (market) professionals. This research employs the theory to compute retail consumer movement pattern on city space by investigating street connectivity (networks). *This research is the first to investigate the retail property market performance via space syntax theory*. The research contributes to the burgeoning research fields related to the retail property market and space syntax. The work attempts to enhance the understanding of space syntax concepts into real estate market concepts. The research bridges applications of space syntax theory (spatial configuration of consumer movements), in investigating the retail property market within city layouts.

Consequently, this research makes a significant and original contribution to knowledge in the following ways:

- The study develops a novel approach to measure and analyse relationships between property market performance and spatial accessibility (that is applicable to all types of properties and cities). Specifically, the research contributes to the understanding of relationships between retail property market performance and consumer spatial behaviour (movement) (see Chapters 5 and 6).
- This research is the most robust and rigorous work on relationship analysis between spatial configuration parameters and urban economic data such as rental value and stock. The research takes two additional steps in contrast to previous studies (Rodriguez et al., 2012; Netzel, 2013; Muldoon-Smith et al., 2015; Giannopoulou et al., 2016), that have investigated spatial configuration parameters and urban economic variables. The research investigates the relationship between the retail property market and consumer movement (through spatial configuration), across three cities at two scales.

- The research is the first to explore the potential of space syntax theory in estimating the locational performance of property market variables. Thus, enhancing the application of space syntax theory in the study of the built environment (real estate**)** (see Chapters 5 and 7).
- The research contributes to better understanding of space syntax and sheds light on some of the noted inconsistencies in analysing relationships between spatial configuration parameters and urban economic variables (see Chapters 2, 4, 5 and 6).

1.3. The research aims and objectives

The overall aim of this research is to investigate the influence of consumer movement on retail property market performance within cities. This involves exploring the relationships between the spatial configuration of consumer movement and locational changes in the retail property market between two census points. The research examines the relationships between consumer movement patterns and locational changes in retail rental value and changes in retail stock (that is, floor area and retail cluster) in three different cities (namely, York, Leeds and Newcastle) at meso and macro scales, with a view to estimating the future location performance of the retail property market within the sampled cities. The research investigates how relationships between variables are affected at different cities and different spatial scales.

To achieve the above goals, the following research objectives are set out:

i. To compute changes in the retail property market within the sampled cities.

ii. To configure consumer movement patterns on sampled spatial layouts.

iii. To investigate relationships between retail property market performance and consumer movement patterns across cities.

iv. To estimate the locational performance of the retail property market.

The following subsections explain the above listed research objectives.

1.3.1 Objective 1: Computing changes in the retail property market within cities.

This research computes locational changes in retail property market variables (namely, retail rental value, retail floor area and retail cluster). The locational changes were investigated to determine retail property market performance across delineated locations within the sampled cities. This objective seeks to reveal the types and extent of changes in retail property market variables across the sampled city layouts. It seeks to understand the market characteristics and behaviour of retail property market variables across all sampled cities (see Chapters 5 and 6).

1.3.2. Objective 2: Configuring consumer movement patterns

Consumer actions on all the sampled spatial layouts have been worked out based on the connecting property of the underlying street network. The research computes consumer movement patterns via the spatial configuration method of space syntax. Street segment analysis was conducted on all the sampled spatial layouts at global scales. As such, syntactic values of integration, choice and NACH metrics were calculated and assigned to all the street segments within the analysed spatial layouts. This allows the spatial accessibility index of integration, choice and NACH metrics (i.e. consumer movement patterns), to be mapped in QGIS for relationship analysis with retail property market performance. The study investigates distribution patterns of integration, choice and NACH metrics across the sampled cities at meso and macroscales to further understand the scientific computation of human (consumer) spatial behaviour across different locations (See Chapters 5, 6 and 7).

1.3.3. Objective 3: Investigating relationships between variables on sampled spatial layouts

Both spatial and statistical analyses were conducted in investigating the relationships between retail property market performance and configured consumer movement. The spatial investigations of variables seek to visualise the locational relationships between the accessibility index of consumer movement patterns and the extent (or types) of changes in retail property market variables. It aims to reveal the visual correlation between consumer movement variables and changes in retail property market variables across all the sampled cities. The spatial relationship investigation attempts to establish if the higher the accessibility index, the more (or less) the changes in RPM variables.

Meanwhile, statistical relationships between variables seek to quantify extent of relationships between variables across all the sampled layouts. Correlation and regression statistical analyses were conducted in this research. The results were useful in validating spatial relationship outputs and estimating the future performance of retail property market variables (objective 4).

1.3.4 Objective 4: Estimating the locational performance of the retail property market

The results obtained from Objective 3 form a crucial part in estimating property market performance within cities. This is because objective 3 determines spatial layouts (and retail property market variables), that are estimable based on the significance of consumer movement relationships and changes in the retail property market. As such, regression models for estimating retail property market performance (dependent variable) are analysed for the estimable spatial layouts and estimable retail property market variables using coefficients of consumer movement index (see Chapters 5 and 6).

1.4. Key limitation of research

The main limitation of this research is that there is no comprehensive method that can measure consumer behavioural (movement) patterns on city (retail) space. Despite the space syntax theory's utility in computing human movement patterns, its basic assumptions on human behaviours and spatial layouts (street network) have been criticised to varying degrees (Ratti, 2004; Batty, 2017) (more details on the shortcomings of space syntax have been reviewed in part of Chapter 4 of this thesis). However, an evaluation into all possible means of measuring retail consumer movement on city space suggests that the spatial configuration approach remains the most suitable method that can compute (and capture) retail consumer movement at city scales.

Other limitations pertaining to the data and techniques adopted in this research have been presented in Chapter 5 of this thesis. The research philosophy which is reliant on the spatial configuration of consumer movement and retail property market performance within cities is discussed in the subsequent section.

1.5. The research philosophy

A pragmatic research approach that sits between positivism and realism research philosophy has been adopted in this study. This is because all the research objectives have been tackled using the most appropriate means and tools (as established in Chapter 5). This study has not focused on utilising space syntax theory to test and validate retail consumers' movement patterns. Rather, it has rested on previous works (theories) that have established that spatial configuration outputs relate objectively with human movement on spatial layouts (Peponis et al., 2008; Hillier et al., 2012). The research adopts positivism in relation to space syntax theory in computing retail consumers' movement patterns on spatial layouts. One of the key assumptions made in this research is that street network are static variable. Likewise, this study is of the positivist view that all the obtained retail market data are accurate data that reflect property market data.

The research has adopted the realism approach to the method of analysing computed consumer movement and retail market variables. In doing so, three distinctive cities, each having unique spatial layouts and retail market components, were selected purposively as the study areas in this research. The essence of this was to attain realistic outputs on the analysed data. Likewise, the experimental research has been conducted at different spatial boundary scales (that is, macroscale and mesoscale). Chapter 5 of this thesis presents details on sampled cities and their spatial boundary demarcations.

1.6. Structure of the thesis

This thesis is divided into seven chapters. This chapter (Chapter 1) introduces the research by presenting the study rationale, objectives, questions and other research overviews. The next chapter (Chapter 2) reviews evolution and future retail trends (with focus the on UK retail market). This is subsequently followed by reviewing issues (aspatial and spatial) influencing the performance of the retail property market in Chapter 3. Reviews on cities spatial layouts, spatial and statistical analyses including space syntax reviews were presented in Chapter 4 of this thesis. These reviews were followed by the research methods in Chapter 5. Chapter 6 discusses the research results and it theoretical and practical implications. The final chapter of the thesis is Chapter 7 which presents the key findings, conclusions, recommendations and areas for further research.

1.7 Chapter Summary

This chapter has presented an overview of the research. It has presented the research background, motivations behind the study, together with the goals and objectives of this research and thesis. The chapter has also identified the key limitation of this study while indicating the philosophical stands of the research. The concepts of spatial configuration of consumer movement in relation to the retail property market performance within cities have been presented herein. The next chapter reviews literature on perspectives of retail future, retail location theories among other urban retail issues.

Chapter Two

Retailing in Cities:

Evolution and Future of Retail Location Theories

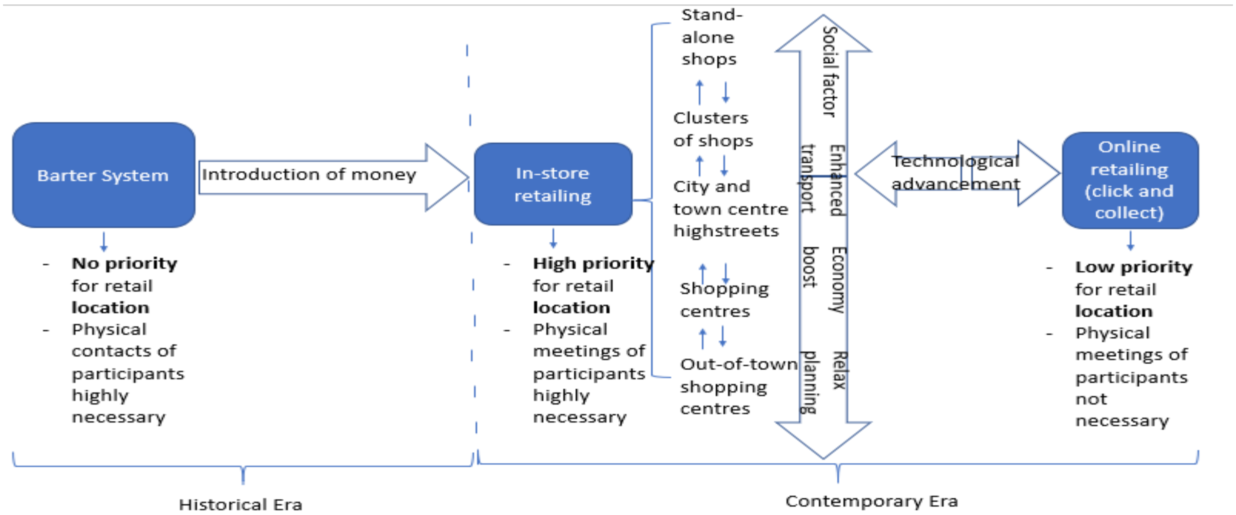
2.0 Introduction

The term cities in this research include towns and urban areas. This chapter reviews existing literature on retail activities in city space. The chapter reviews the evolution and future of retail and city location theories. The next section discuses evolution of retailing.

2.1. The evolution of retailing: From barter system to instore and online retailing

Retailing activity is one of the earliest recognised human activities (Hollander, 1960; Cozen and Cozen, 1979; Levy, 1989; Christensen and Tedlow, 2000; Campa and Goldberg, 2005; D'Arcy et al., 2012; Bamfield, 2013; Kacen et al., 2013). Consequently, it has evolved (through various stages), over time because of various factors influencing its evolutionary stages, as explained in Figure 2.1.1 below (Brown, 1990; 1992).

Figure 2.1.1: Context of Retail Evolution



Source: Adapted from Brown (1990; 1992)

There are two universal broad eras as regards retailing, namely, the historical and contemporary retail eras (Cozen and Cozen, 1979; Shackleton, 1988; Levy, 1989). Brown (1992), further classified retail evolutionary stages into three different stages, namely trade-by-barter system (barter system), physical instore retailing and online retailing, which fit-in into the universal categories of retail evolutions as shown in Figure 2.1.1 (Brown, 1990; 1992). During these periods, significant changes occurred that influenced modes of transaction, reliance on retail spaces (and locations), the necessity for contacts (between consumer and retailers before retailing transactions can be effected) and the relative power of retail market participants (Jones and Orr, 1999; Christensen and Tedlow, 2000; Campa and Goldberg, 2005; Kacen et al., 2013). Brown (1990; 1992), contended that the continuous changes in modes of transacting business between retailers and consumers have been primarily driven by external factors, including social, economic, planning and technology.

It should be mentioned that the common axiom '*necessity is the mother of invention*' has been applied and played a key role in the transformation of retailing periods from barter system to online retailing (common today). During the barter system period, there were no fixed locations for transacting businesses between the two main market participants (i.e. retailer and consumers), even though, physical contact between the two is essential. Retailing was based on trading goods for goods among retail market participants (Cozen and Cozen; 1979). As such, values of goods (as retail products) are not standardised but are based on the individual perceptions of the market participants (Cozen and Cozen, 1979; Dixon, 2007). Apart from the lack of standardisation, the barter system was cumbersome and time consuming for both retailers and consumers (Cozen and Cozen, 1979; Brown, 1990). Consequently, there was virtually equal power sharing between retailers and consumers during the barter system.

The introduction of common means of exchange (i.e. money), made trading easier for both retailers and consumers. Therefore, there was a shift in the method of retailing from bartering to localised instore retailing (Hollander, 1960; Brown, 1990; Dixon, 2007; D'Arcy et al., 2012). During the emergence of instore retailing, retail store locations (and retailers) became the order of the day. This was because consumers had to visit the retail space (stores) for any form of transaction to occur. Fundamentally, instore retailing has a higher locational priority than the barter system (and indeed online retailing) (Brown, 1990; Dixon, 2007; Jones and Livingstone, 2015). At the height of the instore-retailing period, the location of retail stores were the key determinant relating to the success and failure of retail activities (Brown, 1990; 1992; Christensen and Tedlow, 2000; D'Arcy et al., 2007; Dixon, 2007 and D'Arcy et al., 2012). Grewal (2000), recognised that factors including economic, social and government policies (and others) that supported the emergence of instore retailing have also had a positive influence on the locational performance of retail stores. Grewal (2000), explained further that retail stores situated in neighbourhoods within positive economic and social indicators, such as high employment rates, low level of crime, etc., tend to survive and prosper compared to retail stores situated within neighbourhoods characterised by negative indicators, for instance unemployment and high crime rates. Concomitantly, the ability of a retailer to locate in an accessible location with such positive characteristics that will attract targeted consumers, determines who controls the retail markets (Brown, 1992; Grewal, 2000; D'Arcy et al., 2012). In other words, during the in-store period, a retailer positioned in a good location within a given city knew how to influence power in controlling the retail market (Brown, 1992). This is because retail store locations influence consumer patronage and retailers' turnovers and profits (Huff, 1962a; Brown, 1992; 2006).

However, as innovations have increased, more power has shifted into the hands of retail consumers (and away from the retailers) (Brown, 1992; D'Arcy et al., 2012; Bamfield, 2013; Kacen et al., 2013). The contemporary retailing period (that is, online retailing), as instigated by technological innovations and advancements has transformed retailing activities. Online retailing makes business transactions between retailers and consumers more straightforward (at a distance), while boosting consumers' knowledge concerning the retail market (Dixon, 2007; Centre for Retail Research CRR, 2018). Similarly, technology concerning online retailing has created plethora of choices for consumers on where, how, what and when to shop – therefore boosting consumers' confidence and empowering them as retail market participants. Today, consumer power in controlling retailing activities (and retail property market) is on the rise (D'Arcy et al., 1997; CRR, 2018). As a result, the locational relevance of retail stores and power of retailers in controlling the retail market are gradually being reduced and becoming more fragile (Grewal, 2000; Pan and Zinkhan, 2006a; Pan and Zinkhan, 2006b). On a similar note, online retailing has broadened the customer base for many retailers, while also expanding the consumer catchment areas (Pan and Zinkhan, 2006a; Pan and Zinkhan, 2006b). Subsequently, many retailers have had to set up online marketing and sale platforms to meet the current strands of consumer shopping behaviour despite the extra costs involved (Bruce and Daly, 2006; Bertram and Chi, 2018). Specifically, the current changes between both contemporary retailing stages (that is, instore and online) have resulted in unprecedented changes in business models and the activities of many retail property market stakeholders (Fernie et al., 2010; Dodds et al., 2012; Jones and Livingstone, 2015).

Initially - during the early stages of the Internet (and online retailing), there were low (or no) expectations on the possible negative effects of online retailing on physical retail spaces and retail property markets (Brown, 1992; D'Arcy et al., 1997; Dodds et al., 2012). This was because the benefits of the Internet and online retailing surfaced more than the potential negative effects (Brown, 1992). However, various studies (Burt and Sparks, 2003; Bruce and Daly, 2006; Fernie et al., 2010; Budenbender and Golubchikov, 2016; Jones and Livingstone, 2015; Van loon and Aalbers, 2017; Bertram and Chi, 2018; Deloitte, 2018), have linked the growth in online retailing to the deteriorating performance of retail property markets across many cities. Jones and Livingstone (2015), while assessing the role of internet technology on retail markets argued that the location of retail stores is threatened by the broad acceptance of online retailing by the two main market players (that is, consumers and retailers). They concluded that the physical and economic structures of the retail property market are changing due to the continuous growth of online retailing and other changes in modes of transacting business between retailers and their customers (Budenbender and Golubchikov, 2016; Jones and Livingstone, 2015; Van loon and Aalbers, 2017).

Brown (1990; 1992), explained that changes in retailing are an integral part of retail activities that will remain awkward. However, the contemporary changes in retailing brought by technology differs from the changes instigated by common means of exchange. While the introduction and acceptance of money (as common means of trading between consumers and retailers) transformed retailing from barter system into instore, advancement in technology has not completely erode of the relevance of retail stores (Bamfield, 2013; Jones and Livingstone, 2015; Van loon and Aalbers, 2017; Baum, 2017). Essentially, online retailing has not overtaken in-store retailing, as instore retailing usurped the bartering system in retailing (Brown, 1992; Jones and Orr, 1999). Consequently, the future of retailing remains uncertain (Bamfield, 2013; Baum, 2017; DaSilva, 2018). This is because the extent to which internet technology will influence retailers' business models and other commercial property market actors remains uncertain, as there are divergent views on the future of retailing and its consequences on retail property markets in cities (Bamfield, 2013; Bertram and Chi, 2018; Baum, 2018; DaSilva, 2018; CRR, 2018). The next section reviews three broad perspectives relating to the future of retailing and retail property markets.

2.2 Perspectives of the future of the retail property market

This section reviews academics' perspectives on the future of the retail property market. The identified perceptions of Bamfield (2013), Baum (2018) and DaSilva (2018) ideologies on the future of the retail market have been reviewed. The following subsections discuss these in detail.

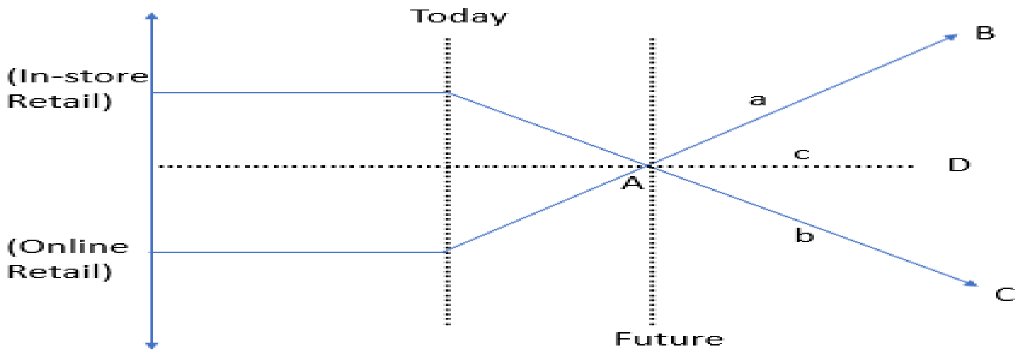
2.2.1 Bamfield ideology on retail market future

Bamfield (2013), identified three possible directions for the future of the retail market in the face of increasing competition from online retailing. His idea on the future of retail was established based on his perception of consumers' shopping methods. Bamfield (2013), classified the future of retailing into three scenarios:

a. Perpetual online retailing
b. Instore retail disappearance
c. Complementary retail future (omni-channel and multi-channel)

Figure 2.2.1 below describes the explanation of the three idiosyncratic views of the future of retail by Bamfield (2013).

Figure 2.2.1: The Ideology of the future of the Retail Market



Source: Adapted from (Bamfield, 2013)

The first scenario regarding Bamfield's perception (i.e. future of continuous online retail) as represented by perception line 'AB' (Figure 2.2.1) predicts that online retailing will experience continuous growth. As such, consumers will continue to shop online rather than visit retail stores. The view suggests that retailers' future business models will be geared toward investing heavily on the Internet of Things, Virtual Reality (VR) and Information Technology (IT) to meet consumer demand, rather than paying rents for physical spaces. Equally, the second scenario (i.e. the disappearance of retail stores), as represented in perception line 'AC' (in Figure 2.2.1 above), indicates that there will be a continuous reduction in demand for retail space. Consequently, instore retailing will be displaced by online retailing in the future, just as instore retailing displaced trade using the bartering retailing system (Hollander, 1960; Brown, 1990; Wringley et al., 2002; Bamfield, 2013). However, the third perspective (i.e. retail does not see the future of retailing as instore retailing versus online retailing but sees the pair as complementary tools that retailers will utilise in meeting consumer demand. The complementary retail future as represented by perception line 'AD' in Figure 2.2.1 suggests that online growth will reach its peak and decline steadily, while demand for retail space will also rise in a reasonable way. The perception 'AD' is akin to *multi-channel and omnichannel retailing* (especially the click and collect strategy) that synergises both online and instore retailing. Thus, this future perception line 'AD' is already in existence and the synergy of instore and online retailing (after the slight changes), is expected to be the future of retailing (Wringley et al., 2002; Fernie et al., 2010; Aubrey and Judge, 2012; Piotrowicz and Cuthbertson, 2014; Bernon et al., 2016).

Nevertheless, Bamfield's perceptions on the future of retail fail to recognise the complexity of consumer behaviour and decisions (Fraj and Martinez, 2006). Bamfield also ignored the fact that not all merchandise and services are tradable online (Wringley et al., 2002; Brown, 2006). In addition, the ideology was limited to technological influence on changes in retail. In other words, his ideology did not consider other factors, such as economic, social and political factors that have always had and will continue to influence consumer decisions and changes in retail markets and retail property (Brown, 1990; 1992, 2006; Fraj and Martinez, 2006; Deloitte, 2017). Most importantly, his ideas on the future of retail do not consider the locational performance of retail spaces that are necessary to assist retail property market actors and consumers to make various market decisions (Brown, 2006). Specifically, future performance and possible changes in retail locations are not described under Bamfield's ideas for decisive decision-making regarding the development, investment and occupation of retail space.

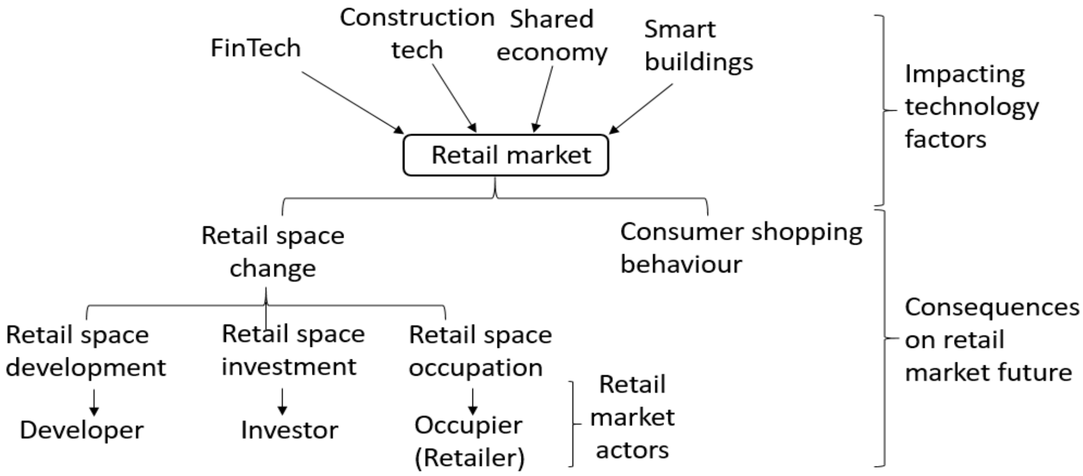
This research is of the view that retail market actors (including, retailers, investors and developers), must have a clearer understanding of changes in retail locations and future performance in order to make reliable decisions on the future of the retail market. Hence, the studies emphasis on examining the locational performance of retail spaces across cities for decisive market decision making by retail market actors. The following subsection presents Baum's concept on the future of the retail market.

2.2.2 Baum's ideology on the future of the retail market

Baum (2018), explained the future of the retail market while describing the future of real estate markets. His main view was that 'hi-tech' will be at the centre point of the future of the retail market. For example, technology will influence retailing and every other sector associated with its property market. He pointed out that technology advancements in the financial sector (e.g., Fintech), construction technology (e.g., Construction tech), smart buildings, Blockchain and a shared economy would increase the adoption of property technology (e.g., prop tech) (Baum, 2018).

The effect of his argument is that the consequential changes in retail markets will not be limited to business transactions between retailers and their customers (e.g., retail consumers), as acclaimed by Bamfield (2013). Baum (2018), further suggested that the future changes that are about to hit the retail property market will include changes in modes of financing retail space development, investment, use, demand, the quantity (size) of retail space and changes in the occupation of retail space. As such, all the key retail market actors including developers, investors and occupiers and consumers will be affected by the technological advancement trends associated with retail prop tech as presented in Figure 2.2.2 below.

Figure 2.2.2: Baum's concept of the future of the retail market



Source: Adapted from Baum (2018)

According to Baum (2018), technology will continue to be the main driver of the retail markets future as it continues to influence consumer shopping behaviours and other retail property market actors. However, Baum's concept on future real estate (retail property) markets did not acknowledge the heterogeneity of real estate that suggests that future changes in the real property market will not be uniform across different locations (Chen and Hao, 2010; Adebayo et al., 2017). Although his concept is not retail property (space), the specific, location and spatial characteristics of real estate were completely overlooked in his overgeneralised future concept of real estate. Furthermore, Baum's concept did not consider other possible factors, such as economic variables that can also influence retail market future (Brown, 1990; 1992). In essence, his concept fails to recognise the role of past indicators in assessing future trends pertaining to retail market indicators. As such, his future prediction on the retail market is not certain to help in the appropriate management and use of retail spaces.

The third reviewed ideology on the future of retailing takes a different perception. The DaSilva concept on the retail market's future is revealed in the next subsection.

2.2.3 DaSilva's ideology on the future of the retail market

While Bamfield (2013) and Baum (2018), completely disregarded the locational implications of the future of the retail market, DaSilva's (2018), perception did consider retail location performance. DaSilva's assessment of the future of retail locations across cities was experimental and data driven (unlike, the previous two concepts). The scholar sourced data and analysed retailers' business performance, consumer entry and exit points and the closure of retail stores in selected cities. The sampled cities in DaSilva's (2018) study includes Chicago, London, New York, Singapore, Jakarta, Paris, San Francisco, Helsinki and Tokyo. Her analysis was based on the machine-learning model that was developed to better inform locational decision-making within city space. The model also recognises the relevance of retail consumer actions in influencing retail space performance. As such, DaSilva (2018), adopted real time data from Foursquare and Taxi trajectories (showing consumers' pick-up and drop-off points) among other datasets to examine the future of retail locations within the cities. DaSilva's model revealed that the higher the diversity of retail location, the more resilient is that location and vice versa. Specifically, when the diversity of retail space declines, there is the likelihood of increased store closures (an indication of a poorly performing retail location). The relationship between retail store closure and retail diversity according to DaSilva (2018), is shown in Figure 2.2.3 below.

Figure 2.2.3: DaSilva's model on the future of the retail market

Source: Adapted from DaSilva (2018)

DaSilva's ideology on the future locational performance of retail space appears logical because many of the preceding retail studies (Brown, 1992; Kirkup and Rafiq, 1994; Nakaya et al., 2007; Fernandes and Chamusca, 2014; Larsson and Oner, 2014), have similarly indicated the relevance of retail diversity on retail location performance. However, the approach that DaSilva (2018), adopts in capturing consumer movement and retail locational performance is incomprehensible. This is because data concerning taxi trajectories containing pick-up and drop-off points do not justify where retail consumers will eventually move-to and shop. Besides, not all consumers will have to commute via taxis to shop in many cities. Therefore, a more comprehensive approach that captures consumer movement patterns across cities is essential as regards understanding the future performance of retail locations.

The subject research investigates the future performance of retail locations within cities by tracking changes in retail market variables and retail consumer movement patterns via a more comprehensive method; the spatial configuration technique. The study's concept rests on investigating the future location of retail spaces through changes in retail market performance and retail consumer movement patterns across cities. This study configures consumer actions (using street segment analysis) and computes changes in retail market variables for each location within cities, in order to estimate the future locational trends of retail market variables within cities. Put differently, this research seeks to investigate the locational performance of retail space to have a grasp of the future direction of retail market performance at different locations within the analysed cities. This study has more practical implications than the existing (reviewed) concepts concerning retail market futures within city spaces. The novel research would be useful for retail market actors regarding making reliable market decisions on development, investment, occupation and the use of retail space within cities. Further discussions on retail location theories within cities are discussed in the subsequent section.

2.3 Retail Location Theories on Cities

This section reviews retail location theories within cities as initially identified in Brown (2006). Brown (2006), recognised four retail location theories that form the foundation for most other locational theories. These theories are nonempirical and pre-online retail theories that were all proposed as far back as late 1920s and early 1930s. These theories have contributed to the understanding of retail phenomenon including consumers' (people) store choices, retail space performance, urban space morphology and general land use patterns and functions. These four retail location theories are:

i. The Central Place Theory (CPT)

ii. The Spatial Interaction Theory (SPT)

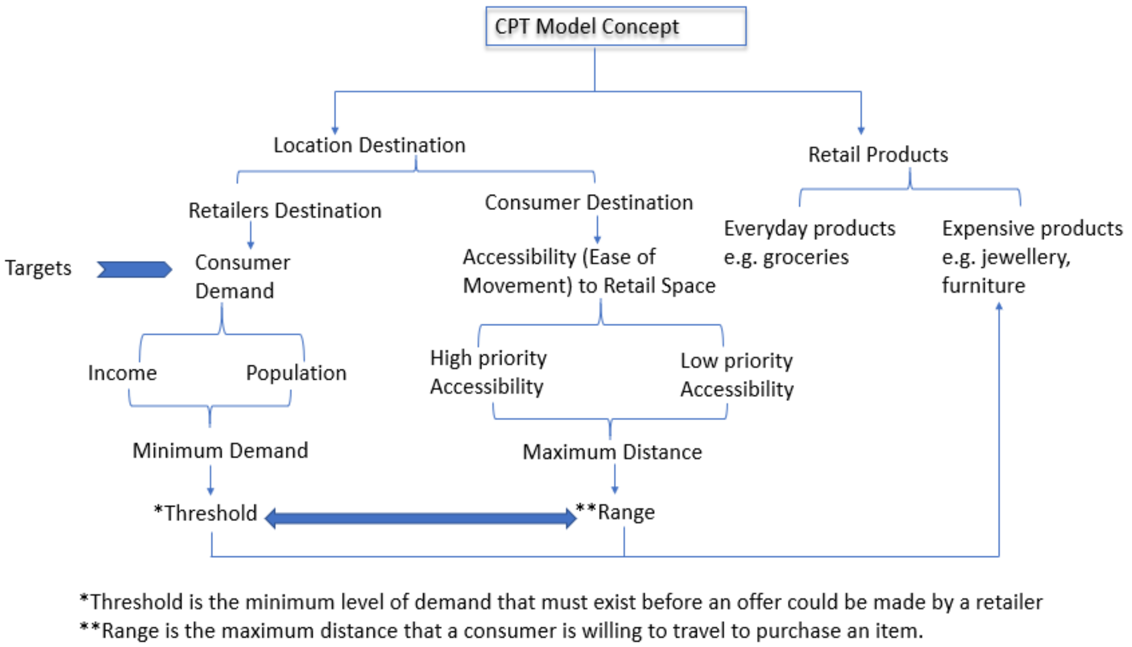
iii. The Bid Rent Theory (BRT)

iv. The Principle of Minimum Differentiation (PMD)

2.3.1 Central Place Theory (CPT)

CPT is often referred to as classic location theory. Walter Christaller postulated the theory in 1933. The model analyses both retailers' and consumers' location destinations and retail products among other assertions. His ideology was based on the premise that ease of movement (i.e. cost of transportation and accessibility) within a city's spatial layout determines retail locations (or spaces) that consumers will visit to transact. Basically, the degree of accessibility index determines where consumers will shop (Christaller, 1933; Brown, 1989; 2006). The baseline principle is that the higher the cost of transportation (ease and deterrence of movements), the lower the consumers' patronage (i.e. footfall count) of retail spaces and vice versa (Christaller, 1933). The theory recognises that there are limits to the distance that a consumer (demand) is willing to travel to purchase an item. He indicated that the maximum distance that a consumer is willing to cover to purchase an item from a retailer is known as ‘the range’. On a similar note, Christaller (1933), established that a retailer‘s locational choice is based on the strength of consumer demand within a defined city (retail) space. The strength of consumer demand for a given (or potential) retail space is a measure of consumer population and income. The CPT model also establishes that certain levels of demand (population and income) must exist before an item can be offered for sale by a retailer. The minimum levels of demand that must exist before an offer is made available by the retailer is termed the ‘threshold’. Christaller (1933), further explained that threshold and ranges vary across different items (goods). Expensive goods, such as jewellery and furniture), have higher thresholds and ranges than inexpensive, everyday goods, such as groceries and newspapers. In other words, consumers are willing to travel far (spending more on transportation) while ignoring accessibility deterrence to purchase expensive items (i.e. high order goods) than inexpensive (i.e. low order goods) items. Figure 2.3.1 below presents an illustration of his idea.

Figure 2.3.1: Explanatory Framework of CPT



Source: Adapted from Christaller (1933) and Brown (2006)

The CPT model further stipulated that provided the motivating factor for setting up a retail store in a given space is to make profit from the retailing business, then, there will be more low order retailers in a given neighbourhood, than retailers of high order goods (Christaller, 1933). The spatial arrangement of retailers within a space is primarily based on the order of goods. Hence, identical retailers are evenly spaced in a triangular arrangement with equally sized hexagonal market areas to an extent that reflects the sorts of goods (Christaller, 1933; Brown, 2006). The consumer's preference for different types of goods emerged into centres of various sizes to form levels of hierarchy and overlaps with centres selling low order goods at the base of the hierarchical pyramid. Many studies (Berry and Garrison, 1958; Berry and Pred, 1965; Camagni and Salone, 1993; Batten, 1995; Taylor et al., 2010), have conducted empirical investigations and corroborated Christaller's (1933) ideologies on the spatial arrangements of retail goods and consumer patronage across different cities.

However, classification of retail stores based on the cost of goods (that is, high order and low order goods) is incomplete (Rogers, 1964). This is because some retailers trade both expensive and everyday goods in the same store as a strategy to attract different types of consumers (Grewal, 2007; Fernie et al., 2010; Aubrey and Judge, 2012; Piotrowicz and Cuthbertson, 2014). Similarly, CPT did not recognise that consumer patronage within a retail environment is beyond the type of goods offered by the retailers. Consequently, the concepts of range of goods and threshold of distance can limit understanding of retail locational performance within city spaces.

While this research upholds CPT as of relevance to retail consumers in analysing and understanding retail location within cities, this research is not mollified by some of its ideologies, especially in classifying retail spaces and retail consumers (itself). Although, this research has not focused primarily on classifying retail spaces (or retail goods), the research categorises retail spaces based on frequency and the purpose of consumers' visits (and movements) to retail spaces, with a view to better understand retail locational performance at cities. Basically, retail space classification in this study is based on the frequency of retail consumer's visits to retail spaces, as against categorising spaces based on expensive and every day (inexpensive) goods (see section 2.5 of this chapter and Chapter 5 of the thesis for further details on retail space classification).

2.3.2 Spatial Interaction Theory (SIT)

Like CPT, SIT also dwells on the conceptualisation of consumer patronage behaviours on retail spatial layouts. William J. Reilly pioneered the SIT in 1929. The model is based on the supposition that consumers are attracted to utilities derived from certain retail locations, and will not necessarily patronise the nearest retailers, as assumed in CPT. Moreover, SIT views competition between retail spaces based on the level of satisfaction provided by retailers or enjoyed by their consumers. This theory emphasised that consumers' dwelling time and footfall along with other retail location performance indicators depend on the satisfaction derived from retail or infrastructural associated facilities (shopping centres, highstreets or city centres).

Similarly, the theory recognises the importance of delineating locations in analysing retail market performance in cities. The canon is based on the understanding that consumer behaviours within a given retail space are subject to gravitation forces like that of Sir Isaac Newton's gravitation principle. Hence, Reilly (1929), developed the retail gravitation model based on Isaac Newton's gravitation theory. Reilly's (1929), retail gravitation model explained that the ability of two retail locations (A & B) to attract consumers' (footfall) is a function of the population of the intermediate location (C) and inversely proportional to the utility available at C, besides the distance of C to A and B (Reilly, 1929). In essence, utility, population and distance are the key variables explored by Reilly (1929) in his retail gravitation model.

Empirical studies by Bennett (1944) and Douglas (1949) investigated Reilly's principle on cities and towns in the USA. They (Bennett, 1944; Douglas, 1949), concluded that the retail gravitation model performs reasonably well as regards certain cities, for instance Laurel, Maryland and Charlotte, North Carolina). However, Losch (1954) and Jung (1959), in their respective studies in Iowa and Missouri both revealed that the retail gravity model does not conform to the corresponding cities' retail. It can be contended that the variation in the empirical outcomes is as result of dissimilarities in all the investigated cities. Specifically, the differences in retail and spatial elements within the towns (and cities) have led to variations in outcomes obtained from the empirical investigation. Similarly, Carrothers (1956) and Huff (1962a), criticised retail gravity models as they both emphasised (at different quotas) that the variables and parameters (especially, utility and inverse square) utilised in the modelling are unrealistic to measure. Despite the divergent views, SIT (specifically, the retail gravitation model), is known for its success in trade area estimation (Goldstucker et al., 1987), market share calculation (Okoruwa et al., 1988), shopping centre impact analysis (Wade, 1983), site selection procedures (Rogers, 1984) and sales-forecasting and performance monitoring techniques (Ghosh and McLafferty, 1987).

However, the initial critique of SIT by Huff (1962a) was countered by Huff (1962b; 1964). Huff (1964), agreed with SIT's philosophy in his probabilistic approach. Huff confirmed that consumer patronage (footfall counts and dwell time) for a given retail site is a function of the available utilities and satisfaction derived from the given sites and that of competing sites. Huff

(1964), postulated that the probability of a consumer patronising a given retail site could be determined from the relative utilities of each competing area. Huff (1964), further developed SIT's philosophy, by considering the fusion of attraction (i.e. centre size) and deterrence (travel time) of consumers. Huff (1964), indicated that the probability of patronising a retail location is directly related to its size and inversely to travel distance by the consumer and inversely to the utility of competing retail sites. Hence, size (stock) of retail space was introduced to the retail gravity model by Huff (1964). Other notable conceptual refinements of SIT include; the intervening opportunities models by Harris (1964), entropy-maximisation procedure by Wilson (1967), retail potential model by Lakshmanan and Hanse (1965), in addition to the preference approach developed by Rushton (1969).

Despite the widespread application of SIT and retail gravity model, these models and other works that have developed it have all computed distances covered by consumers, based on metric measurements. In other words, the pattern of street connectivity as it influences consumer movement and distance covered has not been considered while analysing retail space performance. This research has not developed SIT philosophy per se, although it has measured consumer movement based on street connectedness' rather modest calculation of distances across spatial layout. However, this study upholds the relevance of delineating retail locations in assessing retail market performance across different cities and towns. Consequently, this research adopts a new method of delineating retail locations within and across different cities as initiated by the preceding studies that have analysed retail locations based on the SIT. Further details on the new method of delineating retail location and the computing of retail consumers' movements on city layouts have been presented in Chapter 5 (research method) of this thesis. The next subsection reviews the concepts of bid-rent theory in understanding retail locations within cities.

2.3.3 Bid-Rent Theory (BRT)

The contributions of BRT to the understanding of urban retail space can be broadly categorised into urban land use and urban rent (value) distributions. Robert Murray Haig pioneered BRT in 1926 when he undertook a comprehensive study of land use in New York.

Haig (1962), claimed that BRT was based on assumptions that have been supported and criticised across various quotas. Haig (1962), stipulated that in a given urban area, assuming *travel is equal and easy in all directions*, the centre of the city is the most accessible and thus the lowest cost location (Haig, 1926). He further explained that because the centre has the lowest accessible cost, various activities (especially, commercial activities including retailing) want to be located at the centre to gain from the accessibility advantage. Thus, these activities compete to be located at the centre of the city network, therefore creating an active user and investment property market in the city centre rather than other parts of the city (Alexander, 1974; Brown, 2006; Jackson and Watkins, 2007; Jowsey, 2011). However, the sluggishness and fixity regarding the supply of land to adjust to change in demand, makes rents within the city centre higher than other parts of the city (Burgess, 1925; Barras, 1994; Adair et al., 2003; Jackson and Watkins, 2007; Evans, 2008; Adebayo et al., 2017). Additionally, BRT contends that the imbalance between demand and supply of space, shapes activities (land use) within the urban area, with competing uses bidding with rent to occupy space at the centre. Hence, the highest best uses of space emerges, with commercial land uses, such as retail that requires accessibility to survive and prosper, are found in high concentration at the city centres (Guy, 1998; Brown, 2006; Astbury and Thurstain-Goodwin, 2014; Adebayo et al., 2017a), while other land uses, such as residential and agricultural uses that are willing to trade-off accessibility, are found outside the urban core (Haig, 1926).

Ratcliff (1949), contributed to BRT and expounded that the land use structures of cities are shaped by various economic activities that are concentrated predominantly within the city centre. Similarly, Alonso (1964), contributed towards the understanding of BRT with his work on the land use model, the development of which was based on the rent bidding capacities of human activities that were primarily categorised into commercial, residential and agriculture uses. Alonso (1964), developed a bid-rent curve to further explain land use activities and rental value distribution across city space. In the same vein, the theory indicated that rents are highest in the city centre and reduce with distance away from the city centre in *a uniform concentric manner*. In another development, Scott (1970), also explained rent patterns while focusing on retail rent distribution within a city centre and hence developed a concentric zoning of retail types, in line with the ideologies of Alonso (1964) and Ratcliff (1949). Scott (1970), observed that high order goods (in specialty and departmental stores) are found along the fringes of the city centre, while low order goods, for instance grocery stores are concentrated within the core of a city centre, suggesting that the fringes of city centres are more valuable than the core. Similarly, Scott (1970), revealed that there are distortions in the pattern of the arrangement of retail classes and the rent value of retail space. He did link these distortions in rent and retailers' spatial arrangement to the conflicting decisions of local planners, variations in the properties of street networks, combined with the presence of morphological barriers such as public open space at the sampled city centres.

Conversely, Crainic et al. (2004), criticised the assumptions that Haig (1926), Ratcliff (1949), Alonso (1964) and Scott (1970) based their research upon. Crainic et al. (2004), disproved that travel is equal across city spatial layouts. They argued that city centres are losing their accessibility characteristics as a result of intense traffic conditions and other deterrents that hinder retail consumers movements within city centre space. Similarly, Barredo et al. (2004), also disprove the idea that rent distribution follows uniform patterns within city centres. Barredo et al. (2004), while examining land use distribution in the city of Lagos, Nigeria, indicated that there are many retail spots far away from the city centre that generate higher rental income and value than those in the centre. Hence, they challenged the idea of BRT concerning rent distribution. However, the works of Crainic et al. (2004) and Barredo et al. (2004), do not indicate these assumptions regarding travelling within and across cities.

This research rests on similar assumptions with BRT on the aspect of equal travel in all directions within city spatial layouts. This is because the adopted approach (that is, spatial configuration technique of space syntax principle), assumes that travelling across analysed street networks is equal while analysing retail consumer movement within city space. However, this research focuses its investigation on retail spaces and retail rents both citywide (macroscale) and in city centres (mesoscale) simultaneously (unlike previous studies that have worked on cities and city centres separately). This study contends that the new approach will shed more light on understanding the distribution of retail spaces and retail rental value within cities and city centres - that have created conflicting ideas among preceding scholars (Haig, 1926; Ratcliff, 1949; Alonso, 1964; Scott, 1970; Crainic et al., 2004 and Barredo et al., 2004).

2.3.4 The Principle of Minimum Differentiation (PMD)

Harold Hotelling first postulated PMD theory in 1929. Like BRT, PMD also explained the locational preferences of activities within an urban area. However, PMD ideology differs from BRT in that it was not established on the premise that all activities are attracted to the accessibility and centrality of places. Moreover, PMD theory rests on the premise that the locations of every activity with an urban area is influenced by the surrounding activities within that neighbourhood. Put differently, complementary activities and services within urban spaces tend to attract each other to form clusters (Hotelling, 1929). PMD ideology implies that proximity to complementary activities is more important than the general accessibility characteristics of locations (as emphasised by BRT and CPT) when assessing retail location performance. The ideology of PMD reposes mainly around *retail agglomeration*, besides complementary services and land uses (Hotelling, 1929; Brown, 2006; Teller and Elms, 2012).

There are many studies (Roger, 1969; Hanson, 1980; Okabe et al., 1985; Arentze et al., 1993; Oppewal and Holyoake, 2004; Arentze and Oppewal, 2005; Teller and Elms, 2012), that have upheld PMD's ideology as economies of agglomeration, having perceived retail agglomeration to have a positive influence on competing activities. Roger (1969), Okabe et al. (1985), Arentze et al. (1993) and Popkowski et al. (2004) adopted various approaches in their analyses and concluded that retailers (trading similar goods) and complementary activities (especially leisure) are clustered together within a given city retail space to enhance retailers' turnover, which in turn enhances the location performance of that space. Similar studies (Oppewal and Holyoake, 2004; Arentze and Oppewal, 2005; Brown, 2006), concluded that retail clustering would enhance footfall, dwell time, demand for varieties of goods and consumer expenditure within a retail cluster. As such, the agglomeration of retailers benefits retail locational performance as well as retailer turnover (Hotelling, 1929; Shaw, 1978; Hanson, 1980; Okabe et al., 1985; Arentze et. al., 1993; Oppewal and Holyoake, 2004; Arentze and Oppewal, 2005). In the same vein, Gannon (1972), argued that economic activities in a retail area (where retailers are clustered), is expected to enhance the rental value of retail premises due to competitive demand for space within that area. Gannon (1972), also declared that the clustered spatial arrangement of retailers and complementary activities would benefit consumers and retailers. He emphasised that a clustered retail environment stands to reduce the transportation costs of retail consumers. However, Gannon (1972), cautioned against the agglomeration of conflicting activities within city layouts. He emphasised that this can lead to environmental, social and economic deterioration.

Meanwhile, in the work of Nelson (1958), an empirical survey was conducted on consumer behaviours within clusters of retailers and complimentary services. Nelson observed and revealed that consumer footfall is influenced by the size of the cluster. That is, the bigger the agglomeration (cluster) size, the larger the footfall count recorded, and the better the business performance of that cluster. Nelson (1958), further argued that retail clustering is an important variable to be considered when evaluating the location performance of retail spaces across cities. However, he complained about the asymmetrical nature of city retail clusters and the difficulty involved in capturing and measuring (quantifying) it within any given city space.

In line with the preceding philosophies, this research also upholds the relevance of retail clustering in the understanding of locational performance of retail spaces within cities. The research investigates retail clusters (and other retail market variables), in estimating the locational performance of retail spaces within city space using logical techniques (in computing retail clusters and other retail market variables across city spatial layouts). The research has adopted retail clustering as a variable indicator of the supply-side of the retail property market within the analysed city layouts. Details on how retail clusters within and across cities that have been computed in this study are presented in Chapter 5 of this thesis.

The reviewed retail locational theories, namely CPT, SIT, BRT and PMD form a crucial and underpinning part of this research. The following section further discusses the complexity of city layouts.

2.4 City complexity and retail geography

Having discussed the four basic retail locational theories of cities in the preceding section, this section delves into understanding city layouts (complexity), while reviewing the importance of urban land use modelling in understanding the complexity of cities and their structures.

Cities can be classified based on the agglomeration and distribution of activities across various locations. Cities (or city centres) are complex entities that are often generalised through spatial modelling to make meaning of the complexities (Abler et al., 1971; Shaw, 1978; Lombardi et al., 2012). The essence of modelling events on city (spatial) layouts is to reveal complexity in a more straightforward way (Abler et al., 1971; Lombardi et al., 2012; Adebayo, 2017a; Carol et al., 2018). There are a few spatial models that have simplified the complexities of city subsystems into meaningful simulations. Notable examples are land use models including concentric, sector and multi-nuclei models that reveal the concentricity of cities and their growth pattern. Ernest Burgess (founder of the concentric model) in 1925, described Chicago as a monocentric patterned city, which grew in a centrifugal (outward) way. The s*ector model* postulated by Hoyt (1939), concluded that certain areas of a city are more attractive to various compatible activities, whilst being unattractive to incompatible activities that form another sector. He agreed with Burgess's concentric model that cities grow outward, but not from the city cores. Hoyt (1939), argued that cities emerged from various outer wedges (sectors) of other cities, which are generated by the clustering of complementary activities. Moreover, the *multi-nuclei model* was founded by Harris and Ullman (1945). Harris and Ullman's Ideology was based on the premise that a city has more than one centre from which the city grows. The multi-nuclei model asserts that cities are paradoxes comprising many clusters of activities.

Retail distribution, including activities on high streets are reflectors of city centrality. Basically, locations where retail activities concentrate can reveal the concentricity of a given city space. Urban informatics (Netzel, 2013; Adebayo et al., 2019a, Greenhalgh et al., 2020), have relied on this, while investigating complexity in the distribution pattern of retail locational variables, including accessibility, distance, cluster, floor area and rental value, among others. The relationships between these variables have been explored using different techniques analysed via the visualisation or quantification of relationships. Adebayo et al. (2019b), noted that there are differences in the interpretation of city centrality across different scales for all (investigated) cities. In other words, there is a change in the interpretation of retail property market performance as the city boundaries expand. Adebayo et al. (2019b), demonstrated that there is variation in the performance of retail property markets at mesoscale (2 km radius) and macroscale (10 km radius) regarding the investigated cities. The research output (which is an extract of this thesis), revealed that there are variations in retail property market performance across scales in all investigated cities.

However, the work (Adebayo et al., 2019b), highlighted that the accessibility configuration of city street networks at different scales shows consistency across all investigated cities. That result on accessibility across city scales is crucial, as it clarifies and supports the arguments of space syntax pioneer - Hillier et al. (2012) on *generic city principle.* The principle identifies that all cities (irrespective of size, economic performance or demography) are made up of street networks which can simply be divided into links and nodes. Hillier et al. (1999), observed that analysis conducted on cities from this perspective (generic city principle) will result in generic spatial behaviour for all cities. *Spatial configuration techniques rest on this assumption*. Nevertheless, the assumption has been heavily criticised by urban scholars (Batty, 1991; Greenhalgh et al., 2020) that are of the view that cities are heterogenous.

The complexity of cities frequently shows on the approach adopted in analysing city variables. Dawson (2013), indicated that a comprehensive approach is the best way of analysing city components. Dawson (2013), revealed that retail and other city subsystems require insightful views of other bodies of knowledge including economics, marketing, philosophy, planning and management to make meanings out of the complex scenarios. Dawson (2013), argued that relationships between complex city variables are valuable tools for the planning and management of city centres and high streets. Wrigley and Lambiri (2012), stressed that *there is a gap in the knowledge of the impact of accessibility on the performance of high streets and other retail locations*. However, there are many studies that have attempted to investigate the relationship between accessibility (primarily through spatial configuration) and city economic data, such as land value. Notable examples (Netzell, 2013; Muldoon-Smith et al., 2015; Giannopoulou et al., 2016) have shown there are different types of relationships between the configured parameters (integration and choice) and land values of real property across cities. The relationships outputs between variables across many studies suggest *that there are underlaying factors influencing the relationship outputs.* Table 2.1.1 reveals outputs of relationships between urban land value and spatial configuration parameters.

Table 2.1.1: A compilation of works investigating the relationship between spatial configuration and urban land variables.

s/no	Author (date)	What?	How?	Results
1	Muldoon-Smith et al., (2015)	Relationship between integration and commercial property value in *Leeds* UK	Visuals analysis	Variation in relationship outputs across property types. No consideration for scaling
2	Rodriguez et al., (2012)	Relationship between socioeconomic data and configured parameters of *Sao Paulo* street networks	Visuals and statistics analyses	10 km extent of analysis revealed but not considered. Positive relationship recorded
3	Netzell, (2013)	Relationship between integration (accessibility)	Statistics analysis	2 km extent of city analysis revealed but not considered.

		and retail rental value in *Stockholm,* Sweden		Positive relationships recorded.
4	Giannopoulou et al., (2016)	Relationship between configured parameters and residential property values in *Stockholm,* Sweden	Statistics analysis	Negative relationship recorded. No consideration was given to the extent of city analysis.
5	Chiaradia et al., (2009)	Relationship between choice and integration parameters and residential property values of parts of *London,* the UK	Visuals and statistics analyses	Positive relationship between variables. No consideration of the extent of city analysis.
6	Adebayo et al., (2019b)	Relationship between configured parameters (choice and integration) and changes in retail rental value and stock at *Leeds* and *York* UK	Visuals and statistics analyses	Stronger relationships between changes in retail rental value and configured parameters across cities. 2km and 10km radii analysis of cities. *Importance of scaling shown.*

Source: Research work (2020)

The above works are key to this research. This is because they share a similar foundation regarding analyses that this research considers. The study built on these previous works by investigating spatial configuration parameters; specifically, choice, NACH and integration and retail property market performance across cities. The compiled results (Table 2.1.1), are a clear indication that relationships between configured parameters and city economic variables are neither constant nor consistent. Whilst the variation in the above relationship results might have been caused by variations and complexities in cities, as well as the approach and date of analysis among other variables, *this subject research traces the possible variation in relationships between variables to a lack of consideration of the extent of the analysed cities*. Works of Netzel (2013) and Rodriguez et al. (2012), revealed the extent to which investigations were carried out, although no serious consideration was given as regards the impact of scaling. The logic behind the consideration of the extent of the city analysis (scale) was due to the underlying circumstances of spatial configuration analysis (adopted in measuring consumer movement). The subsequent sub-section presents details on the foundations of this research.

2.5 Theoretical framework underpinning the study

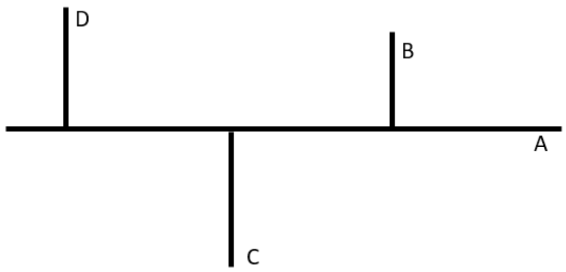
Relationships between two (or more) variables are indications that the values of a dependent variable X corresponds to the values of an independent variable Y, for each case in the dataset. In essence, knowing the values of variable Y can help estimate the value of variable X. In doing this, careful consideration must be given to possible factors that can influence the relationships between variables (LeSage and Pace, 2004; Netzel, 2013). This study argues that should significant relationship exist between variable X, that is, the performance of the retail property market and variable Y, specifically the spatial accessibility index in a given location, then one can estimate for dependent variable X using coefficients of Y in that location for practical reasons. In doing this, consideration has been given to underlying issues that could influence the investigation of spatial relationships between the performance of the retail property market and spatial accessibility index of cities.

2.5.1 Conceptualisation of retail consumer movement via spatial accessibility measures of street networks: Why the extent of city analysis matters in spatial relationship investigations.

Whilst the importance of consumer movement on the success and performance of retail locations is not in doubt, assessment and understanding of consumer spatial behaviour across wide urban retail spaces can be challenging due to retail consumers volatility (Wang et al., 2014; Omar and Goldblatt, 2016). Earlier studies (Christaller, 1933; Batty, 1978; Borgers and Timmermans, 1986; Leeuwen and Rietveld, 2010; Shephard and Thomas, 2012; Helm et al., 2015), that have investigated consumer spatial behaviour across cities, have done so, relying on observational and physiological methods. These methods are however limited in coverage (scope) and are often limited in practical applications (Wang et al., 2014). This study relies on a more static measure of 'streets' in assessing consumer movement by means of the spatial accessibility index of city locations.

Spatial accessibility index denotes the concentration and distribution of human movement on a given street network. The hypothetical illustration in Figure 2.5.1 showing the connection of streets (A, B, C and D) is beneficial in explaining how analysing street connectivity can help inform human movement and the spatial accessibility index of streets.

Figure 2.5.1: Connecting street network I

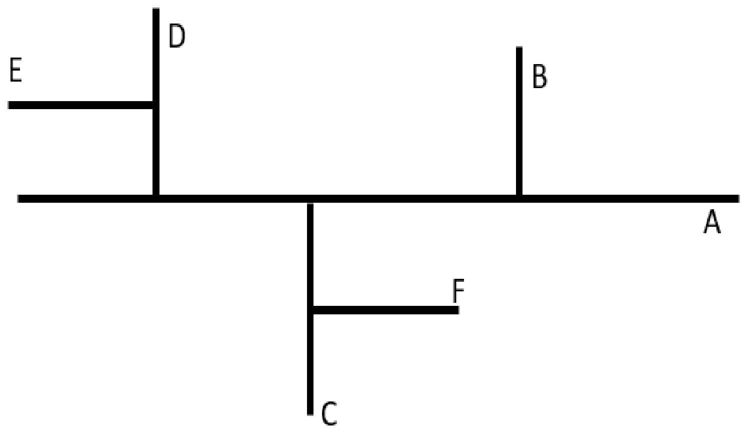


Source: Researcher's own (2020)

Figure 2.5.1 shows four connecting streets that permit human movement across the entire network of streets. However, the power, utility and weight that individual streets contribute to ensuring movement across the network, differ. Conceivably, the role played by street 'A' is greater than that of B, C and D for movement to exist across the street network. For instance, without street A, movement will only be possible within an individual street and not extend beyond that street. However, without street B, movement is still possible across the remaining three streets (that is, A, C and D) and vice versa. Consequently, street A is more likely to experience the highest natural movement in contrast to other connecting streets (B, C and D) (natural movement indicates that other attracting or deterring factors have been completely overlooked in this consideration). Therefore, the spatial accessibility index of street A is the highest because of its location, position and role in ensuring movement in the given street network (Figure 2.5.1). Meanwhile, streets B, C and D have the lowest (and equal) accessibility index in Figure 2.5.1. Spatial configuration analysis (space syntax theory) is built on the above simple logic of ranking streets based on their connectivity property to signal potential human movement on a given street network, without considering other socio-economic factors that deter or enhance human movement to various locations (Hillier and Hanson, 1984; Hillier, 2007). The technique analyses the importance of a street (location) in permitting human movement, while *only* considering all other streets (locations) within the network.

Furthermore, the addition of more connecting streets to Figure 2.5.1 signals more clarification of the hierarchy of consumer movement in a street network. Figure 2.5.2 shows that streets 'E' and 'F' have been added to the initial Figure 2.5.1.

Figure 2.5.2: Connecting street network II



Source: Researcher's own (2020)

The above illustration (Figure 2.5.2), shows that streets 'C' and 'D' are more important than streets 'E' and 'F', while street 'A' maintains its superiority over all other streets. This is because for movement to exist beyond streets E and F, there must be streets D and C, respectively. In essence, the accessibility index of the streets is reprioritised as the street network extends. Meaning the initial lowest accessibility index of streets C and D in Figure 2.5.1 have been shifted to streets E and F in Figure 2.5.2 because of the extensions in the street network. *Specifically, the spatial accessibility index of a given location within a city is not a fixed value but dependent on the extents of the city (boundary) analysis.*

However, earlier studies on retail location theories that have explored spatial relationships between retail rental value and accessibility have done so without considering the possible implications of changes in the spatial extent of the studied cities on the relationships. Notable works, such as bid-rent theory (Alonso, 1964), the concentric zone model (Burgess, 1925), central place theory (Christaller, 1933) and other relevant theories on retail activities within cities were established on the assumptions that city boundaries and street network are fixed. The method, for instance the meticulous observational approach) adopted in the preceding studies could have been responsible for such assumptions. Put differently, the approach does not require an understanding of the extent of a city boundary to develop the urban retail models. However, later studies (Brown, 2006; Huber et al., 2010) have shown that the concepts of the preceding theories including the concentric model, bid-rent theory, the principle of minimum differentiation and retail gravity models are losing relevance because of the continuous changes in city boundaries. It can be argued that these studies have chosen to focus on their various predetermined research goals, thus, the reason for ignoring any possible effects on changes of city spatial boundaries. Nevertheless, for the practical application of the investigated results, it is essential to consider the possible influence of changes in the extent of a city boundary on relationships between spatial accessibility index and urban economic data including rental value, retail cluster, property stock, etc. This is essential, especially in this period of urban study, where spatial analysis tools are available unlike the observational approach of earlier studies.

The computation of the spatial accessibility of street networks can now be achieved using relevant software tools, such as Depthmap. Depthmap is a spatial configuration analysis tool that measures to-movement and through-movement, which respectively indicate integration (closeness) and choice (betweenness) values of individual street segments within a given street network. Simply put, integration value is a measure of how close a street (or location) is to every other location within an analysed street network. It measures the possibility of moving towards that location, if movement is evenly distributed across the street network (Penn et al., 1998; Hillier, 2007). Choice value measures the possibility that a street (location) will be used as a link to all other locations within the street network. In other words, the choice value of a street indicates how likely that street will allow movement to every other location, if movement is to be initiated across all streets within the network. Studies (Penn et al., 1998; Turner, 2007), have shown that these parameters reflect more than 70% of observed human movement on different cities (locations), despite not factoring human behaviours in its computations. Nevertheless, its technique has been criticised for various reasons, including its inconsistencies and pregnable assumptions that human movement follows a set of procedural rules while moving from one location to others (Ratti, 2004). Studies (Timmermans, 1993; Tal and Hardy, 2012) have shown that humans (specifically, retail consumers), show random movement while navigating across street networks for different reasons including shopping. The shortcomings and its criticisms led to formulation of normalised angular choice (NACH) by Hillier et al (2012), to enhance its scientific explanation of human movement and its relationships with urban socio-economic variables (see Chapter 4).

There are a growing number of studies that have applied spatial configuration analysis in investigating the relationship between spatial accessibility index and urban economic data across different cities (Rodriguez et al., 2012; Netzell, 2013; Muldoon-Smith et al., 2015; Giannopoulou et al., 2016; Adebayo et al., 2019). However, it is surprising that none of these studies recognise and considered the possible implications of scale on the relationship results, owing to the certainty that spatial accessibility index depends largely on underlying street network of cities. Rodriguez et al. (2012), investigated the relationship between spatial accessibility index and socio-economic variables in Sao Paulo, Brazil. The study indicated that investigations between the variables were conducted within a 10km radius of Sao Paulo. Similarly, Netzell (2013), hinted that the investigation of relationships between spatial accessibility (mainly, integration) and retail rental value in Stockholm, Sweden covers a 2km radius of the city. Meanwhile other related studies (Chiaradia et al., 2009; Muldoon-Smith et al., 2015; Giannopoulou et al., 2016; Adebayo et al., 2019), that have investigated relationships between spatial accessibility and urban economic data across different cities (London, Leeds, Xanthi and York), did not reveal the extent of the investigated cities. This is not a problem per se since the targeted objectives in these research projects were to visualise and/or quantify relationships between spatial accessibility and various urban economic data.

However, the main concern is that results of these studies have shown different types (and directions) of relationships between investigated urban data and measured accessibility index. For example, Muldoon-Smith et al. (2015), revealed there are positive relationships (at different degrees) between the rental values of commercial (offices, retail and industrial) properties in Leeds and the integration values. That result differs from Giannopoulou et al. (2016), whose research revealed a negative relationship between integration value and residential rental value in Stockholm. However, Netzell's (2013) findings on the relationship between spatial accessibility index and retail rental value in Stockholm is different. Netzell (2013), revealed that there is a positive relationship between integration value and retail rental value in the same city, Stockholm. Furthermore, Chiaradia et al. (2009), recorded a positive relationship between integration (and choice) values and residential property values in part of London. These variations in results in the preceding studies imply that there are underlying factors influencing relationships between urban economic data and spatial accessibility index.

Whilst the variations in relationship results could have been caused by the heterogeneity of the investigated cities and approaches undertaken to establish the relationship, this study argues that a lack of consideration of the extent of city analysis could have influenced variations in the results. This research maintains that for research outputs to be reliable, the procedure and approach undertaken should be repeatable to establish the same reliable outputs. As such, it adopts similar procedures in investigating the relationship between spatial accessibility and the performance of the retail property market across three different cities (Leeds, Newcastle and York) at two different scales (meso and macro). The study explores the relationship between the variables at an extent of 2km (mesoscale) and 10km (macroscale) radii of the investigated cities following the work conducted by Netzell and Rodriguez, respectively. Hence, the hypothetical statement that is investigated herein is that:

The extent of city analysis influences the relationship between spatial accessibility index and performance in retail property markets.

2.6 Chapter Summary

This chapter reviews perspectives on the evolution and future of retailing. It recognises online shopping as a threat and complementary tool to bricks and mortar retailing. Key retail location theories including CPT, SIT, BRT and PMD were all critically discussed. The chapter also reveals other essential studies that have investigated spatial configuration parameters and urban economic data. Arguments as to why the effects of scaling on the relationship between investigated variables have been provided in this chapter. The following two chapters discuss retail property market (demand and supply) performance and the conceptualisation of consumer movement patterns across cities via spatial configuration analysis, respectively.

Chapter Three

Retail Property Market Performance:

Variables of Demand, Supply and Consumer

3.0. Introduction

This chapter focuses on in-depth discussions evaluating retail property market performance. Review of factors influencing retail market (demand and supply) and consumer patronage variables among other issues are also presented in this chapter.

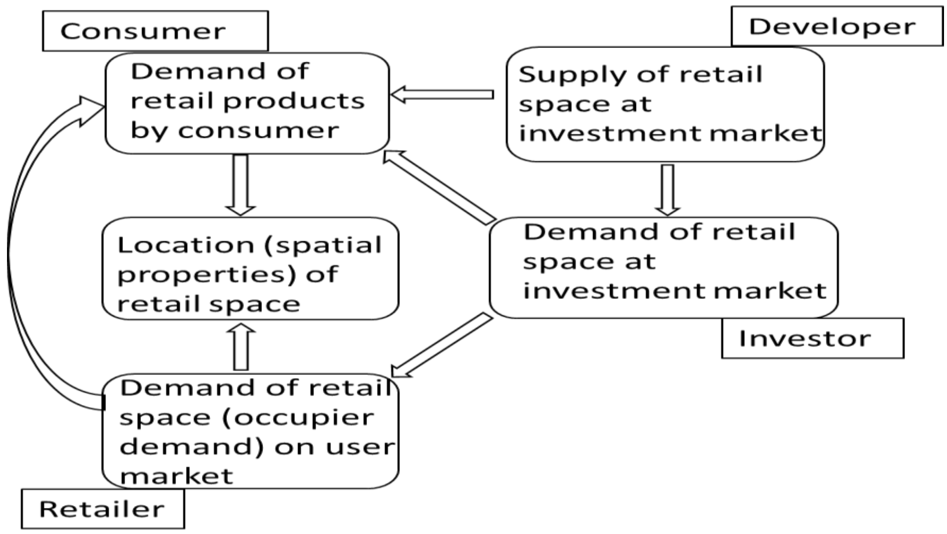
3.1 Roles of consumers in the retail market & factors influencing user and investment markets

There are strong connections between retail consumer demands and the decisions of retail market actors (including, retailers, landlords and developers). Perhaps, the retail market remains one of the most dynamic property markets due to its dependence on retail consumers and the volatility of factors (spatial and aspatial) influencing its users and investment markets (Adebayo et al., 2019a).

Simply put, a user market includes occupation transactions of retail (or other) property between two distinct market actors – one of whom must be an occupier (retailer). Essentially, market transactions that occur between an investor and an occupier, or between a developer and an occupier (in the case of owner-occupier) (Colwell and Jackson, 2004). However, the investment market involves transacting (or transferring) interests inherent in a property between markets actors. One such market actor must be an investor holding an interest in the property with the aim of continuously holding or passing the interest held on to another market actor (Geoffrey and D'Arcy, 1994; D'Arcy and Keogh, 1998; Colwell and Jackson, 2004). In other words, the investment markets involve property interest transactions between developers and investors, or between investors (Colwell and Jackson, 2004). Consequently, retail property developers, investors and occupiers are the key market actors (in the retail property market sector) as they make decisions on what, where and whether to develop, invest-in and occupy retail property spaces (Geoffrey and D'Arcy, 1994; Farragher and Kleiman, 1996; Colwell and Jackson, 2004; Crosby et al., 2012).

The decisions of property market actors on the use and management (including, occupation, investment and development) of retail space are based on different business motives that are central to retail consumers' choices and the demands of retail products and services (Brown, 1990; 1992; Farragher and Kleiman, 1996; French, 2001; Zeng and Zhou, 2001; Crosby et al., 2012; Deloitte, 2018; Adebayo et al., 2019a). Put differently, most decisions made by market actors are dependent on retail consumer demands. However, there are many other factors that influence retail consumer demand, one of which is the location of retail space and other spatial characteristics, such as connectivity, proximity and the accessibility of that retail space (Reilly, 1929; Christaller, 1933; Huff, 1962a, 1962b; Scott, 1970; Brown, 1990; 1992). Figure 3.1.1 illustrates the relationships between retail consumers, retail locations and key decisions on retail spaces by retail market actors. The figure shows the central role played by consumers in influencing the decisions made by retail market actors.

Figure 3.1.1: Relationships between location, retail consumer and the decisions of retail market actors



Source: Researcher's own (2017)

The influence of retail consumers on market actors' decisions can be overwhelming. This is because both user and investment markets' demand for a retail property (space) is a function of the retail consumer demand (and consumption) for retail goods and services (Brown, 1990; Farragher and Kleiman, 1996; Colwell and Jackson, 2004; Wright et al., 2006; Teller and Reutterer, 2008; Pickett-Baker and Ozaki, 2008; Deloitte, 2018). Ordinarily, retailers (i.e. retail space occupiers) will consider the latent patronage ability of retail consumers for goods and services in a local market before demanding to occupy and use the property (space) for retail purpose. Similarly, an investor will seek to invest in retail property space on the assurance that there is (or existing) occupier demand for retail property, with possibly low supply of retail space in that location (Nelson, 1958; Parasuraman and Grewal, 2000; Colwell and Jackson, 2004; Adebayo et al., 2019a). Fundamentally, retail consumers' demands for retail products control the decisions of retailers and investors in retail property markets on what, where and whether to develop, invest-in and occupy a retail property (space) (Adebayo et al., 2019a).

Therefore, understanding consumer behaviour is necessary in evaluating the future performance of retail locations that is valuable as regards the occupation, investment and development of retail space decisions. Christaller (1933), explained that consumer population and income are key variables that drive retailers' occupier demand. Colwell and Jackson (2004) and Wright et al. (2006), while expanding on Christaller's CPT theories, included consumer expenditure and disposable income in consumer population as crucial factors that drive occupier demand and the rental value of retail space. However, these preceding studies (Christaller, 1933; Colwell and Jackson, 2004; Wright et al., 2006), observed consumer powers (demands) as localised powers that are restricted within certain retail catchment areas of a spatial layout.

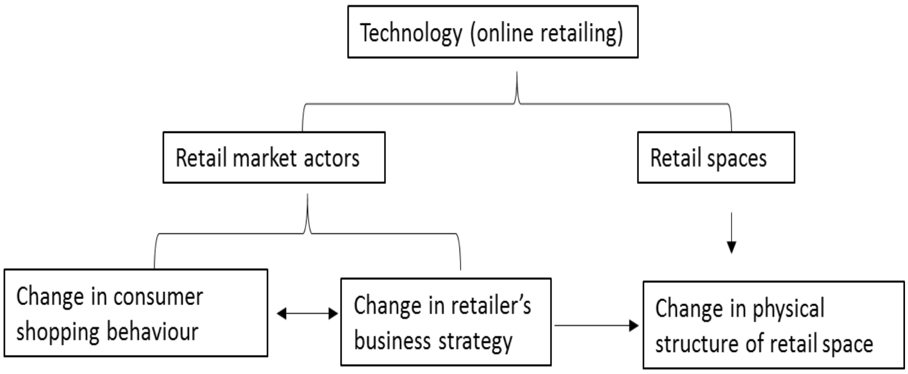
Today, retailers and consumers are better connected via the internet and other supporting facilities, such as e-banking, software apps and so on. As such, online retailing and other aspatial factors (mainly, economic changes), influence the way that consumers transact with retailers (Gerald, 2004). Similarly, the instability of economic variables, such as GDP, interest rates, household disposable incomes etc., are also co-influencing the decisions of consumers and other retail market actors (Wright et al., 2006).

The following two subsections deliberate on the two important aspatial factors, specifically technology and economic variables seeing as they influence retail markets. The subsection presents the influence of technology on retail markets.

3.1.1. Influence of technology (online retailing) on retail markets

The influence of technology (vis-a-vis online retailing) on retail markets can be broadly categorised as influence on *retail market actors* and *retail spaces* as shown in Figure 3.1.2.

Figure 3.1.2: Categorisation of the influence of technology (online retailing) on the retail market



Source: Researcher's own (2019)

Retail market actors, principally retailers and consumers are being influenced by the continuous developments in technology. This is because technology (especially, online retailing) has improved how businesses between retailers and consumers is transacted, while changing consumers shopping behaviours (Timmermans, 1993; Wright et al., 2006). Consumers do not necessarily have to visit retail stores to transact business with retailers. Consumers, with the help of technology (internet, software, hardware gadgets, such as smartphones, laptops, tablets etc.) are now better informed about retailers' offers at various prices and store locations with less fuss (Pickett-Baker and Ozaki, 2008). Similarly, online retailing has broadened the consumer (customer) base for many retailers - while eliminating the demand barriers of local catchment areas across city spatial layouts and regions (Timmermans, 1993; Wright et al., 2006; Pickett-Baker and Ozaki, 2008; Piotrowicz and Cuthbertson, 2014). Consequently, the retailers' business strategies are responding to the broad acceptance of online retailing by the consumers and retailers. Many retailers understanding this change have set up online shopping platforms (Omnichannel retailing) to meet the current trends associated with consumer shopping behaviours, even though there are additional business costs involved (Teller and Reutterer, 2008; Piotrowicz and Cuthbertson, 2014; Van Loon and Aalbers, 2017). Fraj and

Martinez (2006) and Teller and Reutterer (2008), identified the additional business costs involved with Omnichannel retailing to include rental cost on warehouses besides the management of logistics and the maintenance costs of digital hi-tech among other costs, signifying that technological factors have generated both costs and benefits for urban retail markets.

However, similar reports (Deloitte, 2018; Carrol, 2018; CRR, 2018), have shown that there has been an increase in demand for retail warehousing across many cities as a result of increasing online retailing. Bamfield (2013) and Fernandes and Chamusca (2014), articulated their concerns on the negative impacts of online retailing growth on physical retail stores. They explained that retailers' demands for retail stores are changing owing to online retailing. Consequently, demands for real shops is decreasing in many parts of the UK (Bamfield, 2013; Carrol, 2018; CRR, 2018). Rhodes and Brien (2017), also noted that as store closures continue to rise, online retailing is also increasing. Several notable retail brands that have closed in the last few years include Pound Worlds, Woolworths, Maplin, Toys "R" Us, Bargain Booze, New Look, BHS, Jamie's Italian, Prezzo, Mothercare, Carpet Right, Bargain Booze, Carluccio's and many others (Savills, 2018; 2020). While several of the highlighted retailers have downsized (by cutting number of store branches), some have completely ignored physical retail stores and opted for online retailing business. Rhodes and Brien (2017) and BRC (2017) also indicated that numbers of new retail store openings have declined at more than 15% across many UK cities (including London), as online retailing is becoming the preferred means of shopping and as such, grew by more than 15% between 2008 and 2015 (Carrol, 2018). Consequently, there are noticeable changes in consumers' behaviours and the physical structures of retail spaces across many UK cities because of online retailing (BRC, 2015; 2017). Furthermore, it is worth mentioning that retailers understanding of the significance of these changes are restructuring their business models in ways that accommodate consumers' demands both in and off store (Kim, 2001; Faraj et al., 2007; Hackett and Foxall, 2010; Deloitte, 2018).

This research has not investigated the influence of online retail retailing on retail markets per se (as many studies have done so). Essentially, the research investigates the distribution of changes in retail spaces between two periods (market share) which have significantly increased (specifically, 2008 and 2015) (Carroll, 2018). Further discussions on the influence of the economy on the retail market are presented in the following section.

3.1.2 Influence of the economy on retail markets

Whilst the influence of online retailing on retail markets is a relatively new phenomena, economic influences on retail markets have long been established. Many studies (Brown, 1990; Barras, 1994; Jackson and Watkins, 2007; Evans, 2008; Larsson and Oner, 2014) have asserted that there is a positive correlation between economic variables, for instance Gross Domestic Product (GDP), household disposable income, employment rate, etc., and retail property market variables, such as rental value and stock. Barras (1994), Jackson and Watkins, (2007) and Evans (2008), revealed that a strong positive relationship exists between economic performance and real property market performance. Evans (2008), explained that retail property markets (i.e. demand and supply) are more responsive to economic changes than other classes of property markets. Accordingly, professional (human) judgements on retail market variables, such as rent, yield, capital values and so on are frequently based on economic variables (Jowsey, 2011; Larsson and Oner, 2014). Consequently, the economic influence on retail markets has been broadly categorised based on its influence on:

a. Demand variables of retail markets

b. Supply variables of retail markets

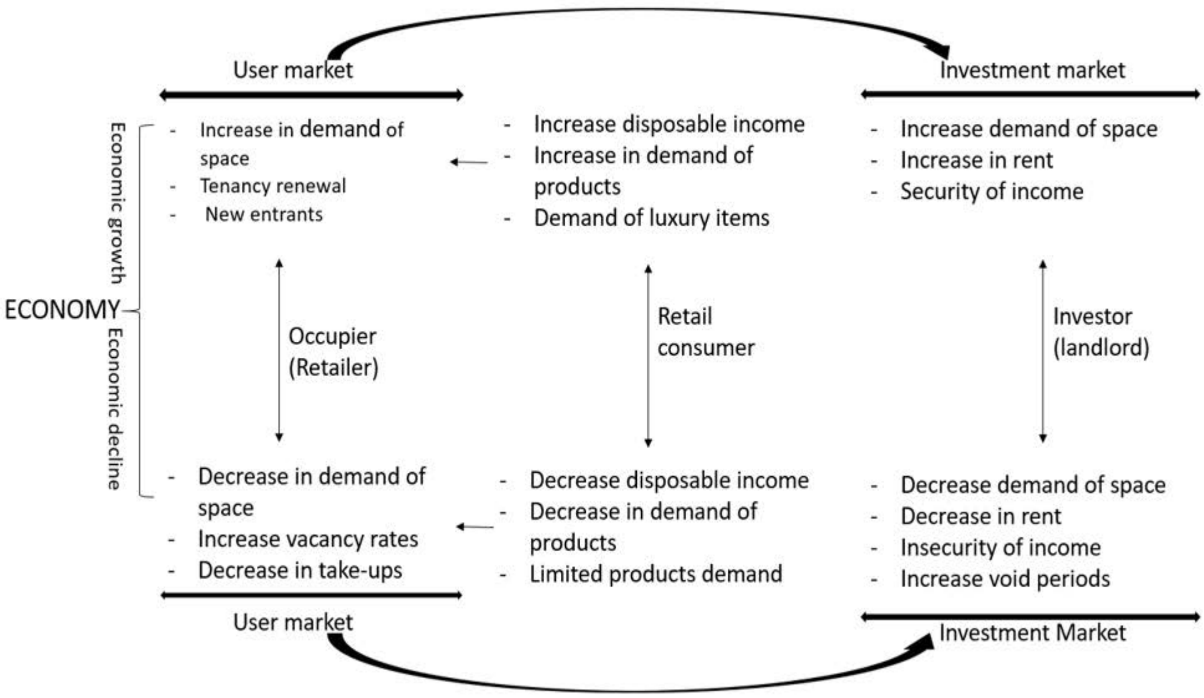
c. Human (real estate professional) judgements on market variables (Barras, 2004; Evans, 2008; Larsson and Oner, 2014).

These three categorises are further explained in the subsequent subsections.

3.1.2.1. The economic influence on the demand variables of the retail market

The retail market demand variables that are influenced by economy include retail consumer demand for retail products, occupier space demand (within user retail markets) and investor space demand (within investment markets) (Barras, 2004; Evan, 2008). These demand variables are interrelated by means of economic performance as shown in Figure 3.1.3.

Figure 3.1.3: Economic influence on retail (user and investment) markets



Source: Adapted from Barras (2004) and Evans (2008)

Equally, a booming economy enhances demand for retail products by consumers, which then results in active user and investment markets. During an economic boom, consumers' disposable incomes increase leading to an increase in demand for retail goods including luxury goods (Cuneo, 1996; Crosby and Murdoch, 2000; Brown, 2006). Consequently, there is an increase in demand for retail space (at the user market) by existing tenants and new market entrants. As the demand for space increases, investors' (i.e. landlords') economic returns (rents) in the investment market increase too (Crosby and Murdoch, 1994; 2000; Barras, 2004; Evans, 2008). However, a depressed economy reduces consumers' disposable incomes and expenditure, thereby reducing demand for retail products. Correspondingly, a depressed economy has certain negative impacts on both users and investment markets (Barras, 2004; Colwell and Jackson, 2004; Evans, 2008). Regarding the user market, demand for additional retail space falls, while vacancy rates and void periods increase. The consequence of this on the investment market is that the rental value of retail space also falls as illustrated in Figure 3.1.3 above.

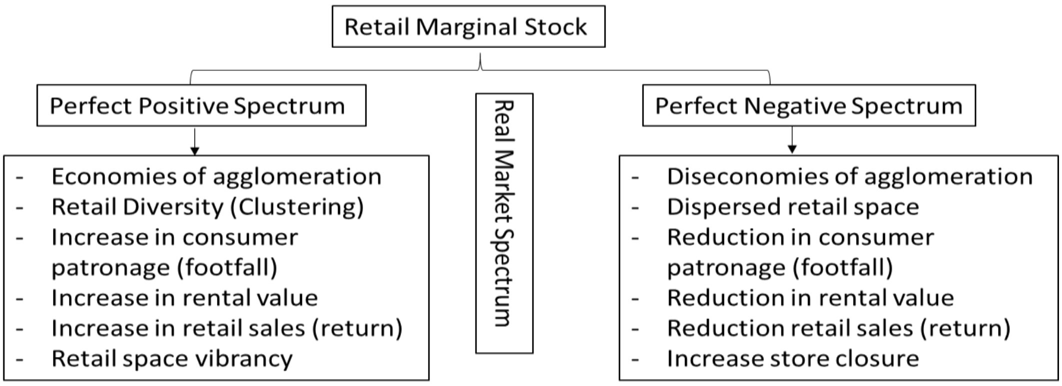
Over the years, many real estate economics scholars (Crosby and Murdoch, 1994; 2000; Greenhalgh, 2008; Jowsey, 2011, Astbury and Thurstain-Godwin, 2014; Corstjens and Doyle; 2017; Adebayo et al., 2019a), have adopted rental value as a reliable variable for estimating the demand-side of a typical property market. This is because rental value reflects the elastic nature of a typical demand for a real economics concept (Jowsey, 2011). However, the reactions of retail market supply variables are inelastic to economic changes. Therefore, the supply variables react differently from the way that the demand variables typically do (Evans, 2008; Jowsey, 2011). The following subsection discusses the typical supply sides of the retail market.

3.1.2.2 The economic influence on the supply variables of retail markets

Evans (2008), advocated the need to consider the supply-side of commercial retail property, even though it rarely changes. Evans (2008), emphasised that economic performance influences the supply of retail space in a typical retail market. He inferred that in a booming economy, there will continue to be an increase in consumer expenditure (powers), user markets and investment markets as regards given retail location 'A'. This performance trend will continue until an additional comparable stock of retail space is supplied into adjoining location 'B'. Since the supply of retail space is inelastic, the new comparable stock in location 'B' will ordinarily take some time (about 4 - 5 years or more) to respond to the active demands of user and investment markets. However, the introduction of new (comparable) stock on adjoining location 'B' will disrupt (and change) the direction (trend) of market performance on 'A'. Consequently, the activeness experienced on the user and investment markets weakens in the long-run even when the economic (indicators) trends remain constant (Clayton, 1998; Crewe and Gregson, 1998; Barras, 2004; Evans, 2008). Evan's (2008) arguments rest on the premise that demand for property precedes supply. Specifically, his ideology ignores the possibility of existing stock attracting demand for property.

As such, there are two main perceptions that perfectly classify the influence of the supply of additional retail space (that is, marginal stock) on the performance of retail property markets. These two views are identified as the perfect positive and perfect negative spectrum of retail marginal stock as shown in Figure 3.1.4.

Figure 3.1.4. Effects of the additional supply of retail space (marginal stock) on retail markets



Source: Adapted from Crewe and Gregson (1998) and Evans (2008)

In a retail market context, a positive spectrum (perception) of marginal stock understands the addition of new retail space to enhance the performance of user and investment retail markets, at least in the long run (Crewe and Gregson, 1998; Lowe and Wrigley, 2000; Williams, 2002; Crewe, 2003; Crosby et al., 2012). This (positive) view anticipates that the addition of complementary retail stock to a location will increase occupier demand and consumer patronage (population and footfall) at that location. The increase in consumer patronage is expected to impact (positively) on retailers' turnover, thereby, increasing rent value and retail space vibrancy (Lowe and Wrigley, 2000; Brown, 2006). It can be argued that this market behaviour scenario overlooks all of the possible risks associated with retail diversity and clustering (Brown, 2006). Retail spaces that incline towards this perfect positive market behaviour are known to uphold the principle of economies agglomeration, which completely ignores the flawed character of property markets (Corstjens and Doyle 1981; Brown, 2006; Leng et al., 2014; DaSilva, 2018).

In contrast, the negative perception sees any addition retail space initiate a competitive market environment for retailers and other retail market actors (Crewe and Gregson, 1998; Evans, 2008; Leng et al., 2014). Instead of a new supply of retail stock space to enhance retail activities and vibrancy at that location, a weak distribution pattern is achieved concerning retail activity, leading to additional cost of movement for consumers and a reduction in retailers' turnover (Crewe and Gregson, 1998; Brown, 2006). In essence, retailers will have to compete for consumers' (expenditures, incomes, populations and footfall), thereby reducing product prices and standards (Kivell and Shaw, 1980; Crewe and Gregson, 1998; Tsolacos and McGough, 1999; Lowe and Wrigley, 2000). This therefore impacts negatively on the security of investor's incomes and reduces rental values (Crewe and Gregson, 1998; Leng et al., 2014).

However, it can be argued that both extreme views (positive and negative) have oversimplified retail market behaviour (to changes in retail stock) at a given space. This is because the retail markets response to the additional supply of retail space varies across many locations (including cities and other spatial demarcations) over certain periods (Evans, 2008; Adebayo et al., 2019b). Nevertheless, Figure 3.1.4 (above) has illustrated the possible market reactions to stock changes.

This research investigates retail property market performance by evaluating locational changes in demand and supply variables across different cities. The research relies on existing ideologies (Evans, 2008; Greenhalgh, 2008; Jowsey, 2011, Astbury and Thurstain-Godwin, 2014) that infer changes in retail rental value as it measures the demand side of property (retail) market performance**.** Conversely, the supply side of the retail property market have been established based on locational changes in retail floor space (retail floor size) and the number of retail unit counts per location (that is, retail clusters). This is simply because of the nature of the retail market. The retail market does not depend on the construction of new buildings for additional stock or changes in stock to exist (unlike offices, industrial and residential markets). This research argues that both variables (for example, changes in the location of retail floor space and retail cluster) exhibit elasticity characteristics of supply in a pure economics concept. The research reasons that supply of retail property is not necessarily additional property stock (building) but includes changes in the number of retail clusters per location and changes in the location of retail floor space. Further explanations regarding demand and supply variables are made in this chapter and Chapter 5 of this thesis. The next subsection presents further discussions on how the economy influences the professional judgements of market variables.

3.1.2.3. Economic influence on the human (professional) judgement of market variables

Apart from the direct influence of the economy on retail markets (demand and supply), a significant change in the economic cycle (say, a shift from a boom to bust economy or vice versa) will influence human (professional) judgements concerning retail market variables (Tsolacos and McGough, 1999; Barras, 2004; Evans, 2008; Jowsey, 2011). An example of this was conspicuous in the last shift between the boom time (in 2007-2008) and the depressed economic era (in 2008-2009). The economic boom in 2007-2008 expectedly created activity in user and investment markets across the UK (and other credit dependent economies) (British Property Federation BPF, 2017; BRC, 2017; Deloitte, 2018; Savills, 2018). As such, professional judgments on yield variables (that should reflect future expectations of future performance), capital value and rental value variables were based on the booming economic performance. However, the sudden transition into a depressed economy that followed in 2008-2009, disrupted the markets as values placed on retail (and other) property were not achieved and the upward only review clauses (common in many UK commercial rental markets) were contested (Dixon, 2007; Crosby et al., 2012). Subsequently, many professional judgements (during the economic recession) on yield, capital and rental values were based on valuation heuristics and individual experiences rather than the supposed comparable evidences in the market (Crosby et al., 2012; Dodds et al., 2012). The main implication of this is that the economic conditions of valuation dates can possibly influence the market judgements of elastic (market data) variables, such as rental value (Dodds et al., 2012; Jones and Livingstone, 2015). Although this study does not enquire whether economic performance influences valuers' judgements on retail rental value, the study has purposefully investigated retail rental value acquired during the boom economy and recovery stages. In essence, market (rent) data obtained from both 2008 (the boom era) and 2015 (recovery era) have been investigated in this research. It can be argued that investigating retail market variables between these two economic points (that is, boom and recovery) would enhance reliability of analysis on the computed changes of rental value across cities that represents demand variable.

However, questions regarding the reliability of economic performance in providing professional judgements on user and investment markets were raised in Crosby and Murdoch (2010), Geoffrey and Eamonn (2010), besides Liang and Wilhelmsson (2011). Liang and Wilhelmsson (2011), queried the relevance of economic performance in providing market judgements and decisions on retail property markets. They argued that macroeconomic variables, such as GDP, disposable income, employment rates etc., provide minuscule insights into local retail (property) markets. This is because macroeconomic variables overgeneralise market activities notably at the local retail market level (Liang and Wilhelmsson, 2011). Likewise, Tsolacos and McGough (1999), criticised the relevance of macroeconomic variables in guiding commercial property market players as regards use and locational decisions. Geoffrey and Eamonn (2010), further argued that macroeconomic variables are highly aggregated data that are measured at national and regional levels. They contended that highly aggregated data hide specific information about the markets, which create less meaningful results for market actors to make locational decisions. Similarly, Nsibande and Boshoff (2017), suggested that local decisions pertaining to user and investment retail property markets should not be evaluated using national and regional economic performance data. Nsibande and Boshoff (2017), maintained that macroeconomic indicators provide early signals on the performance of retail property markets in the short run. As such, locational decisions on the development (by developers), investment (by investors) and occupation (by retailers) of retail space must focus on the local market analysis of retail space performance rather than generalised macroeconomic variables.

Despite the economic influence on the demand, supply and professional judgement of retail market variables, economic (macroeconomic) variables are relatively minor in making localised property market decisions (McGough and Tsolacos, 1999; Brooks et al., 2000; Brooks and Tsolacos, 2001). Reliable market decision making on development, investment, occupation, together with the use and management of retail space will require understanding the retail space and other market variables at local scale levels (Morrison, 1997; McCann and Folta, 2018).

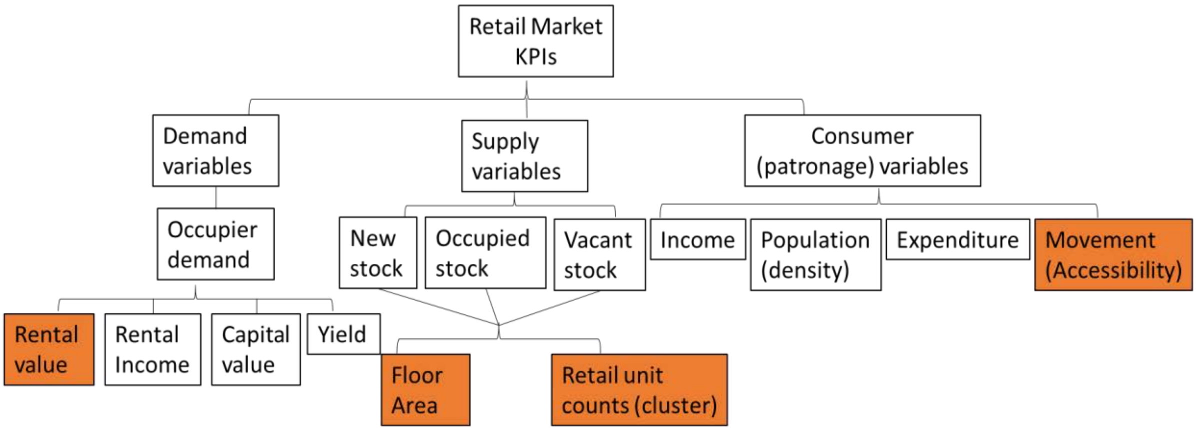
It is in response that this research investigates retail market performance at local levels in cities and city centres to better understand retail locational performance for reasonable decision making pertaining to the use (investment, development and occupation) and management of urban (retail) spaces. The next section explores usable variables in estimating retail market performance on retail spaces. The section presents issues relating to computing retail market performance.

3.2. Estimating the performance of the retail property market on city space

This section introduces Key Performance Indicators KPI (variables) usable in estimating retail market performance on city space. It considers the characteristics of KPI factors while examining issues surrounding estimating retail market performance on retail spaces. The section also clarifies the components of retail space for a better understanding of retail market performance.

In a typical property market comprising both demand and supply sides, the demand variables, for example rental value and occupier demand are commonly utilised in estimating property market performance because of the inelastic nature of the supply variables, such as new and vacant stock) in the short run (Benjamin et al., 1998; Adair et al., 2003; Evans, 2008; Jowsey, 2011). Specifically, demand variables are more elastic and they adjust more quickly to internal and external property market changes compared to the supply variables. Nonetheless, Colwell and Jackson (2007) and Evan (2008) and Jowsey (2013) demonstrated that analysing both (that is the relationship between supply and demand) variables reveals a more holistic market performance than single consideration of demand variables. It is in this regard that this research considers factoring both demand and supply sides in investigating the locational performance of retail markets. This research further contends that a comprehensive estimation of retail market performance should not just consider demand and supply variables, but also the consumer variables. This is connected to the central role played by consumers in coordinating user and investment markets (as earlier discussed). Possible KPIs of a typical retail market (that is, demand and supply) and retail consumers have been explored in this section as summarised in Figure 3.2.1 (below).

Figure 3.2.1: Key performance indicators (KPIs) estimating retail market performance



Source: Researcher's own (2019)

The considered KPIs for demand and supply variables are occupier demand, rental value, rental income, capital value, yield, new stock, occupied stock, vacant stock and total stock (that is, floor space and number of retail units), while consumer variables comprise consumer expenditure, consumer population (density), consumer incomes and consumer movement (Adebayo et al., 2017). This thesis has argued (in the subsequent sections) in favour of rental value, total stock and consumer movement as key indicators adequate in estimating retail market performance on any given city (retail) space. The characteristics of the identified KPIs have been explored with a view to understanding the pros and cons of the indicators in estimating retail market performance. Key issues on how these indicators influence retail (investment and user) markets regarding a typical city (retail) space are have also been discussed.

3.2.1. Estimating the retail property market: issues on occupier demand and stock

There are three broad views relating to the estimation of retail market performance. The first view is that retail property market performance should be estimated through the interaction of demand and supply variables (Colwell and Jackson, 2004). That is, establishing relationships between supply and demand variables. The other is that retail market performance should be estimated by way of computing changes in either of demand and supply variables (Vitalii and Lena, 2016). The third is establishing the differences between two or more variables of demand or supply (Geoffrey and D'Arcy, 1994). For example, the difference between rental value and rental income can indicate the performance of a retail market (Geoffrey and D'Arcy, 1994).

Ideally, retail (investment) markets performance should depend on the interactions between the demand and supply of property space within a given location (Hendershott et al., 2002; Colwell and Jackson, 2004; Greenhalgh, 2008). For example, decisions to invest in retail space should depend on the occupier demand and available total stock, including new, occupied and vacant stock to generate regular rental income and enhance capital value among other investment motives (Brooks et al., 2000; Jowsey, 2011). However, the actual demand for retail spaces remains relatively difficult to compute (Adebayo et al., 2017; RICS, 2017). Many of the retail property demands, including effective demand (specifically, actual take-up), ineffective demand (such as, enquiries on retail spaces) and other demand types are usually not completely captured by real estate data service providers (Vitalii and Lena, 2016; RICS, 2017). This is principally because of the lack of transparency associated with real estate market (Tsolacos, 1995; Tsolacos and McGough, 1999). Conversely, many real estate economic scholars (Kim, 2001; Evans, 2008; Greenhalgh, 2008; Jowsey, 2011; Greenhalgh and King, 2011), when estimating property demand have adopted different property specific KPIs as proxies for property demand. Some of the common KPI variables that have been used as demand proxies in estimating property (investment) market include rental value (Barras, 2004; Greenhalgh, 2008; Colwell and Jackson, 2011; Muldoon-Smith et al., 2015), rental income (Colwell and

Jackson, 2011), capital value (McGough and Tsolacos, 1994; 1999) and yield (Colwell and Jackson, 2004; Jowsey, 2011).

Meanwhile, the supply indicators i.e. total stock, new stock, vacant stock, occupied stock of retail space is relatively easy to compute since it can be estimated based on total quantities of retail floor space occupied, available (vacant) and added in a given place (McGough and Tsolacos, 1999; Vitalii and Lena, 2016). Nevertheless, there are data limitations especially when computation involves bulky floor areas covering a wide retail pitch (Brooks et al., 2000; Evans, 2008; RICS, 2017). The supply side is relatively inelastic and sluggish to respond to market performance (and changes) due to time requirements for planning, construction and financing retail stock development, including change of use to retail space and the addition of new retail sites (Colwell and Jackson, 2004; Dunse et al., 2010). Jackson and Watkins (2007), explained the dynamic effects of supply-side on retail property markets. They noted that retail stock in different locations are incomparable, even though they share similar floor area sizes, facilities and other common variables. They argued that the impact of new stock exceeds the physical floor space and that it is impossible to replicate locational performance within an existing retail stock (Jackson and Watkins, 2007). In other words, existing stock ‘A’ located in location ‘A’ is never equal to the same stock ‘A’ in location ‘B’. Furthermore, they established that whenever new stock in location ‘B’ emerges, the economic (market) performance of retail location ‘A’ will be affected depending on the distances between location ‘A’ and ‘B’. Jackson and Watkins (2007), suggested that the number of retail unit counts (that is, retailers cluster) available within certain locations over a given period of time can indicate the retail (supply-side) market in that location.

On a different note, Vitalii and Lena (2016), argued that any locational changes on either supply-side or demand-side, for a given period, on given spatial layout, is sufficient in determining market performance as regards making locational decisions. Vitalii and Lena's (2016), idea debunked the essence of interacting demand and supply sides before establishing economic performance of retail space. Vitalii and Lena (2016), explained that the performance of both demand and supply in any given location is cyclical, and, as such, market performance can be determined from changes on either side (i.e. demand and supply).

Conversely, because supply (stock) is relatively inelastic, many scholars (Hetherington, 1988; Crosby and Murdoch, 1994; Dipasquale and Wheaton, 1994; D'Arcy et al., 1997; Nanthakumara et al., 2000; Brooks and Tsolacos, 2001; Hendershott 2002; Greenhalgh, 2008; Corstjens and Doyle, 2017) belonging to more radical economic schools of thought (i.e. Ricardo's school of thought), frequently ignore the supply side and consider it as a static variable with little or no influence on property market performance. As such, the performance of property (investment) markets are occasionally based on demand side KPIs only. Table 3.2.1 below summarises the pros and cons of demand side indicators in estimating retail market performance.

Table 3.2.1: Demand indicators estimating retail market performance

S/no	Demand indicators	Pros	Cons
1	Rental value	-Elastic indicator -React to market changes. -Reflect market locational performance	-Do not always indicate rental income of investors
2	Rental income	-Indicates returns on investment	-Do always reflect market performance
3	Yield	-Good indicator of predicting future market performance	-Dependent on volatile variables. -Difficult to hold on

4	Capital value	-Good indicator for investment performance	-Rely on yield

Source: Adapted from Brooks and Tsolacos (2001)

The above Table 3.2.1 (above) indicates that all the demand KPIs have both advantages and disadvantages and that rental value shows the highest strengths in signalling occupier demand of retail space (Brooks and Tsolacos, 2001). Brooks and Tsolacos (2001), argued that rental value is the price of occupying a property space – which is normally expressed as headline price per unit of space (Brooks and Tsolacos, 2001). Rental values are not usually equal to rental income, even though rental value and rental income are occasionally used interchangeably when estimating retail space performance (Clayton, 1998). The market rental value is derivable through the free interaction of demand and supply for property space at a particular point in time in a given location (Jowsey, 2011).

However, the rental income is the net effective rent (i.e. the real income after deducting all possible outgoings), that investors achieve from holding an interest in a real (retail) property at a given point in time (Clayton, 1998). The relationship between the two variables (i.e. rental value and rental income), form a template that can help understand retail property market performance (Brooks and Tsolacos, 2001; Vitalii and Lena, 2016). That is, whenever the rental income is higher than the market rental value - it implies that the retail property performance is moving towards a negative direction and vice versa (Dipasquale and Wheaton, 1994). However, because of the confidentiality involved in real property (market) deals between occupiers and investors, data on rental income variables are typically difficult to access when evaluating retail (and other commercial) market performance – even in the UK, which is ranked as one of the world's most transparent property markets (Fisher, and Harrington, 1996; D'Arcy et al., 1997; Crosby and Murdoch, 2000; Hendershott et al., 2002; Cosby et al., 2012).

Similarly, the yield variable is perceived as a guide to the future performance of investment property markets as it represents risk elements of property investment (Crosby et al., 2012). Yield is usually expressed in percentage and it is calculated based on a variety of factors, such as economic performance, the calibre of tenants occupying the property, vacancy rates, lease agreement terms, unexpired lease terms, location of property, tenants' covenant strengths and other risk elements (Crosby et al., 2012; D'Arcy et al., 2012). The unpredictable nature of yield components make it an unreliable property performance indicator (Brooks and Tsolacos, 2001). Consequently, the character of the yield indicator (as a capitalisation rate) do reflect on capital value indicator, while capitalising rental value with yield to obtain the capital value of a real property (Brooks and Tsolacos, 2001). As such, both yield and capital value are regarded more as property specific performance indicators that are reliable in establishing property (investment) portfolio performance but are inadequate in analysing property market performance (Brooks and Tsolacos, 2001; Jowsey, 2011).

Concomitantly, this research estimates retail market performance by means of investigating (locational) relationships between demand (mainly, rental value) and supply (mainly, floor space and retail unit count) variables (as suggested by Colwell & Jackson, 2004). Similarly, this research estimates retail market performance through investigating (locational) changes in either/both demand and supply variables (as prescribed by Vitalii and Lena, 2016). Furthermore, this research has embedded consumer variables into the estimation of retail property market performance. This is connected to the relevant roles played by consumers in influencing decisions of retail market actors, thereby shaping the retail market.

3.2.2 Issues in establishing retail rental value on retail space

The retail rental value is a unique variable that is easily influenced by many factors. This section discusses issues surrounding estimating retail rental value on a given retail space. The section discusses methods (specifically, zoning and comparison methods), usable in establishing rent among other issues, such as physical attributes, legal and social elements) that may influence the performance of retail rental value.

Rental value is a key indicator of real property performance, and all other demand indicators, namely, rental income, yield and capital value depend on it (Brooks and Tsolacos, 2001). The *zoning method* of valuation is peculiar to retail spaces. Consequently, issues pertaining to the zoning method of valuation when establishing the *market rent* of retail space will be unique to the retail property market. Crosby and Murdoch (1994; 2000), described market rent as an impossible variable to ascertain. They argued that conditions attributed to the ascertainment of market rent in a real property market condition are not usually fulfilled. According to valuation professional guidance notes, a market rent is:

> *"the estimated amount for which a property, or space within a property, should lease (let) on the date of valuation between a willing lessor (landlord) and a willing lessee (tenant) on appropriate lease terms in an arm's-length transaction after proper marketing, wherein the parties had acted knowledgeably, prudently and without compulsion." (RICS global valuation standard, 2017 p.10).*

This definition by RICS (2017 p.10), suggests that for market rent to exist, all the stipulated conditions, including willingness, arms-length transaction, parties' knowledgeability and parties acting without compulsion must be satisfied. However, these market conditions are unachievable across a wider retail pitch where there are many transactions between numerous landlords and occupiers (Guy et al., 1998; Jackson and Watkins, 2007). Thus, not all transactions and retail space rents adhere to market rent principles.

Furthermore, the physical configuration of retail spaces can also influence rental value while using the zoning method (Jones and Orr, 1999). This is because the rental value of retail space can be influenced by the proportions of widths and depths ratio of the subject retail space (Jones and Orr, 1999; RICS, 2017). Consequently, two retail spaces with the same floor space (that share other similar characteristics) will command different property (rental) values just because of the variation in physical configuration (Katyoka and Wyatt, 2008; Crosby et al., 2011). For instance, retail space 'A' with wider frontages (width) is more valuable than retail space 'B' of the same size area that has a shorter frontage, while applying the zoning valuation method (RICS, 2017).

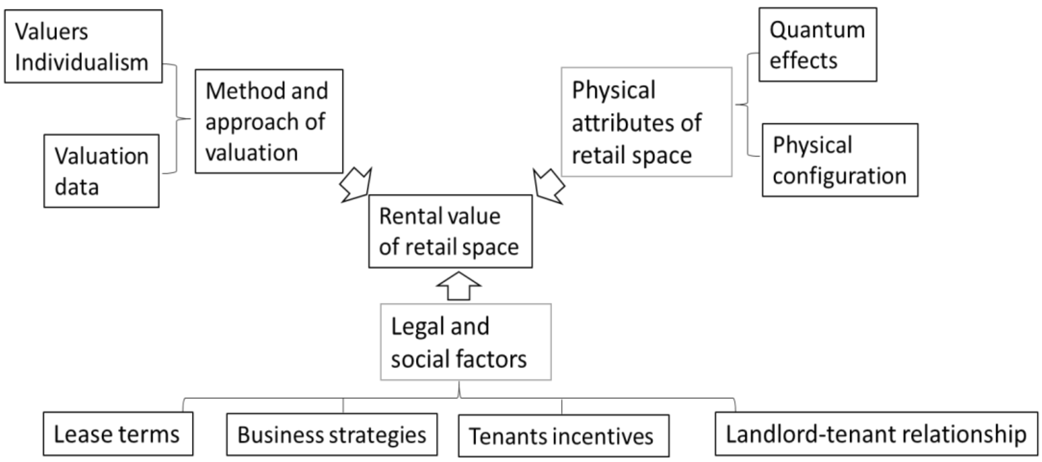
Apart from the zoning method that is unique to retail property, rent (value) of retail space can be determined using the overall area approach (SSE, 2018). Therefore, relative rent per square metre of the entire retail space is established based on (either or combination of) *comparison method*, *accounting or profit method*, *investment method* and *Depreciated Replacement Cost (DRC) method* (RICS, 2017; SSA, 2018). The choice or appropriate method(s) of valuing a retail space depends on the location of the subject property, adjoining properties, occupation (or vacancy) status, available market data, purpose and basis of valuation among other considerations (Johnson, 2013; Jowsey, 2013). However, the DRC method (and residual method) of valuation are rarely adopted in computing the rental value of a retail space. This is because the DRC and residual methods of valuation are only appropriate for establishing rental value when there are neither comparable evidences (for) nor passing rent on the subject retail space being valued (Johnson, 2013).

Ideally, the comparison method is usually the first point for establishing the rental value of retail space (and other property types) (Adebayo, 2014). The comparison method is based on the notion of *comparing likes for like*. However, because of the heterogeneous element of retail space (that makes individual property unique), necessary adjustments must be made to account for the differences in property characteristics (Dipasquale and Wheaton, 1992; Jowsey, 2011). The key procedure for the comparison method requires establishing a unit of comparison, that is, rent per square metre (or per square foot) of comparable and multiplying such with the floor space of the subject retail space before considering the difference in property characteristics (Dixon, 2011; Jowsey, 2011). The difference in the characteristics of the subject retail space and its equivalent is inevitable because of the heterogeneous character of retail spaces (Crosby, et al., 2011; Jowsey, 2011). Intrinsically, data adjustments, which depend on the individual judgements of valuers are required on valuation data (variables) while establishing market rent for retail space (Adebayo, 2014). Consequently, there are possibility of variations in the computed market value of retail spaces as a result of the element of individualism attached to property valuation (Crosby and Murdoch, 2011). Nonetheless, the principle of the comparison method of valuation is essential in establishing rental value, seeing as there are elements of the comparison method in all other methods of valuation, even in the zoning method (Johnson, 2013; RICS, 2017).

Normally, establishing rent per square metre (that is, the relative rent) should account for area (size) differences between the subject and comparable spaces. However, in retail (and other commercial) property markets, there exists the 'q*uantum effect*' on rental value (SSE, 2018). Quantisation (or quantum effect) in the retail property market occurs when landlords charge (demand or accept) lower rents for larger floor space than they would charge for a smaller floor area in the same condition (SSE, 2018). Essentially, small floor space units, such as an automated teller machine (ATM), electronic pick-up lockers (and so on), under retail market quantisation will command higher rental value per unit area when compared with large retail floor space, for instance department stores - even though they are within the same location and share other similar conditions (VOA, 2017; SSE, 2018). The implication of this is that size differences between a comparable retail space and the subject retail space can be an important factor to be considered when establishing market rent for the subject retail spaces. This is because a market rent established for a subject retail space that was based on quantised retail space rent can result in misjudgement of the retail market performance in that location. Although, the quantum effect can be easily predicted and avoided when establishing market rent for the new (subject) retail property by factoring floor space (size) difference while analysing the equivalent. It can still be argued that the quantisation of retail space can influence a unit of retail property rent.

Apart from methods of valuation and the physical attributes (configuration and quantisation) of retail space, there are other legal and social elements, such as the landlord-tenant relationship, and tenants' incentives that internally influence the rental value of retail space as shown in Figure 3.2.2 below.

Figure 3.2.2: Property-specific (internal) factors influencing rent (value) of retail space



Source: Adapted from Adebayo et al. (2019a)

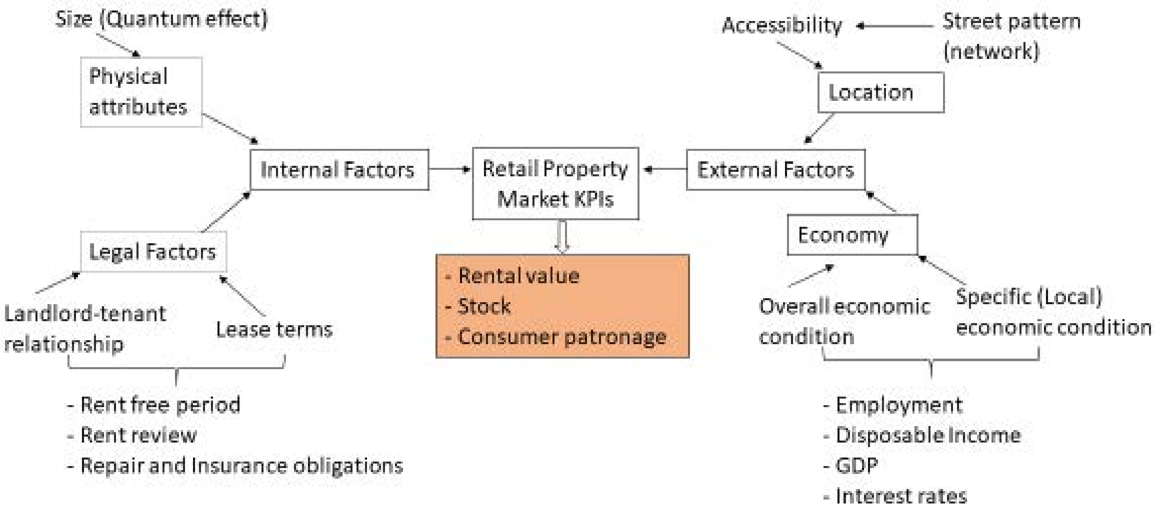
Dixon (2007), argued that a long-term relationship between a lessee (occupier/retailer) and a lessor (landlord) can lead to a lessor receiving lower rent (income) than market rent, even when new contracts (rent renewals) have just been initiated. Basically, rents for retail spaces can be established based on social (relationship) factors as against common economic reasons (Grewal et al., 1998; Brown, 2006; Dunse et al., 2010). Grewal et al. (1998), evaluated various business strategies adopted by retail space landlords. They observed that landlords (and other retail space managers) plan to ensure that retail premises are not vacant but are vibrant and occupied by some blue-chip (anchor) retailers. They stated that this is done to attract retail consumers and other local tenants (and businesses). Accordingly, tenant incentives are issued to retailers (tenants) as a business strategy to foster landlord-tenant relationships while achieving other business goals. Tenant incentives, such as rent-free periods, break option clauses, repairs and insurance obligations are agreed upon to ensure that landlords' business goals are achieved in the long-term (Johnson, 2013). However, the consequence of this is that market rent becomes an opportunity cost for other business goals in the short run. This is because the net effective rent (after considering all tenant incentives) become lower than the market rent. Specifically, the market rent becomes an unrealisable figure for the retail space, until a new set of tenant incentives are reintroduced into the market (Grewal et al., 1998; Dunse et al., 2010; Johnson, 2013).

The complexity of establishing retail space rents extends to hidden lease terms between landlords and retailers. The legal factors including lease terms, repair and insurance obligations, rent review clauses and many other terms that can change the effectiveness of rent (or rental income) of retail space are usually not pronounced in many property transactions (Amit and Schoemaker, 1993; Tse, 1999; Bretten and Wyatt; 2001; Fisher et al., 2007; Ambrose and Yildrim, 2008). Although, there are various real estate data service providers, such as Co star, EG and other commercial real estate agents that publicise some of the lease terms that may influence rental value when quoting rents for published transactions. There is countless other information (data) within lease terms that might influence the rent of retail space that is hidden from the public (Ambrose and Yildrim, 2008). However, Crosby et al. (1998), argued that the basis to which a valuation exercise is conducted is reasonable enough to ascertain market rent. Crosby et al. (1998), articulated that valuation practice allows a margin of error (roughly +/- 15% of the computed valuation figure), regarding the market value of all property (including retail spaces). Essentially, a valuation exercise conducted on the basis of an open market, can be regarded as market value, even when the established valuation figure is not eventually achieved from the lease (lettings) or sale of that property (Crosby et al., 1998; 2012). The acceptable margin of error varies and is dependent on many factors, including type and use of property, purpose of valuation and valuer experience among others (Bretten and Wyatt; 2001; Fisher et al., 2007). Consequently, market rents are not necessarily effective (achieved) rents but can indicate and guide market actors concerning the performance of real property (retail space), despite the non-existence of an ideal open market rent.

It can be contended that the above assertions have focused predominantly on the internal factors influencing the rental values of retail spaces. These factors are hidden and often go unnoticed when analysing retail market (rent) performance on a wider (city) scale. However, these factors are capable of disrupting uniform distribution of retail rental value across city space, thereby debunking existing works on city (rent) models that had suggested uniform distribution of rental value across cities (Alonso, 1964; Jones & Orr, 1999; Colwell & Jackson, 2004).

Similarly, further consideration has been given to other (external) factors influencing retail rental value and other KPIs of the retail property market. According to Wyatt (1996), there are external factors influencing rental value and other property market indicators (apart from the internal factors). Wyatt (1996), identified location (access) and overall economic conditions as the main external factors influencing property market performance. Figure 3.2.3 summarises the factors (internal and external) influencing retail market KPIs.

Figure 3.2.3: Combined overall factors (internal and external) influencing retail market performance



Source: Adapted from Wyatt (1996)

It can be argued that external factors, namely, economy, location and accessibility are the main influencing factors as regards retail property markets. This is because these external factors influence both the retail consumer’s patronage (including, movement and expenditure) and retail market (demand and supply) variables (specifically, rental value and stock). An instance of the influence of an external (economic) factor was felt in the last economic recession (in 2008) that had significant (negative) impacts on retail markets (causing an increase vacancy rates, reductions in net rents, increases in void periods, besides reductions in capital values among others) (Astbury & Godwin, 2014; ONS, 2017). As such, the internal factors are more property-specific elements that would not affect retail consumers. For example, lease term, landlord-tenant relationship and the physical attributes of retail property, such as floor size, dimension and quantum effects) are less important to retail consumers and overall market performance when compared to location and accessibility (Wyatt, 1996; RICS, 2017; Adebayo et al., 2019b).

Concomitantly, further issues on estimating consumer patronage variables are discussed in the next section.

3.2.3 Estimating the retail property market: issues related to consumer (patronage) variables

It can be contended that the retail market remains one of the most dynamic property markets due to its high dependence on consumers' decisions among other factors. As such, it is pertinent that consumer variables are considered when estimating the performance of the retail market. This section discusses four (4) possible variables pertaining to consumer patronage, namely, consumer income, consumer population (density), consumer expenditure and consumer movement (as highlighted in Figure 3.2.1, above). This section examines the pros and cons of these variables in estimating retail market performance and argues that consumer movement has the most suitable consumer variable in estimating retail market performance on city layout. Table 3.2.2 below summarises the pros and cons of these consumer variables in estimating retail property market performance.

Table 3.2.2: Consumer patronage variables in estimating retail property market performance

s/no	Consumer Variables	Pros	Cons
1	Income	- Quantifiable	- Does not equate to expenditure - Difficult to establish and prone to error - Extremely volatile and depends on other economic data

2	Population (Density)	- Computable on a wide scale - Easy to establish per location - Transparent	- Ignores consumer movement and visits - Does not equate expenditure and retail market performance
3	Expenditure	-Can reveal retailers' turnover when available	- Data sensitivity and difficult to obtain across a wide scale - Volatile and depends on the economy
4	Movement	- Can indicate accessibility and footfall - Can be estimated or computed based on street connectivity using a scientific approach - Does not depend on sensitive economic data	- Difficult to measure comprehensively and accurately

Source: Researcher's own (2019)

The incomes (and earnings) of retail consumers are potential expenditure of consumers, profits for retailers and earnings (rent) of landlords (from owning an interest in retail space) in a given location (Falkinger, 1994). Studies (Mooij, 2000; Mooij and Hofstede, 2002), have shown that the incomes of potential consumers influence retailers' turnover, which in turn influences demand (rental value) for retail spaces. Similarly, consumer incomes influence the type of retailers and products (i.e. high order goods or low order goods) offered for sale in a given location (Brown, 2006). Consumer incomes are quantifiable and relatively apparent, making it easy to establish within a given location. However, the income of an individual or a group of consumers does not necessarily imply expenditure on retail products. Fundamentally, consumer income does not necessarily influence retail market performance as regards city layout. This is because the purchase of retail products by consumers are neither restricted to their locations of earnings (workplace) nor the locations of consumer residences (Mooij, 2000). In other words, applying consumer income as a consumer patronage variable can be misleading in relation to estimating the performances of the retail property market in a given location.

Similarly, consumer population density is transparent, location based and easy to compute. As such, there are possibilities for estimating retail market performance through the computed consumer population density (Christaller, 1933; Brown, 2006). However, consumer population (density) does not equate to consumer expenditure, as there are risks as a result of consumers travelling away from locations where they reside. Accordingly, estimating consumer variables via consumer population density can be distorted when consumers travel to other locations to shop. However, consumer expenditure is practical in estimating retail market performance because it shows facts regarding retail location performance and indicates retailers' turnovers, which can impact on retail rental values and other retail market KPIs (Brown, 2006). The main shortcoming of consumer expenditure is that it is difficult to ascertain because of the sensitive nature of consumer expenditure data (and retailers' turnover), which makes it unavailable to use across city analysis. This dearth of data makes it unsuitable to analyse retail market performance across a wide scale.

Conversely, consumer movement variables estimate the accessibility index of locations within cities, which then reveal the potential performance of locations for retail and other purposes (Adebayo et al., 2019a; 2019b). It influences retailers' location preferences, which in turn impact occupier demand and rental value distribution across cities. Unlike consumer expenditure, consumer movement does not rely on sensitive data to estimate retail market performance in cities (Adebayo et al., 2017). However, the main challenge of consumer movement (estimating retail market performance within cities), is that it is difficult to accurately measure across wide scales. This is because it is impossible to track individual consumer movement across retail (city) space. Nevertheless, there are scientific theory and applications (mainly, space syntax) that can estimate consumer movement potential across wider scales based on the underlying connecting street network of cities. This research relies on this principle (space syntax) to explore consumer movement in order to estimate retail market performance across different cities spatial layouts. Details on space syntax theory in computing consumer movements are presented in Chapter 4 of this thesis.

3.2.4 Preceding ideologies on retail consumer behaviours in retail space

There are preceding ideologies that have explained differences in consumer shopping and movement behaviour in city (retail) spaces. This subsection gives account of these ideologies as regards retail consumer movement.

It can be contended that consumers' shopping behaviours will influence consumer movement patterns within any given spatial layout. Retail consumers' behaviours within retail spatial layouts (cities and buildings) are difficult to explain, quantify and envisage despite its significance in estimating retail market performance and guiding the decisions of retail property market actors. This is because an individual (consumer) thinks, behaves, moves to various shopping destinations to meet their retail needs (and purposes), bargaining techniques and other shopping criteria are asymmetrical (Galata et al., 1999; French, 2001). There are five (5) notable retail studies that have considered consumers' movement behaviours within city retail space. These studies are - Erogulu and Harrell, (1986); Lal and Rao, (1997); Galata et al., (1999), Popkowski et al. (2004) and Parasuraman and Grewal (2000). These studies are subjective data (and not scientific) but have categorised consumers based on various factors that enhance and discourage consumers' presence at different locations within the city space. They are good ideas that explain what attracts consumers to different retail destinations. The subsequent subsections will explain these five distinct concepts.

3.2.4.1 Erogulu and Harrell's (1986) concept

Erogulu and Harrell (1986), classified retail consumers based on purpose of their visit to retail stores. They categorised retailer consumers as task-oriented shoppers and non-task-oriented shoppers. It was explained that a task-oriented shopper is a retail customer that visits clusters of retail stores with a preconceived idea of what (to purchase) and where to purchase such items. A task-oriented consumer is assumed to understand the spatial layout of the retail space network. Such consumers are time cautious and they neither wander about nor window-shop whenever they visit stores (Erogulu and Harrell, 1986), whereas non-task-oriented shoppers spend more dwelling time within the retail space and part-take in other leisure and social activities.

3.2.4.2 Lal and Rao's (1997) concept

In a similar approach, Lal and Rao (1997), classified retail consumers based on the available time (and time spent) by consumers. Lal and Rao (1997), categorised consumers as time-constraint shoppers and cherry -pickers. Time-constraint shoppers share similar qualities with the task-oriented shoppers, while the cherry-pickers' behaviours are parallel to the non-task-oriented shoppers associated with Erogulu and Harrell's concepts. Consequently, the dwelling time of time-constraint shoppers within a retail space is typically low, while the cherry-picker shopper spends more time in retail space. Similarly, the movement pattern of a time-constraint shopper is expected to follow the shortest available route to his/her shopping destinations (Lal and Rao, 1997). Meanwhile, a cherry-picker may or may not necessarily take the shortest routes as there is no specific destinations for a cherry-picker since such a consumer will navigate across different stores.

3.2.4.3 Galata et al's (1999) concept

Conversely, the classification of retail consumers made by Galata et al. (1999), was based on the level of services available, required and/or demanded by consumers when they visit retail space. As such, Galata et al. (1999), categorised retail consumers into service seekers and non-service seekers. Service seekers are more utility driven, and the available amenities and infrastructural facilities provided for consumers are particularly important to this category of consumers. Subsequently, the more convenient the facilities, the more the retail locations performance in terms of footfall, rent, vibrancy and retailers' turnover. This idea supports Pacione's (1974), points on measure of retail attraction forces that had revealed the extent of available shopping facilities as key attractors of retail consumers to different locations across cities.

3.2.4.4 Popkowski et al's (2004) concept

The categorisation of retail consumers provided by Popkowski et al. (2004), synergises the thoughts of Lal and Rao's (1997) and Galata et al. (1999). Essentially, the concept classified retail consumers into; time-service seekers, time-price seekers and cherry pickers. Time-service seekers are a group of consumers that appreciate good customer service in an appropriate manner while shopping. Such consumers are cautious of their dwelling time and the services provided by the retailers. Meanwhile, time-price seekers are also cautious of dwelling time within retail space; they are more driven by the prices of products (Popkowski et al., 2004). Conversely, Popkowski et al. (2004), characterised the cherry-pickers as those that are extremely cautious of what to buy and therefore seek product quality, value for money and are never in a hurry to purchase items whenever they visit retail space. The behaviours of these categories of shoppers are expected to influence their movement patterns within retail space while shopping.

3.2.4.5 Parasuraman and Grewal's (2000) concept

In the work of Parasuraman and Grewal (2000) on retail consumers' loyalty, retail consumers were categorised based on the quality of products and services offered by the retailers to their consumers. Intrinsically, Parasuraman and Grewal's concept classified consumers into product-quality driven shoppers and service-quality driven shoppers. Product-quality driven shoppers are consumers that are driven by the quality of products more than customer services offered by the retailers and vice versa.

The above details pertaining to categories of retail consumers have signalled what could attract consumers to certain retail stores (locations). Similarly, the concepts have indicated why certain retail stores (locations) may perform better than others. However, any individual (consumer) can fall into any of the above categorises, as studies have shown that the behaviour of humans as retail consumers changes (Childers et al., 2001; Goodman, 2009). As such, a product-quality driven shopper can change to be a service-quality driven shopper. Similarly, a time-constraint shopper, can suddenly become a cherry picker and so on. It is therefore difficult to quantify consumer movement as regards estimating retail property market performance based on mere observation of shoppers within retail space.

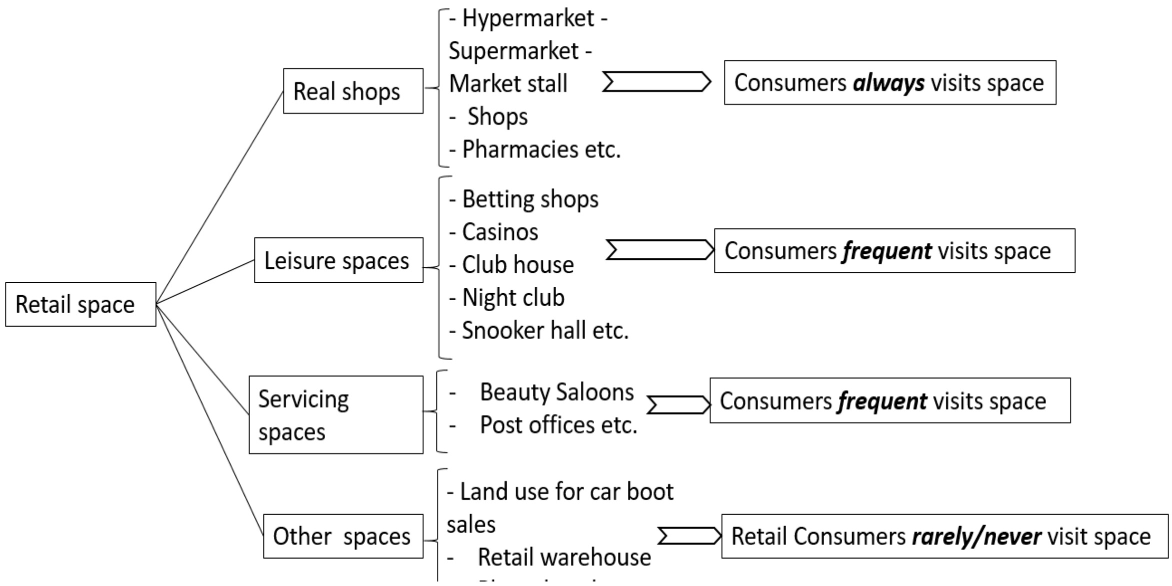
The relevance of consumers in coordinating the retail property market, requires that a more stable means of capturing consumer behaviour in spatial layouts should be adopted in examining retail market performance. Consequently, this research adopts a scientific concept (space syntax) to compute retail consumer movement behaviour using spatial configuration techniques. Spatial configuration techniques establish the accessibility index to all locations across a given layout to estimate the possible influx of consumer movement based on the underlying street connectivity.

As Huff (1962a) argued, retail spaces located on good, accessible links perform better than retail spaces with poor accessible links in terms of consumer footfall, retailer returns, property value and occupier demand as well as retail vibrancy. Consequently, estimating the accessibility index across spatial layout will not only measure consumer movement (and the accessibility index), but also indicate retail property market performance. This research adopts a positivist view towards the scientific computation of retail consumer movement across city spatial layouts using the space syntax principle. Nonetheless, the research explores the most relevant variable (metrics) of spatial configuration to retail property market performance. Parts of chapters 4 and 5 of this thesis discuss the spatial configuration techniques pertaining to space syntax in computing retail consumer movement in city retail spaces.

3.3 Understanding the components of retail space (supply) in cities

According to the Scottish Assessors Association (SAA) (2018), a retail space can be defined based on two different components associated with *use* and *method of valuation*. The use component describes retail space as commercial premises that are held for the purpose of and utilised for trading goods (and services) between retailers (occupiers) and their customers (consumers) (Bamfield, 2013). Retail spaces under the use definition include shops, stalls, kiosks, post offices, pharmaceutical shops, beauty salons and so on. It can be argued that such spaces (under the definition of use) include all commercial spaces that retail consumers visit to influence the trading of goods and services. However, there are other commercial spaces that are utilised for retailing but which consumers do not necessarily visit for trading. A common example of such space (not visited by consumers) are retail warehouses. The frequency of consumer visits to retail spaces vary across the broad categorisation of use of retail space as illustrated in Figure 3.3.1.

Figure 3.3.1 Categorisation of retail space uses based on frequency of consumer visits



Source: Research work (2019)

Figure 3.3.1 categorises retail spaces mainly into four (4) spaces based on use and frequency of consumer visits to retail spaces. It shows that the frequency of consumer visits changes with the categorisation of retail spaces into real shops, leisure spaces, servicing spaces and other spaces (Brown, 1991; Wright et al., 2006). Retail consumers tend to visit real shops more often than they would normally do for leisure, servicing and other spaces (Brown, 1991; 2006). This is because real shops provide everyday goods that all consumers need, irrespective of social or economic status (Brown, 1991).

However, the definition of retail space under the method of valuation are commercial premises (spaces) that are valued based on zoning principles (RICS, 2017). The zoning method of valuation is based on the principle that the front area (frontage) of a retail space (known as zone A) is the most valuable area of the retail space. Consequently, the value of retail space reduces towards the rear of such premises by half as regards the zoning reduction factor as shown in Table 3.3.1 below (RICS, 2017).

Table 3.3.1: Principles of zoning reduction factor

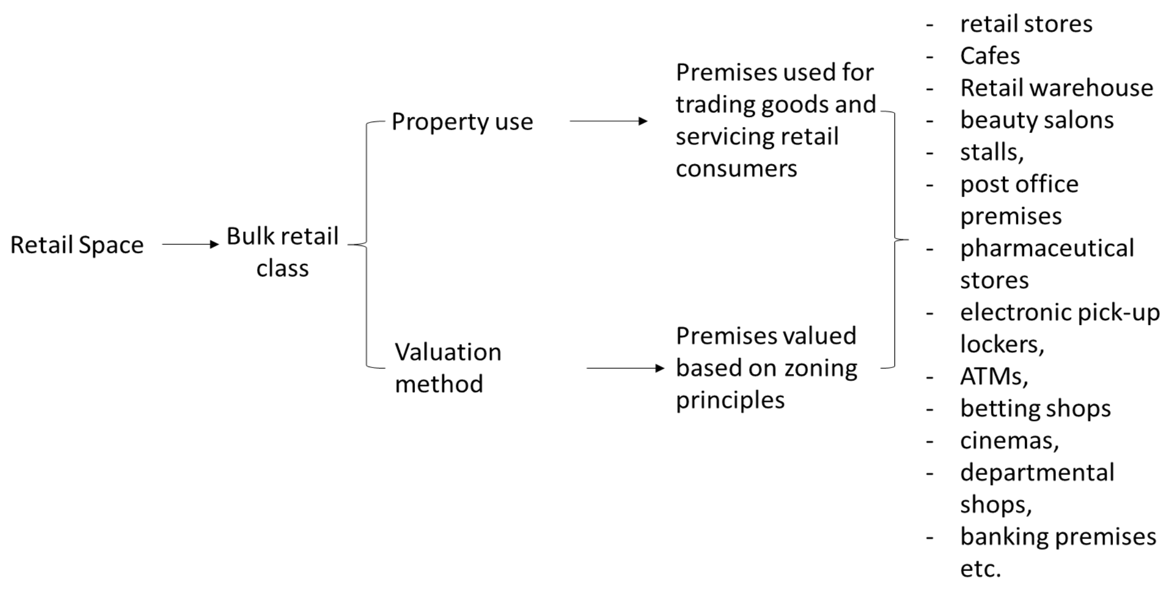
Zones	**Reduction Factor**
A	100%
B	50%
C	25%
D	According to local evidence

Source: Adapted from RICS (2017)

The main implication of the zoning method to retail space definition is that there are other commercial premises that are not utilised for trading purposes but are valued using zoning principles. Therefore, such spaces are considered as retail spaces in retail bulk classifications (VOA, 2017). The effect of the zoning method on these non-retail use premises is that market information from such premises are useable as equivalent spaces (utilised for retailing) during market rent valuation (RICS, 2017). In effect, these premises are classified as retail space, even though they are not used for trading goods. Therefore, an overlapping bulk classification of commercial spaces between offices, industrial, retail and other uses exist in the commercial property market (Astbury and Thurstain-Goodwin, 2014; VOA, 2017). How does one measure the performance of the retail location in this overlapping situation?

A common example (but odd commercial space) classified as retail space is the banking and building society premises located within clusters of retail stores mostly found on the highstreets and city centres (SSA, 2018). Retail space incorporates banking premises located within clusters of retail stores but exclude banking premises located in isolation that are normally valued using other methods (instead of the zoning method). Hence, retail space is an accumulation of commercial premises valued on the basis of zoning principles, those utilised for trading goods and servicing retail consumers other than offices and industrial spaces as illustrated in Figure 3.3.2 below. Some of the retail space premises include (but are not limited to) shops, stalls, cafes, beauty salons, retail stores, electronic pick-up lockers, Automated Teller Machines (ATMs), betting shops, cinemas, departmental shops, banking and building society premises (located within retail store clusters) and so on (V0A, 2017).

Figure 3.3.2: Basic components of retail spaces



Source: Adapted from VOA (2017)

The complexity regarding the exact definition of retail spaces components within city spatial layouts has remain unsolved. While certain studies limit their understanding of retail spaces as real (small) shops (Timmermans, 1993; Machleit et al., 1994; Bamfield, 2013), some have inferred retail spaces to include real shops and servicing spaces (Eroglu and Machleit, 1990; Greenhalgh et al., 2018). Similarly, there are scholars (Buttle, 1984; Benjamin et al., 1998; Corstjens and Doyle, 2017; DaSilva, 2018) that have investigated retail spaces across cities without stating the components of the analysed retail spaces. The main consequence of this indifference in studies is that there have been variations in researchers' results and recommendations on retail spaces, specifically, retail market performance within cities.

3.4 Chapter Summary

This chapter has deliberated on the issues influencing variables for estimating retail property markets in city layouts. The chapter presents the crucial roles retail consumers play in shaping retail markets. As such, it establishes that variables of demand, supply and consumers are key to the effective estimation of retail property market performance. The chapter argues that the KPIs necessary for effective estimation of retail property markets are; rental value (demand variable), stock – floor area and retail cluster (supply variable) and consumer movement (consumer patronage variable). The chapter resonates with the essence of computing consumer movement by way of a scientific approach (spatial configuration technique) to capture the accessibility index across a city layout. Further deliberation on computation of consumer movement via the spatial configuration technique and issues pertaining to the spatial analysis of the retail property market are discussed in the subsequent chapter.

Chapter Four

Consumer movement and the retail property market within city spatial layouts: The roles of Space syntax, GIS and Inferential Statistics

4.0 Introduction

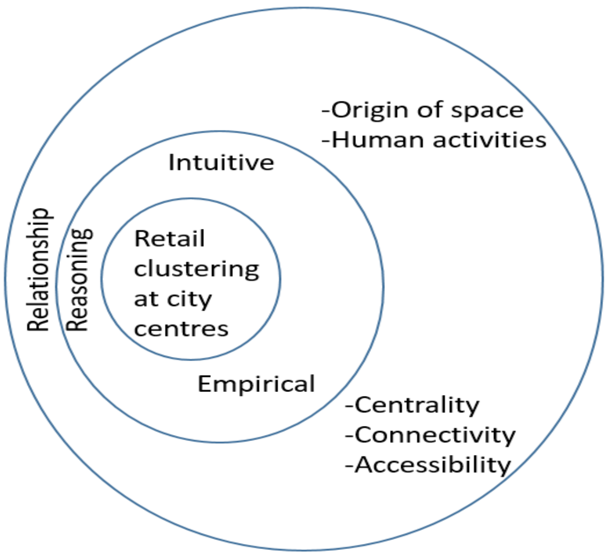
This chapter discusses the context of consumer movement computation on city space with specific focus on the application of space syntax theory. Issues related to space syntax rules in configuring movement on city space are deliberated. The chapter also discusses the roles of Geographic Information System (GIS) and inferential statistics in analysing the variables associated with configured consumer movement and the retail property market.

4.1 Review of city characteristics and the role of accessibility in estimating city retail spaces

A city layout is made up of connecting streets comprising street segments containing nodes and links to form a network of locations that permits movement (Dieberger and Frank, 1998; Peponis et al., 2008). Cities (spatial structures) exhibit similar characteristics as living organisms in terms of growth, movement (within) and adaptation. As such, *all* cities grow and change structure overtime, although at *different rates* (Abler et al., 1971; Alexandra, 1974; Batty, 2008; Newman et al., 2016). These changes and growths within city structures are ordinarily initiated through the nature of a *city's spatial layout* and the *socio-economic activities* within it (Alexandra, 1965; 1974). A city's spatial layout and distributions of socio-economic activities determines a city's growth pattern as it attracts human movement to various locations within and therefore, the structure of land use across cities (Cozen and Cozen, 1979; Peponis et al., 1997; Peponis and Wineman, 2002; Barredo et al., 2004). The spatial layout of a city helps to shape retail consumer movement, which in turn plays a role in determining the distribution of retailers and the performance of retail space on city networks. Put differently, the pattern and nature of street connectivity determines the retail consumer passage, consumer concentration and land use distribution within a given city space (Crainic et al., 2004; Du and Mulley, 2006; Dalton and Dalton, 2009; Dhanani et al., 2010; Fidler and Hanna, 2015).

It is worth emphasising that evidence from Alonso (1964), Timmermans (1993), Srinivasan (2002), Brown (2006), Teller and Reutterer (2008) and Stonor (2008), have shown that retail activities and other complementary (commercial) land use clusters more in the city centre than any other locations within a city space. The concentration of retail activities in the city centres can be understood based on two broad views related to *intuitive* and *empirical* reasoning (Brown, 1990; 2006). Figure 4.1.1 illustrates Brown's ideas on intuitive and empirical reasoning on retail clustering within a city centre.

Figure 4.1.1: Views of intuitive and empirical reasoning on retail clustering in a city centre



Source: Adapted from Brown (1990)

Intuitive reasoning is based on the premise that there is an initial relationship between the *origin of a space* (place) and *human activities* (Hillier et al., 1993; Hillier, 1996; Wilkins, 2009; Chunni and Yu, 2013). That is, human activities (specifically, retail activities) concentrate at the initial point of a city's origin. Based on this, it can be contented that city centres host retail activities and other complimentary services within spatial layouts more than any other part of the city because the centre is the origin of the city (Wilkins, 2009; Chunni and Yu, 2013). Consequently, retail activities initially concentrate at the city centre (i.e. origin of a city space) but do not grow in the same proportion as the city grows (Chunni and Yu, 2013; Stonor, 2013). However, empirical ground is based on established evidence that has shown that *centrality*, *connectivity* and *accessibility* exhibit positive relationships (Sugiura, 1991; Hillier et al., 1993; Batty, 2008; Stonor, 2013). Specifically, the centrality positioning of a city centre makes it a highly connected and accessible location for consumer patronage and retailing activity (Huff, 1962b; Alonso, 1964; Lowe and Wrigley, 2000; Stonor, 2013). Consequently, the centrality, connectivity and accessibility properties of locations across cities will influence consumer movement, distribution of land use (especially retail spaces) and indicate the future performance of locations across cities (Brown, 1990; Adebayo et al., 2017). This implies that the accessibility computation of locations across cities are key indicators of the location performance of retail space while indicating consumer movement potential within a city layout. This research rests on the premise that the accessibility measurement of city space is crucial to estimating the future location performance of city (retail) spaces. However, computing the accessibility index across city space can be challenging. The next section focuses on accessibility measurements on city space for retail property market analysis.

4.2 Context of the accessibility measurement for retail property market analysis on city space

Accessibility computation of city space can signal the distribution of location magnetism on city space, which then defines consumer movement patterns within a city layout. Curtis and Sheurer (2010), clarified that accessibility is a multifaceted concept that cannot be packaged into a one-size-fits-all index. The arguments put forward by Curtis and Sheurer (2010), were maintained in Geurs et al. (2015) and Geurs and van Wee (2004) and suggested that there are many perspectives in relation to the accessibility measurement of cities in urban studies. Geurs and van Eck (2003) and Geurs and van Wee (2004), explained that establishing an accessibility index across city spatial layouts will require careful consideration of spatial and aspatial factors. They emphasised the complexity of indicators and factors to be considered in establishing an accessibility index across city spaces. Geurs and van Eck (2001), noted that factors, such as metric and topological distances, infrastructural facilities including, bus stops, metro stations, road junctions, city centres and many other *important places* are complex to model into accessibility computation. Geurs and van Wee (2004), noted that the phrase '*important places*' is subjective and can mean different places (locations) to different people. As such, accessibility computation is not a straightforward subject that can be easily computed (Geurs and van Eck, 2003; Geurs and van Wee, 2004; Geurs et al., 2015).

Accessibility measurements across city space can be broadly categorised into two parts based on variables and techniques of estimating it. These two categories are *functional* and *spatial* accessibility (Geurs and van Eck, 2003; Geurs and van Wee, 2004; van Wee et al., 2013; Geurs et al., 2015). Geurs and van Wee (2004), explained that comprehensive analysis of functional and spatial accessibility is impossible. Consequently, at least one of functional or spatial accessibility would dominate the accessibility measurements of city space.

Simply put, a functional accessibility measurement involves estimating the relative ease of movement from origin 'O' to destination 'D' on a city spatial layout while taking into consideration the deterrence factors, for instance the costs of movement, time spent on movement and the distance travelled (Reggiani, 2012; Jie et al., 2017). It also considers the socio-economic activities and distances to certain infrastructural facilities, including city centres, transportation hubs, such as bus stops, railway stations, airports), supermarkets, retail stores, banks, playgrounds, schools and any other functions that may be marked relevant to people. Thus, functional accessibility approach is relatively difficult to ascertain because of the numerous and undefined variables that must be considered while estimating it (Baradaran and Ramjerdi, 2001; Geurs and van Wee, 2004; Geurs et al., 2015). The accessibility computation under the function accessibility category possibly will yield different outputs for the same location when input variables change slightly (Geurs and van Wee, 2004).

However, a *spatial accessibility* measurement approach adopts scientific means in estimating the accessibility index across city spatial layout. It focuses principally on the connectivity properties of streets and considers neither socio-economic activities nor infrastructural developments on the city space (Jiang et al., 2000; Geurs and van Wee, 2004). Spatial accessibility measurement solely determines the relative connectedness of places (i.e. stationary streets) in relation to other places within the city space. It perceives the city network as shape components that can be disarranged and rearranged into different elements while computing the accessibility index of each and every component (Geurs et al., 2015). Hence, spatial accessibility measurement does not concern itself with deterrence factors, but the interconnectivity pattern of streets whilst evaluating the accessibility index of parts or all of the given city space (Jiang et al., 2000; Baradaran & Ramjerdi, 2001; Litman, 2003).

The words *accessibility* and *connectivity* may occasionally be used interchangeably. However, in the discipline of spatial science, accessibility refers to as index that measures the relative nearness of a location to another, while connectivity is considered as the linked characteristics of locations within the spatial network (Tal and Handy, 2012; Chen et al., 2014). Depending on the factors considered when estimating accessibility, both can been seen to have a positive correlation (Litman, 2003; Castanho et al., 2017). Specifically, *the higher the connectivity of a street, the higher the accessibility index and vice versa*. It can be contended that the previously mentioned statement only adheres to accessibility index computed based on the spatial accessibility measurement. This is because when socio-economic and other human activities are considered during accessibility computation, a well-connected location can be computed as being difficult to reach and access (Guers and van Wee, 2004). Consequently, accessibility computed based on the functional accessibility measures do not necessarily mean that there will be a positive relationship between both measures (i.e. connectivity and accessibility).

Accessibility as a concept of retail activities on city spatial layout refers to the proximity, relative ease of movement and the distance between retail consumers and retailers (retail stores) (Baradaran and Ramjerdi, 2001; Jimenez and Perdiguero, 2011; Swoboda et al., 2013). Although the metric distance between retailers and consumers is an important factor in estimating the accessibility of retail locations, metric distance does not always denote proximity and ease of movement between locations (Swoboda et al., 2013). Yet, the ease of movement across a city spatial layout determines the concentration of retail consumers (and retail activities), with locations having high deterrence elements (to slow consumer movement), besides a high concentration of retail functions and vice versa (Baradaran and Ramjerdi, 2001; Swoboda et al., 2013). Thus, certain level of deterrence must exist to hinder (and slow) consumer movement within city spatial layouts for retail activities to exist within city space

(Jimenez and Perdiguero, 2011; Swoboda et al., 2013). In essence, the accessibility computation of cities for retail market analysis requires an approach that combines the principles of spatial and functional accessibility.

One such approach capable of computing spatial accessibility and simultaneously showing deterrence elements for controlling consumer movement in city spatial layouts is *space syntax*. This is because space syntax theoretical tools can compute spatial accessibility while indicating the deterrence factors of movement on spatial layout by means of spatial configuration at controlled (local) and uncontrolled (global) radii (Hillier and Hanson, 1984; Hillier et al., 1993; Hillier, 1996; Peponis et al., 2008). This research investigates consumer movement on a city layout via spatial configuration of accessibility index. The research focuses on investigating consumer movement patterns through the spatial accessibility computation of city layouts on a global (uncontrolled) scale in order to achieve the research objectives. Details on the methods adopted in configuring retail consumer movements within city spatial layouts are presented in Chapter 5 of this thesis. Meanwhile, the following section presents the theoretical contexts of spatial configuration techniques and space syntax theory.

4.3 Space Syntax theory: the spatial configuration of consumer movements on the spatial layout of a city

The space syntax philosophy is based on the premise that all cities are made up of similar components (links and nodes) and therefore exhibit generic spatial behaviour on a global scale (Hillier and Hanson, 1984; Hillier et al., 1993; Hillier, 1996; Hillier and Tzortzi, 2006). Put simply, the principle of space syntax in configuring movement on city layouts adopts the same technique for all cities irrespective of size (and other characteristics) differences.

Space syntax is the theory of space and a set of analytical, quantitative and descriptive tools for analysing the layout of space, including buildings and cities (Hillier and Hanson, 1984; Hillier, 1996). Space syntax theory was initially developed as an architectural tool for understanding how layouts of cities (and buildings) influence the movement (and visibility) of people within the designed space (Hillier and Tzortzi, 2006; Carol et al., 2018). Space syntax ideology is established on the premise that human movement through connecting city spaces follow a set of procedural rules (Hillier and Hanson, 1984; Hillier et al., 1993; Hillier, 1996). That is, for every human movement decision within a city space, there are certain unified causes based on the connectivity pattern of that space to every other space within the spatial network (Hiller and Hanson, 1984). Nowadays, the theory's applicability has extended beyond architectural (building) investigations to more city space analyses, including areas of city planning (Jiang et al., 2000; Hillier and Lida, 2005; Karimi, 2012; Stonor, 2013; Lerman et al., 2014), land value assessment (Chiaradia et al., 2009; Law et al., 2013, Muldoon-Smith et al., 2015, Giannopoulou et al., 2016), urban land use studies (Peponis et al., 2008; Lerman et al., 2014), city crime detection analysis (Jones and Fanek, 1997; Hillier, 2004; Wu et al., 2015) and many others. One of the factors responsible for the extensive applicability of space syntax is the development of space syntax ideologies in computer algorithms that has allowed street segment analysis to be conducted through the spatial configuration technique using road centre lines (otherwise known as street map data) (Penn et al., 1998; Figuerdio, 2015).

Spatial configuration is a common technique in space syntax that is applicable in computing the movement (and visibility) index of spatial layouts including cities and buildings) by analysing the complex relationship between streets (or locations) while considering all other locations within the layouts. A prominent tool utilised for spatial configuration analysis is Depthmap. Depthmap explicitly analyses movement on passage, such as street network in cities or corridors/rooms in buildings) to establish the potential of human movement while navigating the entire available space (Dalton, 2001; Peponis et al., 2007). The spatial configuration of street segments of a city layout is based on the underlying street network of that city, which is the input data analysed in Depthmap. Consequently, computation of retail consumer movement (through spatial configuration) on city layouts is based on the spatial properties, for instance connectivity, segment length, node counts etc.) of the input data (that is, street/road centre lines). Stated differently, the technique computes consumer's supposed movements based on street segment (spatial) properties without factoring in consumer behaviour and other socio-economic factors that can deter or support consumer movement at various locations within a given city (Hillier et al., 1993; Penn et al., 1998; Peponis et al., 2007). Nevertheless, researches (Chiaradia et al., 2009; Law et al., 2013, Giannopoulou et al., 2016), have shown that configured movement metrics measures (namely, integration and choice) correlate with observed human movement in city space.

Spatial configuration using Depthmap can compute supposed consumer movement by assigning syntactic values to individual street segments (within the analysed network) based on the connectivity (and other spatial) properties of that street segment in relation to all other street segments within a given network (Adebayo et al., 2019b). Consequently, all locations (street segments) are scored to reflect potential movement influx or otherwise the accessibility index of all locations within the configured network. In doing so, configured metrics (variables) of integration, choice, total depth, segment length, connectivity and others are computed for all the analysed street segments within the analysed city layout. Basically, an individual street segment is assigned the syntactic (ranked) values of configured metric variables and their corresponding location characteristics (that is, eastings and northing coordinates) in Depthmap. It is the easting and northing (X and Y) coordinates of the configured street segments that permit the locational (spatial and quantitative) analyses of consumer movement (accessibility) index and other socio-economic variables, such as retail rental values) (Adebayo et al., 2019a).

Over the years, the availability of big spatial data (especially road centre lines) has encouraged urban (space syntax) analysts to adopt segment map analysis over hand drawn axial maps while analysing space on a city scale (Penn and Turner, 2004; Kolovou et al., 2017). Segment map analysis allows users to analyse street networks at various controlled metric radii (i.e. local configuration analysis) in order to reflect various modes of human movement within a given city space (Jiang, 2008). Dalton & Dalton (2007), revealed that high metric radii represent rapid modes of transportation, e.g. vehicular movement, while some lower metric radii will indicate cycling or walking within the city street network. Peponis et al. (2008), also indicated that 400m and 800m metric radii represent 5 minutes and 10 minutes' walk respectively within a given city street network.

Of all the configured metric outputs in Depthmap, integrations and choice metrics are known as the movement metrics that reflect the spatial accessibility measures of city space (Hillier and Hanson, 1984; Chiaradia et al., 2009, Law et al., 2013; Adebayo et al., 2019a). This research focuses on exploring the configured metric measures of *integration* and *choice*, which are otherwise referred to as *to-movement* and *through-movement* metrics respectively (Hillier et al., 1989). These configured metrics are based on a set of scientific definitions (rules). The next subsection discusses the rules guiding the assigned syntactic values of integration and choice metrics.

4.3.1 Rules, roots and contexts of Integration and Choice (movement) metrics measures

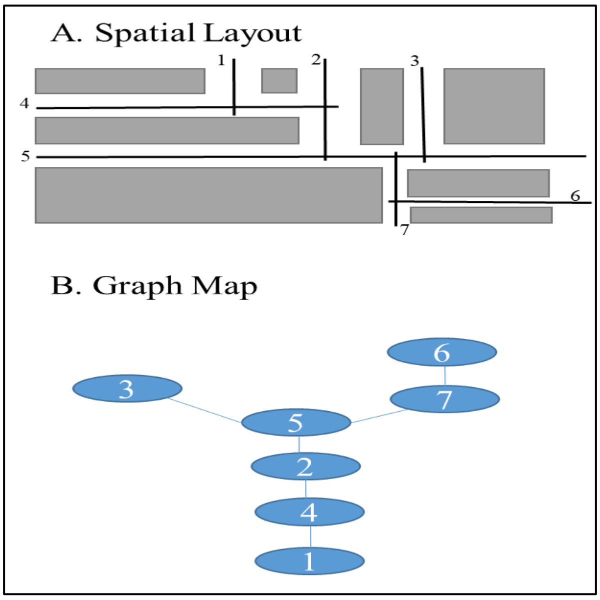
Space syntax is a multifaceted theory that combines knowledge of architecture, sociology, urban morphology, mathematics, geometries, statistics, cognitive science, computer science, geography and many other fields of study into one. Peponis et al. (1997), stated that:

'One of its (space syntax) weaknesses could be the fact that it is based on a wide theoretical rules which makes it difficult for someone, in either the scientific or the practical field, to instantly understand and accept….'

Thereby, Peponis et al. (1997), agreed that the concepts of space syntax theory and its configured metrics components are complex. This is because of the dissimilar assumptions and rules guiding the configured movement metrics and the traditional street network (computation) principle. This section expounds on this in a simple way by relating configured movement metrics with existing known street network theory for a practical understanding.

Space syntax theory was built on traditional graph theory and network analysis that computes centrality indices by way of analysing streets and junctions as links and nodes respectively (Hillier, 1999; Jiang et al., 2000; Penn and Turner, 2004; Kooshari et al., 2016). However, the space syntax principle contradicts traditional network analysis assumptions in that space syntax theory treats street nodes and junctions as links during spatial configuration analysis as illustrated in Figure 4.3.1 below (Kooshari et al., 2016).

Figure 4.3.1: Interpreting spatial layouts (links and nodes) on graph analysis



Source: Adapted from Kooshari et al. (2016)

Figure 4.3.1 illustrates a simple movement computation process based on spatial configuration analysis of space syntax theory. The figure shows an example of a spatial layout having connecting street segments (links) and corresponding junctions (point nodes where two or more street segments meet). The street segments with links 1 to 7 are represented by nodes 1 to 7 in the corresponding graph map shown in Figure 4.3.1. However, in a typical street network, the reverse is the case on a graph map (Alexandra, 1974; Sadalla and Magel, 1980).

Nonetheless, there are similarities in the applications and interpretations of centrality indices (namely, *closeness centrality* and *between centrality*) of traditional street network analysis and spatial configured metric outputs (namely, *integration* and *choice* metrics) of space syntax (Hillier et al., 1987; Kim and Sohn, 2002; Hillier and Lida, 2005). In traditional network analysis, centrality of closeness is a measure of the shortest number of links required to reach all the other links in a network (Porta et al., 2005). Therefore, it refers to being central as minimising the distance to all other locations within a given spatial layout. The example in

Figure 4.3.1 shows that link 5 will have the highest closeness centrality score because it is the location that is closest to all other locations, if one is to navigate the entire spatial layout. The measure of closeness centrality (in traditional network analysis) is synonymous with the integration metric measure of space syntax.

Integration metrics, also known as to-movement metrics, is the measure of distance from any location on a spatial layout to all other locations within the spatial layout (Hillier and Hanson, 1984). It describes how easy it is to get to one location from all other locations (Hillier et al., 1987; Hillier et al., 1993). Basically, integration metrics computes how close a location is to all other locations within a given configured spatial layout. In practical retail terms, integration outputs would compute how consumers' movements would be distributed across a given configured spatial layout while depicting the relative ease of a consumer to assess various locations. The output of integration (and other configured metrics) maps are typically coloured in a scale from red to blue (or black to white in a grayscale map) to indicate the high-to-low range of integration metric values (Hillier, 1996).

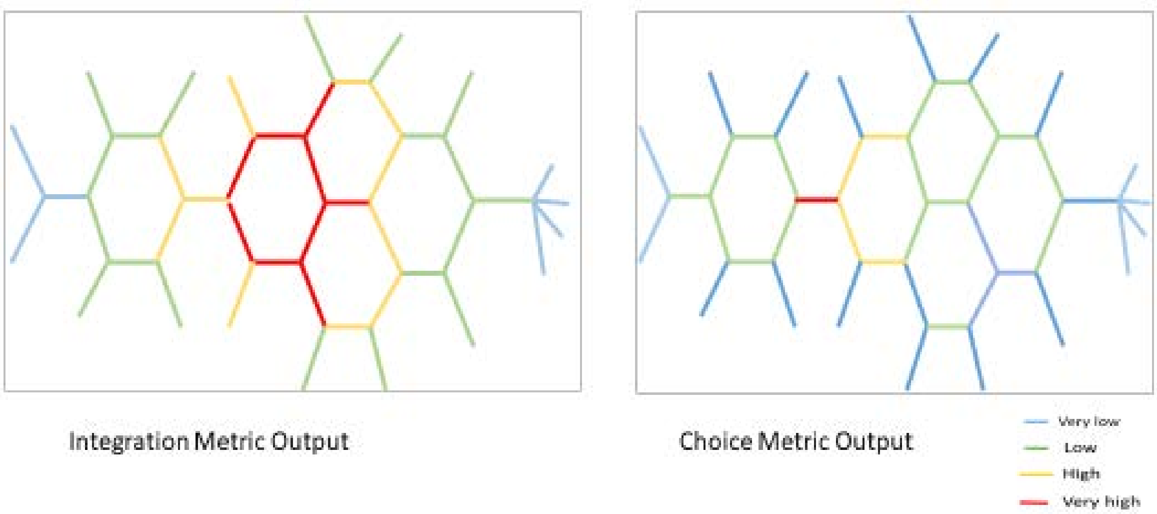
Using the above illustration from Figure 4.3.1, location 5 (specifically, link 5), will show the highest integration metric value. This is because the location (street/link) '5' is the closest to all other locations within the spatial layouts. Essentially, it will take fewer steps to reach Location 5 (than other locations) when movement is initiated on all the 7 locations (links). Whereas, it will take more steps (distances) to reach Locations '6' and '1' when movement is initiated across the entire spatial layout. Consequently, Locations '6' and '1' will be ranked as the most segregated locations having the least integration metric value. It is this simple ideology that has been developed into computer algorithms to score locations across cities - having a colossal number of street segments with complex spatial relationships.

Furthermore, it is important to understand that the space syntax notion of distance on space is purely topological distance and not metric distance (Hillier, 1996). This signifies that distances are computed based on the number of turns (steps) taken rather than metric distance measurements of locations on spatial layouts. Locations consisting of the least turns are perceived to be closer than locations having more turns, in the space syntax context (Hillier and Lida, 1995). That is, the lesser the number of turns taken to reach a destination, the closer that location is, even though, the metric distance measurement says otherwise. Hillier and Hanson (1984), argued emphatically that metric distance does not equate to closeness. Consequently, movement configuration in the space syntax context is established upon the premise that humans make the least turns while navigating spatial layouts (Peponis et al., 2008). This assertion has been corroborated by cognitive scientists (Badler, 1999; Borgatti, 2005; Rektor et al., 2005) that have observed human movement within city spatial layouts.

Similarly, the betweenness centrality of network analysis is synonymous to choice metric of space syntax theory (Hillier et al., 1993; Hillier, 1996). Simply put, betweenness centrality is a measure of the number of times a street (or location) acts as a bridge along the shortest path between two other streets (Bevalas, 1948; Freeman et al., 1991; Borgatti, 2005). In essence, it measures the intermediary capacity of a street segment to all other street segments within analysed spatial layout (Freeman et al., 1991). In the context of space syntax, choice measures how likely a street segment (location) is to be passed through on all shortest routes from all locations to all other locations in the spatial layout (Hillier et al., 1987). As such, it is often referred to as the through-movement metric (Hillier et al., 1987). In useful retail terms, choice or betweenness centrality describes how likely consumers are to pass through a location while taking the shortest route to every other location available within a spatial layout (Adebayo et al., 2019b). Consequently, all locations are scored based on their ability to serve as an intermediary for movement into all other locations of the analysed spatial layouts. By applying this definition of configuring choice metrics in Figure 4.3.1, it appears obvious that Location 5 (again) will have the highest choice index, while Locations ‘6’, ‘1’ and ‘4’ will have the least choice values. This is because Location 5 will act more as bridge along the shortest path than all other locations. Meanwhile, Locations ‘6’, ‘1’ and ‘4’ are less likely to act as a bridge while navigating the entire spatial layout and as such, have the least choice value.

However, even though the configured metrics of integration and choice have shown Location 5 as having the highest to-movement and through-movement index, it is important to understand that this may not always be the case. For example, given a broader imaginary spatial layout with more street segments and applying the definitions of integration and choice metrics to it, the configured map outputs will be equivalent to Figures 4.3.2 below.

Figure 4.3.2: Configured integration and choice metric outputs on an imaginary spatial layout



Source: Adapted from Hillier (1996)

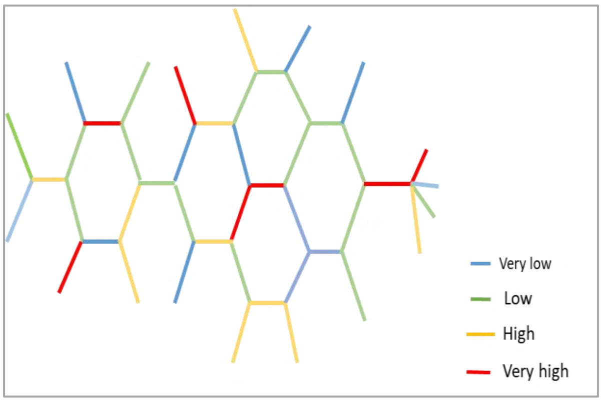
From the above illustration in Figure 4.3.2, the outputs of integration and choice metrics are not the same based on the definitions of the two configured metrics. The figure indicates that many of the street segments will be ranked as a very low (blue) value in choice metric configuration. It implies that the blue marked streets are extremely unlikely to serve as bridges to link other streets. Meanwhile, few of the locations (street segments) will be ranked as very low value as regards the integration index. Namely, changes in network size makes the differences between both movement metrics more apparent.

Ratti (2004), criticised the relevance of choice (and integration) metrics in explaining the accessibility and human movement potential on spatial layout based on its inconsistencies in values with slight changes in input data (road centre line). On a similar note, Batty (2008), criticised irregularity in the configuration metrics as influenced by changes in network sizes and spatial boundaries. Batty (2008), explained that the assigned syntactic values of street segments changes as the spatial boundary of a city spatial layout changes, even though the analysed layouts are of the same city. The influence of changes in network sizes on outputs of movement metrics (especially, choice) was also acknowledged in Hillier & Lida (2005) and Jiang (2009). Consequently, Hillier et al. (2012), developed a normalised choice (NACH) metric to normalise some of the inconsistencies associated with choice metrics. The developed NACH metric was introduced to normalise the effect of changes in network sizes on the output of choice metrics, while enhancing choice metrics applicability in computing (explaining) movement within city spatial layouts (Hillier et al., 2012). Hillier et al. (2012), further explained that normalising choice metrics can be achieved by dividing configured choice metric values with corresponding total-depth metric values. The developed mathematical formula for NACH is thus:

'Log value (Choice) + 1/ Log value (Total depth) + 3' … (Hillier et al., 2012).

The above equation implies that analysis of the NACH metric requires similar amounts of choice and total depth to be computed during spatial configuration in Depthmap (Hillier et al., 2012). That is, if a controlled choice metric, say, at 800m is inputted for normalisation, then, the corresponding total depth metric must be 800m. In doing so, Depthmap separates the configured spatial layouts into chunks and redistributes syntactic values across the street segments for every 800m metric. Consequently, many locations are reassigned various ranks of high to low syntactic values to reflect a new set of through-movement configurations as illustrated in Figure 4.3.3.

Figure 4.3.3: Configured NACH metric outputs on imaginary spatial layout



Source: Adapted from Hillier (1996)

The recent introduction of the NACH metric has not abolished the relevance and rules of choice metrics as a through-movement metric (Hillier et al., 2012). Rather NACH metrics has offered more scientific definitions of through-movement metrics. Hillier et al. (2012), clarified that NACH output has enhanced the visual outputs of through-movement, especially on large street segment networks, compared with the choice metrics.

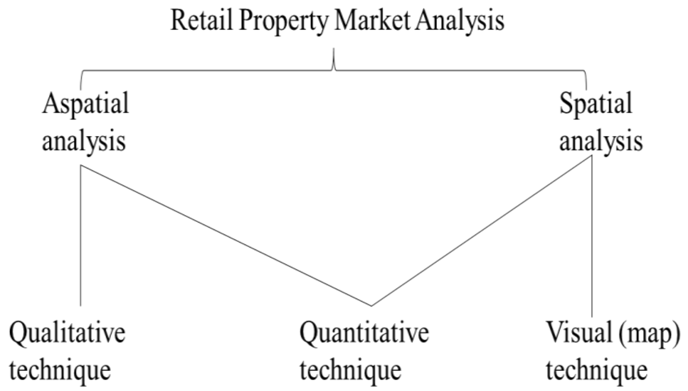
This research adopts the fundamentals integration, choice and NACH in representing consumer movement patterns on spatial layouts. This is necessary to further investigate the relationship between configured consumer movements and changes in retail market variables. Thereby, the three sampled cities (previously explained in Chapter 3 and further explained in Chapter 5) have been investigated at city and city centre scales for macroscale and mesoscale analyses respectively to further explore the effects of network sizes on the relationship between the investigated variables. Specifically, the implication of changes in spatial layout sizes on the influence of the relationship between consumer movement and changes in retail market variables have been completed. This triangulating approach (consumer movement, retail market and sampled cities), is expected to provide reliable results on the influence of configured consumer movement regarding retail market performance, in order to estimate the future of retail market variables across different locations and cities.

However, relationship analysis of configured movement metrics and retail market variables cannot be executed in space syntax (Depthmap) interface. Consequently, a geographic information system (GIS) interface is required for this spatial investigation to be achieved. The subsequent section discusses the roles of GIS in analysing the variables of retail market performance.

4.4 Analysing variables: Application of GIS in analysing retail market variables

There are several reasons for analysing real estate (specifically, retail property) market variables. A common cause is to make market decisions on management and the use of retail property including the development, investment and occupation of retail space (Anselin, 1998; Adebayo et al., 2019a). By this, adequate analysis of the retail property location is crucial among other factors. Analysis of retail property markets can be achieved via broad categorisations of aspatial and spatial analyses as illustrated in Figure 4.4.1 below.

Figure 4.4.1: Taxonomy of retail property market analysis



Source: Researcher's own (2019)

The aspatial analysis of property (retail) market variables do not consider the location references of variables. As such, the presentation of analyses and results (visual) are limited to numeric, charts, tables and other representations (but not maps) in the quantitative and qualitative based investigation of market variables as regards market decision-making (Openshaw, 1997; Pavlvoskaya, 2002). Meanwhile, the spatial analysis of market data are quantitative and map based analyses that quantify and represent variables for market-decision making while investigating the locational relationship between analysed property variables. Basically, the qualitative analysis of retail market variables are generally not considered in spatial based analysis techniques of the property market (Openshaw, 1997; Goodchild and Longley, 1999).

Each of these broad techniques (for example, spatial and aspatial analyses) have their pros and cons when adopted in analysing market variables. Table 4.4.1 (below) summarises the pros and cons of aspatial and spatial analysis.

Table 4.4.1: Pros and cons of aspatial and spatial analysis of retail property market variables

Analysis	**Pros**	**Cons**
Aspatial	i) Some detailed outcomes can be achieved via the qualitative technique of aspatial analysis. ii) Large market data can be analysed through quantitative techniques. iii) Results are presentable in tables and figures (charts) for quick decision-making.	i) Locational relationship of market variables cannot be visualised through both quantitative and qualitative techniques. This can hinder decisive market decision-making. ii) Outputs through this means are rigid, as querying of data input are impossible.
Spatial	i) Visualisation of market variables performance in relation with one another can be done through the spatial analysis technique. ii) Robustness and flexibility in analysing market variables via the query tools.	i) Depending on the level of analysis, market output details can be small. ii) Spatial analysis requires extra technical knowledge to operate tools for decision-making.

Source: Researcher's own (2019)

The above table (Table 4.4.1) suggests that both the aspatial and spatial analyses of the retail property market can be adopted for property market decision-making. Consequently, there has been increasing synergy in analysing property (retail) market variables by aspatial and spatial techniques to benefit from the strengths of both (Wyatt, 1999; Pavlvoskaya, 2002; Parker and Pascual, 2002; Adebayo, 2014).

However, this research has focused on analysing the retail property market using spatial analysis. This is primarily because this (spatial analysis) is sufficient for investigating the intended goals of the research. Concomitantly, Geographic Information Science (GIS) tools have been adopted in order to investigate the research objectives, as Depthmap (and other space syntax tools) for street segment analysis, lacks the capability to analyse other data variables, for instance retail market data (Adebayo et al., 2019a). Put differently, no meaningful spatial analysis and investigation of other datasets, such as property value and stock can be conducted using space syntax tools without GIS (tools).

In this context, GIS can be recognised as a technique for analysing and visualising spatial relationships between aspatial and spatial variables containing locational references which produces maps (and other means of data outputs) to guide stakeholders' decision-making on their interests in retail property. Furthermore, GIS can synergise aspatial and spatial data analyses for more reliable decisions on the locations of retail spaces. An additional justification for adopting GIS as a valuable tool for real estate market analysis has been linked to the fact that real property markets are based on locations, which are unique and immovable (Wyatt, 1999; Nakaya et al., 2007; Greenhalgh, 2008; Adebayo, 2018). Consequently, market analysts is able to factor in the locational attributes of property (with other variables) through the help of GIS tools, such as ArcGIS, QGIS, STATA and so on). It should be mentioned that GIS combines spatial and aspatial techniques in analysing the locations of retail property market variables, for instance retail rental value, retail stock, changes in rental value, changes in stock) and other related data, such as consumer movement data). GIS outputs are principally *visuals* and *numeric* (quantitative) information that are presentable in the form of maps, videos, charts, figures and tables (Okabe et al., 1985; Goodchild and Longley, 1999). The appropriate means of displaying market outputs analysed through GIS depends on many factors that are mostly connected to the final users and reason for the analysis (Goodchild, 1991; Vitali and Lena, 2016). However, maps are often the most common visual outputs from GIS analysis (Goodchild, 1991; 1992; Church, 2002). This is because maps enable visualisation of the locational performance of market variables (and configured consumer movement metrics) to be possible.

Maps are spatial outputs of analysed input data utilised in conducting spatial (market) analysis (Onsurd, 1995; Chrisman, 2002; Goodchild and Longley, 1999; Adebayo, 2012). Similarly, maps can be spatial data inputs that needs to be analysed to produce other data outputs of maps and other visual representation (Onsrud, 1995; Church 2002). The mapping of market variables is the process of conducting spatial analysis on input market data to reveal the locations of those variables in relation to one another (Chrisman, 2002; Church, 2002). Although, analysed outputs of retail property variables can be presented in various forms including charts, maps, tables, pictorial representations etc., real estate decisions being centred on the location performance of data variables regularly require visual representation in maps to guide making reliable market decisions. Map visual representation in GIS can be categorised as:

i. Vector maps
ii. Raster maps

Depending on the market analysis, both (maps) classifications can be adopted as input and output data in GIS (Onsrud, 1995; Church, 2002; Chrisman, 2002). A vector map consists of points, linear and polygonal (area) features that represent the locations of retail property markets (or other types of geographic) data/variables (Goodchild and Longley, 1999; Adebayo, 2012; 2018). The types of feature representation is dependent on what is being represented; level (and detail) of analysis among other factors (Openshaw, 1992; Onsrud, 1995; 2003). For example, a retail property (store) can be represented as a polygon or point feature depending on the level of analysis. When analysing data at a very detailed (microscale) level (say, buildings in a street level analysis), the retail store can be represented as a polygonal feature.

However, analysis on a larger scale (say, city level analysis) will represent the same retail store as point features because of changes in the level of analysis (Onsrud, 1995; 2003).

In vector mapping, layers and features of vector maps can be added, removed and converted during data analysis. Further studies of the application of GIS in retail property market analysis have shown that vector mapping can further be developed into 2.5 or 3 dimensional column maps to indicate amounts (or quantify) of market variables at different locations to enhance visualisation and GIS application in the real estate market (Church, 2002; Greenhalgh and King, 2013; Adebayo et al., 2017; 2019b). In so doing, a grid system platform is typically created to serve as a background vector layer that all points and polygonal features, such as retail properties can be analysed and visualised in 3D (see Chapter 5 of this thesis for details about grid systems).

However, a raster map is an image data output (or input) made up of a set of pixels (Openshaw, 1992). It should be noted that a vector map can be converted into a raster map in a process known as 'rasterization' and inversely in a process termed 'vectorisation'. The adoption of vector or raster mapping representation of any spatial analysis depends on the nature and purpose of analysis, including the available data inputs (Goodchild, 1991; 1992). The smallest unit of a raster map is a pixel which is normally measured in high or low resolutions (Goodchild, 1991; Openshaw, 1992). Some of the common formats regarding the data inputs of a raster map include TIFF, JPEG, BITMAP and so on. Examples of spatial analyses that can be conducted through raster mapping include land use change detection analysis, flood risk analysis, forestry and ecology studies, so on and so forth (Adebayo, 2012). The key differences between vector and raster mapping are summarised in Table 4.4.2 below.

Table 4.4.2: Characteristic differences in vector and raster mapping

S/No	Characteristics	Raster mapping	Vector mapping
1	Map features	Images in pixels	Points, linear and polygons
2	Map formats	TIFF, JPRG, Bitmaps	Shapefile, DBF, text, tab etc.
3	Suitable applications (uses)	Urban land use changing detection analysis, flood risk assessment, aerial mapping, hydrological studies, forestry analysis, site suitability analysis, etc.	Real estate markets analysis, site suitability analysis, property location assessment, spatial investment appraisals, spatial development appraisals and analysis, etc.
4	Analyses coverage and scales	Large scale analyses including regional, national, continental or global analyses	Multifaceted scales, such as street level, city centre level, city, regional and national levels.

Source: Researcher's own (2019)

It can be argued that vector mapping is more applicable to this research (retail property markets analysis) than raster mapping. This is because the variables (configured consumer movement and retail market variables) under investigation can be better understood as points, linear and polygonal features, than as ordinary pixels. Consequently, vector mapping of GIS allows the integration of these distinct datasets to be conducted. Consequently, data features of configured movement metrics can be merged with that of retail property market variables for comprehensive analysis that is capable of facilitating decision-making. Similarly, the level of market analysis is conducted at city and city centre scale levels. Hence, this research has adopted vector mapping GIS in analysing and visualising the retail property market and consumer movement patterns (computed via space syntax ideology of spatial configuration) at city and city centre scales.

However, GIS (vector mapping) also exhibits certain limitations in analysing property markets. Some of these limitations include:

i. GIS tools rely heavily on input data. Thereby, any mistakes embedded in the input data will not be corrected in the output market information.

ii. Although GIS has the ability to integrate varieties of datasets, datasets that are not in suitable formats cannot be integrated except datasets that are converted into suitable formats. This may be difficult to achieve or occasionally impossible.

iii. Markets analyses through GIS can lack market details, such as explaining the causes of the failure (or successes) of real property locations. It does not recognise other possible elements apart from the input data variables.

iv. As useful as GIS tools are, they often require technical expertise before they can be utilised effectively (Goodchild and Longley, 1999).

v. Limited statistical and quantitative analysis can be achieved within the GIS environment. Meaning further statistical tools might be required in quantifying the extent of the relationship between investigated variables when using GIS.

These shortcomings have been considered when analysing variables using the GIS tool (see further details on this in the research method chapter (Chapter 5) of this thesis). Additionally, GIS tools remain valuable in achieving the research aim and objectives despite the fact that the spatial techniques of consumer movement patterns will be configured through space syntax tools and theory. The GIS (precisely, vector GIS) will enhance retail property market decision-making and therefore enhances the applicability of this research. However, the GIS lacks the capability to quantify the extent of a relationship so as to explicitly understand the relationship across variables. As such, there is a need for statistical (inferential) analysis on retail market variables and consumer movement data to achieve the research objectives. The following subsection discusses the application of statistical tools (principally, correlation and regression) in analysing retail market (and configured consumer movement) variables.

4.5 Application of inferential statistics in analysing and estimating variables

Quantitative analysis is central to real estate market analysis. This is because both aspatial and spatial analyses of real estate market variables are subjected to quantitative techniques for various reasons. The reasons for adopting the quantitative technique is not limited to quantification of real estate variables but also includes establishing relationships between market (and other) variables with the possibility of estimating dependent (market) variables on developed statistical models (Brooks and Tsolacos, 2001; Du and Mulley; 2006; Faul et al., 2009). Common statistical models adopted in the analysis of real estate variables include the hedonic price model (HPM), geographic weighted regression (GWR), spatial autocorrelation, vector auto regression (VAR) and a host of others (Mok et al., 1995; Chau and Chin, 2003; Du and Mulley; 2006). Statistical models can be developed for interrelated variables in order to estimate the future trends of the dependent variables based on the related independent variable(s). In essence, a relationship must exist between the dependent and independent variables before estimation of dependent variables can be established. This research contends that if a relationship exists between configured movement metrics and changes in retail market variables, then changes in retail market variables can be estimated based on the developed statistical model using the configured metrics as independent variables.

Many of the models including HPM, GWR and VAR adopted estimating and establishing a relationship between real property market variables (and other related variables, for instance accessibility, are based on traditional correlation and regression statistics (Ezekiel and Fox 1959; Brunsdon and Fotheringham, 1996; Du and Mulley, 2006). Correlation measures the extent of the relationship between two or more variables by revealing coefficients of the variables in relation to one another. Correlation coefficients always range from -1 to +1 values.

Meaning a correlation coefficient of -1 and +1 indicate a perfect negative and perfect positive correlation, respectively. There are different types of correlation coefficients, including *Pearson Coefficients*, *Spearman's rho Coefficients* and *Kendall's tau coefficient* (Rodgers and Nicewander; 1988; Mok et al., 1995).

The Pearson correlation coefficient measures the straight line relationship between variables. Spearman's rho correlation measures monotonic relationship between variables, one of which must be ranked, while Kendall's correlation measures similarities in the ordering of data when it is ranked by quantities. Hence, applications of the correlation may be different based on the reason for analysis and distributions of the data variables (Rodgers and Nicewander; 1988; Faul et al., 2009). For example, the relationship between variables that have been ranked are better investigated using Spearman or Kendall coefficients in contrast to Pearson coefficients (Ezekiel and Fox; 1959; Rodgers and Nicewander, 1988). This is because a straight linear relationship should be expected as regards such ranked data variables (Ezekiel and Fox, 1959). With the approach adopted in this research in analysing the relationship between variables, Spearman's rho coefficient has been adopted to analyse all variables, given that the configured movement metrics are ranked variables (see Chapter 5 for further details).

Meanwhile regression analysis is typically conducted to estimate one variable on the basis of the other. In doing so, regression models are normally developed to estimate dependent variables based on the modelled relationship with the independent variables (Rodgers and Nicewander, 1988). The results are usually coefficients of constant values and independent variables that can be adopted to estimate the future value of the dependent variables. This method has been used in many econometric models that explain and predict property prices (Brooks and Tsolacos, 2000; Nanthakumara et al., 2000; Hendershott et al., 2002), government taxes (Hendershott et al., 2002), investor's returns (Dunse et al., 2010; Nsibande and Boshoff, 2017) and many others.

This research appreciates the applicability of correlation and regression tools in computing the extent of the relationship between retail market variables and configured retail consumer movement metrics. The research contends that the coefficient significance level can signal which of the configured movement metrics variables are relevant to all the changes in retail market variables across different spatial layouts. A significant relationship between variables across these spatial layouts can signal future trends in retail market (dependent) variables while simply developing a regression statistical model. It is important to understand that this research is not econometric based. As such, variables computed using regression models are based strictly on configured metric outputs of street networks and collated changes in retail market variables. Therefore, the research does not focus on improving the fitness of the developed regression models (presented in Chapter 5). Simply put, the computed changes in retail market variables, namely, changes in retail rental value, floor space and retail clusters represent the dependent variables. While configured consumer movement variables, specifically, integration, choice and NACH have been modelled as explanatory (independent) variables (see details in Chapter 5 of this thesis).

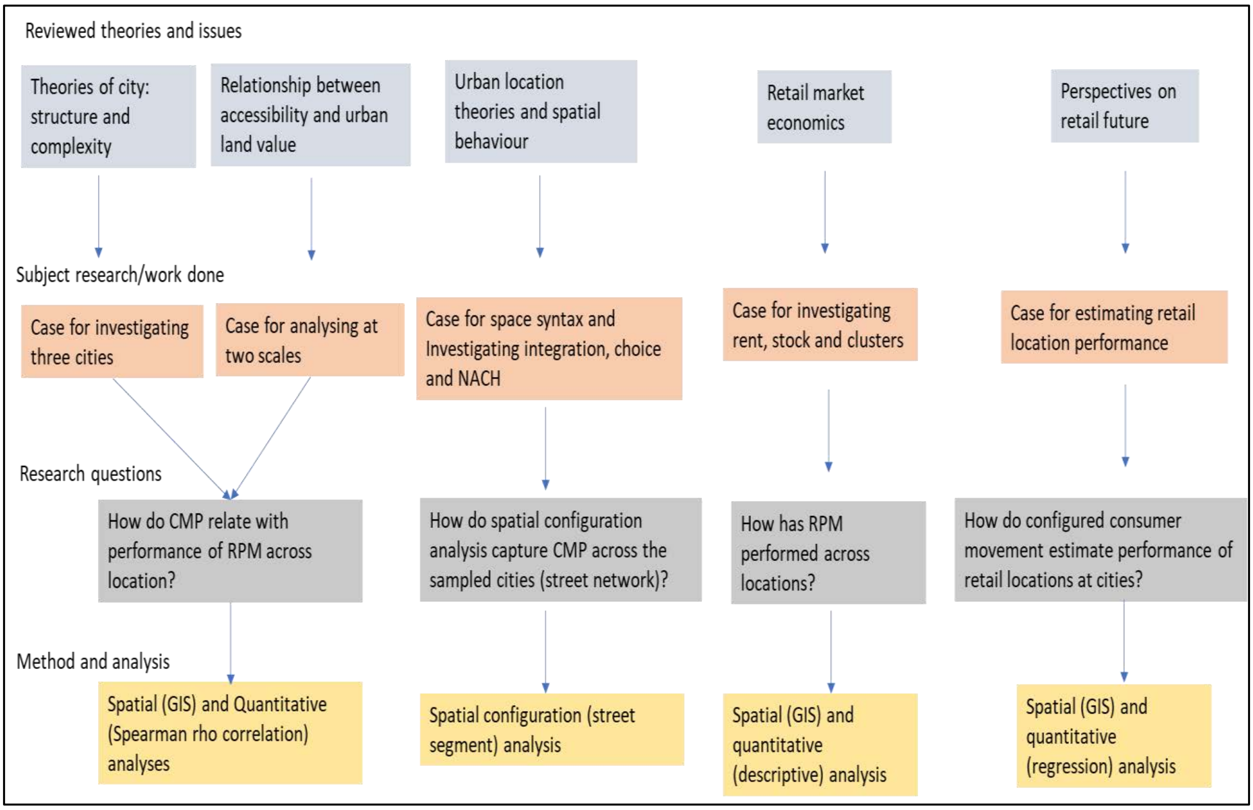
4.6 Chapter summary

This chapter has deliberated the nature of city layouts and how space syntax theory computes spatial accessibility for retail consumer movement patterns on city layouts. The chapter explored the key assumptions and rules guiding the principles of computing human (retail consumer) movement on spatial layouts. The chapter argues that spatial configuration outputs of integration, choice and NACH metrics can be investigated further at city and city centre layouts to investigate the effects of spatial layout sizes on the relationship outputs of consumer movement and retail market variables. The chapter discusses the applications of GIS and statistical tools in analysing retail property market performance through configured consumer movement and changes in retail property market variables.

4.7 Research framework underpinning the research method

Chapters 2, 3 and 4 of this thesis have presented arguments in relation to the perspectives on the future of retail, urban retail location theories, complexity in city structure, variations in relationship outputs, besides retail market economics among other important issues. The argued issues form the foundation for the methods and analyses adopted in this subject research as shown in Figure 4.7.1 below. The review on the future of retail (see Chapter 2) supports analysing the location performance of retail space. Similarly, the theory of city structures (Chapter 3) reviewed support investigating cities at different scales. Chapter 4 presents analysis of consumer movement by way of space syntax theory. *The subject research estimates the location performance of retail space within cities using spatial configuration parameters*. The consideration given to estimating retail property market performance was that there must be a statistical relationship between spatial configuration (consumer movement) parameters and changes in retail market variables.

Figure 4.7.1: Research framework underpinning the research questions and methods



Source: Researcher's own (2020)

Results from previous studies reveal that there are variations in the relationships between variables (Table 2.1.1 Chapter 2). This research queries whether the variation is due to differences in cities and the scale of analysis. The logic behind analysing cities and scale have been explained in Chapter 2. The research topic questions the lack of consideration of changes in scale when investigating relationships between variables. Moreover, the research contributes to our understanding of *cities*, *retail property markets, retail geography, spatial configuration, space syntax and spatial analysis (scaling).* Three cities, three retail market variables, three consumer movement parameters, in addition to two scales were all investigated in this thesis. Chapter 5 contains details of the approaches adopted in achieving the research goals.

Chapter Five

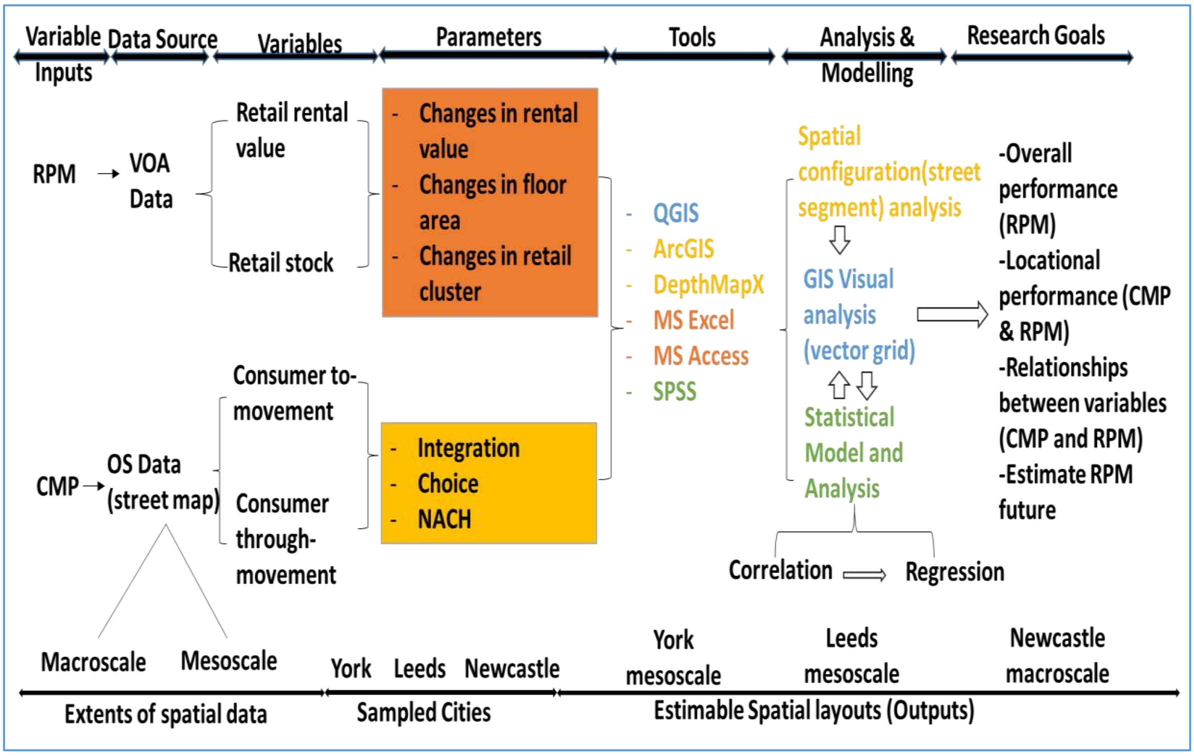
The Research Method

5.0 Introduction

This chapter presents the research methods. It presents the data, software tools and technical approaches adopted in executing all the research objectives. The chapter emphasises the rationale of the data, tools and techniques adopted in conducting the research. The chapter also presents crucial results from the pilot investigations that have shaped this research.

A framework summarising the research data inputs, data sources, parameters, software tools and analyses conducted are presented in the Figure 5.0.1 below.

Figure 5.0.1: Framework of research method



Source: Researcher's own (2019)

The above framework (Figure 5.0.1) attempts to summarise the key steps taken on data variables in achieving the research objectives. The figure indicates that the Valuation Office Agency (VOA) and Ordnance Survey (OS) data are the two data sources that form the basis of the analyses of the RPM and CMP variables, respectively. The derived research parameters from the RPM variable inputs are changes in retail rental value, retail floor space and retail cluster, which were obtained from analysing the VOA data using MS Access and MS Excel tools. Similarly, the figure shows that the spatial configuration outputs of integration, choice and NACH metrics (of sampled street networks) form the other research parameter adopted in investigating CMP, using DepthMapX and ArcGIS tools. The QGIS tool (GIS analysis) has played a central role in conducting locational analyses on the investigated variables (parameters) using vector grids, while the SPSS tool played another crucial role in conducting statistical analyses of correlation and regression on the analysed variables. Details of Figure 5.0.1 form the components of this chapter.

5.1 Elucidating RPM and CMP variables

Recollect that this research investigates the relationship between retail property market variables and consumer movement patterns to estimate the future location performance of the retail property market across sampled layouts. Hence, there are two broad variables investigated in this research, namely:

i. Retail property market (RPM) variables,

ii. Consumer movement pattern (CMP) variables

5.1.1 The RPM variables

There are many indicators that can be used as a benchmark to measure retail property market performance within a given city (or city centre). However, this research adopts changes in retail rental value and changes in retail stock to measure the location performance of retail spaces. The rationale behind the choice of retail rental value and retail stock is further explained herein.

Retail location performance can be measured through the following retail indicators:

i. Consumers footfall (Local Data Company LDC, 2017),
ii. Retailers Turnover (Sales/profits) (Hillier, 1985; Springboard, 2017),
iii. Retail outlets vacancy/occupancy data (Muldoon-Smith, 2016),
iv. Consumer expenditure (Christaller, 1933; Tsolacos, 1995; Brown, 1990; 1992; 2006),
v. Tenant mix/offer (Brown, 1992; Kirkup and Rafiq, 1994)
vi. Consumers dwelling time (Farag et al., 2007; Bohl, 2014; LDC, 2017)
vii. Rental value (D'Arcy et al., 1997; Colwell and Jackson, 2004; Greenhalgh, 2008; Adebayo et al., 2019a),
viii. Retail stock (Huff, 1964; Adebayo et al., 2019a) etc.

Changes in any of the above indicators for retail spaces across a wide area of a city or city centre will provide an indication of the RPM performance in relation to that space. However, the main challenge lies in the availability of these data to compute RPM performance within a city space. Basically, it can be challenging to access any of the above listed RPM indicators for two dates across a city (or cities). Preliminary investigations into this research explain that there are only two broad methods of obtaining any of the above indicators to establish RPM performance. These two methods have been presented in the next subsection.

5.1.1.1 Methods (options) of sourcing RPM indicators

The two broad methods of sourcing for RPM indicators are:

i. Method 1: Field data collection,

ii. Method 2: Utilising existing collated data.

i. *Field data collection*: The field herein refers to the physical retail sites, retail stores, highstreets and shopping centres where data on retail market indicators could be obtained. The field data collection methods involve obtaining data on the performance of indicators from the field, either from occupiers, retail property managers, property owners, consumers and other retail stakeholders depending on the indicators concerned. This approach increases the likelihood of collecting specific, required and more defined data necessary to establish retail property market performance. However, this method can be very time-consuming and almost impossible to achieve for a wide area, such as a city centre or city space) for many of the aforementioned indicators. This is because, for example, it might take an average of 3 years for rental value figures to change and certain other indicators, for instance stock and vacancy data might take a few more years for a reasonable change to occur (Barras, 1994; Muldoon-Smith, 2016). Consequently, this research contends that the sourcing of (any) RPM indicators (to compute changes) over time can be better achieved through utilising existing collated data (that is, method 2).

ii. *Utilising existing collated data*: This method involves sourcing for relevant data from organisations holding such data. There are organisations (both private and public) holding some of these RMP indicators across many cities and city centres in the UK. Preliminary investigations into this have shown there is no known single organisation (source) holding any of the aforementioned RPM indicators across all cities (including city centres) for two reasonable periods (where changes should have occurred) except for the *Valuation Office Agency*. The VOA holds records on rental value, floor space and the retail addresses of all retail properties (and other commercial properties) across England and Wales for 2010 and 2017, where reasonable changes in retail rent and stock should have occurred. (This is one of the reasons for adopting the VOA data for the computing of the RPM variables, despite its shortcomings). Hence, this research settles for *retail rental value* and *retail stock* as indicators of RPM performance on the selected sampled cities. This is because the VOA makes them available but more importantly, they are capable of reflecting the demand and supply of retail property markets at any given city. These RPM variables have proven to reflect market performance across cities (see Chapter 6 for details on obtained results). Further details on VOA data have been presented in the following subsection.

5.1.1.2 The VOA data: Advantages and Disadvantages

The VOA holds valuation summary lists (meaning, VOA data) for all rateable commercial including retail, offices and industrial properties across England and Wales for taxation purposes. The rational for utilising VOA data in this study (that is based on property market analysis), is not limited to the data availability, completeness, relevance and comprehensiveness (Greenhalgh and King, 2013; Astbury & Godwin**,** 2014; Muldoon-Smith, 2016). The recent public release of VOA (2010 and 2017) datasets provides the opportunity for understanding the actual changes that have occurred in commercial property market (variables). Table 5.1.1 summarises the key features of VOA data that make it relevant in computing spatial changes in the retail property market.

Table 5.1.1: VOA key components

S/No	Features	Use
1	Rateable Value (£)	Adopted as retail rental value since rateable value is based on market rent as at date of valuation
2	Floor area (sqm)	Measuring and computing retail stock
3	UARN*	Detecting and cleaning multiple records of hereditaments. Common key that links 2010 and 2017 data
4	Scat Codes	Define retail property (space)
5	Address (postcodes)	To generate Eastings and Northings coordinate values for geo-spatial analysis Computing retail cluster.

UARN* is Unique Address Reference Number. Source: Researcher's own (2020)

The VOA data contain commercial (retail) market indicators useful in estimating market performance on any given cities' locations within England and Wales. The VOA data holds 2010 and 2017 data sets containing rateable values (based on market rental values as at the date of valuation), floor spaces, UARN, occupiers, Scat codes, property uses, date of valuation and property addresses for all non-residential properties in England and Wales (VOA, 2017). These available variables in the VOA data allows this study to define retail spaces, generate spatial coordinates (for spatial analysis) and compute locational changes in retail rental value, retail floor space and then retail unit clusters with a high level of precision. Essentially, the VOA data are appropriate for the research investigation at hand if carefully managed.

Other advantages of the VOA data to this research are:

i. VOA data is an open data source, which is easily accessed.

ii. It contains important data variables that are relevant in analysing RPM performance. The data holds, rental value, floor space, the addresses of retailers and many others (as indicated in Table 5.1.1 above).

iii. The data also holds a common key to the two datasets that permit linking the same addresses. As such, changes in data variables can be calculated with a high level of precision.

iv. The data are based on market data as at the date of valuation. This implies that market analysis (and research) can be conducted using the data even though it is collated for taxation purpose. The valuation dates for 2010 and 2017 datasets is April 2008 and April 2015, respectively. Meaning analysis of the 2010 dataset is equal to market analysis of that property as at April 2008 and vice versa.

However, there are shortcomings that the VOA data exhibit when considering it for estimating retail property market performance across a given spatial layout. One such flaw is that there are limited property market variables that can be obtained from it. The only relevant variables that can be extracted from the VOA data are retail rental value and retail stock (floor space and retail cluster) variables. Other retail market indicators, such as consumer dwelling time, turnover, consumer expenditure and others are not obtainable from the VOA data. Similarly, VOA data itself is not a market based data, rather it is a tax-based record that is typically updated on a regular basis. This regular data updated by the VOA remain a serious challenge for a market analyst, notably when focusing on analysing locational changes in market variables, for example rent and stock. This is because the VOA keep all existing records in the valuation summary list, while updating the data, leading to multiple records for single property (hereditaments). Therefore, the VOA dataset require careful data cleansing to avoid multiple counting of data variables that can generate serious errors when computing changes for market variables. Likewise, there are difficulties in linking the VOA datasets with other government owned spatial data, making it impossible to directly analyse other variables with it. The VOA holds a common key (that is, UARN) that is unique to itself and cannot be linked with other government geographic datasets that have a Unique Address Reference Number (UARN). Finally, the datasets are substantial and require extra computing skills to carefully refine the data for it to be used for retail property market analysis. Consequently, obtaining the required RPM variables from the VOA datasets involves applying additional steps and techniques that are clarified in the following subsection.

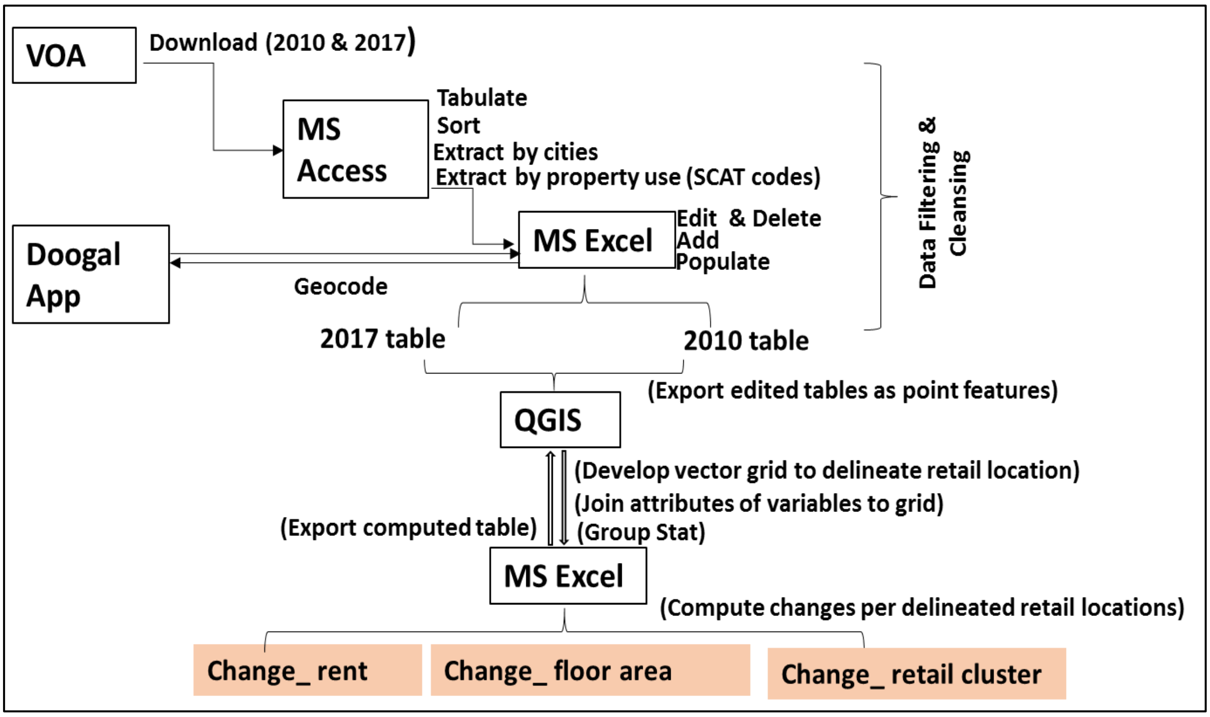
The next subsection presents the key procedural steps that were taken as regards the VOA data to obtain the required data variables (that is, changes in retail rental value, retail floor space and in retail cluster) to investigate RPM performance.

5.1.1.3 Procedures & tools applied to extract and compute RPM variables from the VOA data.

Having settled for the VOA data as the key source of RPM variables for this investigation, there are necessary procedures that must be taken in retrieving the required data variable from the VOA's raw data. This section discusses these basic steps and tools adopted in ensuring that the required RPM research parameters, namely, changes in retail rental value, floor space and retail cluster are obtained from the 2010 and 2017 VOA datasets.

Figure 5.1.1 presents the key tools and procedural steps taken to obtain the RPM variables for a sampled analysed spatial layout. The same procedures have been undertaken for the other spatial layouts.

Figure 5.1.1: Procedural steps and tools in computing RPM variables



Source: Researcher's own (2020)

Figure 5.1.1 shows how locational *changes in retail rental value*, *retail floor space* and *in retail cluster* are derived from the VOA data for a typical spatial layout.

The first step was to download and save the VOA data for 2010 and 2017. The downloaded data were voluminous and could be loaded entirely on to MS Excel. Thus, distinct tables (databases) were created using MS Access for 2010 and 2017 datasets. The tables were linked to their corresponding downloaded data. The linked databases were then sorted and filtered out by cities (using city names and postcodes), and most importantly by property use (using Scat codes). (It should be noted that it is extremely important to have a clear definition of the extent of retail property coverage for 2010 and 2017 datasets across all sampled cities to avoid errors when computing changes. Further details on this has been presented in the following subsection).

Having completed the first set of filtering in MS Access, thereby reducing the size of data, the data were arranged in two tables (one each for 2010 and 2017). This was performed such that each row contains the retail hereditaments and the columns contain the variables, such as UARN, rates billing authority, address and postcodes, city/town name, floor space, rentable (rental) value, date of valuation, date of latest updates and other administrative features used by the VOA in the administration of commercial property rates. The tables were then exported into MS Excel for further editing and filtering.

Within MS Excel, all the columns headings were renamed to have uniform headings for 2010 and 2017 table. A few of the columns, such as billing account number that are not essential for retail market analysis were deleted. The tables were arranged according to the UARN. This allows all the multiple records to be visibly arranged. Consequently, all multiple records in the tables were deleted. Equally, additional columns were created for geographic (eastings and northings) coordinates. To obtain the geographic coordinates, the postcodes of all hereditament were carefully geocoded using Doogal app (Doogal is problematic in geocoding hereditaments' addresses, hence, the reason for geocoding using postcodes). This research contends that geocoding retail locations using postcodes will be appropriate for understanding retail location performance within the city (macroscale) and city centre (mesoscale), which this research focuses on.

The obtained geographic coordinates from Doogal were then populated for all the retail properties accordingly. The outcome of this is that each retail hereditament has geographic coordinates that can be geolocated into GIS for spatial investigation. It is important to understand that the 2010 and 2017 tables can be linked and combined by employing the UARN to compute changes in retail market variables at this stage. However, preliminary investigations have debunked the crux of computing changes in the retail market at stage. This is because many of the retail properties that do not have records for the two dates will be computed as an error, denoting that existing and emerging changes in retail locations will not be visible during analysis. Most importantly, it will be impossible to compute changes in retail clusters if the two data are combined using the UARN at this stage).

Consequently, additional steps were taken in GIS to resolve this. The edited tables were exported into quantum GIS (QGIS) tool for further editing. At the QGIS, three crucial steps were carefully taken. The first step was to delineate sampled city layouts (hosting retail properties) into retail locations using vector grids. The primary aim of this was to create a uniform platform for locational analysis between the retail market variables and the configured consumer movement patterns (to be discussed in section 5.1.2). The second was to combine attributes in the tables (2010 and 2017) with the grid using common ID. The third was to calculate the sum of individual RPM variables (specifically, changes in retail rental value, retail floor space and in retail cluster) per grid (see also the advantages and shortcomings of adopting vector grid systems in section 5.2 of this chapter).

The summed RPM variables per grid for 2010 and 2017 were then exported into MS Excel again, where changes in retail market variables per delineated retail locations were computed using the following formulae:

Changes in retail rental value = ∑ 2017 retail rent per location - ∑2010 retail rent per location (1)

Changes in retail floor area = ∑ 2017 retail floor area location - ∑2010 retail floor area location (2)

Changes in retail cluster = ∑ 2017 retail unit counts per location - ∑2010 retail unit counts location (3)

Consequently, the above computed changes regarding retail market variables (in tables) were finally exported back to QGIS for *geo-spatial analysis* with the consumer movement pattern variables.

While filtering (sorting out) retail hereditaments from the bulk of the commercial hereditaments (property) in MS Access (as previously mentioned), it is important to emphasise the role of having a uniform definition of retail property space when using the above technique in computing locational changes in retail market variables. This is for the reason that any discrepancy in filtered and cleansed data from the VOA for 2010 and 2017 could produce erroneous computation and findings. Put differently, clear logic with regards to defining retail property space for 2010 and 2017 is essential for this study (to avoid biasness and poor judgement on the computation of changes using the equations 1 to 3). The following subsection highlights the components adopted in defining the retail spaces for 2010 and 2017 across the sampled cities.

5.1.1.4 Defining the components of retail spaces for RPM analysis

Retail spaces in this research has been defined based on Special Category (SCat) codes belonging to the VOA. The VOA uses Scat codes to group together properties of similar types. Hence, there are numerous SCat codes in the VOA dataset. In research that focuses on computing changes in retail property variables between two dates across different sampled cities, there is a need to have a uniform component of what defines retail premises. This will ensure that the same set of retail spaces have been analysed across the defined cities and dates. Table 5.1.2 summarises lists of all the scat codes adopted in defining retail spaces in this research.

Table 5.1.2: List of SCat codes defining retail spaces in the research

S/no	Scat Code	Scat Description	Author's Description
1	24	Betting Offices	leisure space
2	47	Caravan Parks (Leisure) (National Scheme)	leisure space
3	199	Night Clubs & Discotheques	leisure space
4	226	Public Houses/Pub Restaurants (National Scheme)	leisure space
5	234	Restaurants	leisure space
6	238	Roadside Restaurants (National Scheme)	leisure space
7	253	Snooker Halls/Clubs	leisure space
8	409	Cafes	leisure space
9	49	Casinos & Gambling Clubs	leisure space
10	56	Cinemas (National Scheme)	leisure space
11	60	Clubhouses	leisure space
12	44	Car Supermarkets	other space
13	147	Land Used For Car Boot Sales	other space
14	155	Large Shops (Over 1850m²)	real shop
15	235	Retail Warehouses & Food stores	other space
16	97	Factory Shops	real shop
17	98	Farm Shops	real shop
18	139	Hypermarkets/Superstores (over 2500m²)	real shop
19	152	Large Food Stores (750 - 2500m²)	real shop
20	154	Large Shops (750 - 1850m²)	real shop
21	165	Markets (Other Than Livestock)	real shop
22	210	Pharmacies	real shop
23	243	Sales Kiosks	real shop
24	249	Shops	real shop
25	268	Stores	real shop
26	442	Takeaway Food Outlet (Predominantly Off Premises)	real shop
27	504	Kiosks Within/Part of Specialist Property	real shop
28	510	Stores Within/Part of Specialist Property	real shop
29	209	Petrol Filling Stations (National Scheme)	service space
30	211	Photographic Booths	service space
31	417	Hairdressing/Beauty Salons	service space
32	429	Post Offices	service space

Source: Adapted from VOA (2017)

The listed 32 SCat codes form the overall definition of retail spaces across all the sampled cities for 2010 and 2017 datasets. These 32 SCat codes have been further grouped into four groups of real shops, leisure spaces, services spaces and other (retail warehouse) to reflect the frequency of consumers' visits to these spaces. This is required to understand the overall performance of retail property types (which has been presented as part of the results in Chapter 6 of this thesis) prior to conducting relationship analysis with consumer movement patterns on city spaces. Further clarification on consumer movement pattern variables have been presented in the next subsection.

5.1.2 CMP Variables

While RPM variables have been sourced from the VOA, the CMP variables have been computed through spatial configuration analysis of city spatial layouts (RCL) obtained from Ordnance Survey. This section presents the concepts of CMP. It reveals all possible means through which consumer movement variables can be obtained from city space. It presents the advantages and disadvantages of the available options and provides justifications for adopting spatial configuration technique over others.

Typically, a CMP variable is a measure of the concentration (or flow) of retail consumers in city retail spaces through achievable means. The CMP variables seek to identify the distribution of retail consumers at different locations across a given city spatial layout. This study recognises that there are five possible options for establishing retail CMP on a given city layout. The following subsection presents the possible methods for computing CMP variables.

5.1.2.1 Methods (options) of computing CMP variables

This study identifies five (5) broad methods that can possibly be adopted to compute or ascertain retail consumer movement patterns on any given city spatial layouts. These methods are:

i. Method 1 - Physical data collection,

ii. Method 2 – Digital tracking of movement,

iii. Method 3 – Sourcing existing collated footfall data,

iv. Method 4 - Remote sensing and satellite imagery,

v. Method 5 - Spatial configuration (and street segment) analysis method.

Table 5.1.3 summarises the advantages and disadvantages of the five (5) identified methods, which have been subsequently explained.

Table 5.1.3 Advantages and disadvantages of the methods for establishing CMP variables

S/no	Methods	Advantage(s)	Disadvantage(s)
1	Physical data collection	-Provide accurate information about consumer movement on city retail spaces.	-it can be time consuming and -Impossible to measure substantial number of consumers at once.
2	Digital tracking of movement	-Provide accurate data on spatial (location) and temporal (time) of movement (at the same time) for various consumers	-Legal limitation -Time consuming, and - Limited area and consumers' coverage
3	Existing collated data (footfall counts)	-Provides footfall count data on strategic locations within the city at different dates and seasons.	- Inadequate, as number of recording cameras (storing footfall data) do not fairly represent number of existing movement corridors (streets)
4	Remote sensing and satellite imagery	- The method is comprehensive and can cover the whole city under investigation.	- Difficult and almost impossible to retrieve usable information about consumer movement at the city. - The method is expensive and requires further technical analysis to obtain required CMP information.
5	**Spatial configuration method**	-The technique considers all the possible corridors of movement within a city layout -Indicate the likelihood influx of consumers (people) movement on all the streets.	- Considers only street connections, while ignoring other possible factors that can deter or enhance consumer movement

Source: Researcher's own (2019)

i. *Physical data collection*: This method of computing the CMP on a city includes physical assessment, physical observation, manual counting and the recording of retail consumer (or group of consumers) movements on spatial layouts. This can be achieved through physical studies and recording human (consumer) movement behaviour across street networks. This method gives an in-depth and absolute measure of consumer movement patterns within spatial street network. However, the task can be time-consuming, challenging and almost impossible to measure for all potential consumers at once across a city spatial layout.

Meanwhile there are studies (Vasconcellos, 1997; Crainic et al., 2004; Hillier et al., 2012; Kooshari et al., 2016; Carol et al., 2018) on city transportation and walkability that have counted, observed and recorded human movement across connected spatial layouts. Results from these various studies have indicated that human movement across connected spatial layouts follow consistent patterns with the majority of individuals making few turns while navigating within a street network (for example, similar to space syntax theory).

ii. *Digital tracking of movement*: In this digital age, there are opportunities for consumers' movements to be tracked within and across cities to map movement flows. Tracking mobile devices (including phones, cars and others) will provide information on consumer's movement flows including location and time (spatial-temporal) data within cities. However, movement can only be tracked for sampled consumers and cannot possibly cover the entire movements of consumers within city retail space. Similarly, this can also take time to achieve, as there may be legal consequences involved in tracking people's movement with or without their consent. This and the limited data coverage for this particular option implies that other possible options should be considered.

iii. Sourcing existing collated data: this method was considered (as it is similar to the method adopted for RPM variables). The method includes employing existing collated consumer movement data, such as footfall (or tracked mobile) data. Preliminary investigation in this research shows that there are cameras (with recording sensors) available in several locations across a few cities in the UK, recording, counting and storing the numbers of passers-by (footfall). The pilot study shows that few local councils (and certain data holding companies) hold such data. Local city councils including that of Leeds, York, Newcastle, Milton Keyes and a few others hold footfall recordings of people's (consumers) movements within their city centres. Further investigations of these data confirms that these data do not show comprehensive records of consumers' footfall data. This is due to limitations in the number of recording cameras.

Although, the recording cameras in these cities are positioned in strategic locations (mostly concentrated in the city centres) to capture and record the number of passers-by. They are inadequate in providing reliable CMP as the number of recording cameras (storing footfall data) do not fairly represent the number of existing streets and covers limited retail spaces within the city (and city centre) layouts.

Table 5.1.4 below summarises the number of recording cameras (with sensors) holding footfall data for a few of the investigated cities (city centres) within the UK during the pilot study stage of this research.

Table 5.1.4 Recording cameras for footfall data on selected UK cities

S/No	Cities	No. of Cameras	Availability	Comments
1	Leeds	8	Publicly available (Open data) from 2011 to 2017	Data available for just eight (8) locations.

2	Newcastle	2	Safeguarded data. Available on request from NE1 BID	The two locations do not reflect true consumer flow data
3	Milton Keynes	Unknown	Highly protected data	Data are strictly protected and require financial commitments to obtain.
4	York	6	Publicly available	The available data do not cover enough areas to represent the CMP

Source: Researcher's Desktop Survey (2017)

Consequently, other options that are more comprehensive are explored.

iv. *Remote sensing and satellite imageries*: the previous method (that is, sourcing existing data from camera recordings) can be categorised as a form of remote sensing. However, remote sensing (and satellite imagery) is more than capturing an event via stationary cameras. Remote sensing and satellite imageries involves the use of various tools including drones to capture data from space without having a physical presence in such locations. Due to this, data that are more comprehensive can be captured as regards city space (better than stationed cameras). However, the main problem concerning this method is that it collects too much unwanted data pertaining to city space. This makes it difficult and expensive to adopt to have a meaningful understanding of retail consumer movement within city retail space (Mao and Jain, 1992; Benz et al., 2004). Consequently, other options that can satisfy understanding consumer movement patterns across city space are required.

v. *Spatial configuration (street network) analysis*: this method has been adopted in computing the CMP variables in this research. The method (that is, spatial configuration) involves computing the accessibility index of streets (segments) based on space syntax theory. This method estimates the chance of consumers' presence within a city space based on the connectedness of streets to all other streets within the spatial layout (street network). As such, all streets within the network are analysed (based on their spatial connectivity properties) and assigned syntactic values. The assigned syntactic values indicates the probability of an influx of consumer (people) movement on all the analysed streets. The results from this are coloured (choropleth) maps with corresponding attribute variables of integration (specifically, to-movement) and choice (that is, through-movement) and other metrics variables. The method is comprehensive as it has the potential to cover the entire city space. However, the method is technical and often requires computing skills to obtain possible consumer movement patterns within city space. The following subsection discusses the spatial configuration analysis method that has been adopted in computing the CMP variables in this research.

5.1.2.2 Spatial configuration analysis method

The spatial configuration analysis method is an inferred means of computing consumer movement in city retail space. This is for the reason that this method does not directly count, observe or study retail consumer movement but studies the underlying street networks that consumers will always utilise when navigating across city retail space. Although this method computes the CMP without observing the actual consumer movement patterns in city spatial layouts, studies (Peponis et al., 1997; Hillier, 1999; Peponis et al., 2008) have shown that its outputs reflect more than 70% of the actual movement patterns of people within spatial layouts. This research attempts to adopt this technical and scientific approach to investigate its relationships with market (socio-economic) driven events (such as retail activities) in city (retail) spaces. *This investigative research attempts to contribute to knowledge of the application of space syntax theory to commercial retail property markets within cities.* Moreover, this section focuses on the logic (advantages) and limitations (disadvantages) of adopting the spatial configuration analysis method in establishing the CMP variables. The subsequent sections present the advantages and disadvantages of spatial configuration analysis.

5.1.2.2.1 Logics (and advantages) of adopting the spatial configuration analysis method

The following is the logic and advantages of adopting the spatial configuration analysis method in computing the CMP variables in city retail spaces:

i. The method provides a comprehensive understanding of consumer movement across all locations (streets) of any given analysed city space. Unlike other possible approaches related to computing the CMP, spatial configurations compute the accessibility index of all available streets within the investigated spatial layouts. Consequently, all interested locations are covered and ranked during spatial configuration analysis.

ii. The method presents an opportunity for exploring a novel theory (that is, space syntax theory) to assist with the understanding of retail property markets within cities. This research contends that there is a dearth of knowledge in the application of spatial configuration analysis to the real estate market, despite its relevance in computing spatial accessibility, which is essential for the practice and theory of the real estate (retail) market.

iii. The method generates different configurations of metric outputs, such as to-movement and through-movements), which can be adopted to represent the CMP variables and conduct spatial and statistical analyses with retail property market variables.

iv. The method attempts to combine scientific rational into the socio-economic variables of RPM. As such, exploring new possibilities of understanding the future of retail property market performance that has practical implications on making reasonable decisions on the use and management of city retail spaces. In essence, this method is suitable for the goals of this research. Simultaneously, this study adopts and relies on method 5 in computing the CMP variables. Nevertheless, there are recognised limitations attributed to this method. The next subsection presents the limitations and disadvantages of adopting method 5 in computing the CMP variables. This is required to understand the shortcomings of this method of computing CMP variables.

5.1.2.2.2 Limitations (and disadvantages) of adopting the *spatial configuration analysis method*

This section highlights the limitations and disadvantages of adopting spatial configuration analysis in computing the CMP variables. Some of the limitations (and disadvantages) of computing the CMP variables via the spatial configuration analysis method are:

i. The idea is extremely technical and does not measure consumer movements with city space directly although it does suggest it. This occasionally makes it challenging to understand in the context of the real estate market. For example, the method does not recognise street sizes (widths), speed-calming controls and other traffic signals that can be perceived in the real estate market context. The inability to see the CMP variables as computed by spatial configuration analysis may discourage its acceptance and understanding in the real estate (retail) market context. Put differently, there is a need to unravel the complexity of this method to assist with the understanding of real estate market actors and enhance the applicability of spatial configuration analysis in the real estate markets.

ii. The method is not perfect. The method understands human (consumer) behaviour as a scientific (rational) entity rather than a social entity that is occasionally irrational in behaviour.

Consequently, not all retail consumer movements in city space fall within the scientific view of computing human movement in a city space using this method.

iii. The method explicitly relies on street connections, therefore, the effects of socio-economic and other factors including cultural, topography etc., on consumer movement are completely overlooked.

iv. The method is based on movement occurring on a street only. As such, movement via railway lines (and others) that conveys a large volume of potential consumers are completely ignored.

v. The method is based on certain specific rules and requirements that relies considerably on street components as the input data for analysis. This suggests that the transfer of errors from the underlying data sources is highly possible using this method for computing CMP. As such, a decent understanding of the underlying data for spatial configuration analysis (method 5) of computing the CMP variables is necessary to minimise errors.

The ensuing subsection discusses possible ways of sourcing underlying data for spatial configuration analysis.

5.1.2.2.3 Modes of obtaining underlying data for spatial configuration analysis (method 5)

When considering computing the CMP by way of spatial configuration, there are several ways of obtaining the underlying data for this purpose. This study broadly classified these approaches into three (3) as thus:

i. Digitising and Drawing,
ii. Applying existing configured model outputs,
iii. Acquiring and utilising existing street maps from spatial data holding companies.

i) *Digitising and Drawing*: This includes both electronic and manual means of tracing (or drawing) street layouts from an underlying base (street) maps. The advantage of this method is that the user (i.e. person digitising) understands and explains the street connections more than all other methods. The consequence of this is a well-detailed spatial (street) layout. However, the approach is only suitable for microscale analysis (covering small areas) because it can be time-consuming digitising street connections for an entire city space. Similarly, drawing and digitising are prone to common mistakes, such as dispositioning of nodes, straightening of curve roads and vice versa, misjudging the streets connections on a base map and so on, which can invalidate all the configured outputs.

ii) *Employing existing model outputs*: Spatial configuration of spatial layouts (and street networks) have been conducted for various aspects of urban studies including, crimes, urban planning, urban landscape design, transport studies, commercial property markets and so on. Therefore, there are existing configured (models) outputs from preceding analysis that can be utilised as the CMP for the retail market analysis. However, techniques utilised in configuring spatial models depend largely on the type of analysis been conducted. Consequently, this research opted for existing street map data in configuring the CMP.

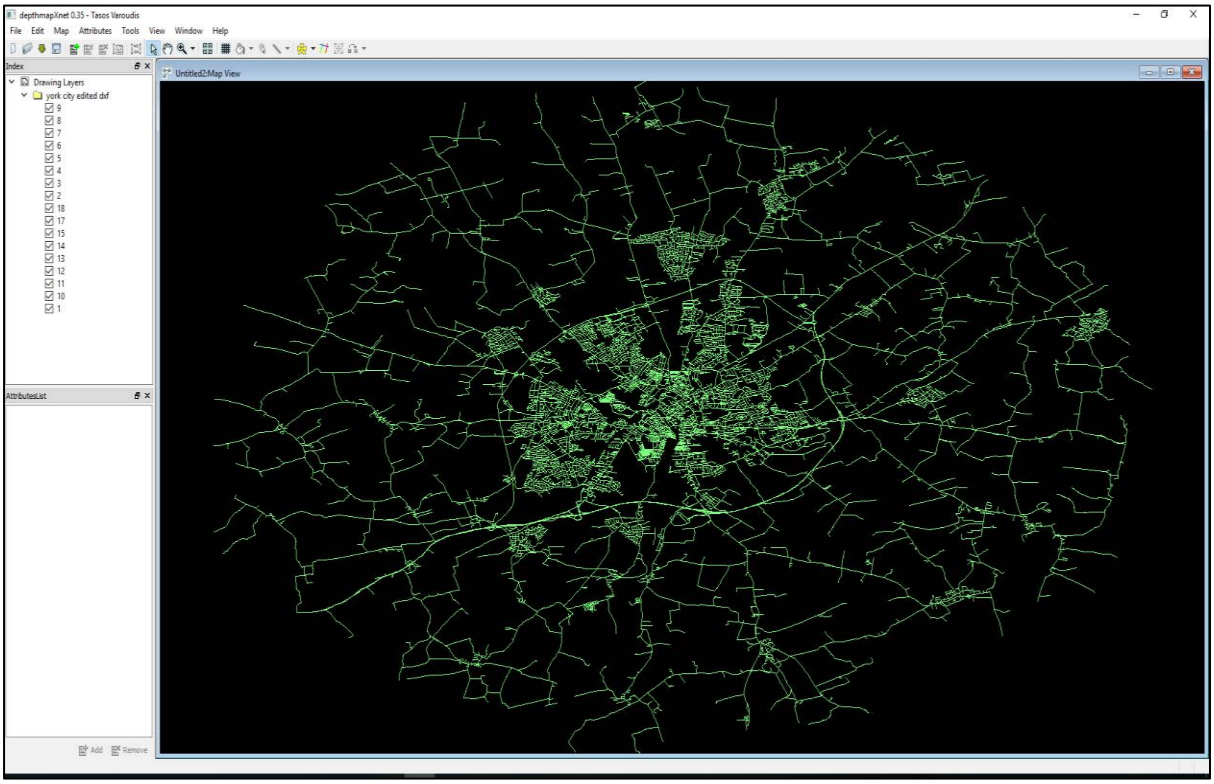
iii) *Acquiring existing street map (RCL) data*: Several organisations hold street map data in various formats for educational and commercial purposes. These street maps are replicas of street connections within cities including highways linking cities. Obtaining the street map data is easy and flexible, as the user only has to indicate the amount of street map data required from the supplier. Hence, street map data are obtainable for macroscale (city) and mesoscale (city centre) analyses.

However, there are certain characteristics that useable street map (RCL) data must possess before it can be considered suitable for computing the CMP on city spatial layout. These characteristics are:

i. Continuity and Connectivity,
ii. Comprehensiveness and Coverage,
iii. Convertibility and flexibility.

i) *Continuity and connectivity*: Street map RCL data that is to be used as underlying data for configuring CMP must be continuously connected for spatial configuration analysis to be effective. This is one of the essential conditions that must be fulfilled for spatial configuration analysis (specifically, street segment analysis) to be conducted. The consequence of the street map data not having continuity and connectivity qualities will result in no or erroneous configuration outputs. This is because in reality, there are no single streets within a city spatial layout in isolation without being connected to at least a street. Of course, there is the possibility of having disconnected streets on the edges of the supplied street map data, care must be taken to ensure such isolated streets are carefully deleted in order not to obscure the analysis. As such, it is often reasonable to over request amounts of street map data from the supplier to reduce the impact of this edge effect on the data. It is important to make it clear that there are certain street map data that do not possess the quality of continuous connections of street lines, such as OS MasterMap (urban path) layer. Such street map data is therefore not suitable in configuring CMPs. Figure 5.1.2 shows an example of a connecting street network (York spatial layout) with continuity and connectivity properties at DepthMapX. The Figure shows the connecting street network prior to the street segment (spatial configuration) analysis.

Figure 5.1.2: Example of a street network characterised by continuity and connectivity spatial properties in DepthMapX.



Source: Researcher’s own (2017)

ii) *Comprehensiveness and Coverage*: Ideally, street map data for computing the CMP must be well detailed and cover all the possible (available) routes that a retail consumer will move through to get in and out of shopping destinations (retail stores). This includes all internal routes within the covered shopping malls and other small streets hosting retail stores and so on. However, the preliminary assessment conducted on all possible sources of street map data revealed that there is no supplied street layer that covers all routes within UK cities. This study, recognising the distortion effects that manual drawing (that is, digitizing) of a street map may cause (as mentioned earlier in digitisation and drawing), did not opt for manual extension of the street map data by drawing (or digitising) these uncovered (missing) routes. This is because the result of extending the supplied street map (by digitising additional routes within it) will increase the chances of dispositioning nodes, which in turn will increase the errors on the spatial configured metric outputs.

Besides, for an alpha[1] spatial analysis at macro (city) or meso (city centre) scales (which is the scope of this research), the street map data layer that covers the external street links is sufficient for the scope of this research. Similarly, it is important to note that ground truthing[2] on positioning and pattern of all the digitised (added) routes will be necessary when an analyst digitises (draws) or extends the supplied street map. This (ground truthing) is almost impossible for an entire city street network as it will be time consuming despite not been part of this research objective. Hence, this study opted for existing street map data that cover the streets (and highways) of the sampled spatial layouts regarding spatial configuration analysis.

iii) *Convertibility and Flexibility*: another quality that the underlying RCL data must pass is the ability to be converted into different suitable formats. This is because street map RCL data have to be transferred from different software packages (specifically from GIS to SS/DepthMapX then back to GIS – (see the CMP processing procedures in the next sections for further details). The RCL data must be able to adapt to changes in spatial environments[3] and tools. Therefore, the format of the street map RCL data must be open to possible changes in formats during the processing stages and spatial analysis.

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[1] Alpha analysis is external spatial analysis, such as city or city centre configuration analysis. The opposite is gamma analysis which comprises internal (within building) spatial configuration analysis.
[2] Ground truthing is terminology used in spatial analysis for on-site validation of positioning (and other characteristics) of data variables using Global Positioning System (GPS) and other apparatus.
[3] Spatial analysis environments in this research are GIS (with ArcGIS & QGIS tools) and Space Syntax (with DepthMapX tool).

Preliminary investigation conducted on the available sources and characteristics of street map data indicated that all data (vector) layers of the Ordnance Survey (OS) map adhere to the three (3) above classified criteria, except the OS MasterMap (urban path) layer that is characterised by disjointed line segments. However, the ***OS MasterMap (road link) layer*** was adopted in this study as the street map RCL data for computing CMP variables because of its connectivity, comprehensiveness, coverage and suitability properties with computing tools and data formats embraced in this research.

Conversely, one of the main challenges associated with the OS MasterMap (and other street map data) is that the data supplied always incorporate street connections within cities as well as highway roads (connecting two or more cities). Hence, highways and streets are treated as the same (streets) during the spatial configuration analysis of the street map. The consequence of this is that the highway routes will always appear as the most connected routes during the configuration analysis. Nevertheless, additional steps, including planarising[4] the highway junctions and on-site verification can be carried out to reduce this anomaly, when computing the CMP variables for RPM analysis while using existing street map data. As such, the study utilises street map RCL data (i.e. OS MasterMap –road link) while taking the required steps to ensure that the computed data reflect the CMP for RPM analysis. The next section discusses steps and tools employed in obtaining the CMP variables (through spatial configuration) for the RPM investigation.

5.1.2.3 Procedures and tools in establishing the CMP variables: How retail consumers' through-movement and to-movement variables emerged.

[4] Planarising refers to the process of flattening road junctions and/or bridges such that the DepthMap individually recognises the junctions and the bridges carrying human movements as it is, rather than computing it as a whole single street during the spatial configuration analysis.

The CMP variables that this research investigates are primarily ‘choice metrics’ and ‘integration metrics to represent the through-movement and to-movement of retail consumers, respectively. However, the choice (global) metrics have been normalised to obtain normalised angular choice (NACH [5]) metrics. Consequently, *integration, choice* and *NACH metrics* represent the CMP variables on all the sampled spatial layouts. Details of how these are obtained are presented in this section.

The street map data employed in this research are obtained from the Edina Digimaps (that hold varieties of OS data for educational purposes). Having acquired the street map data, that is, OS MasterMap road link data (henceforth, OS data) for all the sampled cities layouts, the following chronological steps were taken on each of the sampled spatial layouts’ layers to obtain the CMP variables analysed in this experimental research:

i. *Import the OS data* into the GIS environment for data (position and coverage) validations: This step was achieved by overlaying the supplied OS data on a street vector base map. Any of the GIS (tools) imbedded base maps, such as Google maps, Bing map, Apple map and Open Street Map OSM could have served the purpose of data *coverage* validation. However, validation of the geographical positions of OS data are best completed using the *OSM*. This is because the OS data and the OSM base map are referenced based on British coordinate systems (also known as Ordnance Survey National Grid OSNG reference System), whereas Google maps and others are usually referenced based on the World Geodetic System 84 WGS84. Preliminary investigations have shown that failure to verify the positioning of OS data using

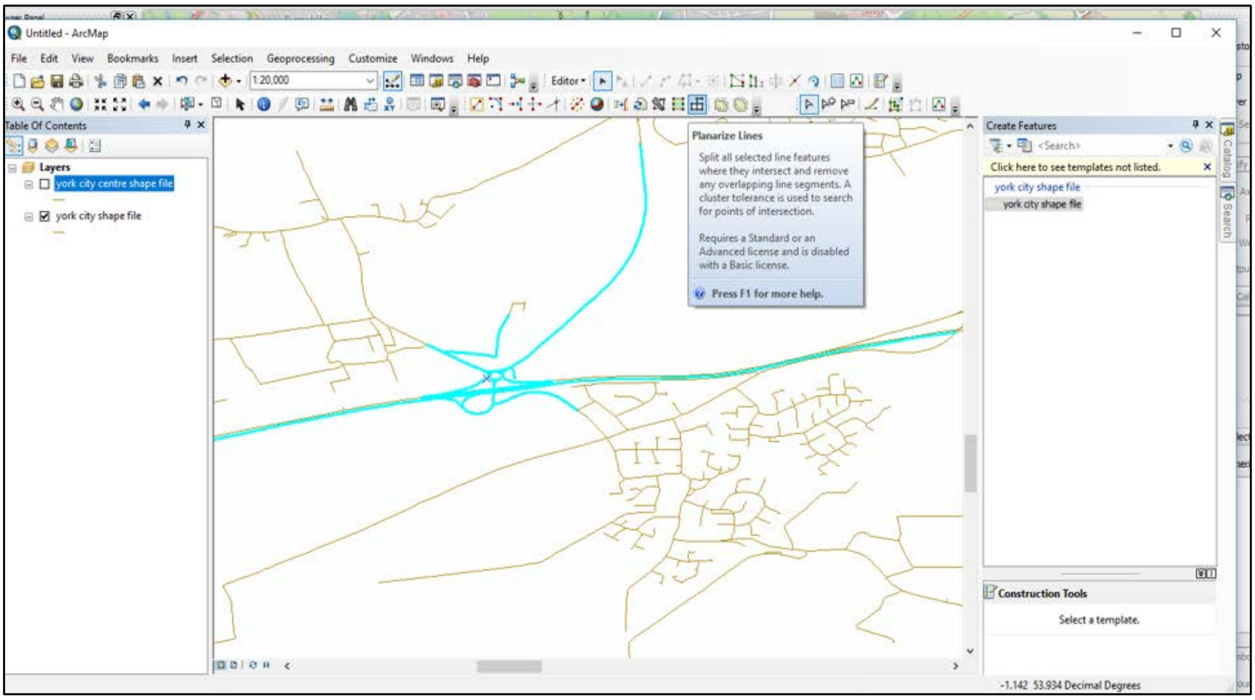
[5] NACH is normalised angular choice metrics that have been proven to better enhance choice metric outputs by dividing choice metrics (global or local) by the corresponding total depth metric value. It is assumed to have a better correlation with a property (urban) value than the local choice metrics (Hillier et al., 2012).

an appropriate base map with the same reference systems will amount to sagging or dislodging of streets (and other spatial variables) during visualisation of outputs. This can lead to serious error during the locational investigations of variables.

Similarly, data validation of OS data can be completed on either of the ArcGIS and QGIS tools or any other GIS software package. Nonetheless, this study adopted for *QGIS tool* in validating the positioning and coverage extent of the supplied OS data because the format of supplied OS data is in Geography Markup Language 3 (GML3), which is an appropriate data format for QGIS but not for ArcGIS tools. Being satisfied with the amount of OS coverage and positioning, the OS data was then exported into ArcGIS as a shapefile for further editing.

ii. *Editing of OS data* (shapefile layer): the verified exported OS data layer was subsequently imported into the *ArcGIS 10* tool for editing. The two key editing tasks that were conducted on all OS data layers are *planarising* and *deleting* of disconnected street segments at the edges of the layers (as earlier explained above). The planarising tool and editing (deleting) tool of ArcGIS 10 were respectively utilised in planarising (highway nodes and overlapping bridges) and deleting unconnected street segments at the surrounding edges of the shapefile layer. It is important to note that the QGIS tool does not have the ability to planarise and delete street segments. This is the logic behind editing the OS data layers in the ArcGIS 10 and not in the QGIS. Figure 5.1.3 shows an example of editing (planarising) of a sampled (York) spatial layout in ArcGIS 10.

Figure 5.1.3: Example of street network planarisation (and editing) in ArcGIS 10.

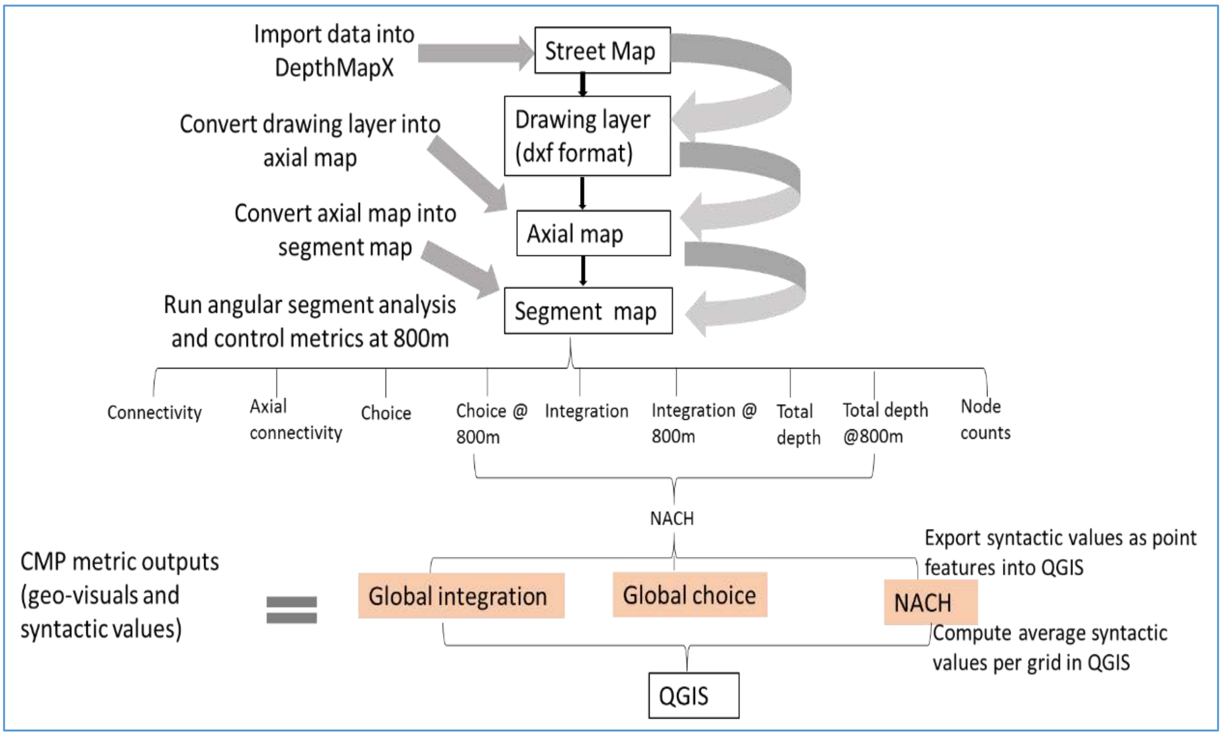


Source: Researcher's own (2019)

This process enhances the reality of the street network during spatial configuration analysis. The edited layers are then exported as drawing layer formats, that is, *dxf format*. This is because the space syntax environment (for example, DepthMapX) where the main spatial configuration (street segment) analysis were conducted only recognised drawing layers (dxf or dwl) formats.

iii. *Spatial configuration (street segment) analysis*: The edited (planarised) OS data was subsequently imported into DepthMapX as dxf format for spatial configuration analysis. Figure 5.1.4 below summarises the basic steps undertaken to convert street map (OS data) into the CMP metric variables.

Figure 5.1.4. Basic steps in converting street map data into the CMP variables in DepthMapX



Source: Adapted from Hillier et al. (2012)

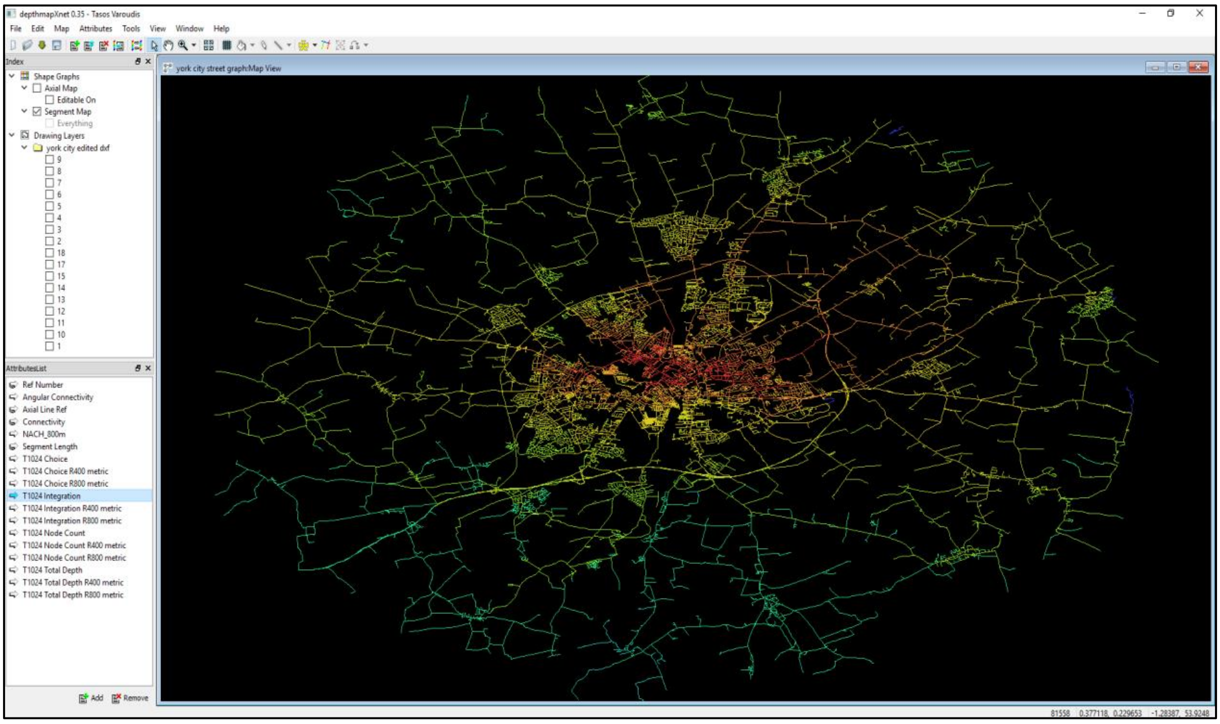
The procedures follow the standard process for conducting street segment analysis as pointed out in Hiller et al. (2012). The imported drawing layer (in dxf format) was converted into axial map. The converted axial map was subsequently converted into a segment map prior to running *street segment analysis* at global and local[6] (800m) scales. The segment analysis was allowed to run fully[7] to generate syntactic values of connectivity, axial connectivity, choice metrics (global), choice metrics @ 800m (local), integration metric (global) and integration metrics @ 800m radii (local), total depth (global), total depth @ 800m and the node counts. The study recognising the errors of choice metrics (as explained in chapter 4), normalised the local choice metrics (@800m) by dividing its total depth @800m to achieve the NACH metrics as thus:

[6] This was necessary to configure the NACH as all spatial configuration are conducted on global scales.
[7] Depending on the number of street segments and the capability of the computer hardware, the segment analysis of an average sized city spatial layouts can run for more 24 hours.

NACH = Log value (Choice @ 800m) + 1/ Log value (total depth @800m) + 3 (Hillier et al, 2012)

Hence, the *integration*, *choice* and *NACH* metrics, which are representatives of to-movement and through-movements, emerged as the CMP variables. Figure 5.1.5 illustrates an example of the spatial configuration (integration metric) output of a sampled (York) spatial layout. Other metric outputs, such as choice and NACH metrics for the sampled spatial layout can also be visualise at this stage. The same procedures were undertaken for all the sampled spatial layouts.

Figure 5.1.5: Spatial configuration (integration) output of a sampled spatial layout



Source: Researcher’s own (2019)

The above spatial configuration integration metrics output indicates the concentration index of consumers on the spatial layout. The differences in the colour of street segments signals the difference in concentration of retail consumer movement. In effect, the red coloured streets represent locations with the highest accessible index that should have the highest concentration of consumer movement assuming the entire streets network is to be navigated. Similarly, streets coloured orange, yellow, green and blue show (in that order), the level of accessibility index of those streets based on the scientific definition of the integration metrics of spatial configuration analysis. Put differently, streets marked orange are not expected to have as much movement as that of red marked streets but have more consumer movement than the yellow marked streets. Likewise, the yellow marked streets are expected to have more concentration of consumer movement than the green and blue streets. As such, the coloured streets are ranked syntactic values of spatial configuration outputs. The above interpretation of colour grading index applies to choice and NACH metrics. Specifically, the accessibility index of streets can be visualised and analysed by shading the rank syntactic values of configured metric outputs to analyse the to-movement (integration) and through-movement (choice and NACH) of human (consumers) on any connecting street network.

However, the DepthMapX tool does not have the ability to integrate other data variables, such as the RPM within it, meaning relationship analysis with the RPM variables cannot be conducted within the space syntax environment. Consequently, the CMP metric outputs were exported into QGIS as *point features* in order to conduct relationship analysis with the RPM variables. The logic behind exporting the CMP metric outputs as point features (and not linear street segment as seen in Figure 5.1.5 above), allows the possible investigation of the locational relationships between the CMP and RPM variables. Consequently, the CMP metric outputs are exported as txt (tab) format into QGIS and not Map Info (linear formats). This crucial step allows points features of the RPM and CMP variables to be converted into polygons features, suggesting that polygons represent delineated retail locations across the sampled spatial layouts. The following section focuses on the technique adopted in relation to integrating the RPM and CMP variables for locational investigations of the relationships between the variables across the sampled layouts.

5.2 Techniques and tools of integrating variables for the relationship investigation: Delineating retail locations with vector grids

The preceding section has presented procedures and logics behind obtaining all the investigated CMP variables (namely, integration, choice and NACH metrics) and RPM variables (specifically, changes in retail rental value and in retail stock). This section presents techniques on how these variables have been integrated in GIS to allow relationships investigations to be conducted across the sampled spatial layouts.

Regarding the GIS, there are two broad approaches that can be adopted in conducting relationship analyses between the CMP and RPM variables. These approaches are:

- Overall relationship analysis,
- Locational relationship analysis.

An overall relationship analysis approach involves conducting relationships (spatial and statistical) on the entire RPM and CMP variables within a given spatial layouts. Simply put, relationship analyses between variables are conducted on all the available the RPM and CMP variables without caution concerning the locational differences of these variables within the analysed spatial layout. This approach quantifies the entire relationships between variables within the sampled layout simultaneously. Therefore, the differences in the relationships of variables across different locations within the analysed sampled layouts are not noticed using the overall approach. (This study has analysed the overall performance of RPM on sampled and conducted locational relationship analysis between RPM and CMP variables across the sampled layouts).

Meanwhile, the locational relationship analysis approach involves conducting comparative relationship analysis on the RPM and CMP variables across the sampled layouts. As such, the relationship between variables is investigated within and across the delineated locations of the analysed spatial layouts. This approach enables an understanding of the relationships between variables across different locations of the analysed spatial layout. That is, the locational analysis approach enhances the understanding of relationships between variables across delineated locations. Therefore, one can visualise relationships between variables at different parts of the analysed spatial layouts. Similarly, this approach enables estimating the RPM variables (that is, the last objectives of this research) to be conducted per location and not just on an overall basis. The research contends that doing this will enhance the applicability of the research, given that it breaks the relationships between variables into locational characteristics within the sampled cities. Hence, the research adopts the locational relationship analysis approach to understand how the RPM and CMP variables relate within delineated locations across the analysed spatial layouts.

In order to conduct locational relationship analysis between variables on the sampled layouts, five (5) necessary steps were taken. These key steps are:

i. Delineate sampled city layouts into locations (using vector grid).

ii. Join variable attributes to delineated locations.

iii. Compute and group variable statistics per delineated locations.

iv. Style variables for visualisation.

v. Overlay CMP and RPM variables on one-to-one basis for spatial relationship analysis.

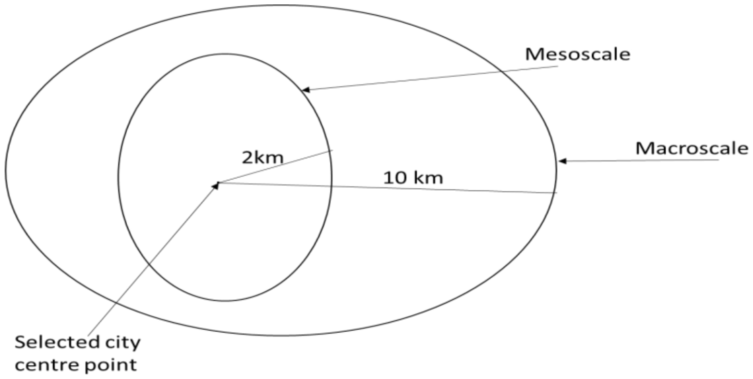
Details of these five (5) steps are presented in the following subsections.

5.2.1 Delineating sampled city layouts (mesoscale and macroscale) into locations using vector grid

The first step was to delineate all sampled spatial layouts into retail locations using the vector grid tool. This led to other steps being taken in relation to analysing locational relationships between CMP and RPM variables on the sampled city layouts. In doing so, the differences in the analysed city spatial boundaries (that is, mesoscale and macroscale) were considered. Fundamentally, the delineated locations of all sampled cities regarding mesoscale and macroscales differs to reflect the differences in sizes of the city spatial demarcations. This subsection presents a recap of the concepts of the mesoscale and macroscale of a city's spatial layout. It presents the key steps, logics, advantages and disadvantages of adopting vector grid in delineating locations at city mesoscale and macroscale.

In this research, mesoscale refers to the extent of the city's layout size comprising a radius that is less than 2km from the selected centre point of that city. It can be understood as the city centre extent of a city**,** while the macroscale of the same city layout is the spatial extent of that city layout comprising a radius of more than 10km from the same given city centre point as illustrated in Figure 5.2.1 below.

Figure 5.2.1: Concepts of mesoscale and macroscale

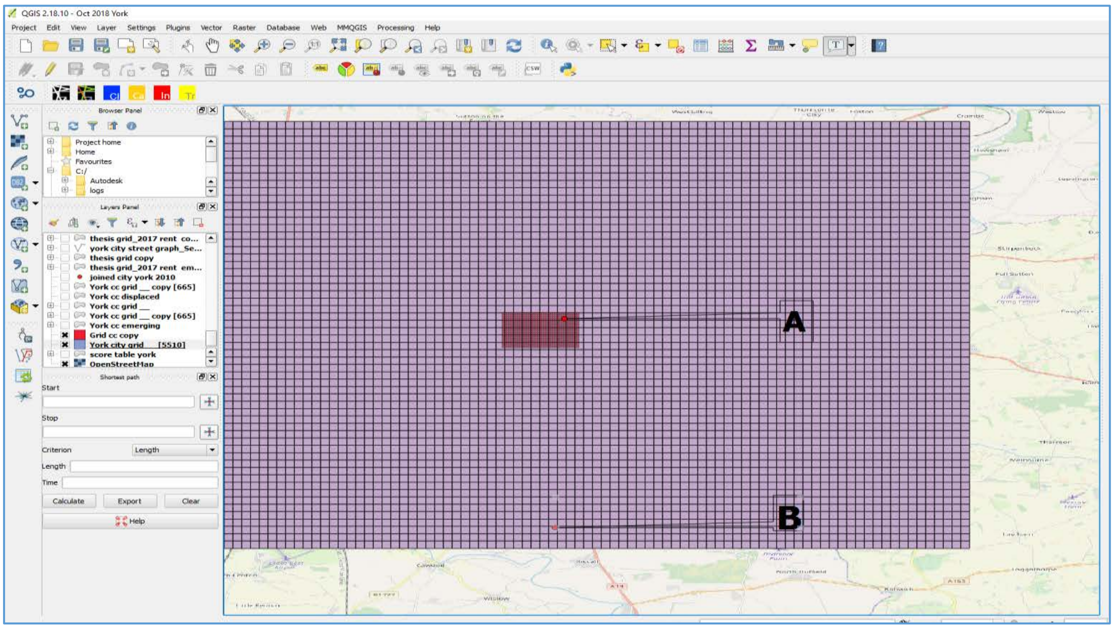


Source: Researcher's own (2019)

Consequently, the sampled spatial layouts of the three sampled cities are; York mesoscale, York macroscale, Leeds mesoscale, Leeds macroscale, Newcastle mesoscale and Newcastle macroscale. The locational relationship investigations between the RPM and CMP variables were completed across these six sampled layouts.

To do this, a vector grid tool in QGIS was adopted to delineate all the aforementioned sampled spatial layouts into grids, such that all the mesoscales and macroscales of the analysed cities have equal dimensions of grid areas (otherwise, referred to as delineated retail locations). The chosen delineated area of a grid at mesoscale and macroscale is approximately 7,200 sq. m and 115,000 sq. m respectively across the sampled cities. The logic behind these sizes was principally to ensure decent visualisation of the locational relationships between variables at mesoscales and macroscales spatial extents. Similarly, the equality in the sizes of the delineated retail locations (grids) across the city spatial layouts was necessary to have uniformity in the process taken in investigating the locational relationships between variables across the sampled cities. Concomitantly, all the delineated grids (retail locations) were assigned unique ID and spatial coordinates. Figure 5.2.2 shows the full extent of the delineated city layout at mesoscale (A) and macroscale (B) in QGIS using vector grid. (Show a single grid and diameter at a mesoscale and macroscale).

Figure 5.2.2: Example of vector grid delineating city (York) spatial layouts at a mesoscale (A) and macroscale (B) in QGIS.



Source: Researcher’s own (2019)

The basic rationale behind adopting vector grid in delineating spatial layouts into retail locations was to:

a. Create a uniform location backdrop for all variables (CMP metrics and RPM) to seat for geo-spatial analysis. The grid serves as a uniform spatial platform for locational investigation of these variables.

b. Enhanced visualisation of spatial variables at the mesoscale and macroscale. This is because vector grids can be styled (coloured) to reveal the extent and index for the RPM and CMP variables per delineated location (see later subsection on styling variables for visualisation of details). Likewise, vector grids can further be enhanced into 3D columns to reveal the performance extent of the market variables across different spatial layouts that can easily influence the decision-making of market actors. Hence, it enhances the applicability of GIS and space syntax in the real estate market context (see Appendix D for results).

c. Allow a better understanding of space syntax lexica. Space syntax terms, such as streets segment, nodes, axial lines, axial connectivity and so on can be seen as location, location and location (using vector grid), which is more understandable in the real estate (retail) market context.

d. Enhance statistical analysis of variables per locations. This allows the locational estimate of the RPM variables to be possible. Thereby, enhancing applicability and understanding of the research.

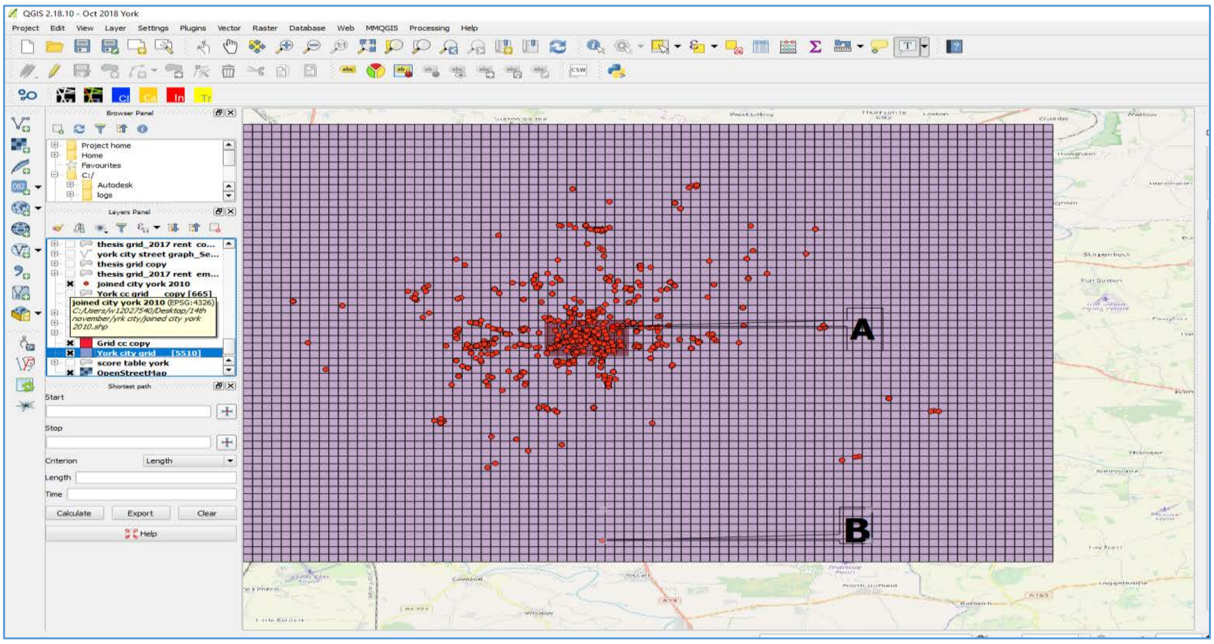
However, adoption of vector grid in delineating spatial layouts for analyses of the CMP and RPM variables relationships could result in a *misunderstanding and overgeneralisation* of the variables. This is because whilst analysing the RPM and CMP variables within a delineated grid, there are high possibilities of having different qualities, attributes and index of points (variables) within a square grid (irrespective of the grid size). In essence, variable points within the same grid are influenced (negatively or positively) by other accompanying variable points within the grid. In other words, the dominant point variable takes over and represents the entire grid, making all other (subservient) points unnoticed during analysis. As such, the characteristics of individual variables can be enhanced or diminished using the grid method. This could mean that a retail store that has performed woefully, could be seen otherwise, just because it has been grouped into the same location with stores that have performed well and vice versa. Similar, a street segment having low syntactic value can be outweighed by surrounding neighbouring street segments (in the same grid) having high syntactic value and vice versa.

Consequently, the type of computation of variables within the vector grid (to represent each grid) must represent the meaning and interpretation of that variable in the grid. This was the logic behind *summing* the variable points of the RPM and *averaging* the variable points of the CMP metrics (see details in subsection 5.2.3 explaining computing stat). (Preliminary investigation into this research shows that summing the CMP variable per grid could not maintain the same visual constituency as obtained in the original output in DepthMapX).

5.2.2 Joining variables' attributes to delineated locations

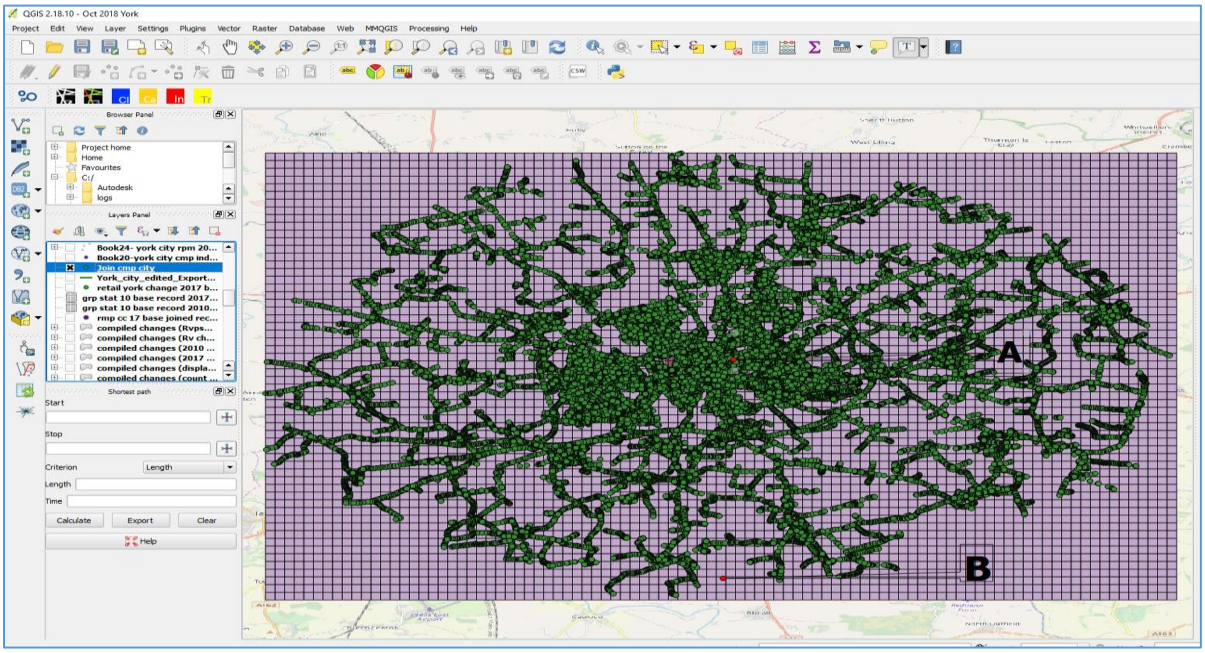
Having established the vector grids for all the sampled spatial layouts, all the point feature variables were linked to their corresponding vector grids using the *join-attribute-by-location tool* in QGIS. The points of the CMP and RMP variables were separately combined to the developed grid ID as joined vector layers as shown below in Figure 5.2.3 and Figure 5.2.4 respectively. Consequently, the geographical locations of all the variables in points were established.

Figure 5.2.3: Example of combined point feature of RPM variables to delineated vector grids of a sampled city spatial layout



Source: Researcher’s own (2019)

Figure 5.2.4: Example of combined point feature of CMP variables to delineated vector grids of a sampled city spatial layout



Source: Researcher’s own (2019)

The individual positioned points hold the attributes of their corresponding variables. Basically, the points in Figure 5.2.3 hold the attribute values of the RPM variables, which is, changes in retail rental value and changes in retail stock. Similarly, the positioned points in Figure 5.2.4 hold the attribute (syntactic) values of the CMP variables, which is integration, choice and NACH metrics. The distribution of the points of the RPM (Figure 5.2.3) and CMP variables (Figure 5.2.4) confirms the positioning and concentration pattern of the retail properties and street network of the sampled city (York). The attributes (values) of these linked points have been computed and grouped accordingly as explained in the following subsection (stage).

5.2.3. Computing and Grouping variable statistics per delineated locations

A *group-stat tool* in QGIS was utilised to compute the attributes of the CMP and RPM variables per grid. There are different options available for computing the attributes of the variables per grid in QGIS. Some of these statistical options include the sum, average (mean), count, mode, standard deviation etc. The CMP variables (for example, integration, choice and NACH) have been computed by *averaging* the total syntactic values of the street segments (points) per grid, whereas the RPM variables (namely, changes in retail rental value and changes in retail floor space) were summed-up per grid. Conversely, changes in retail cluster were computed by totalling the number of RPM variables per grid. The reasoning behind averaging the CMP variables and summing the RPM variables is to obtain the average accessible index per grid and the total changes in retail rental value and retail stock per grid. Consequently, all the RPM and CMP point features were blended into the grids, thereby converting these points into polygons. The result was the group stat values for the CMP and RPM variables per grid. These were analysed visually and statistically to investigate the relationships between these variables.

5.2.4 Styling variables for visualisation

The polygonised group stat values of the RPM and CMP variables were styled (coloured) based on the ranges of values across the analysed spatial layouts. This stage was necessary to enable visualisation of variables per grids (that is, delineated locations). To achieve this, two key steps were taken. The first step was to rank (and classify) the values of the data variables. The second was to style ranked variables using suitable graduated colours to represent the ranked variables across delineated locations of the analysed sampled layouts.

All the values of the CMP variables (across all the sampled spatial layouts) were automatically set to Natural Breaks (Jenks) classification mode of QGIS, while ranking the variables to five classes. These classes were then styled using an *inverted graduate spectral* colour, ranging from red to blue. This was necessary to maintain a uniform visualisation pattern with the spatial configuration outputs from DepthMapX. Consequently, all the CMP variables at all spatial layouts exhibit the same visualisation pattern in GIS (QGIS) as initially obtained in DepthMapX. Essentially, the accessibility interpretation of the street segment outputs in linear formats have been maintained in polygonal formats in QGIS (see Figure 5.1.5 and Appendix A for details). As such, the same colour patterns of the accessibility ranking are maintained across all the sampled spatial layouts. Table 5.2.1 below summarises the accessibility rankings, colour representations and value interpretations of the CMP's five classes.

Table 5.2.1: Accessibility ranking of the CMP variables for geo-visualisation

S/No	Accessibility rank	Graduating colour	Value (Index)
1	Most Accessible	Red	Very high value
2	Accessible	Orange	High value
3	Least Accessible	Yellow	Moderate value
4	Segregated	Green	Low value
5	Most Segregated	Blue	Very low value

Source: Researcher's own (2019)

Meanwhile, the RPM variables have been manually classified based on the value ranges of the computed changes in retail rental value and changes in retail stock. The principle as regards the manual classification was to meaningfully arrange changes in retail rental values and changes in retail stock based on the extent of positivity and negativity of the changes (the QGIS cannot automatically do this). In essence, there was no uniformity in the classification of changes in the RPM variables for visualisation across the sampled layouts. (This was because of the differences in the performance of the variables across the sampled spatial layouts). Therefore, variable outputs are ranked into five (5) or three (3) classes depending on the extent of the changes in RPM variables across the sampled layouts. Basically, changes in retail rental value were ranked into 5 classes across all the sampled spatial layouts, while changes in stock were ranked into 3 classes (because of inelasticity in changes in retail stock). Conversely, changes in the RPM variables have been ranked from high negative to high positive and styled accordingly.

In order to have uniformity in the visualisation of changes in RPM variables across all analysed sampled layouts, the same graduated colour style has been adopted across the six sampled spatial layouts, from deep brown (high negative changes) to deep green (high positive changes). Table 5.2.2 summarises the rankings of the changes in RPM variables and their colour representations across the sampled spatial layouts.

Table 5.2.2: Rankings of RPM changes for geo-visualisation

S/no	RPM Change	Graduating colour	Value (Index)
1	High Negative	Deep Brown	Negative
2	Low Negative	Light Brown	Negative
3	Neutral	White	Insignificant
4	Low Positive	Light Green	Positive
5	High Positive	Deep Green	Positive

Source: Researcher’s own (2019)

Hence, visualisations of the CMP and RPM variables emerged. This therefore enables locational (spatial) relationships analyses between these variables across all the sampled layouts by overlaying variables on a one-to-one basis. The following subsection gives details on the overlaying of variables for spatial relationship analysis.

5.2.5 Overlaying the *CMP and RPM variables on a one-to-one basis for spatial relationship analysis*

Having styled both the CMP and RPM variables for visualisation. Spatial relationships between these variables were investigated in QGIS. In doing so, individual layers of the CMP variables (namely, integration, choice and NACH) and RPM variables (specifically, changes in retail rental value, retail floor space and in retail cluster) were correspondingly *overlaid* on each other to investigate (and visualise) locational relationships.

The styled CMP variables (that is, accessibility grid tiles), serve as the base for the RPM variables during the spatial relationships' investigations across the six analysed spatial layouts. The spatial relationships conducted between all the variables of the CMP and RPM are undertaken on a *one-to-one basis*. Put differently, a layer output of the RPM variable (for example, changes in retail rental value) was overlaid on a layer output of the CMP variable (say, integration) of a sampled spatial layout (say, York mesoscale). This means that for a sampled spatial layout, there were nine (9) different one-to-one relationship analysis between the RPM and CMP variables as presented in Table 5.2.3 below.

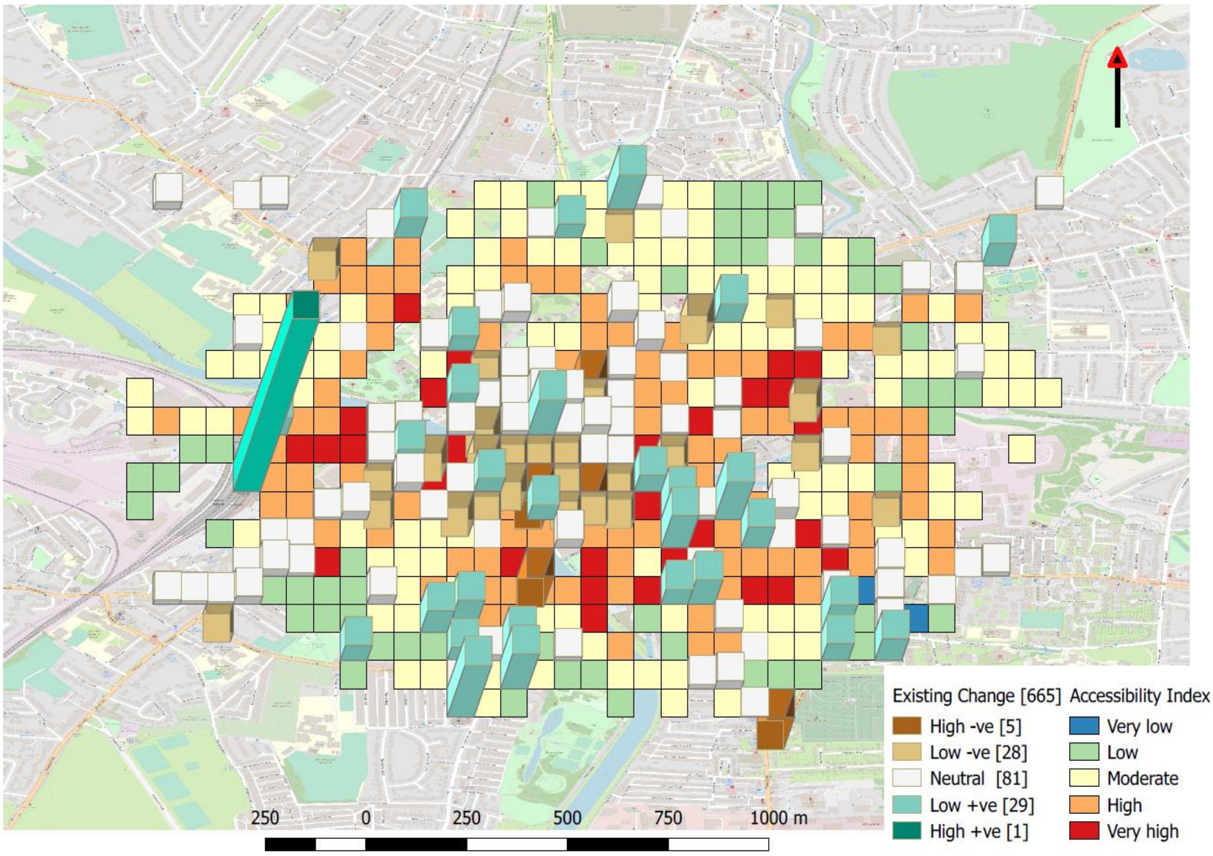
Table 5.2.3: Spatial relationship outputs between the CMP and RPM variables on a typical spatial layout

RPM / CMP	Changes in retail rental value (∆Rent)	Changes in retail floor area (∆FA)	Changes in retail cluster (∆C)
Integration	1. Integration, ∆Rent	2. Integration, ∆FA	3. Integration, ∆C
Choice	4. Choice, ∆Rent	5. Choice, ∆FA	6. Choice, ∆C
NACH	7. NACH, ∆Rent	8. NACH, ∆FA	9. NACH, ∆C

Source: Researcher's own (2019)

Table 5.2.3 illustrates the spatial relationships outputs (maps) between the CMP and RPM variables at one sampled layout. It indicates that nine (9) spatial relationship maps will be obtained from a sampled layout. Consequently, 54 relationship (vector) maps were obtained in all the six sampled layouts. To enhance visualisation of the relationships between the analysed variables, the grid pattern of the RPM variables were extruded using columns. As such, a 3D column stack representing the amount of changes in the RPM variable were overlaid on the accessibility tiles of the CMP variables as presented in an example figure, Figure 5.2.5.

Figure 5.2.5: Spatial relationship outputs between the RPM variable and CMP variable of a sampled layout.



Source: Researcher's own (2019)

The heights of the columns represent the number of changes in the RPM in that location, while the colours show the types of changes that have occurred. For example, brown meaning negative changes and green columns indicating positive changes in the RPM. Conversely, the accessibility index tiles show the extent of the configured consumer movement across the sampled spatial layout, where red represents the highest concentration of consumer movement and blue signifies the lowest concentration of consumer movement as indicated in Figure 5.2.5.

At this stage, the main investigation conducted was to visualise (and assess) relationships between the configured concentration of consumer movement (that is, accessibility index) and the amount (and type) of changes in the RPM variables at different locations across the sampled layout. The spatial relationship investigation attempts to establish – *if, the higher the accessibility index, the more (or less) the changes in RPM variables*. That is, the study visually assesses how the accessibility index relates to the RPM (variable) performance across the locations of the sampled layouts. Locations having high accessibility and high changes (negative or positive) in RPM variables are considered to show relationships and vice versa. Such an assessment was conducted across all the 54 relationship outputs of all the sampled CMP and RPM variables across all the sampled layouts. (However, preliminary investigations of the spatial relationships demonstrate that changes in floor space and changes in retail cluster exhibit similar characteristics throughout. Hence, the presentation of the result in Chapter 6 has shown the pairs relationship performance as changes in stock (see Chapter 6 for further discussion on the results).

This relationship outputs reveal different results (as further discussed in Chapter 6) across the analysed spatial layouts, especially across mesoscale and macroscale relationship investigations. However, this research contends that this method of assessing relationships between the RPM and CMP variables could not provide conclusive relationship outputs between the analysed variables. This is primarily because the approach could neither ascertain nor quantify the extent of the relationships between variables across the sampled layouts, despite extruding the RPM variables for better visualisation of the extent of the relationship.

Consequently, statistical analysis between the variables was necessary to determine the extent of the relationship (among other objectives). The following section presents the method, techniques and reasons for conducting statistical analysis on the locational relationships between the RPM and CMP variables.

5.3 Statistics Analysis of Variables: Correlation and Regression

Having conducted spatial relationships investigations on the variables by overlaying the RPM (stack columns) on the CMP accessibility tiles in QGIS. The attribute data of the spatial outputs were exported in tables into SPSS for statistical investigations. This section presents details on the statistical investigations conducted on all the variables across the sampled layouts. There are two broad goals for conducting statistical analyses on the RPM and CPM variables across all the sampled layouts. The first is to *quantify* the *significance of* the *relationships* between each of the CMP variables (integration, choice and NACH) on the obtained changes in RPM variables (changes in rental value, floor space and retail cluster) across all the six (6) sampled layouts. The second (which rely on the first) was to *estimate future changes (performance)* in the RPM per location across all the sampled layouts.

The computed group stat value (that is, attributes) of the RPM and CMP variables were exported from QGIS into SPSS as tables for all the sampled layouts. Each table represents each spatial layout and contains the investigated parameters of the RPM (i.e. changes in retail rental value and changes in stock) and the CMP (i.e. integration, choice and NACH)**.** Two interrelated statistical tests that were conducted on the sampled variables to achieve the intended research goals. These statistical tests were correlation and regression analyses. The following subsections present details of these tests.

5.3.1 Correlation analyses: Spearman rho coefficients

Correlation analysis was conducted on all the six tables to measure the extent of the relationship between the RPM parameters and CMP parameters across all the analysed sampled spatial layouts. In simple terms, the correlation tests quantify the relationship between the ranked values of the CMP and RPM variables (as obtained in QGIS). Accordingly, the *monotonic relationships* between these variables were investigated using Spearman rho coefficients tests in SPSS. It is important to state that since the investigated variables are rank values (and not numerical values), a straight-line relationship is not expected but a monotonic relationship (see Chapter 4 for more details). This justifies the essence of adopting Spearman rho coefficients and not Pearson coefficients. The main investigations of the Spearman rho coefficients' results were to assess the occurrence of the significance of the CMP variables on the RPM variables on all the sampled layouts. Essentially, the research investigates the number of times all the CMP variables show significant relationships with the RPM variables across the sampled layouts. Consequently, this study was able to establish the spatial layouts and RPM variable(s) that show significance with all the CMP variables. This research contends that scenarios (spatial layouts and RPM variables) whereby all CMP variables demonstrate significant relationships with RPM variables can be predicted as taking the CMP variables (as the independent variable). Specifically, the spatial layouts that have all the CMP variables showing significance with any of the RPM variables should be able to estimate the future performance of that RPM variables in that spatial layout via regression analysis of the data variables. Consequently, correlation testing using Spearman rho coefficients was able to establish *estimable spatial layouts* and *estimable RPM variables*. The ensuing subsection presents the regression analyses conducted on the investigated variables.

5.3.2 Regression analyses: multiple regression coefficients

The main reason for experimenting regression analysis on the configured CMP variables and computed RPM variables was to investigate the possibility of predicting the future performance of the RPM variables across delineated locations on the sampled spatial layouts. In doing this, the RPM variables were computed as the dependent variables on the independent variables of the three investigated CMP variables as presented in equations 4–6 below:

$$Y_1 = a + b_1X_1 + b_2X_2 + b_3X_3 \quad (4)$$

$$Y_2 = a + b_1X_1 + b_2X_2 + b_3X_3 \quad (5)$$

$$Y_3 = a + b_1X_1 + b_2X_2 + b_3X_3 \quad (6)$$

Where:

‘Y_1, Y_2 and Y_3 are the RPM variables, representing changes in rental value, floor space and retail cluster.

‘a’ is the constant regression coefficient

‘b’ is the coefficient of the corresponding independent variable

‘X_1’, ‘X_2’ and ‘X_3’ are configured consumer movement metrics (independent) variables representing integration, choice and NACH metrics, respectively.

Please note that this experimental research has not focused on the above models accuracy but its potential applicability. Hence, further tests on the model fitness and errors have not been conducted in this thesis, although recommended (see Chapter 7). However, inserting the variables into the corresponding models will mean that the estimated values of the dependent variables will be:

Estimated Changes in retail rental value = a + bIntegration + bChoice + bNACH (7)

Estimated Changes in retail floor area = a + bIntegration + bChoice +bNACH (8)

Estimated Changes in retail cluster = a + bIntegration + bChoice + bNACH (9)

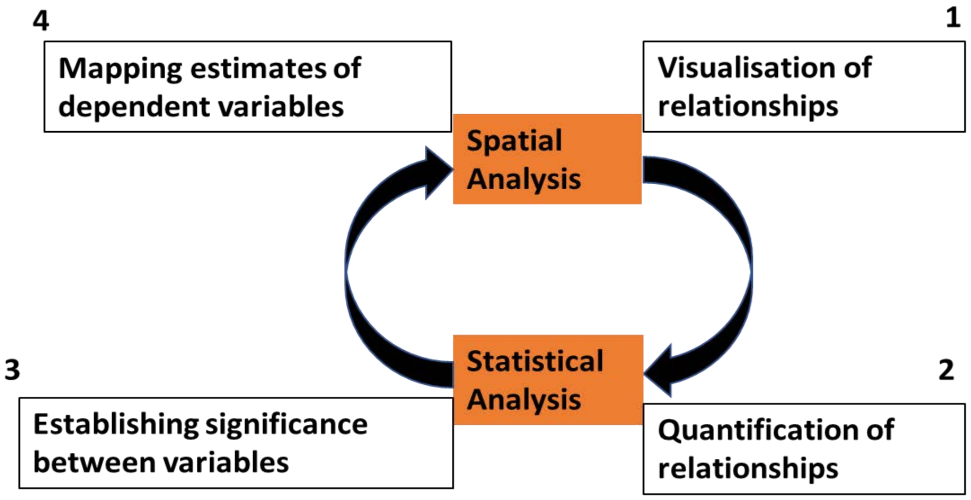
The above equations 7, 8 and 9 apply to all delineated locations across all the sampled layouts. For instance, the estimated values of locational changes in retail rental value, retail floor space and retail cluster can be calculated based on the obtained variables of CMP per grid. The research relies on the trends of estimated changes per locations rather than the actual estimated values per location. Therefore, the reliance on the above models is based on the calculated significance between variables and not the fitness of models to predict variables.

To visualise the trends estimated changes in RPM across all the estimable spatial layouts, the coefficients outputs of the corresponding models have been computed in the imported tables. As such, the multiple regression models have been computed to estimate the locational changes in the RPM variables. These tables were then exported into QGIS and georeferenced for visualisation of the estimable RPM variable(s) estimated for the estimable spatial layouts. It is important to understand the research has not mapped out the estimated values of the RMP variables as having a weak or no relationship at various spatial layouts in the final research outputs. Doing so could amount to meaningless results which could misguide retail market actors on the future locational trends of retail market variables (see Chapter 6 for details of results obtained).

5.4 Relationship analyses and presentation of the *research findings*

Relationship investigations between variables have been performed via spatial and statistical analyses in a circular manner. That is, the initial relationship investigation started with spatial analysis, then statistical analysis before being completed by spatial analysis as shown in Figure 5.4.1.

Figure 5.4.1: Procedural stages in analysing the relationships between variables



Source: Researcher's own (2020)

The initial spatial analysis between the investigated variables were examined in QGIS to visualise the relationships and prepare the variables for statistical analysis. Thereafter, statistical analysis was conducted to perform two key roles. The first role was to quantify the visualised relationships between variables. The second was to determine the significance/insignificance of the relationships between the variables, while testing for Spearman's rho correlation using SPSS. Subsequently, spatial analyses were conducted in QGIS to map the estimates of the dependent variables using the coefficients of the independent variables obtained from the earlier statistical analysis. (Spearman's rho correlation test was adopted since the investigated variables are ranked values).

Vector grid is the foundation of both analyses and presentations in this research. This is because it delineates city space (and street network) into locations for market analysis (interpretation) and developments of choropleth and 3D column maps, which have been used in presenting research results.

However, there are other means that could have been employed to present the results. This include the use common UK (geographical) boundaries such as, middle supper output area (MSOA) or local supper output area (LSOA) or any other form of artificial delineations of cities. These delineations (MSOA and LSOA) are beneficial because they are readily available and can easily be analysed with other datasets (including spatial accessibility and urban economic data). However, such delineations are insensitive to property market because property market relies on location and other similar elements.

It should be noted that technical (GIS) skills were put in place to transform variables' features from linear (streets), to points and then polygon (grids). This was necessary to enhance practical application and potential of the research findings. Table 5.4.1 reveals grid sizes (polygon features), retail units (points features) and street segment (linear features) across the investigated layouts.

Table 5.4.1: Sizes and number of grids (locations) per spatial layout

Spatial extents		Cities	Size of tiles	No. of retail units (point)	No. of Street Segments (linear)	No. of locations (polygon)
Mesoscale		Leeds	40,000m^2	2,726	16,144	292
		Newcastle	40,000m^2	2,027	12,499	295
		York	40,000m^2	1,159	11,412	128
Macroscale		Leeds	250,000m^2	8,101	71,106	876
		Newcastle	250,000m^2	5,320	76,221	519
		York	250,000m^2	2,190	41,816	252

Source: Researcher's own (2019)

Table 5.4.1 indicates that there are opportunities for visualisation of the relationships completed via points, linear and polygonal features analyses. However, this research has conducted relationships between variables via polygonal features because of the research objectives that aims to estimate the RPM performance. Specifically, visualising relationship analyses via points or linear features would have limited these investigations into analysing just the relationship between variables (and not estimating the RPM variable). Besides, preliminary investigations in this study have revealed similarities in the relationships between variables across all features.

Likewise, interpretation of the outputs of the RPM performance and CMP have been presented in charts (column charts) and tables respectively. This is conducted in order to capture, compare and analyse variables (RPM and CMP) across all sampled spatial layouts. All investigated locational changes in both RPM and CMP were computed into percentages for easy interpretation and comprehension of relationships. All vector maps were presented in Appendices A and B, while the tables summarising the characteristics and relationship of the variables are presented in tables in Chapter 6. The following subsections presents the investigated cities.

5.5 The study areas: sampled cities and spatial layouts

The sampled cities in this research are York, Leeds and Newcastle. These three (3) cities have been selected intentionally due to their unique characteristics in spatial distributions and retail markets. The following subsections discuss details on the sampled cities.

5.5.1 The City of York

The city of York is located in North Yorkshire, England on latitude $53^{0}58^{I}$ North and longitude $01^{0}04^{I}$ West of Greenwich Meridian (OS, 2018). The city was built on the confluence of the Rivers Ouse and Foss. The city (political) land boundary covers roughly $230km^2$, while the most developed part (including, the city centre) covers a land area of approximately $62Km^2$ (Boundary Commission for England BCE, 2018). The inner core of the city centre is strict in relation to further development, for the reason that historic listed buildings border it. The entire population residing in York is slightly above 200,000 consisting of about 90,000 households (ONS, 2018). However, the city attracts more than 7 million visitors (tourists) annually, who contribute to the city's retail expenditure (VisitYork, 2017).

York was the pilot study for this research. The rationale behind studying York is due to the monocentric landscape of the city fabric and retail distribution pattern within the city network. York is perhaps one of the few monocentric modern cities that has no large purpose-built shopping centre within its spatial network. As such, excessive artificial control of the retail property market (that is possible in shopping centres by landlords and managers) is almost impossible within the city. Put differently, a close-to-perfect ownership market exists in York. This allows for an uninterrupted investigation into the city's retail property market at macroscale and mesoscale levels. Similarly, the city is relatively well-defined and small, both in land area, and the commercial (retail) property market size. Hence, the city is suitable for piloting the research method.

5.5.2 The City of Leeds

Leeds is the regional capital and main economic driver for Yorkshire, England. It is located in West Yorkshire on latitude $53^{0}48^{I}$ North and longitude $01^{0}33^{I}$ West of Greenwich Meridian (OS, 2018). Leeds is a city of roughly 690,000 people covering an area of $562km^2$ (ONS, 2013). The city is the second largest metropolitan authority in England and the largest in the North of England. Leeds welcomes 25 million visitors every year who spend over £654 million within the physical retail space annually. Leeds city centre is compact and developments have spread across the border, even though two thirds of its land area is open spaces and greenbelt (BCE, 2018).

The reason for choosing Leeds as the second study area for this research is because of its distinctiveness from the pilot study area i.e. York. While York is a relatively well-defined and small city, Leeds is a bigger city that has retail developments spread extensively across its city network. In addition, both city centres are distinct. Unlike, York that has no covered shopping centre within its city centre, Leeds has four (4) shopping centres within its core. Meaning market competition between the retail property landlords is *not as perfect* as that in York. This research anticipates that analysing retail property markets within these two distinctive cities will shed new light on the relationship between spatial configuration outputs (CMP) and retail property markets. To confirm this further, the research examines a third peculiar city that differs from Leeds and York in terms of spatial and retail distributions. Consequently, the City of Newcastle was investigated.

5.5.3 The City of Newcastle

Newcastle, herein, refers to the spatial jurisdictions of Newcastle upon Tyne and Gateshead. Although Newcastle upon Tyne and Gateshead are governed by different local authorities and are divided by the River Tyne, developments in both cities are closely connected. Consequently, the retail activities that exist between these two local authorities are more robustly combined. The City is located in Northeast England on latitude 54^{0} 58^{I} North and longitude $01^{0}36^{I}$ West of the Greenwich Meridian. Newcastle (including Gateshead) is a city of roughly 501,000 people and covers an area of approximately 170km^2 (ONS, 2017; OS, 2018). Newcastle has more than one city (retail) centre within its spatial layout. The notable city centres are Newcastle's city centre, Gateshead centre and the Gateshead Metro Centre. However, a single landlord (that is, Intu) owns 50% of the retail floor space within the city centre. Consequently, most of the retail floor space in the defined spatial layouts of Newcastle is owned and controlled by a single landlord. Denoting that a monopoly could exist in the retail market in comparison to Leeds and York.

This research has selected York, Leeds and Newcastle as the sampled study area because of the variations in the cities' retail market characteristics. Table 5.5.1 summarises the differences in the retail market and spatial characteristics of the three sampled cities.

Table 5.5.1 Characteristics differences in the Retail Markets of York, Leeds and Newcastle

s/no	Characteristics	York	Leeds	Newcastle
1	Centricity	Monocentric	Monocentric	Polycentric
2	Size	Small	Large	Small
3	Number of shopping centres	No purpose-built shopping centre	Up to four (4) purpose-built shopping centres	More than one purpose-built shopping centre.

4	Proportion of retail space ownership	Not applicable	Different ownerships (Landlords), but dominated by few	Owned and controlled by a landlord
5	Market competition	Close-to-perfect market	Oligopoly markets	Monopoly market

Source: Researcher's own(2018)

Simultaneously, investigations of the relationships between the performance of the retail property market and consumer movement patterns have been completed on these three cities at macroscale and mesoscale layouts.

5.6 Chapter summary

This chapter has further explained the RPM and CMP variables. The chapter presented the reasoning behind adopting existing (VOA) data in analysing the RPM variables. Similar justifications for configuring street networks in obtaining the CMP variables have been presented in this chapter. It reveals the procedural steps taken in obtaining all the variables' indicators adopted in conducting relationships analyses between RPM and CMP across the sampled cities layouts. The chapter presented and explained options on the methods and tools available for conducting locational (spatial and statistical) analyses on the relationships between retail property markets and retail consumer movement patterns across cities. Concomitantly, the chapter reveals justifications for the tools and methods adopted in this research. Overall, the chapter presented the logical, methodological approaches adopted in executing the research objectives. The next chapter presents results relating to the identified research objectives.

Chapter Six

Results Discussions & Implications

6.0 Introduction

This chapter presents and discusses the research results. The chapter is divided into five main sections. The first section presents the results related to the characterisation of the RPM and CMP variables across the sampled layouts to meet objectives 1 and 2 of this research, respectively. The second section presents the relationships between the RPM and CMP variables to meet objective 3 of this study. The third section presents the estimates of the RPM variables to meet objective 4 of this research. Sections four and five present the implications of the findings and summary of this chapter, respectively.

6.1 Characterisation of RPM and CMP across the sampled layouts

This section presents the results regarding the locational performance of the RPM and CMP variables across the sampled layouts. Appendices A and B contain results (location vector maps) for the RPM and CMP variables, respectively. This section highlights and discusses key findings from investigating the locational performance of the RPM and configured CMP variables across all the sampled cities at meso and macro scales. The following subsection presents results on the performance of the RPM variables across the sampled layouts.

6.1.1 Locational performance of the *RPM variables across sampled layouts*

Results (Appendix A) obtained from analysing the data reveals that locational changes in retail market variables across the sampled layouts can be broadly classified into three (3) types, namely:

i. Existing location change,

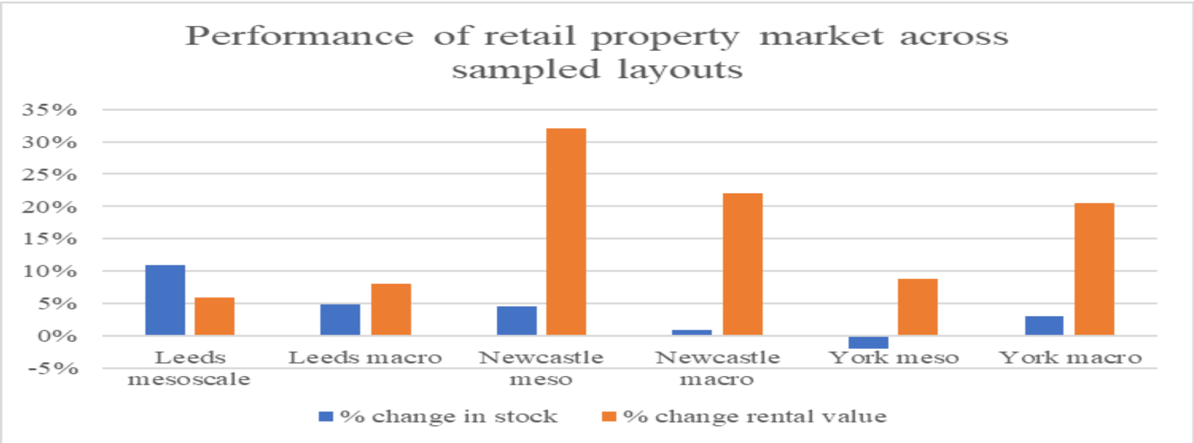
ii. Emerging location change,

iii. Displaced location change.

The *existing changes* are locational changes between retail market variables that have occurred at both the initial (2010) and later (2017) two census points (in time). Existing changes covers more than 90% of the three change types across the sampled layouts. Further results on existing changes reveal that locational changes in retail markets can be *positive*, *negative* or *neutral* (no) changes. Meanwhile, *emerging location change* are new locations that were not in existence in 2010 but occurred in 2017. The emerging change is an indication of positive retail market changes, whilst the *displaced locational changes* are locations that have lost 2010 retail space by 2017. Hence, this suggests that the displaced changes are negative performance indicators of retail market variables. Moreover, it should be mentioned that the existing, emerging and displaced locational changes have been mapped to reflect comprehensiveness in the RPM performance. However, only existing changes have been adopted in conducting visual and statistical relationships with CMP variables (section 2 of this chapter). As a consequence, this allows prevailing changes to be investigated and not just displaced along with emerging changes. Doing so does not have any serious implications, as more than 90% of the investigated locations are within the existing locational change category.

Locational investigations on the distributions of the RPM variables denote that *variations in* the *spatial boundary sizes of cities influence* the *interpretation of* the *market (RPM variables) during visualisation (in GIS)*. Results on the locational performance of the RPM variables across sampled layouts reveal that city layouts and retail market interpretations at mesoscale and macroscale differ for the same city (see Appendix A). Basically, the patterns of distribution of the RPM variables performance at a city macroscale differs at the city mesoscale. For example, at the York macroscale, the pattern of RPM performance indicates the city is monocentric. However, at the mesoscale, the pattern of RPM performance does not suggest that the city is monocentric. Likewise, the RPM performance at Leeds macroscale reveals the multi-nuclei (polycentric) characteristics of the city. However, the same visual result is not obtainable at the mesoscale analysis, suggesting the city layout and retail market interpretations are influenced by the sizes (scales) of the analysed city spatial layouts. Although such results are expected to emerge because of changes in city areas, it should be noted that preceding researches that have characterised cities as monocentric (Burgess, 1925) and multi nuclei cities (Harris and Ullman, 1945) completely disregard the influence of the extent of the analysis. Similarly, earlier studies (Brown 1990; 2006; Lowe and Wrigley, 2000) on urban retail completely overlooked that the extent of the investigated cities can influence the understanding of city characteristics and retail property markets. Figure 6.1.1 presents a clearer picture of retail property market performance across the sampled cities at mesoscale and macroscale.

Figure 6.1.1. Percentage changes (2010-2017) in retail rental value and stock across sampled cities at scales



Source: Research output (2019)

Figure 6.1.1 reveals the dynamic characteristics of retail property market (performance). The aggregate changes in retail rental value and stock between 2010 and 2017 differ in degree across scales. Essentially, *interpretation of the performance of retail property markets at cities changes as the extent of the analysed cities changes*. Notably, the direction of retail stock performance at York mesoscale is different from that of York macroscale and vice versa. Put differently, the aggregate changes in property market variables (rent and stock) is positive or negative, is not a true picture, until the extent of the analysed cities are considered. *These results caution as regards analysing city property market performance without considering the extent of the city analysis*. The results challenge similar studies (Jones and Orr, 1999; Lowe and Wrigley, 2000; Theriault et al., 2005; Adebayo et al., 2019a; Greenhalgh et al., 2020) that have explored changes in property market variables in cities without considering the amount of cities covered in their analyses. (See Appendix E for details of RPM overall performance across the cities).

Further analyses into the locational performance of RPM show that the demand (i.e. changes in retail rental value) and supply (i.e. changes in retail stock) variables exhibit constant behavioural change distributions across the three sampled cities at meso and macro scales. Thus, the demand variable shows more (market) elasticity than the supply variables across all the sampled layouts. In simple terms, changes in retail rental value have occurred more at different locations than changes in stock across all the sampled layouts. Whilst there are many factors that would have been responsible for such performance behaviour in the demand and supply of retail property markets across cities, this research does not focus on these factors but the relationships between the changes in retail market variables and consumer movement. The next subsection presents results on the visual patterns of consumer movement as configured by means of the space syntax ideology of street segment analysis.

6.1.2 CMP variables across sampled layouts

Whilst the distribution patterns and performance interpretations of the RPM variables vary across macro and meso scales, results pertaining to the configured CMP variables (namely, integration, choice and NACH) indicate that the distribution and interpretation of the CMP variables are consistent across the sampled layouts as summarised in Table 6.1.1 below (see Appendix B for the vector maps relating to the CMP parameters).

Table 6.1.1: Distribution of CMP parameters across sampled layouts

CMP variables	Accessibility interpretation	Leeds meso (n=311)	Leeds macro (n=934)	Newcastle meso (n=296)	Newcastle macro (n=520)	York meso (n=134)	York macro (n=251)
Integration 0-20	Very low	2 (1%)	57 (6%)	0 (0%)	1 (0%)	0 (0%)	0 (0%)
Integration 21-40	low	6 (2%)	0 (0%)	2 (1%)	0 (0%)	2 (1%)	0 (0%)
Integration 41-60	Medium	60 (19%)	70 (7%)	66 (22%)	87 (17%)	9 (7%)	19 (8%)
Integration 61-80	High	170 (55%)	566 (61%)	140 (47%)	336 (65%)	65 (49%)	115 (46%)
Integration 81>	Very high	73 (23%)	241 (26%)	88 (30%)	97 (19%)	58 (43%)	117 (47%)
Choice 0-20	Very low	278 (89%)	902 (97%)	277 (94%)	500 (96%)	80 (60%)	219 (87%)
Choice 21-40	low	18 (6%)	22 (2%)	12 (4%)	7 (1%)	32 (24%)	19 (8%)
Choice 41-60	Medium	10 (3%)	6 (1%)	4 (1%)	2 (0%)	13 (10%)	10 (4%)
Choice 61-80	High	3 (1%)	3 (0%)	2 (1%)	8 (2%)	5 (4%)	2 (1%)
Choice 81>	Very high	2 (1%)	1 (0%)	1 (0%)	3 (1%)	4 (3%)	1 (0%)
NACH 0-20	Very low	9 (3%)	58 (6%)	0 (0%)	48 (9%)	3 (2%)	0 (0%)
NACH 21-40	low	10 (3%)	0 (0%)	3 (1%)	6 (1%)	5 (4%)	0 (0%)
NACH 41-60	Medium	78 (25%)	28 (3%)	10 (3%)	108 (21%)	12 (9%)	26 (10%)
NACH 61-80	High	176 (57%)	803 (86%)	36 (12%)	279 (54%)	113 (84%)	216 (86%)
NACH 81>	Very high	38 (12%)	45 (5%)	247 (83%)	79 (15%)	1 (1%)	9 (4%)

Source: Research output (2019)

Table 6.1.1 shows that the investigated CMP parameters exhibit relatively consistent characteristics across the sampled layouts. For example, the choice parameter across the scales show that the majority (range 60%-97%) of the delineated locations have a very low (blue tile) choice value. Meanwhile, results on integration and NACH parameters appear similar across all the scales – where the majority of the locations are ranked within the high accessibility index (for example, 61-80). These results suggest that the CMP parameters, namely, integration, choice and NACH exhibit relatively consistent trends across cities, irrespective of the changes in cities and the extent of the analysis. The results presented in Table 6.1.1 are a clear indication that CMP indexes have been computed and scored scientifically based on the underlying streets (spatial configuration) of the cities. Essentially, the *accessibility index across the cities exhibit relatively similar behaviour, irrespective of the scale*. This result supports and further clarifies Hillier's (2007; 2010) philosophy on generic cities. In other words, the extent of city analysis may be inconsequential when investigating the spatial accessibility of a city network. However, when such investigation requires analysing relationships with urban economic data, such as rental value and stock, careful consideration of the extent of the analysis is essential.

Further investigations on the visualisation pattern of integration metrics across all the six sampled layouts maintain that the accessibility pattern follows a constant pattern that indicate the core of spatial layout as the most accessible, and moreover, the outermost parts of the spatial layouts, as the most segregated parts (see Appendix B). Specifically, the accessibility index of the spatial layouts reduces at distance out of the spatial layout core. These results are similar to Alonso's (1964), Bid-Rent Theory concerning the accessibility behaviour of city layouts. The distribution pattern of integration metrics across all the sampled layouts also reveals that few locations are ranked as very low index. The integration metrics maintains that the core of a spatial layout is the most accessible (red) part of that spatial layout irrespective of the layouts' sizes. Basically, the core of all the sampled layouts are the closest locations to every other location within the spatial layouts. The *interpretation of integration outputs is logical and adhere to existing city accessibility studies* (Lowe and Wrigley, 2000; Geurs and van Eck, 2003; Geurs and van Wee, 2004; van Wee et al., 2013; Geurs et al., 2015; Brown, 2006) that have signalled the concentration of retail (and commercial) activities at the city centres because of accessibility and centrality advantages.

Similarly, the visualisation of choice parameter across the six sampled layouts are uniform but differ from the integration outputs. The choice distributions depict that many of the delineated locations (across the six spatial layouts) are indicated as very low accessibility index (only a few are ranked as high accessible locations). Specifically, the *choice metrics indicate that many locations will least serve as a link to every other locations when navigating the entire layouts while taking the shortest routes* (see explanations on CMP variables in Chapter 4). This result suggests that choice metrics are better at capturing consumer movement patterns on a few street networks than large street networks. On a similar note, the configured NACH metrics shows that there is uniformity in the pattern of accessibility distributions across all the sampled spatial layouts. The pattern distribution of NACH outputs at mesoscale and macroscale is such that many of the delineated locations are ranked as high accessible index, and very few locations consist of a very low index. Although NACH metrics outputs do not demonstrate intelligible (uniform) patterns of accessibility within cities as obtained in choice (and integration) metrics, analysis conducted in this study indicates that the NACH metrics better interpret CMP on street networks in contrast to choice metrics. This is because of the improved distribution of NACH's accessibility index in comparison to choice metrics.

Results across all the sampled layouts show that the pattern of consumer through-movement metrics (specifically, NACH and choice) are not visually the same despite both being the measures of through-movement. Conversely, *there is no known existing city or retail models that have explained accessibility, movement or city spatial behaviour in the way Choice and NACH parameters have*. This suggests that *through-movement configurations of city spatial layouts are more of a scientific narrative than obtained reality*, despite, studies such as (Peponis, et al., 1997; Chiaradia et al., 2009) revealing the relationships between property market variables and through-movement metrics. The result explains the reason why some studies (Rodriguez et al., 2010; Netzel, 2013; Muldoon-Smith et al., 2015) have focused on investigating only integration (to-movement) parameters and not choice (through-movement) when investigating the relationships between spatial accessibility and property/urban market variables. This result confirms that the reality of human/consumer movement might not necessarily follow a structured pattern of configuring the through-movement metrics (choice and NACH), as obtained in the to-movement metrics (integration), where the accessibility patterns follow illustrations of Bid-Rent Theory and other city retail models. Based on these findings, *through-movement metrics are scientifically important rather than being factual*, whereas the *to-movement metrics exhibit traits of fact (on city retail behaviour and accessibility) despite being computed using scientific rules*.

It can be argued that the locational performance of retail markets is not entirely dependent on retail consumer movements. Similarly, consumer movement does not entirely depend on street connectivity that spatial configuration analysis is based on. Consequently, *a perfect relationship across spatial layouts between CMP and RMP variables is unlikely*. Nevertheless, there is the possibility of having locational relationships between the configured CMP variables and the performance of RPM on spatial layouts. It is the possibility of the relationship between the CMP variables and RPM variables at various cities (and scales) that have been investigated in this research. Results on locational relationships between RPM performance and consumer movement (CMP) index on the sampled cities at mesoscale and macroscales are presented in the subsequent section.

6.2 Locational relationships between RPM and CMP variables

Relationships between RPM and CMP variables across spatial layouts have been broadly investigated in two stages. The first stage visualises the locational performance of the RPM and CMP variables across the sampled cities at meso and macro scales in GIS. The second stage quantifies relationships between variables across all sampled spatial layouts in SPSS. Results pertaining to the geo-visualisation of the locational relationships between the RPM performance and configured CMP variables have been attached as an appendix (see Appendix C, Figures 1-36). The following section discusses the key findings from the geo-visualisation of relationships between RPM and CMP across the three sampled layouts.

6.2.1 Geo-visualisation of the *spatial relationships between RPM and CMP variables*

Visual relationships between RPM variables (that is, changes in retail rental value and in retail stock) and CMP variables (integration, choice and NACH) were performed by superimposing RPM stack columns on the CMP tiles (see Chapter 5 for details). Visual relationships between variables were decided on the basis of the locational ranking of changes in retail market (stock and rental value) and the accessibility index of the CMP variables. Specifically, *the location changes of high (negative and positive) RPM variables on high accessibility index tiles, means that a relationship exists between variables in that location and vice versa*. In other words, alignments between variables rankings were visually explored and the perceptions of all the locations are judged to determine the spatial relationship between variables.

As expected, the results explain that there is no perfect relationship (correlation) across all the visualised variables at all the sampled layouts. However, there are indications that suggest possible correlations based on the global visualisation of the locational relationship between the CMP and RPM variables. As such, relationships (results) between variables have been grouped into *correlation unlikely* and *correlation likely* at this stage. The probability of a correlation between variables are further quantified using a statistical tool (for example, Spearman-rho coefficients) in the next stage (see Appendix C for details of maps showing the spatial relationships between the RPM and CMP variables across all sampled layouts). Table 6.2.1 summarises key findings from the spatial relationships between the RPM and CMP variables across the sampled layouts.

Table 6.2.1: Geo-visualisation of the relationships between the RPM and CMP variables across sampled layouts

No.	Variables	Cities	Extents	Key result (findings)	Interpretation
1	ΔRent [1], Integration	York	Mesoscale	Changes align with high accessible index	Correlation likely
2	ΔRent, Integration.	York	Macroscale	Changes align with high accessible index	Correlation likely
3	ΔRent, Integration.	Leeds	Mesoscale	Changes align with high accessible index	Correlation likely
4	ΔRent, Integration.	Leeds	Macroscale	Changes align with high accessible index	Correlation likely
5	ΔRent, Integration.	Newcastle	Mesoscale	Changes align with high accessible index	Correlation likely
6	ΔRent, Integration.	Newcastle	Macroscale	Changes align with high accessible index	Correlation likely

[1] ΔRent is change in retail rental value

7	ΔStock [2], Integration.	York	Mesoscale	Changes occurred often on the high accessible index	Correlation likely
8	ΔStock, Integration.	York	Macroscale	Changes do not align with high accessible index	Correlation unlikely
9	ΔStock, Integration.	Leeds	Mesoscale	Changes occurred often on the high accessible index	Correlation likely
10	ΔStock, Integration.	Leeds	Macroscale	Changes do not align with high accessible index	Correlation unlikely
11	ΔStock, Integration.	Newcastle	Mesoscale	Changes align with high accessible index	Correlation likely
12	ΔStock, Integration.	Newcastle	Macroscale	Changes align with high accessible index	Correlation likely
13	ΔRent, Choice	York	Mesoscale	Changes do not align with high accessible index	Correlation unlikely
14	ΔRent, Choice	York	Macroscale	Changes do not align with high accessible index	Correlation unlikely
15	ΔRent, Choice	Leeds	Mesoscale	Changes often align with high accessible index	Correlation likely
16	ΔRent, Choice	Leeds	Macroscale	Changes do not align with high accessible index	Correlation unlikely
17	ΔRent, Choice	Newcastle	Mesoscale	Changes do not align with high accessible index	Correlation unlikely
18	ΔRent, Choice	Newcastle	Macroscale	Changes do not align with high accessible index	Correlation unlikely
19	ΔStock, Choice	York	Mesoscale	The few changes occurred most on the high accessible index	Correlation likely
20	ΔStock, Choice	York	Macroscale	Changes do not align with high accessible index	Correlation unlikely
21	ΔStock, Choice	Leeds	Mesoscale	Changes do not align with high accessible index	Correlation unlikely
22	ΔStock, Choice	Leeds	Macroscale	Changes do not align with high accessible index	Correlation unlikely
23	ΔStock, Choice	Newcastle	Mesoscale	Changes do not align with high accessible index	Correlation unlikely
24	ΔStock, Choice	Newcastle	Macroscale	Changes do not align with high accessible index	Correlation unlikely
25	ΔRent, NACH.	York	Mesoscale	Changes often align with high accessible index	Correlation likely
26	ΔRent, NACH	York	Macroscale	Changes often align with high accessible index	Correlations likely
27	ΔRent, NACH	Leeds	Mesoscale	Changes often align with high accessible index	Correlations likely
28	ΔRent, NACH	Leeds	Macroscale	Changes often align with high accessible index	Correlations likely
29	ΔRent, NACH	Newcastle	Mesoscale	Changes often align with high accessible index	Correlations likely
30	ΔRent, NACH	Newcastle	Macroscale	Changes do not align with high accessible index	Correlations unlikely
31	ΔStock, NACH	York	Mesoscale	Changes often align with high accessible index	Correlations likely

[2]ΔStock refers to changes in retail floor space and in retail cluster. Preliminary investigations have indicated a perfect correlation between these two supply variables. As such, their relationships with any of the CMP variables are the same.

32	ΔStock, NACH	York	Macroscale	Changes do not align with high accessible index	Correlations unlikely
33	ΔStock, NACH	Leeds	Mesoscale	Changes often align with high accessible index	Correlations likely
34	ΔStock, NACH	Leeds	Macroscale	Changes do not align with high accessible index	Correlations unlikely
35	ΔStock, NACH	Newcastle	Mesoscale	Changes often align with high accessible index	Correlations likely
36	ΔStock, NACH	Newcastle	Macroscale	Changes do not align with high accessible index	Correlations unlikely

Source: Research outputs (2019)

Geo-visualisation of the relationships between variables across sampled layouts signal that *correlation exists between changes in retail rental value and integration metrics across all the sampled layouts, irrespective of the extent of city analysis*. Likewise, results show that relationships between changes in stock and configured integration metrics also exist across mesoscales of all the sampled cities. In essence, the results confirm that there is more consistency in the relationships between the integration and RPM variables (that is, ΔRent and ΔStock), than other CMP variables (namely, choice and NACH) across sampled cities at scales. Table 6.2.1 shows that correlations between changes in retail stock and integration are likely across all the three mesoscales (plus the macroscale of Newcastle). This result upholds and adheres to Pavlovskaya (2002), Chiaradia et al. (2009), Netzel (2013) and Muldoon-Smith et al. (2015), findings concerning the effects of integration on retail rental value.

Furthermore, results suggest that a weak relationship exists between the performance of the RPM (for instance, changes in retail rental and retail stock) and configured *choice metrics*. Results indicate that correlations are generally unlikely between RPM performance and configured choice metrics across the sampled layouts. The only exceptions are at Leeds mesoscale and York mesoscale where relationships between RMP and choice metrics are likely. This result upholds the earlier indications (in Chapter 4) that choice metrics do not logically depict possible movement on spatial layouts as shown in the result (see Appendices B & C). The results also supported the essence of introducing *NACH metrics* by Hillier et al (2012). Results indicate that NACH metrics show the greater potential of correlating with the performance of the RPM variables than the choice metrics. The summary table pertaining to the results (Table 6.2.1) reveals that NACH metrics show more opportunities of correlating with changes in retail rental value and retail stock at the mesoscales of the three sampled cities. However, there are indications that NACH metrics does not correlate with RPM variables at macroscales for all the sampled cities based on the output maps.

Results have shown that relationships visualisation is less obscured at mesoscales than the macroscales across the three sampled cities, denoting that the extent of city analysis is observed as an important factor influencing relationships between variables. This is because relationships between variables across sampled layouts are more obvious at mesoscales than macroscales across the sampled cities. Basically, the difference in spatial layouts sizes show the possibility of influencing relationships between RPM and CMP variables.

It is important to understand that while geo-visualisation of RPM and CMP variables have been conducted to comprehend locational relationships between retail market performance and consumer movement, results obtained via visualisation are unpredictable. This is because there is no distinct line that can be drawn across visualised relationships. Thus, *there are occasions whereby changes in retail market variables occur on both the high accessibility and low accessibility index*. These irregularities in locational relationship weakens confidence in the outputs for visualising the configured CMP variables and the computed performance of the RPM. Essentially, variables relationships via geo-visualisation lacks intelligibility that can perfectly establish relationships between variables. Consequently, established relationships via visualisation are based on probability (possibility) clauses that require further verifications (Adebayo et al., 2019b). However, there are particular studies (Muldoon-Smith et al., 2015; Giannopoulou et al., 2016) that have investigated spatial configured metrics and urban (property) variables (especially rents), which have relied on the visual outputs of configured metrics. This research contends that the locational relationships between configured CMP and computed RPM cannot be concluded based on the mere visualisation of variables. Simultaneously, statistics quantification of configured (and other property) variables would be necessary to validate and establish more reliable relationship outputs between variables. Validating visual relationships via correlation coefficients will quantify relationships and deliver a greater understanding of the relationships between variables. Similarly, computing correlation coefficients will further assist in developing statistical models for estimating the future locational performance of RPM (that is, the last objective of this research). This research contends that - '*should a (significant) relationship exist between any of the RPM variables and CMP variables, then such CMP variables can be modelled as independent variable(s) for estimating the future of the dependent RPM variables'*. To quantify the relationships between the RPM and CMP variables, Spearman-rho coefficients[3] have been adopted to investigate and quantify correlations between the ranked variable of the CMP and RPM variables. The following section presents Spearman-rho correlation coefficients of variables across all the sampled layouts.

[3] Spearman rho coefficients have been adopted because straight-line relationships are not expected from the ranked (grid) variables. The main reason for conducting spearman correlation is to verify/validate visualisation of variables relationships and to determine the estimable RPM variables and spatial layouts. However, multiple regression coefficients (a product of straight-line graph) have been adopted in estimating the estimable RPM and spatial layouts.

6.2.2 Statistics relationships between variables: Spearman-rho correlation coefficients.

The statistical relationships between variables (RPM and CMP) using Spearman-rho correlation coefficients have been conducted to establish the estimable (RPM) variables and estimable spatial layouts. Spearman-rho correlation coefficients have been adopted to quantify relationships across RPM and CMP variables on account of the rank value characteristics of CMP variables (as previously explained in Chapter 4). The statistical correlation tests between variables have been computed while using the RPM and CMP variables as dependent and independent variables, respectively. Spearman-rho coefficients of variables have been computed across the three cities at mesoscale and macroscale to quantify the significance of relationships between configured CMP variables and the performance of RPM variables. The main reason for quantifying relationships between variables is to validate visual relationships and at the same time establish possible scenarios for estimating RPM (independent) variables using equations 7-9 (revealed in Chapter 5). To estimate RPM performance, *this research depends on situations whereby* ***all*** *CMP variables shows significant statistical relationships with changes in RPM variables*. In essence, this research only further investigates estimating dependent variables (RPM) on spatial layouts that show that all CMP variables have a significant influence (relationship) on changes in retail market variables. The spatial layouts that have all CMP variables having a significant relationship with RPM variables are identified as *estimable spatial layouts* and those that do not have all the CMP variables having a significant relationship with RPM variables are tagged *inestimable spatial layouts*. Similarly, the RPM variable(s) that have all the CMP variables comprising a significant relationship are identified as *estimable RPM variable(s)* and vice versa. Consequently, the research rejects estimating RPM variables on spatial layouts that CMP variables do not show significance in relation to RPM performance.

Table 6.2.2 presents Spearman-rho coefficients (outcomes) revealing the significance of the relationships between all CMP and RPM variables across all the sampled layouts.

Table 6.2.2: Spearman-rho correlation coefficient results

Sampled layouts	Variables	NACH	Choice	Integration
York Macroscale N=252	ΔRental Value	X	X	✓ (0.341)
	ΔRetail Stock	X	X	✓ (0.257)
York Mesoscale N= 128	ΔRental Value	✓ (0.206)	✓ (0.248)	✓ (0.471)
	ΔRetail Stock	X	X	✓ (0.375)
Leeds Macroscale N=876	ΔRental Value	X	X	✓ (0.194)
	ΔRetail Stock	X	X	✓ (0.248)
Leeds Mesoscale N=292	ΔRental Value	✓ (0.183)	✓ (0.187)	✓ (0.411)
	ΔRetail Stock	✓ (0.157)	X	✓ (0.390)
Newcastle Macroscale N=519	ΔRental Value	✓ (0.191)	✓ (0.172)	✓ (0.221)
	ΔRetail Stock	X	X	✓ (0.197)
Newcastle Mesoscale N=295	ΔRental Value	✓ (0.128)	X	✓ (0.333)
	ΔRetail Stock	X	X	✓ (0.333)

✓ = correlation significant at 0.01 level (2-tailed)
X = no significant correlation at 0.01 level (2-tailed)

Table 6.3.2 maintains that the integration metrics is the most consistent (and relevant) CMP variables on the performance of the RPM variables. Correlation results indicate that integration metrics significantly relate with the RPM variables (for instance, changes in retail rental value and retail stock) across all the sampled layouts. The results validate the visual relationships between variables, which had earlier suggested relationships between integration metrics and RPM variables across all the sampled layouts. The results uphold the relevance of integration metrics to city property variables as previously identified in Chiaradia et al. (2009), Law et al. (2013) and Muldoon-Smith et al (2015). Likewise, the correlation results have unlocked hidden visual relationships between variables. For example, the Spearman-rho correlation coefficients indicate that there are significant relationships between changes in retail rental value and NACH (and choice) metrics across spatial layouts, even though the visual relationships were unclear. This upholds the relevance of validating the visual relationships of the configured and computed market variables.

The compiled correlation results in Table 6.2.2 have shown that *changes in retail stock* are inestimable using the multiple regression equations 8 and 9 (see Chapter 5). This is because there is no scenario (spatial layout) whereby all the CMP variables have significant influence on changes in retail stock. These results could be linked to the sluggishness in changes in retail stock. Therefore, equations 8 and 9 do not meet the conditions for estimating the retail property market. The results support Evans (2008) arguments on difficulties in ascertaining the future performance of commercial property stock due to sluggishness as regards the supply-side. Although, spatial configuration of consumer movement appears to comprise more static variables (because it relies on street connectivity), *relationship analyses between variables do not show convincing outputs that the future performance of changes in stock are predictable based on the spatial configuration of consumer movements*. Fundamentally, it is almost uncertain in estimating future changes in retail property stock based on the mere investigation of street connections (spatial configuration).

However, results have indicated that relationships between all the CMP variables and changes in retail rental value are significant across *York mesoscale*, *Leeds mesoscale* and *Newcastle* *macroscale*. The results uphold the earlier visualisation outputs and more importantly, imply that locational changes in retail rental values are predictable base on the developed regression equation 7 (revealed in Chapter 5) for York mesoscale, Leeds mesoscale and Newcastle macroscale. Basically, *the relationships between CMP and RPM (mainly, changes in retail rental value) at York mesoscale, Leeds mesoscale and Newcastle macroscale meet the condition of estimating changes in retail rental value using equation 7*. However, estimating the changes in retail rental value at York macroscale, Leeds macroscale and Newcastle mesoscale are considered inestimable. This is because all the CMP variables do not demonstrate a significant relationship with changes in retail rental values at York macroscale, Leeds macroscale and Newcastle mesoscale. This research has not furthered investigations on estimating changes in retail stock (across all spatial layouts) and changes in retail rental values at macroscales of York and Leeds and Newcastle mesoscale as they are considered inestimable spatial layouts.

It is important to understand that while the Spearman-rho correlation results have shown significant relationships between variables across some aforementioned sampled layouts (York mesoscale, Leeds mesoscale and Newcastle macroscale), *the coefficient values across the relationships suggest that the obtained meanings between variables are weak*. This is because coefficient values of the significance of the relationships ranges from 0.128 to 0.471. This signifies that there are no strong significant relationships between configured consumer movement and locational changes in retail market variables as per the computed Spearman-rho correlation coefficients. These results are unsurprising, owing to the numerous factors influencing retail rental value (and retail stock) on spatial layouts and the characteristics of configured movement metrics (which is based on street connectivity rather than observed accurate movements of consumers). However, the only surprising result is the relationships between variables at Newcastle that show a significant relationship at a macroscale and not at a mesoscale. Whilst this study has not investigated the reason for such relationship results, the research suspects that the uniqueness of the retail property ownership market at Newcastle (characterised by monopoly) could be the reason for such a result. This research marks such investigations on the influence of the ownership market on relationships between CMP and RPM as an area of future research.

This research understands that the developed regression models (equations 7-9) can be enhanced by factoring in other CMP variables (and other variables that can influence RPM). However, it is important to recognise that it is beyond this the scope of this research to ascertain or enhance the model fitness of equations 7-9 (this is an area of future research). Instead, this experimental research adheres to exploring the relevance of spatial configured (consumer) movement (to-movement and through-movement) to changes in retail market in order to estimate future locational performance. This study focuses on the future performance of retail rental value on the estimable spatial layouts based on configured consumer movement variables (that is, integration, choice and NACH). The subsequent section presents regression coefficients adopted in mapping the future performance of the retail rental values of the estimable spatial layouts.

6.3. Estimate performance of RPM (retail rental value) at York, Leeds and Newcastle: Regression coefficients

This section presents results on the future (estimate) performance of retail rental value at York mesoscale, Leeds mesoscale and Newcastle macroscale. The RPM variables (i.e. changes retail rental values) and all CMP variables (integration, choice and NACH) were computed (in SPSS) such that the dependent and independent variables are changes in retail rental value and CMP variables, respectively. Table 6.3.1 summarises the regression coefficients between independent (CMP) variables and dependent (RPM) variables across the estimable sampled layouts.

Table 6.3.1: Regression coefficients results of the CMP variables on changes in retail rental value

Estimable Layouts	CMP Variables	Regression Coefficients (ΔRent- dependent)	Sig.
York Mesoscale N = 128	Constant	107.122	0.06
	NACH	-29.732	0.271
	Choice	0.257	0.452
	Integration	-0.974	0.048
Leeds Mesoscale N= 292	Constant	75.172	0.003
	NACH	-37.673	0.058
	Choice	1.114	0.057
	Integration	-0.545	0.094
Newcastle Macroscale N= 519	Constant	11.553	0.582
	NACH	-10.169	0.563
	Choice	1.246E-8	0.109
	Integration	0.002	0.591

Source: Research outputs (2019)

Table 6.3.1 shows the coefficients and significance of linear relationships between dependent (change in rental value) and independent variables (NACH, choice and integration) across the estimable spatial layouts. As expected, the results revealed that there are no perfect linear relationships between variables and that the develop model (i.e. equation 7) mostly suits Leeds mesoscale, York mesoscale and Newcastle macroscale in that order. This is because the significant values of the constant coefficients at Leeds and York mesoscale are very close to zero (see Table 6.3.1 above). Specifically, the possibility that the predicted outcome at Leeds mesoscale is higher than the York mesoscale and Newcastle macroscale when RPM is estimated using equation 7. However, this research has disregarded the significance level and has assumed that the model is fit for all the estimable spatial layouts (*remember that this research does not aim to enhance the fitness of the established model - equation 7)*. Applying the above coefficients (in Table 6.3.1) into the corresponding model at York mesoscale, Leeds mesoscale and Newcastle macroscale will mean:

Estimated RPM @ York mesoscale = 107.122 - 0.974Int + 0.257Choice -29.732NACH (10)

Estimated RPM @ Leeds mesoscale = 75.172 - 0.545Int +1.114Choice -37.673NACH (11)

Estimated RPM @ Newcastle macro = 11.553 +0.002Int +1.246E-8Choice -10.169NACH (12)

Where:

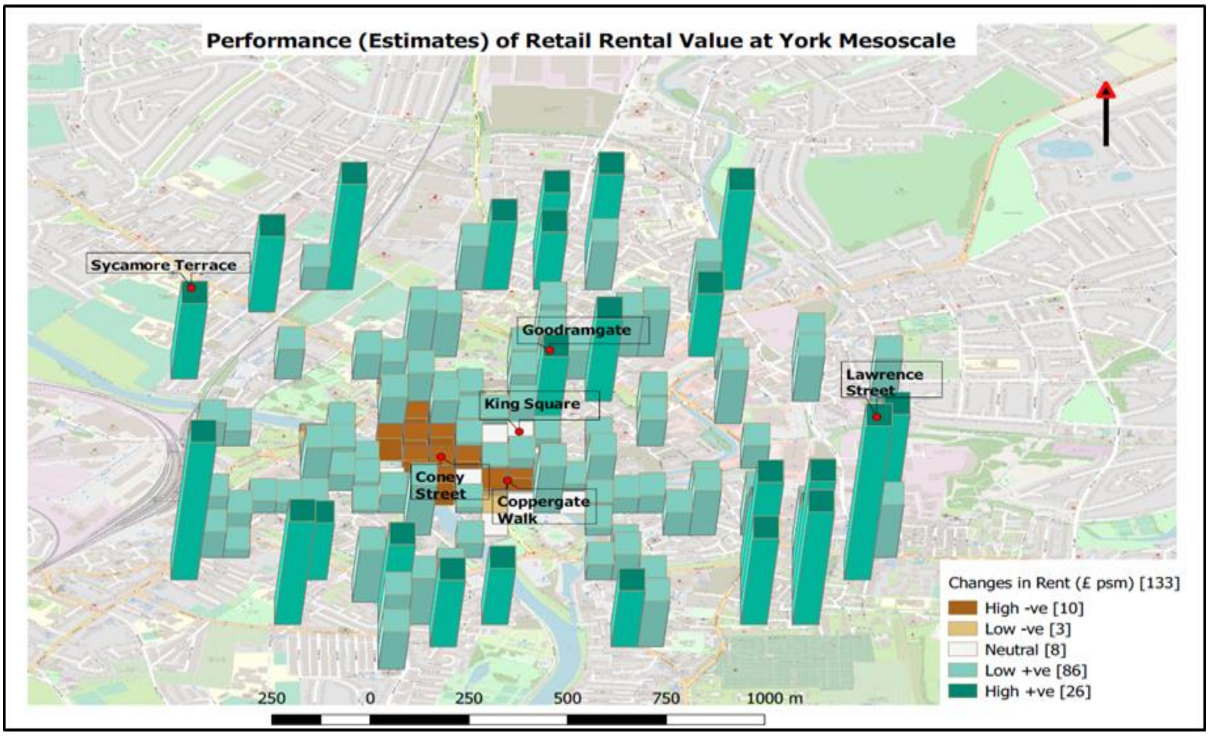
Estimated RPM = predicted values of locational changes in retail rental value.

Int = Integration

NACH = normalised angular choice

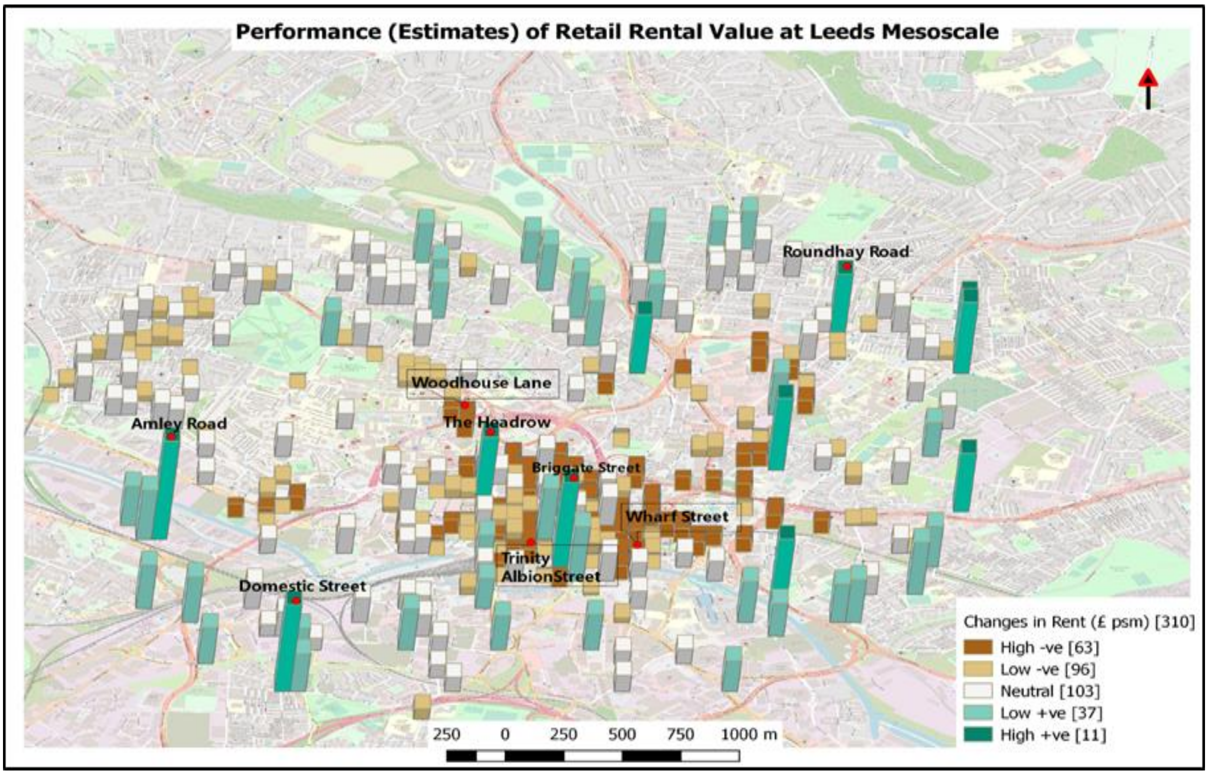
The above equations (10-12) were populated for all locations within the corresponding estimable spatial layouts using the MS excel and QGIS. Consequently, column (choropleth) maps were produced (in QGIS) to reveal future locational changes in retail rental value based on spatial accessibility. Figures 6.3.1, 6.3.2 and 6.3.3 reveal estimate of RPM performance (that is, predicted changes in retail rental value) across York mesoscale, Leeds mesoscale and Newcastle macroscale respectively.

Figure 6.3.1: Estimate changes in retail rental value at York mesoscale



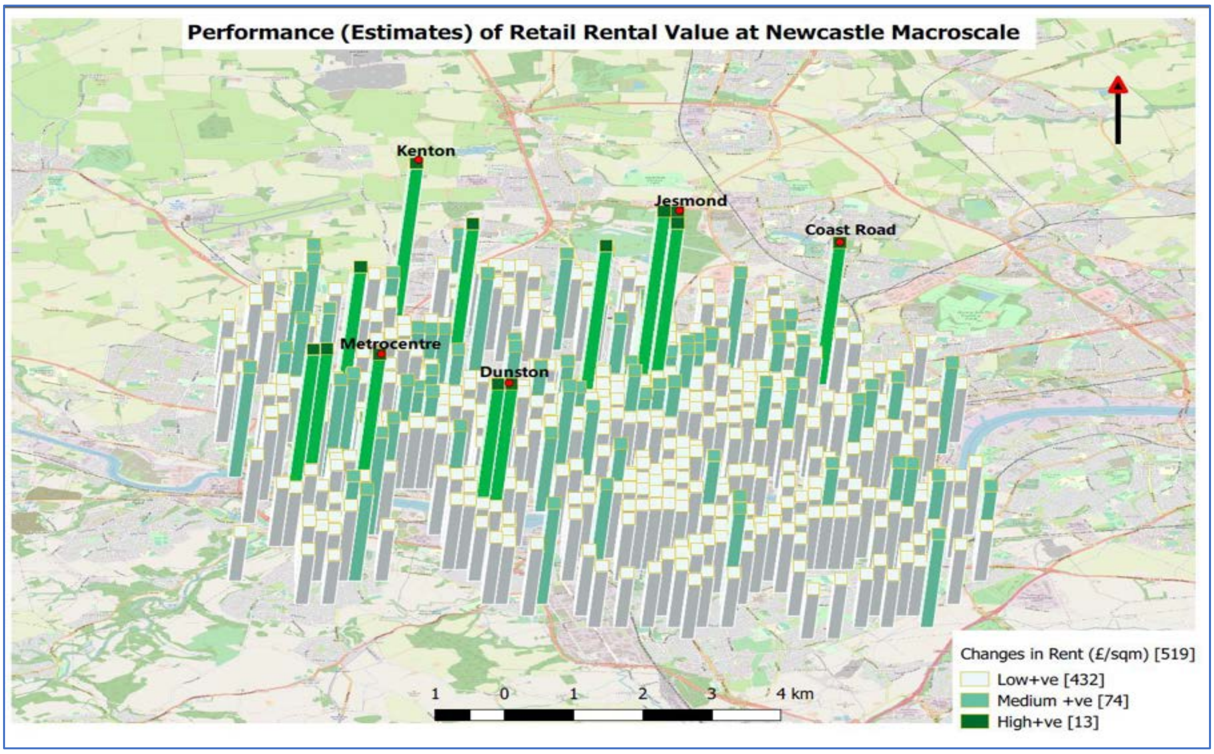
Source: Research work (2019)

Figure 6.3.2: Estimate changes in retail rental value at Leeds mesoscale



Source: Research work (2019)

Figure 6.3.3: Estimate changes in retail rental value at Newcastle macroscale



Source: Research work (2019)

The results (Figures 6.3.1 – 6.3.3) show there are variations in future potential to earn rent based on accessibility across the 3 estimable layouts. The estimate of RPM performance at York mesoscale revealed that distribution of retail rental value changes will follow a constant regular pattern. Thus, many of the delineated locations are estimated to experience *positive changes* in the future, with few locations (concentrated at the spatial layout's core, such as Coney Street and Coppergate Walk) experiencing negative changes. Meanwhile, the estimate of RPM performance at Leeds mesoscale shows that the locational distribution of future changes in retail rental value will be irregularly distributed. The predicted RPM performance at Leeds mesoscale shows that distribution of positive and negative (and neutral) changes in retail rental value will occur in an irregular (haphazard) pattern. Consequently, many of the delineated locations are predicted to have *negative changes* in retail rental value in the future. Similarly, the estimate of RPM performance at Newcastle macroscale shows that distribution of predicted locational changes in retail rental value differs from that at York mesoscale and Leeds mesoscale. Moreover, the estimate of the RPM performance at Newcastle macroscale predicted that all delineated locations across the spatial layout will experience *positive changes*. Basically, the estimate of RPM performance at Newcastle macroscale do not predict any negative changes in retail rental value across the entire spatial layouts. Consequently, the estimate of RPM performance (for example, future changes in retail rental value) at Newcastle macroscale have been ranked as low positive, medium positive and high positive (instead of the positive, neutral and negative changes obtained at York and Leeds mesoscales). Although this research has not validated these predictions on changes in retail rental value across the estimable cities (this is not within the scope of this study), it is important to note that such maps and techniques can be employed as real estate and urban planning tools in informing vital decisions on the use and management of urban retail spaces (assets). The subsequent section discusses the practical and theoretical implications of research results.

6.4 Implications of research results

Results from this research have ranges of implications on the practice and theories of real property markets and cities (urban studies/built environment). These implications (of research outputs) have been broadly divided into *theoretical* and *practical* implications. The research is relevant to decision-making on property (location) investment, property development, property occupation, planning and so on. This section discusses the key practical and theoretical implications of the research outputs.

6.4.1 Practical implications of research outputs

The main practical implication of this research outputs evolves round decision making for better management and optimum utilisation of urban resources. The developed techniques for analysing the locational performance of variables make this research a genuine tool for undertaking property market decisions on investment, development, occupation, acquisition, and planning. The locational relationships between supply (stock) and demand (rent) market variables can serve as a valuable tool for establishing locational decisions on investment, development and occupation. Similarly, the relationships between property market variables and consumer movement (accessibility index) can equally serve as a tool for property market decisions for the optimum utilisation of urban resources. Furthermore, the estimation of property market performance outputs would be relevant to guiding property market stakeholders on the use and strategic management of urban resources and spaces.

Although this thesis has not been tailored towards decision-making per se, the adopted techniques (that analyse the locational performance of property market variables and others) and research findings have shown that decision-making on urban spaces can be undertaken using the map outputs. This research anticipates that further research that is tailored towards the decision-making process of property market actors can be performed using the developed research technique.

6.4.2 Theoretical implication of research outputs

The research outputs have enriched the understanding of commercial (retail) property markets of cities. The research results uphold some of the existing theoretical models on real property markets, while providing new insights on these models to enhance understanding of genuine property market analysis of cities. It is important to understand that while this research has focused primarily on retail property markets, the adopted approaches are applicable across all the genuine property types of any given cities and spatial scales. Hence, the implications of the results cover the entire real property markets. Several of the key theoretical implications of the research outputs span across the following:

1. Land value (rent) distribution and property market interpretation of cities: this research has contributed to the understanding of land value distribution at cities. Results from this research have upheld existing theories including CPT, BRT, PMD, SIT and RGM) that had explained the concentration of land value (and retail activities) at city centres and the distribution pattern of land value across cities. Existing theories (e.g. CPT and BRT) have indicated that distribution of rent follow a uniform pattern, such that rent reduces once one moves out of the city centre. Similar theories (RGM and SIT) have indicated that demand and retail stock are typically the highest within city centres. *Findings from this research have indicated that results in the extent of city analysis (scale) is an important factor that influences the distribution and interpretation of retail property markets at cities*.

2. Application of space syntax theory in real estate (property market) terms: There are preceding theories and studies (Hillier, 1996; Law et al., 2013; Giannopoulou et al., 2016) that have revealed the relevance and influence of spatial configuration metrics, such as integration, choice and NACH at local and global metric radii to property market variables and urban land value. These preceding studies have interpreted the spatial configuration metrics of space syntax in the technical terms of street segments,

axial lines, axial maps, convex spaces, nodes, links and so on. These space syntax terminologies have hindered applications of this relevant theory in the real estate market. This is because property markets and property market actors do not understand these technical terms despite its value to the property market. This novel research has developed a means of understanding all the space syntax metrics terminologies as location elements to enhance the applicability of the theory into a genuine property market understanding. *This research introduces concepts of space syntax (spatial configuration) into analysing and estimating property market performance on cities* (see Appendix F for details on published works from the research).

3. Spatial analysis in real estate (property) studies: GIS and spatial analysis of property market variables are becoming common practice in real estate studies because of the potential for showcasing the locational performance of property market events. Real estate studies (including, Wyatt, 1996; 2000; Dunse et al., 2010; Greenhalgh and King, 2013) have established the relevance of the spatial analysis of property market variables. Hence, spatial analysis is becoming the newest type of analysis in real property research alongside quantitative and qualitative methods of analyses. This research has also shown the relevance of the spatial analysis of property market variables in form of maps. Conversely, results from this research have cautioned against pure reliance on the spatial analysis of property market variables. *Findings from this research have shown the need to validate spatial analysis outputs using statistical (quantitative - inferential) analysis.*

4. A new perspective for understanding property market performance in cities: cities are known as unique entities with distinctive characteristics and components. This research

has shown that while cities are unique, there are certain homogenous characteristics that they exhibit. Results from this novel research have shown that RPM variables (that is, changes in retail rental value and retail stock) exhibit a homogeneous property market across cities. Similarly, the CMP variables are uniform across heterogonous cities. *These results confirm a new perspective in relation to urban studies and commercial property market at cities*.

6.5. Chapter summary

The chapter presents research findings on the characteristics of RPM performance and CMP variables across sampled cities. It demonstrates what relationships exist between variables through geo-visualisation and statistical quantification. The chapter shows that scale is an important element that influences RPM interpretation and relationships between RPM and CMP variables. Analyses in this chapter confirms that significant relationships exist between all CMP variables (integration, choice and NACH) and changes in retail rental value at York mesoscale, Leeds mesoscale and Newcastle macroscale. Hence, changes in retail rental value has been estimated using coefficients of the CMP variables for the estimable layouts. Additionally, the practical and theoretical implications of the research findings have been presented herein. The next chapter concludes this thesis.

Chapter Seven

Conclusions and Recommendations:

Review of Research Findings and Identification of Further Research

7.0. Introduction

This chapter reviews the key research findings and draws conclusions based on the research findings. The chapter presents relevant recommendations while identifying areas of further research. The following subsection presents reviews on the research findings and summaries of conclusions drawn.

7.1 Review of key research findings and conclusions

Consumer movement remains critical to retail property market performance. Spatial configuration analysis of street networks remains an effective way of computing the accessibility index of cities to measure the distribution and concentration of retail consumer movement. This research has shown that changes in retail market variables and the configured spatial accessibility index can be measured and analysed to forecast the locational performance of retail property markets. Such outputs can be visualised to help in property market decision-making across cities.

The research findings show that there have been changes in all the three explored RPM variables (namely, changes in retail rental value, retail floor space and in retail cluster) between the computed change periods (that is, 2010 and 2017) across all the sampled cities. These changes in RPM variables are a yardstick for RPM performance across the sampled cities. The results show that distribution of the RPM performance bifurcate across property market characteristics of demand and supply. Thus, changes in retail rental value across the three cities show more elasticity (percentage changes) and have occurred in more locations compared to both changes in retail floor space and changes in retail cluster. Hence, changes in retail rental value across the cities exhibits the demand characteristics of a typical property market. Meanwhile, both changes in retail floor space and changes in retail cluster (specifically, changes in retail stock) exhibits similar characteristics that adhere to the supply-side of a typical property market. Results (from spatial and statistical analyses) across the three cities confirms that changes in retail stock exhibit the characteristics of low (no) percentage changes that have occurred in few locations (mostly at city centres). Hence, changes in retail stock across the three cities are sluggish and inelastic (and rarely occur). Simultaneously, *this research concludes that there are homogenous spatial behaviour of RPM variables across the three sampled cities despite the uniqueness in the analysed cities.* In other words, visualisation of RPM locational performance across the investigated cities could not signal the uniqueness of individual analysed cities. This is because distribution of changes in retail rental value (and changes in retail stock) across the three sampled cities at mesoscale and macroscale maintain the same spatial characteristics of elasticity at demand-side (i.e. changes in retail rental value) and inelasticity at supply-side (i.e. changes in retail stock). Specifically, *the uniqueness of all the sampled cities has not changed the spatial characteristics behaviour of retail market performance within these cities* (even though the maxim of cities heterogeneity is common in urban and real estate studies). However, findings from this research revealed that the changes in the scale of city analysis influence market interpretations of RPM performance on that city layout. For example, visualisation and interpretation of RPM variables are different at mesoscale and macroscale of the same city**.** This result is the same for all the three investigated cities. Simply put, this research concludes that the *scale of city analysis influences the connotation and interpretation of RPM performance in that city*.

Meanwhile, spatial configuration of consumer movement based on street network (connectivity) shows that all the three explored metrics (that is, integration, choice and NACH) exhibit distinct visual characters across the three explored cities. The pattern of distribution of the accessibility index of the three CMP variables are *the same* across all the sampled cities at mesoscales and macroscales. To be precise, the accessibility distribution pattern of integration, choice and NACH are unique and do not change despite changes in the spatial extent of the investigated cities. Consequently, the research concludes that *changes in the spatial extents of the analysed cities do not influence the distribution and interpretation of the spatial accessibility (CMP) index of a given layout*. The result strengthens the argument of the space syntax founder (Hillier and Hanson, 1984; Hillier, 1996) on the generic spatial behavioural pattern of human movement on city layouts. In other words, the CMP variables exhibit homogenous spatial accessibility behaviour that are not affected by changes in city spatial extents (that is, mesoscale and macroscale). This is unlike the RPM variables that are observed to exhibit homogenous spatial market behaviour across all the three sampled cities but are affected by changes in spatial layouts extents.

Furthermore, the research reveals that *there are spatial and statistical relationships between the RPM variables and CMP variables.* Results show that the extent of the relationships between variables differs across variables. Geo-visualisation of locational relationships between RPM and CMP variables show that RPM performance relates better with the accessibility index of integration metrics for all the sampled cities at macro and meso scales. Essentially, integration metrics shows the highest contributory effect to changes in retail property market variables out of all the investigated CMP variables across the spatial layouts. Similarly, *results (visuals and statistics) show that changes in retail rental value exhibit better relationships with the CMP variables (especially, integration metrics) than changes in retail stock across all the sampled layouts.* This indicates that the relationships between changes in retail rental value and CMP variables are more significant than relationships between changes in retail stock and CMP variables. Conversely, geo-visualisation of relationships between variables across all sampled cities shows that *relationships between variables at mesoscales are more intelligible (and stronger) than visualised relationships at macroscales of analysed cities*. Results across the analysed sampled layouts further indicates that visualising locational relationships requires validations and quantifications to ascertain the extent of the relationships between variables, as there are no perfect visualised relationships that could be drawn across all sampled layouts.

Statistical analyses on variables across all the spatial layouts quantify the significant level of relationships between the RPM and CMP variables. The quantification of the relationships between variables (using Spearman-rho coefficients) show that there are hidden relationships between the CMP variables (especially, choice and NACH metrics) and RPM variables, when relationships are visualised. Further results concerning the CMP variables show that the integration (that is, to-movement) metrics variable display significant practical palpability in contrast to the other investigated CMP variables. Results show that integration metrics outputs exhibit a logical visual understanding of the concentration of retail consumer movement on all the sampled layouts. The integration metric was able to identify the cores (centres) of all investigated spatial layouts as the most accessible locations/parts of the city's layouts. In the same way, integration metric was able to identify all the outskirts of these layouts as the most segregated (that is, lowest accessible) locations (in accordance with existing city accessibility theories such as BRT and CPT). However, visualisation of accessibility index outputs of choice and NACH (that is, through-movement) metric could not give any discernible pattern of concentration of retail consumer movement at all sampled layouts. Results show that accessibility distribution obtained from choice metric indicate that many of the delineated locations are highly segregated (which in reality is not entirely true). Similarly, results obtained from the NACH metrics indicate that accessibility index distribution does not follow any logical pattern of human movement on city layouts (unlike integration metric outputs). The scientific interpretations of through-movement metrics (specifically, calculating the possibilities of all locations or street segments being used as a bridge to reaching all other locations within the configured spatial layouts) have not yielded a logical interpretation of consumer movement pattern across all the sampled cities at macro and meso scales. As such, the through-movement metrics (especially, choice metrics) do not show a significant *visual* relationship with RPM variables across the sampled layouts. However, further statistical analysis in quantifying relationships between variables show that the choice and NACH variables do have significant relationships with changes in retail rental value, despite the inability of visual representation of accessibility index to show it. Furthermore, statistical analyses of relationships between variables maintain that syntactic values of integration metric are more significant than both choice and NACH variables.

The research concludes that visual investigations of the relationships between the CMP and RPM variables can signal the extent of the relationships between variables (which has huge practical advantages) but are not enough to understand the intrinsic relationships between variables. Hence, statistical investigations between variables are important steps that can shed light on understanding the relationships between CMP and RPM in any given location. This research challenges existing analyses on relationships between spatial configuration outputs and property market variables that have relied solely on visual outputs of variables without validating it with statistical analyses.

In addition, analyses from this study have shown that relationships between CMP variables and changes in retail rental value are more intelligible and stronger at cities' mesoscales than macroscales. The only exception to this rule is Newcastle that saw significant relationships between variables at macroscales. Although, it is beyond the scope of this research to investigate why such significant relationships exists between variables at Newcastle macroscale (and not Newcastle mesoscale), this research *assumes* that the monopoly of retail property market at Newcastle mesoscale could have been the reason for such results, given that free market interaction exists more at Leeds and York mesoscales (this assumption has been identified as an area for further research). The research concludes and upholds that property market characteristics and relationships with the accessibility index are unique to individual spatial layouts (cities) and results should not be generalised. (See Appendix D for details on arguments on retail market competitiveness).

Spatial configuration parameters can be modelled to estimate retail (or any other property) location performance. The condition for estimating RPM performance was not met by all the RPM variables at all the sampled layouts. The condition that the three CMP variables must show significant relationships with RPM variables was not met by all the three investigated RPM variables at all investigated spatial layouts. Hence, there are estimable and inestimable RPM variables and spatial layouts. Statistical analysis confirms that only changes in retail rental value (estimable RPM variable) meet this criterion at York mesoscale, Leeds mesoscale and Newcastle macroscale (estimable spatial layouts). Further analyses show uniqueness in the estimate of the RPM performance (that is, changes in retail rental value) across the estimable layouts. Estimates of RPM performance at York mesoscale are projected to have uniform positive changes in retail rental value, with few locations (concentrated at the core of the spatial layouts) showing negative changes in retail rent. However, many of the delineated locations at Leeds mesoscale (Leeds city centre) are estimated to have negative changes in retail rental value. The pattern of estimated changes in retail rental value at Leeds city centre are not uniformly distributed (like that obtained at York mesoscale). Meanwhile, the estimated changes in retail rental value across delineated locations at Newcastle are positive and are expected to occur in an irregular pattern. Hence, estimate of the RPM performance via CMP (spatial configuration of street network) has shown uniqueness in RPM performance at each city (spatial layouts) despite the generic spatial behaviour of the CMP variables. These results are strong indications that cities and the performance of the property market at cities are heterogenous.

7.1.2 Summary of conclusions

Although similar data and approaches have been employed in this research, results have shown that property market characteristics and relationships between the spatial accessibility (CMP) index and RPM variables at cities are heterogenous and should not be generalised. Similarly, findings have shown that the extent of city analysis should be carefully considered when generalising the property market performance of a city or any given location.

The study concludes that consumer movement influences the performance of retail property markets, especially, changes in retail property rental value. The study also concludes that integration metrics has the most impact as regards practical use in real estate and urban studies (out of the analysed CMP variables) because of its visual intelligibility and stronger statistical relationships with RPM variables. This study concludes that there is need to validate spatial (visual) relationships between variables using relevant statistical tools to unlock hidden relationships between spatial configuration outputs and other analysed variables. The study has shown that both statistical and geo-visualisation of spatial configuration parameters and urban economic data should be considered when analysing variables for validation of outcomes and practical enhancement of results. The study concludes that statistical analysis of spatial relationship between variables will enhance understanding of the influence of the spatial configuration of consumer movement on retail property market performance.

7.2 Recommendations and areas of further research

Recommendations issued in the section are based on the research findings, research limitations and conclusions drawn from investigating the relationships between the RPM and CMP variables at city spatial layouts. This study recommends further investigations into relationships between the spatial accessibility (CMP) index and the performance of retail property market at cities to better understand relationships between the investigated variables. The research recommends that similar approaches taken for York, Leeds and Newcastle should be completed on other cities. Likewise, similar approaches that have been conducted at mesoscales and macroscales should be tested at neighbourhood (microscale) analysis, while geocoding retail spaces at street addresses rather than postcodes (as done herein). This would enhance practical application of the developed research method.

Owing to the contributory impacts of integration metrics, this study recommends further research on the potential of integration metrics at various metric radii to compute spatial accessibility. This will enhance the understanding of space syntax in urban and real estate studies. Other relevant correlation coefficients, such as Kendall coefficients should be explored in investigating and quantifying relationships between configured consumer movement and retail property market performance. Additional research should focus on enhancing the estimate (regression) models that had been developed in this research (for example, equations 7-9). Such regression models should factor in other syntactic and non-syntactic variables to improve the prediction accuracy of the model. Other existing econometric models, such as the Spatial Error Model, Spatial Lag Model, Spatial Durbin Model can be adopted in estimating the spatio-temporal performance of retail locations across cities.

Similarly, the research recommends other means of measuring consumer movement on spatial layouts to validate the scientific means of the spatial configuration of retail consumer movements. Digital tracking, manual tracking and counting together with the use of remote sensing technology are a few other methods that can be adopted to establish retail consumer movement (and spatial behaviour) at city spatial layouts. Such approaches can be compared with consumer movement captured via spatial configuration (scientific technique). This would shed new light on understanding consumer spatial behaviour and its relationships with changes in retail property markets.

Furthermore, this study recommends that adequate and comprehensive retail property market data should be stored and managed by private (commercial data companies) and public institutions for analysis, rather than relying on taxation-based (VOA) datasets for retail property market analysis. This will enhance retail property market analysis and reduce the errors associated with the VOA data, such as double counting, multiple records and overlapping between other commercial property data (as pointed out in Chapter 3). Similarly, the study recommends that development of more suitable and integrating software that can conduct spatial (GIS) analysis, spatial configuration (space syntax) analysis and statistical (descriptive and inferential) analyses. Application of python programming language can be pursed for this purpose. This will ease the spatial and statistical analyses of variables while minimising errors involved in transposing or exporting analysed data during data analyses.

Furthermore, Ordnance Survey (OS) should improve on street coverage. If possible, railway tracks can be connected with street networks to ensure comprehensive layouts. This will ensure adequate coverage of all possible movement that consumers might undertake within analysed cities. At the moment, OS maps are produced for generic spatial analyses and not specifically for spatial configuration analyses. Locations of other cities functions, for instance tram stops, bus stops, train stations and other infrastructures that drives property values should be integrated into spatial configuration outputs and the explored retail property market variables.

This research has shown the applicability of space syntax theory in a more meaningful and understandable way in relation to commercial property market actors. The study recommends that further research into applications and the relevance of spatial configuration metrics (outputs) at global and local scales should be explored to enhance the application of space syntax theories to practice and theories pertaining to real estate (commercial property) markets. This study recommends application of the developed research methods to other property types including, residential areas, offices and industrial properties. As it is, the developed method is applicable to all property types at cities.

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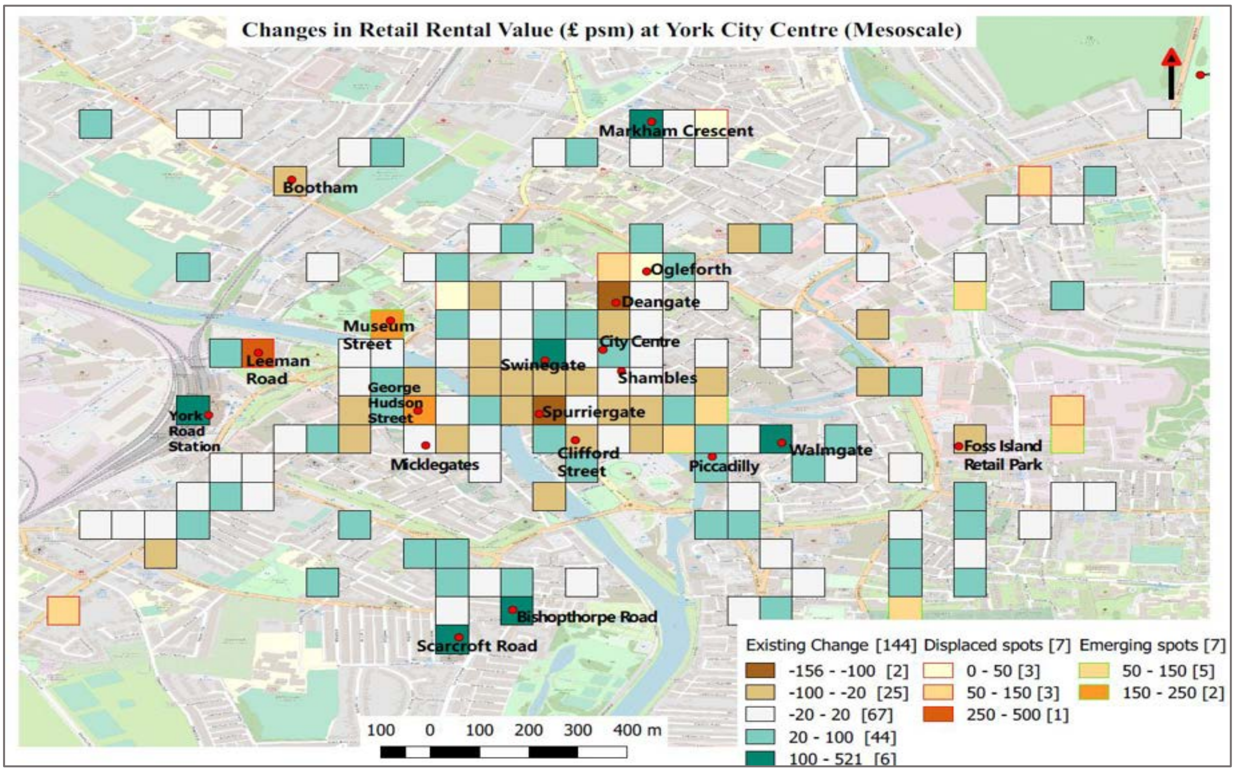
APPENDICES

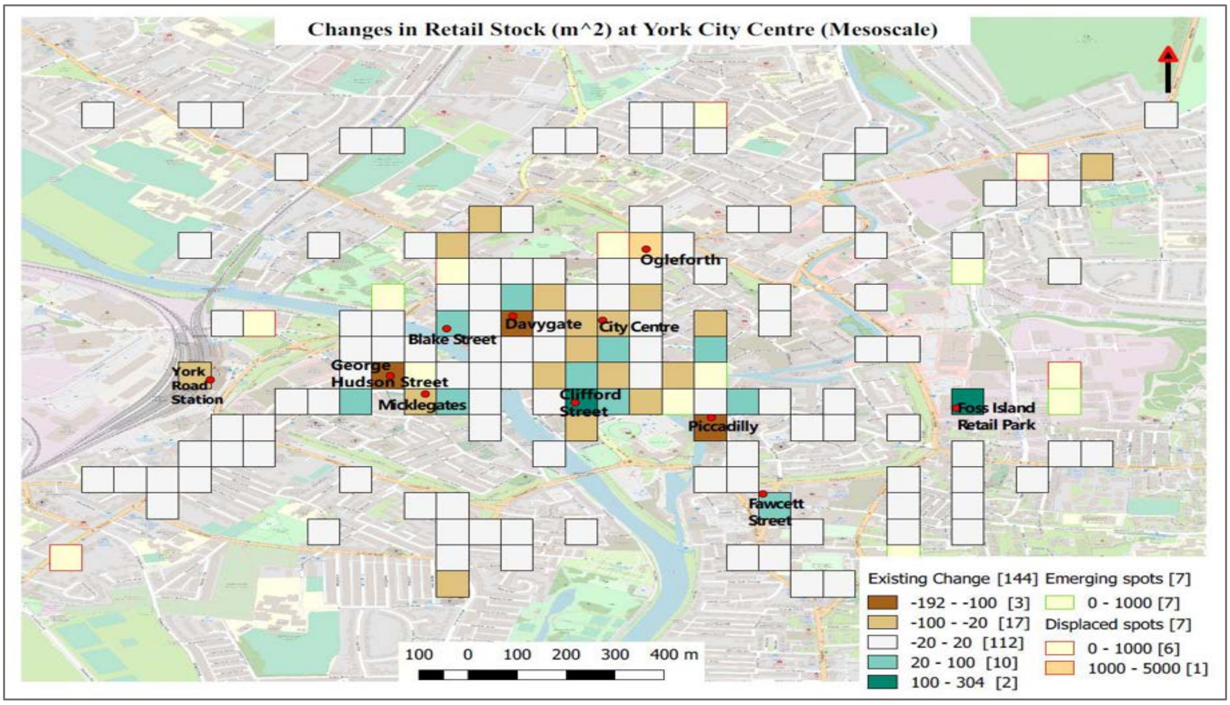
Appendix A: Locational performance of RPM variables

1. Locational changes in retail rental value at York mesoscale



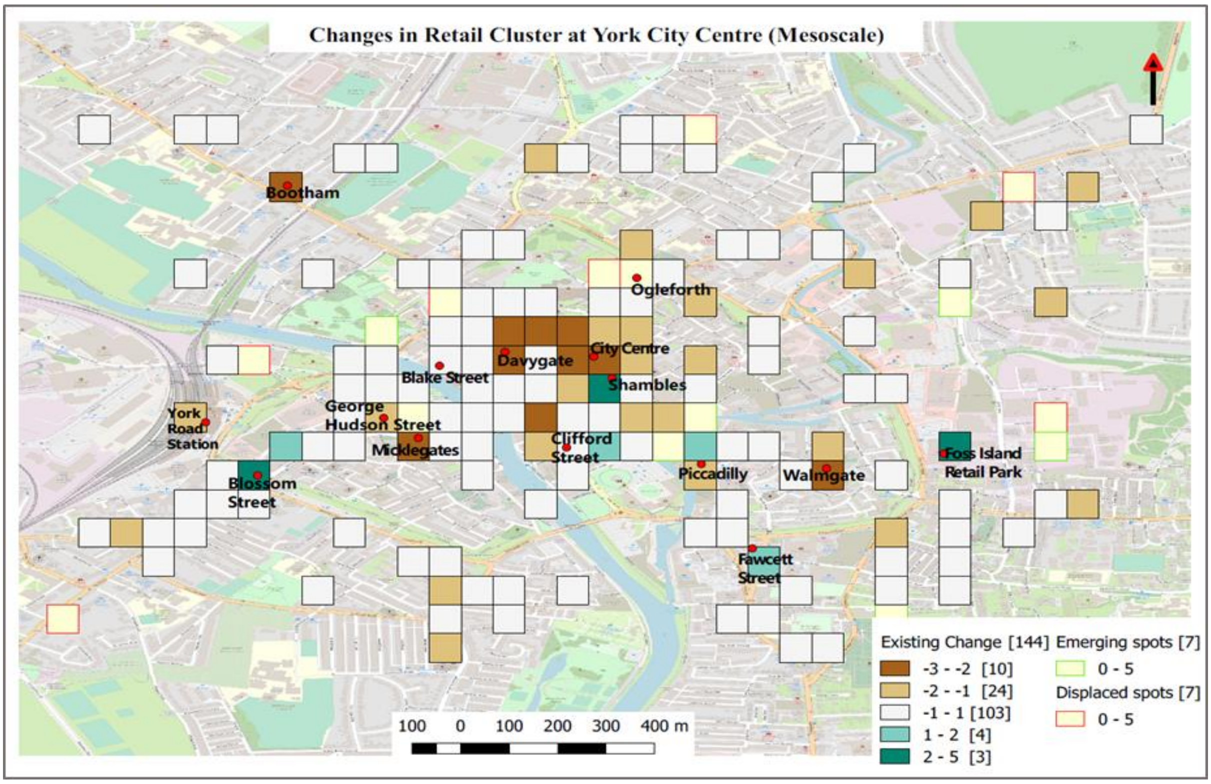
Source: Research work (2019)

2. Locational changes in retail floor area at York mesoscale



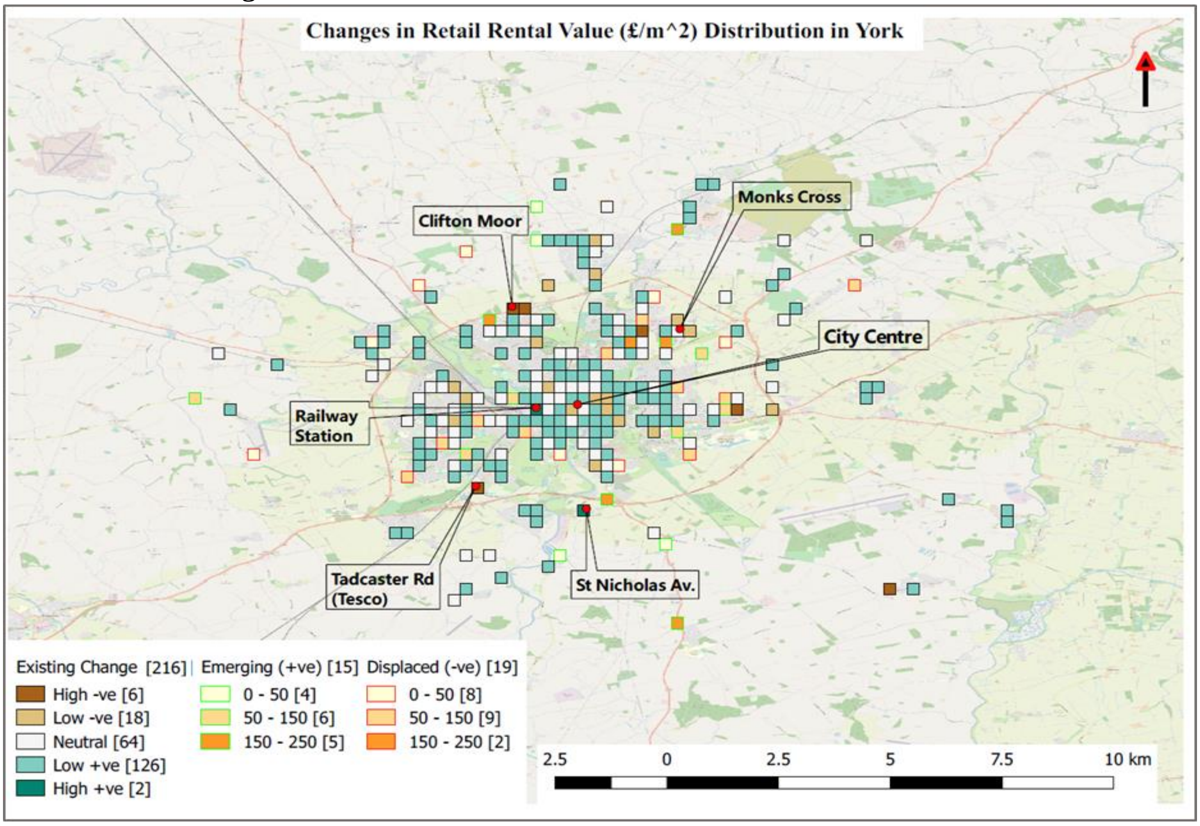
Source: Research work (2019)

3: Locational changes in retail cluster at York mesoscale



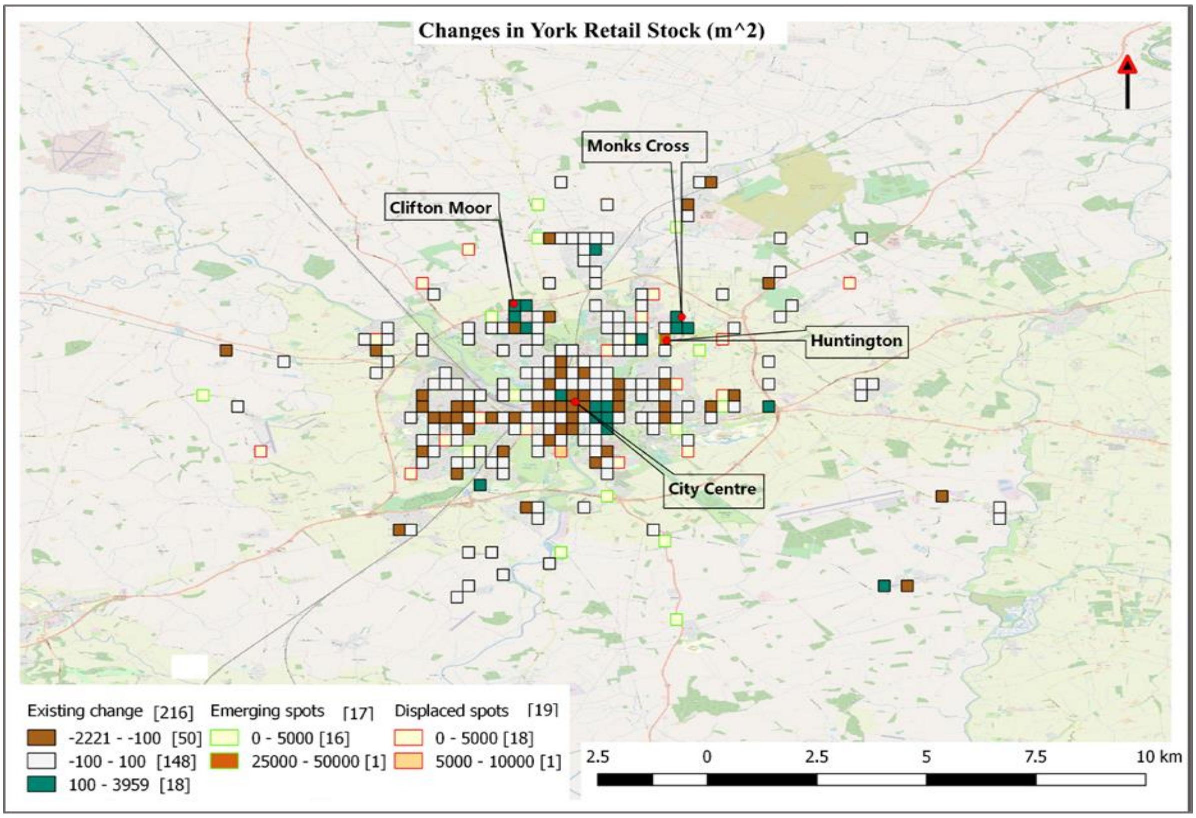
Source: Research work (2019)

4: Locational changes in retail rental value at York macroscale



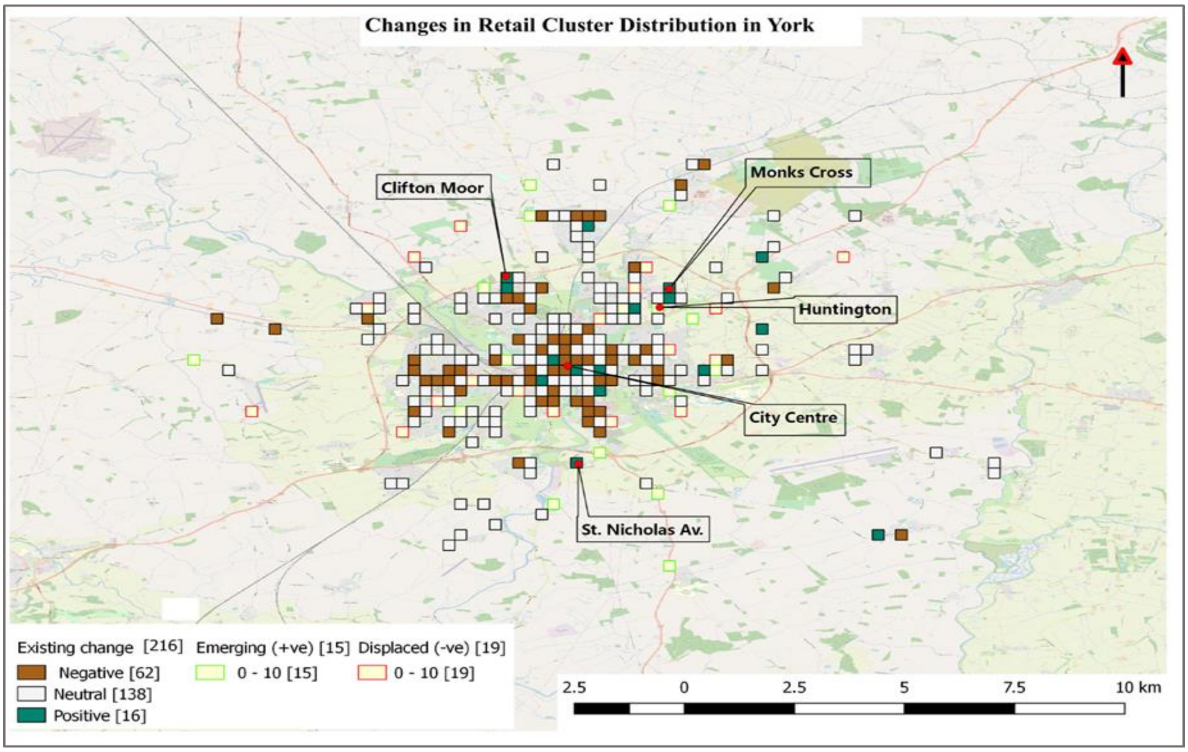
Source: Research work (2019)

5: Locational changes in retail floor area at York macroscale



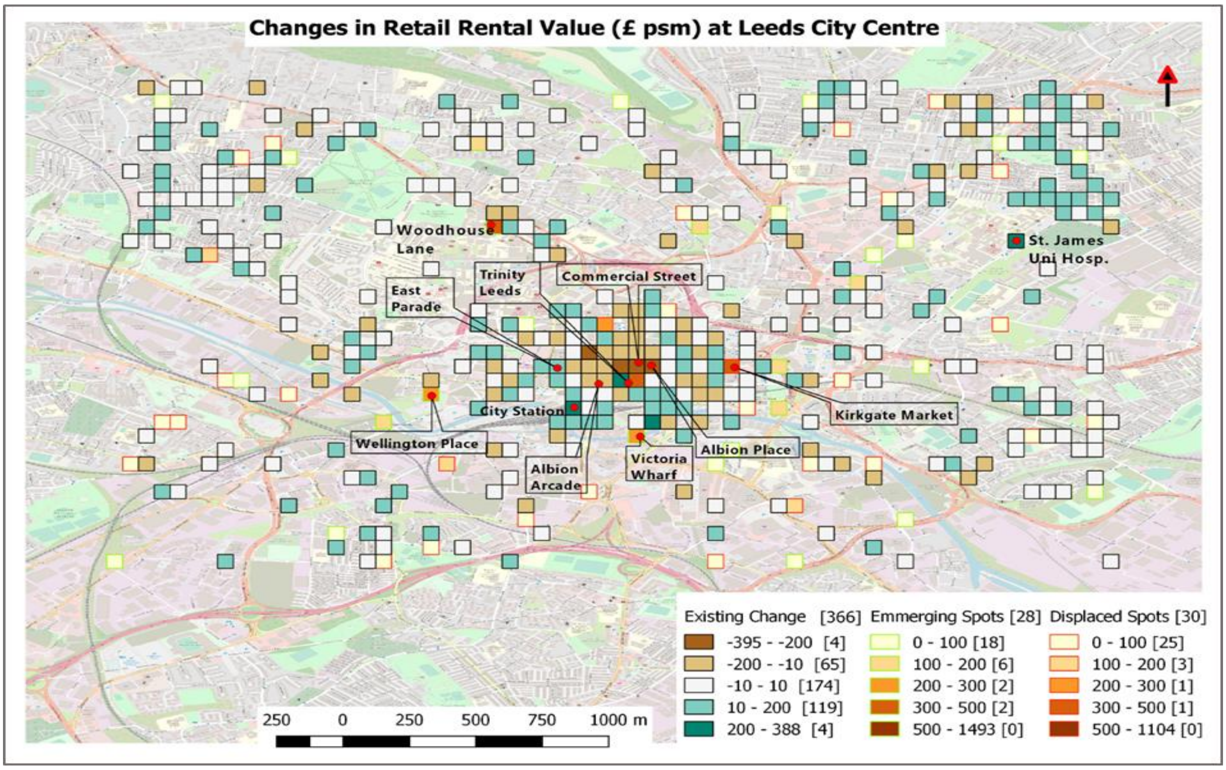
Source: Research work (2019)

6: Locational changes in retail cluster at York macroscale



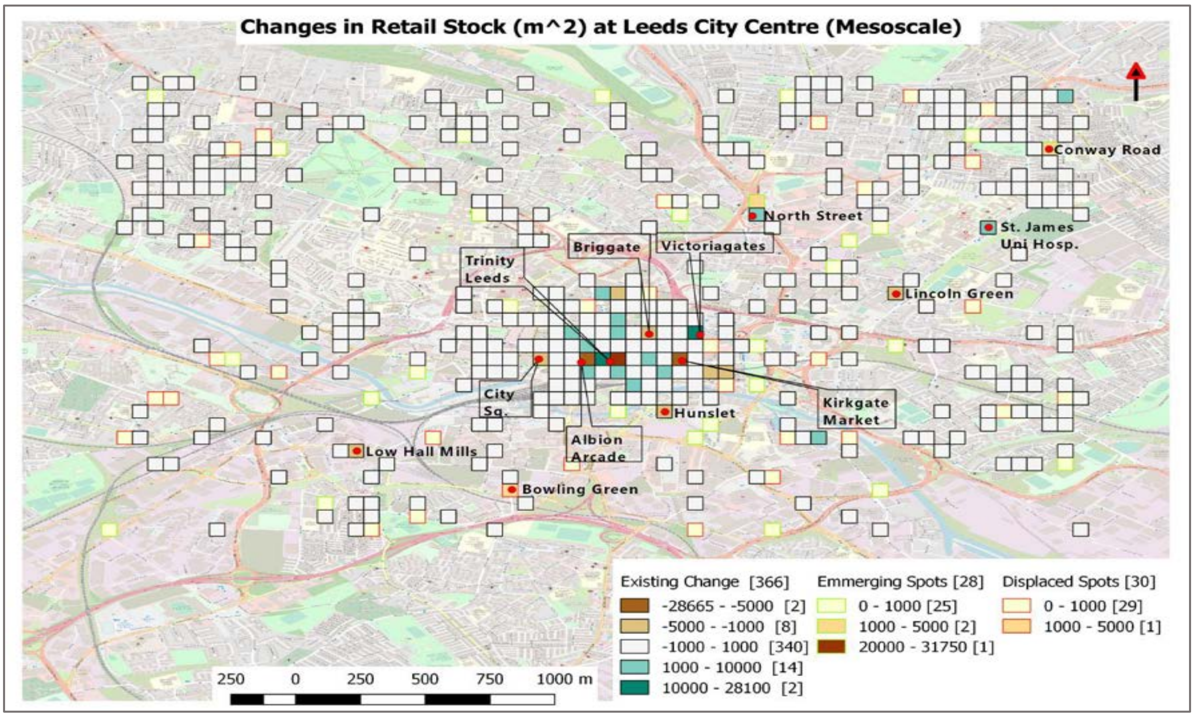
Source: Research work (2019)

7: Locational changes in retail rental value at Leeds mesoscale



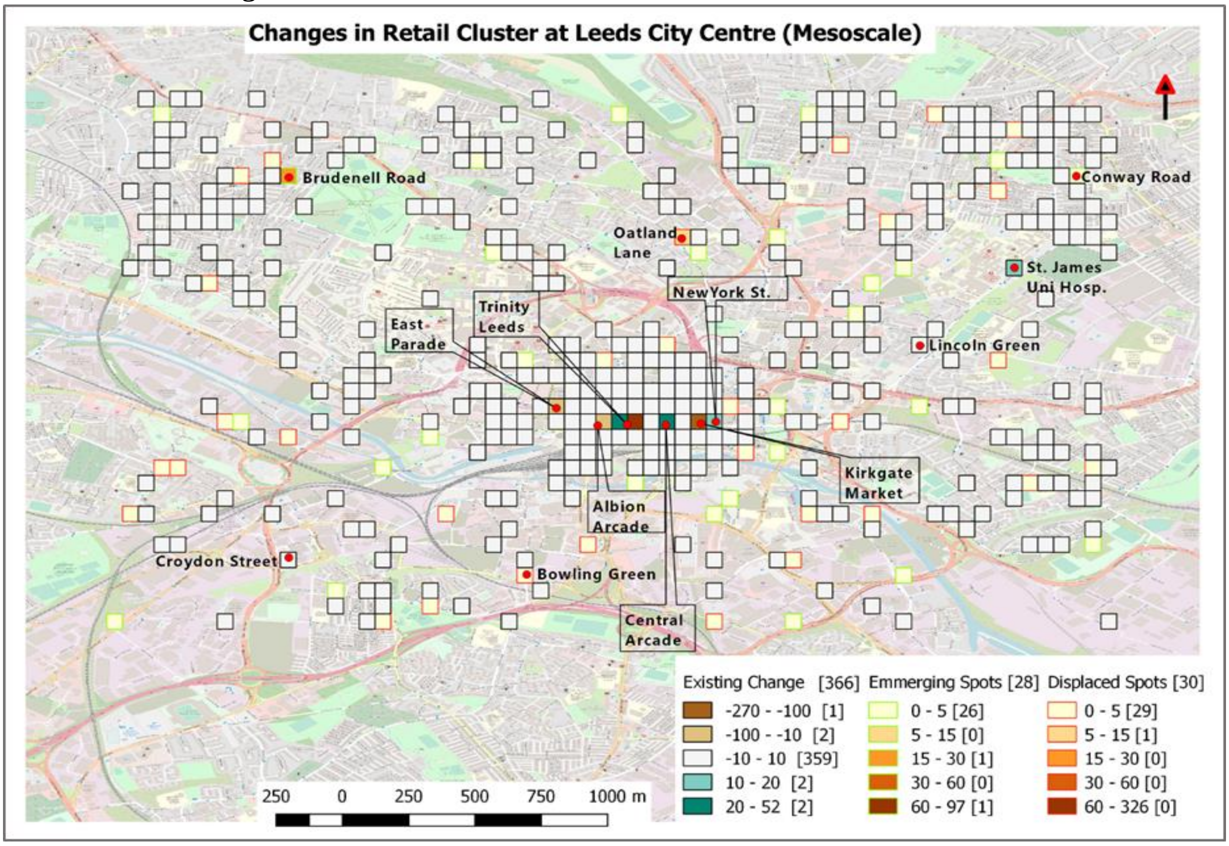
Source: Research work (2019)

8: Locational changes in retail floor area at Leeds mesoscale



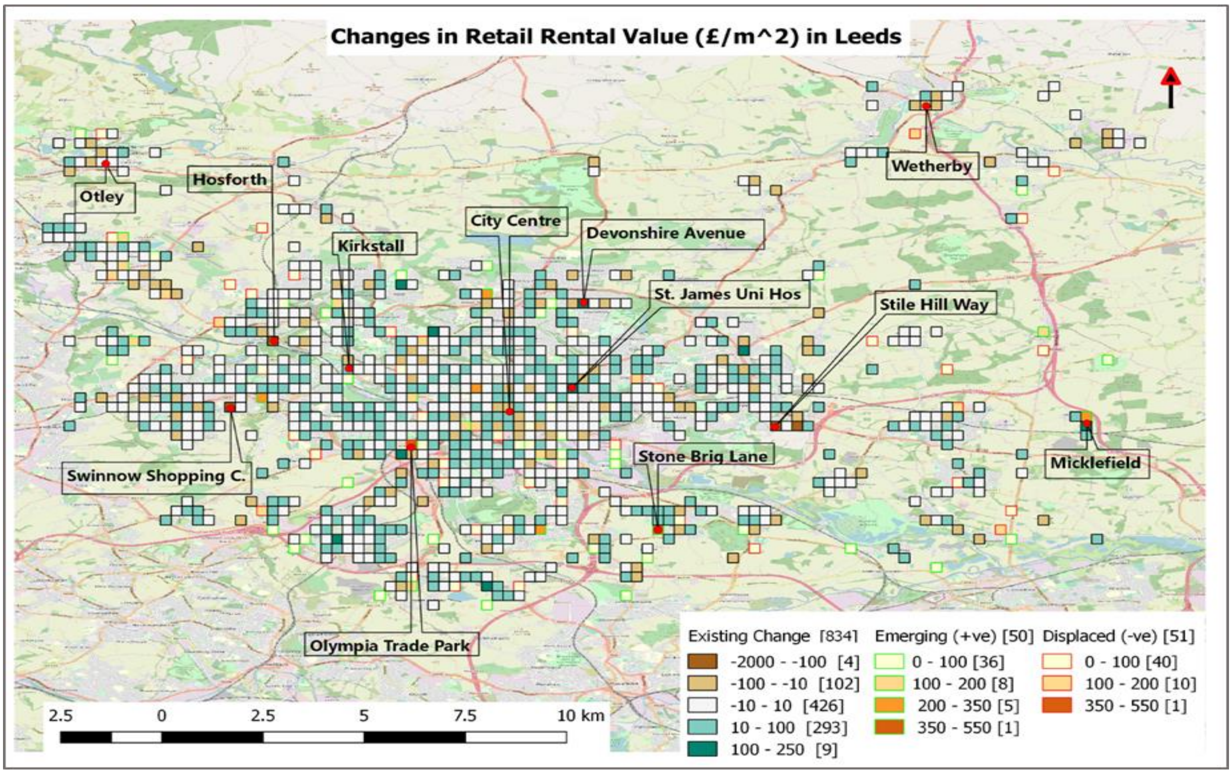
Source: Research work (2019)

9: Locational changes in retail cluster at Leeds mesoscale



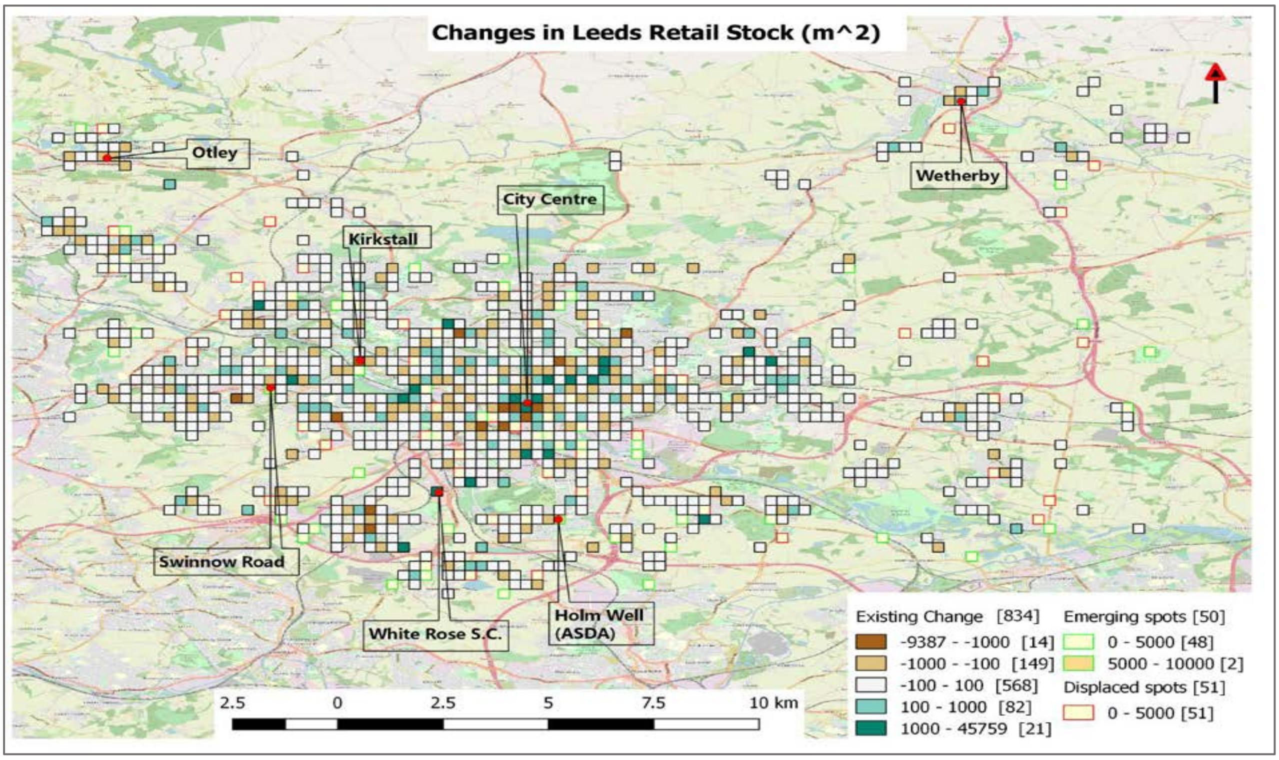
Source: Research work (2019)

10: Locational changes in retail rental value at Leeds macroscale



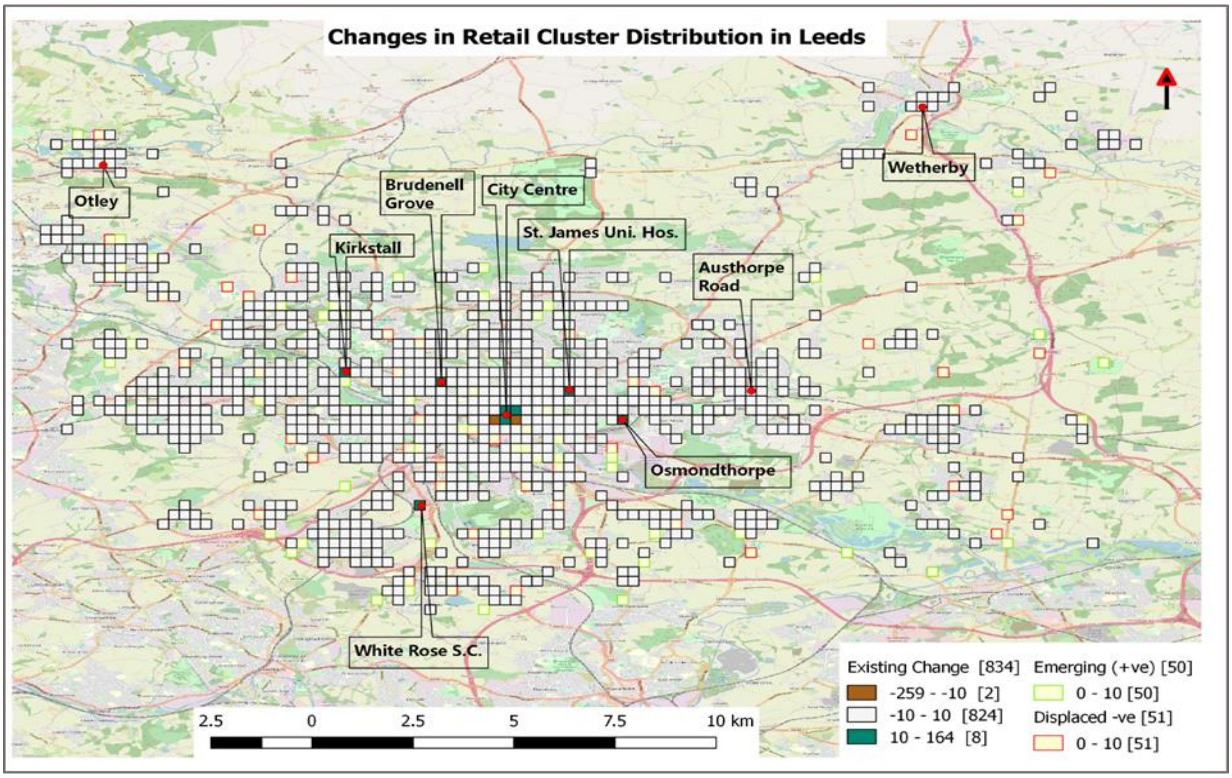
Source: Research work (2019)

11: Locational changes in retail floor area at Leeds macroscale



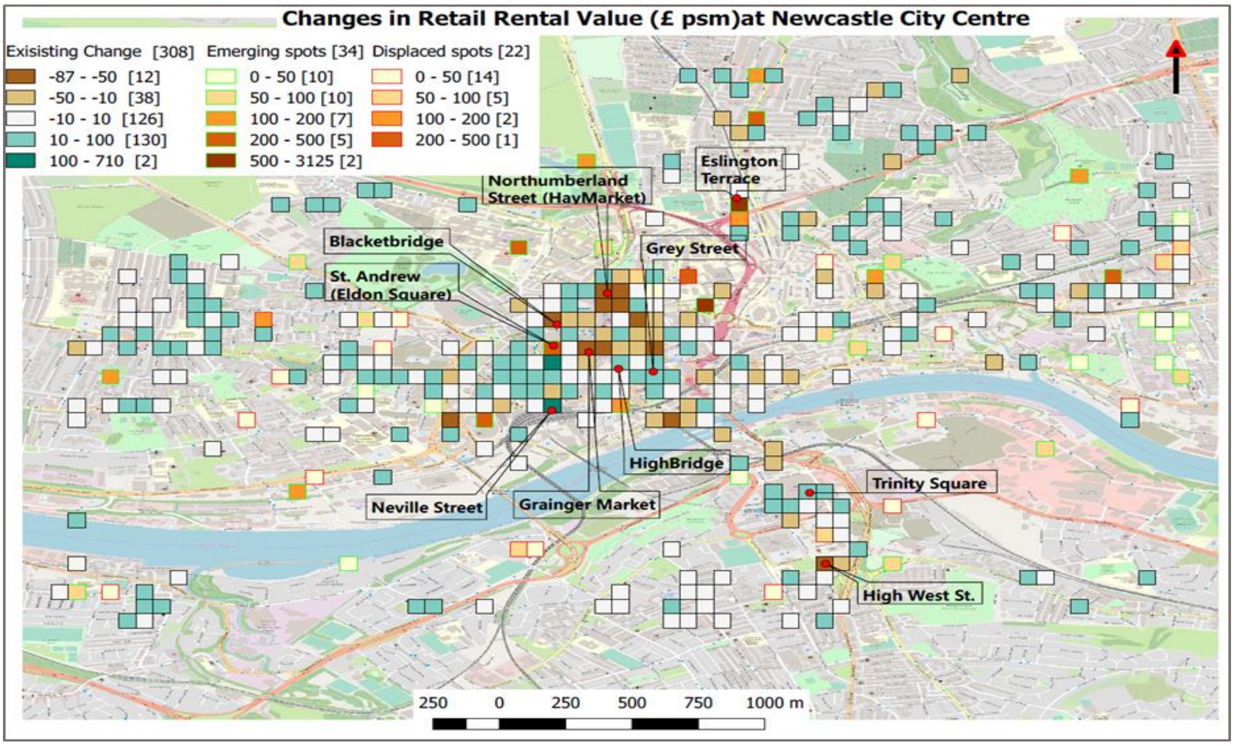
Source: Research work (2019)

12: Locational changes in retail cluster at Leeds macroscale



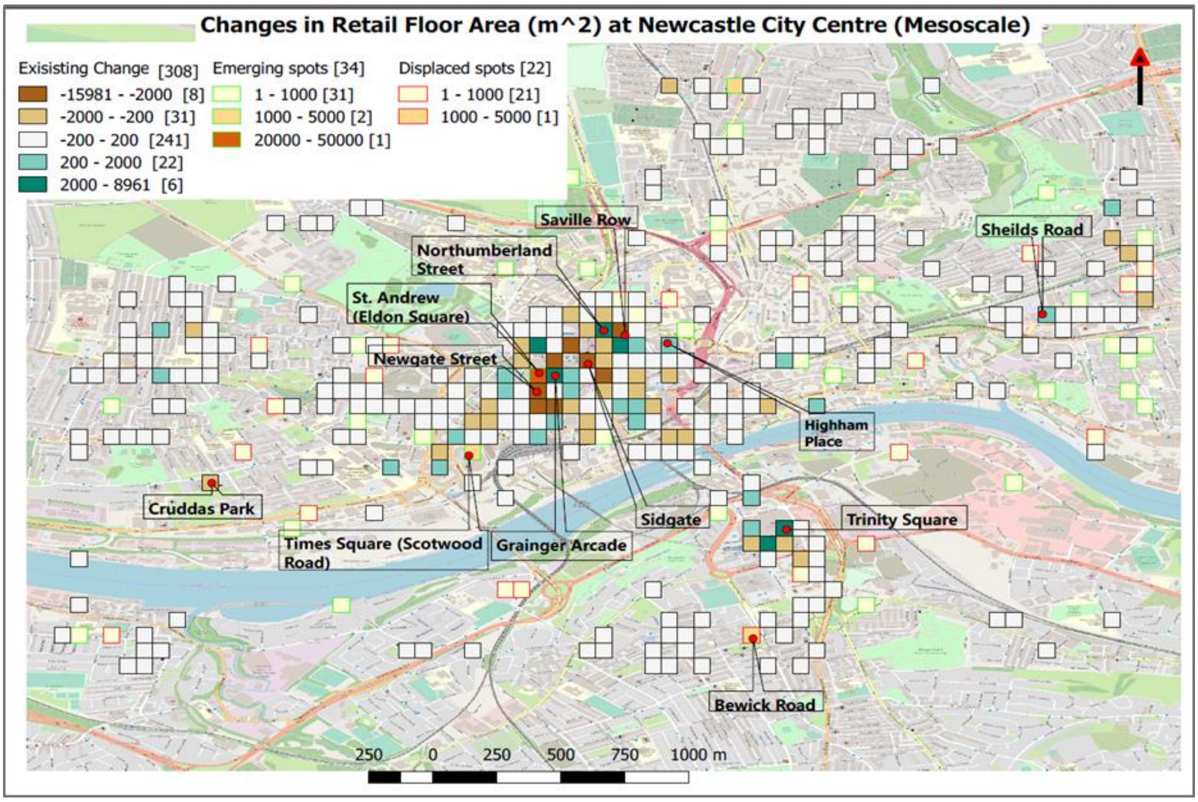
Source: Research work (2019)

13: Locational changes in retail rental value at Newcastle mesoscale



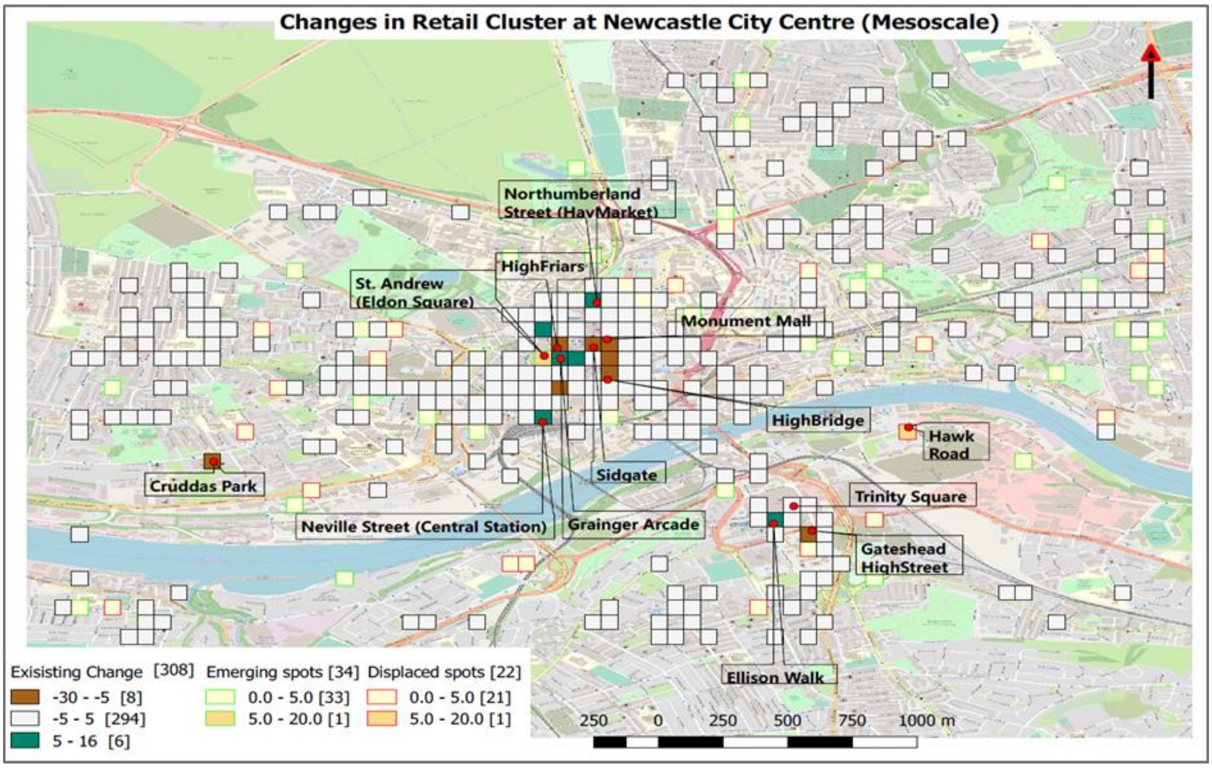
Source: Research work (2019)

14: Locational changes in retail floor area at Newcastle mesoscale



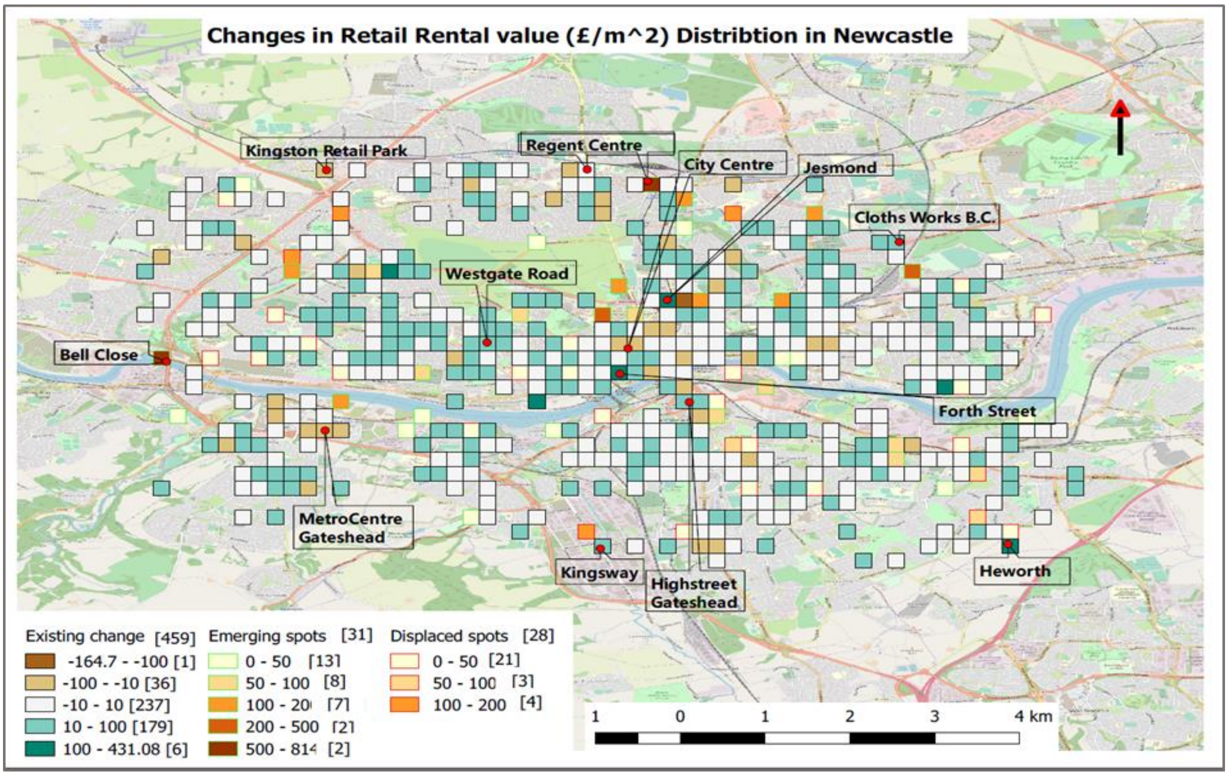
Source: Research work (2019)

15: Locational changes in retail cluster at Newcastle mesoscale



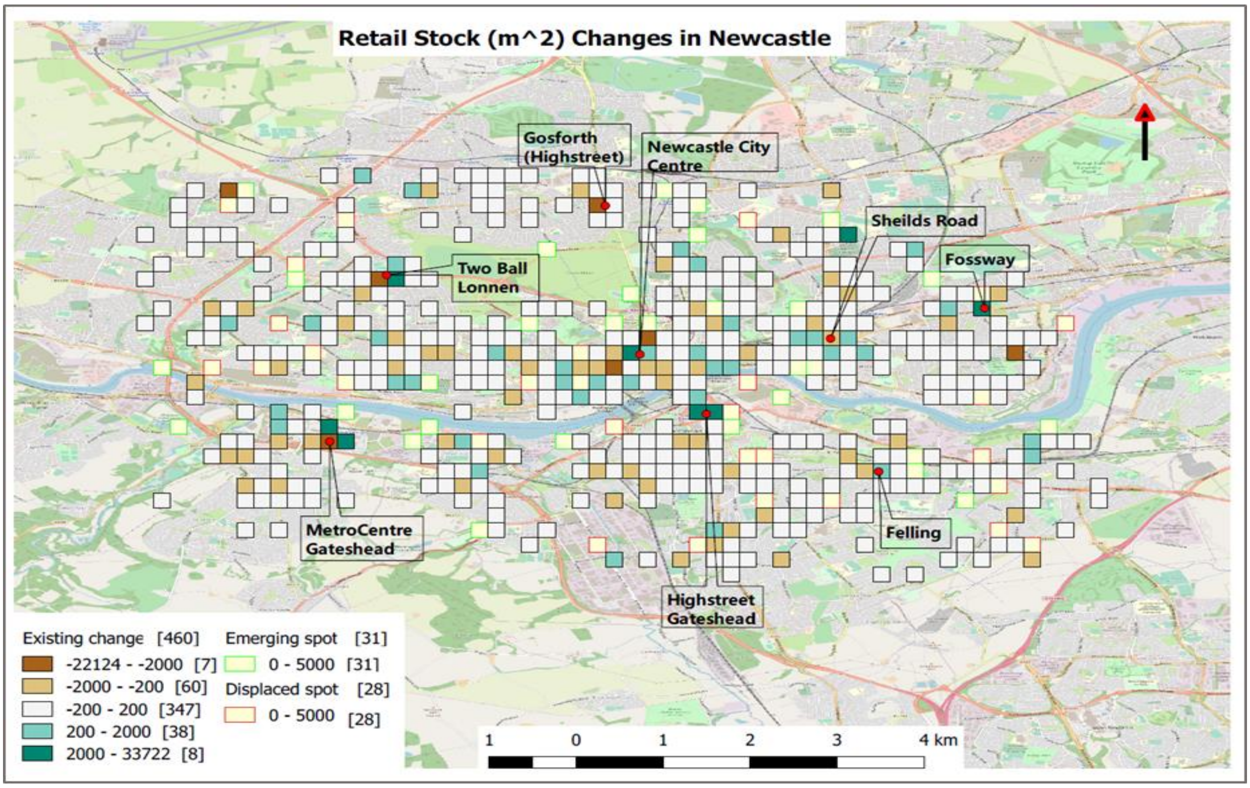
Source: Research work (2019)

16: Locational changes in retail rental value at Newcastle macroscale



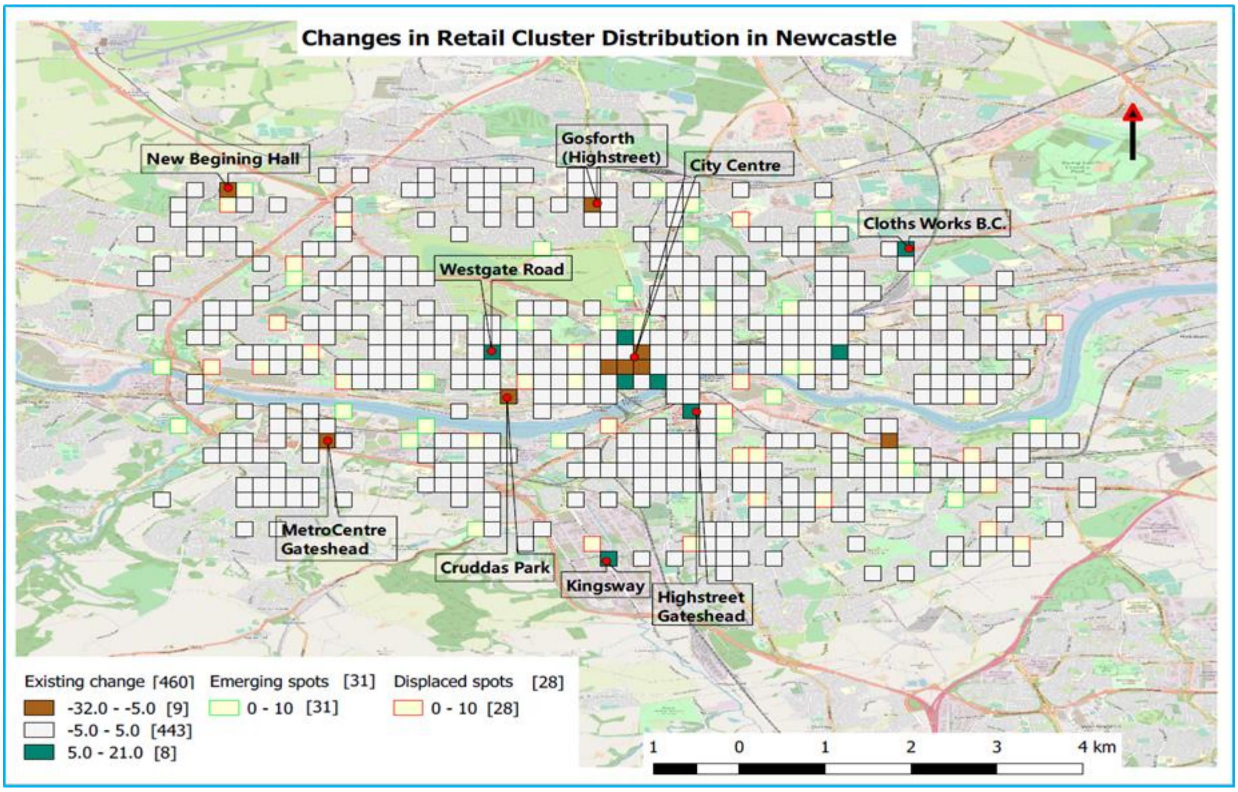
Source: Research work (2019)

17: Locational changes in retail floor area at Newcastle macroscale



Source: Research work (2019)

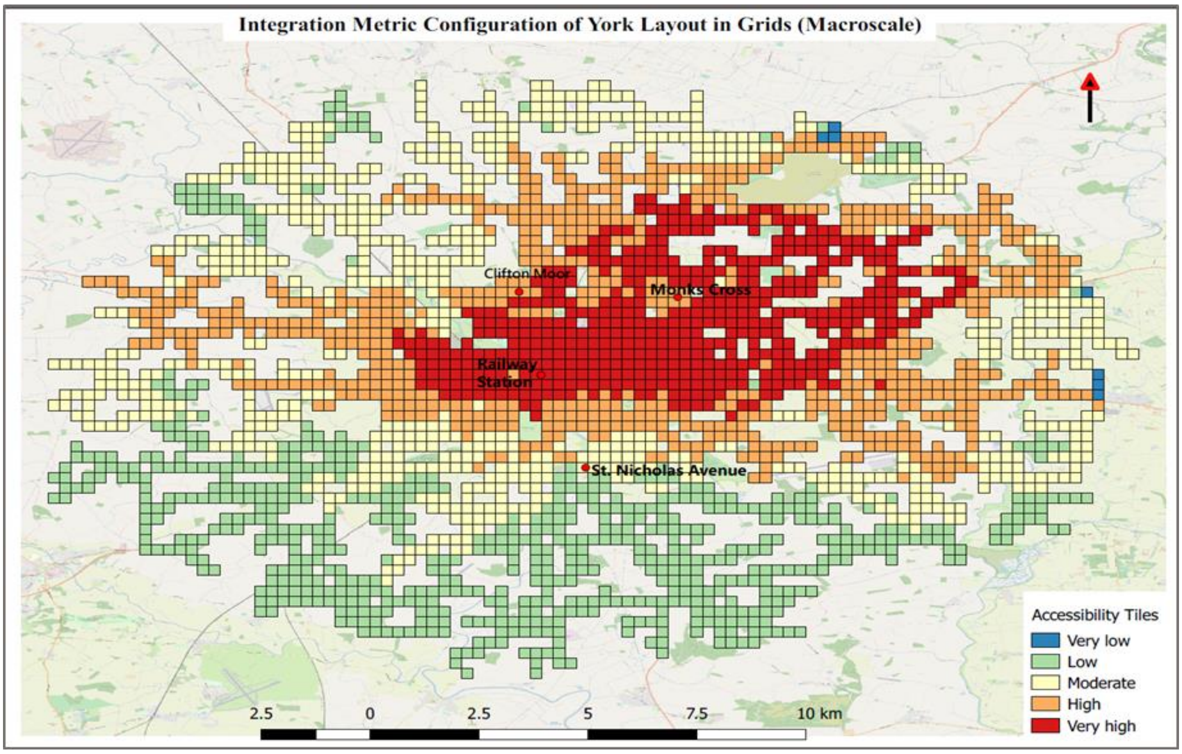
18: Locational changes in retail cluster at Newcastle macroscale



Source: Research work (2019)

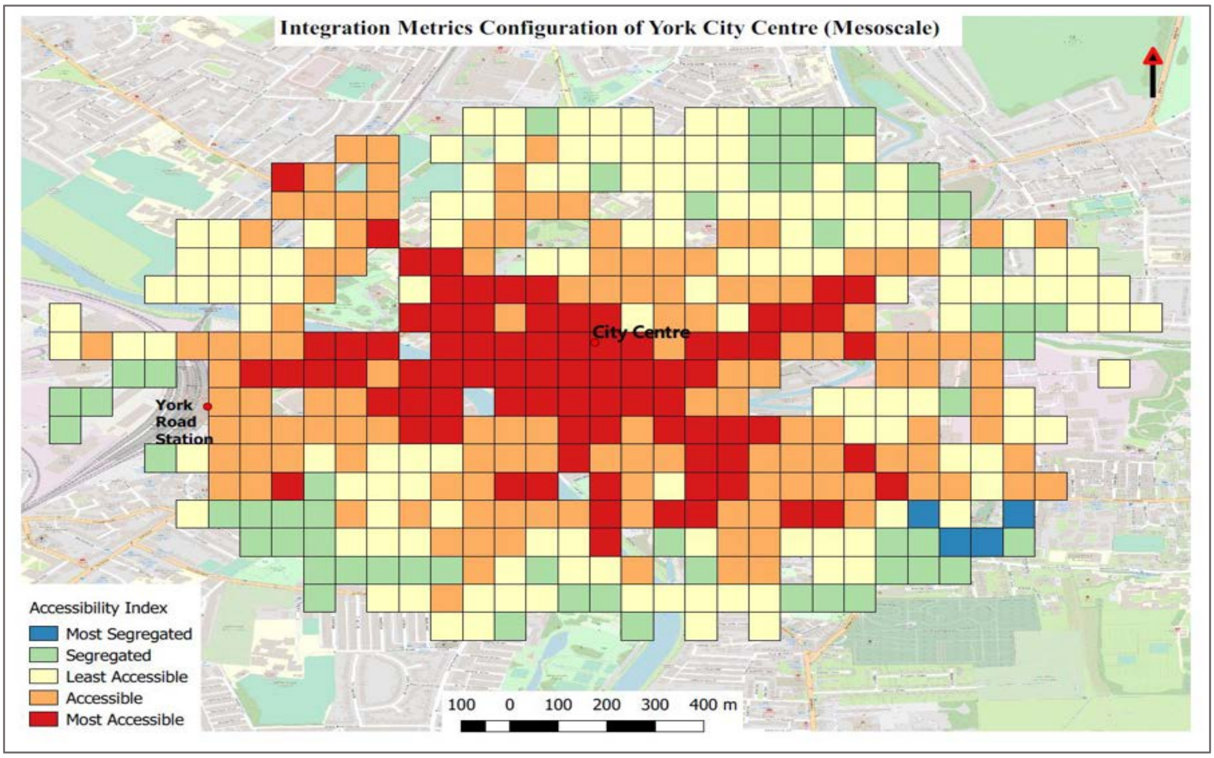
Appendix B: Locational distribution of CMP variables

1. Integration metric outputs of York macroscale (in polygonised grid)



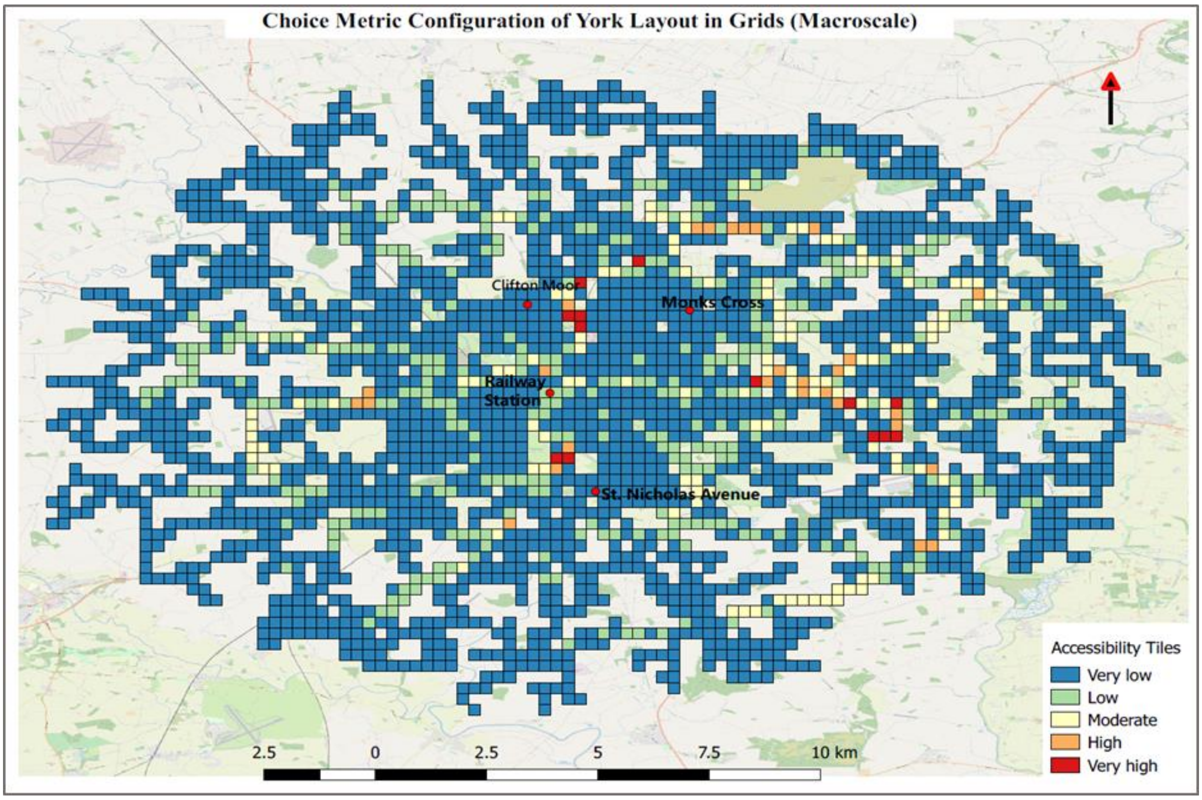
Source: Research work (2019)

2. Integration metric outputs of York mesoscale



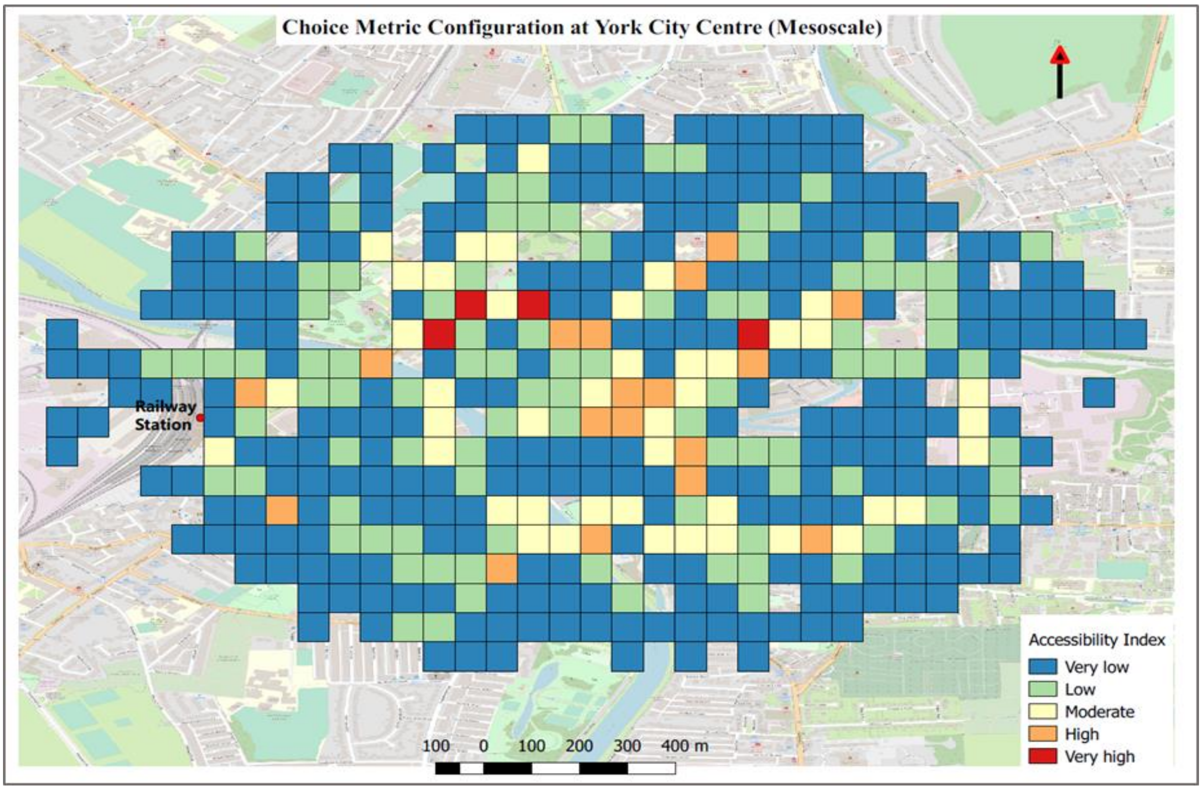
Source: Research work (2019)

3. Choice metric outputs of York macroscale



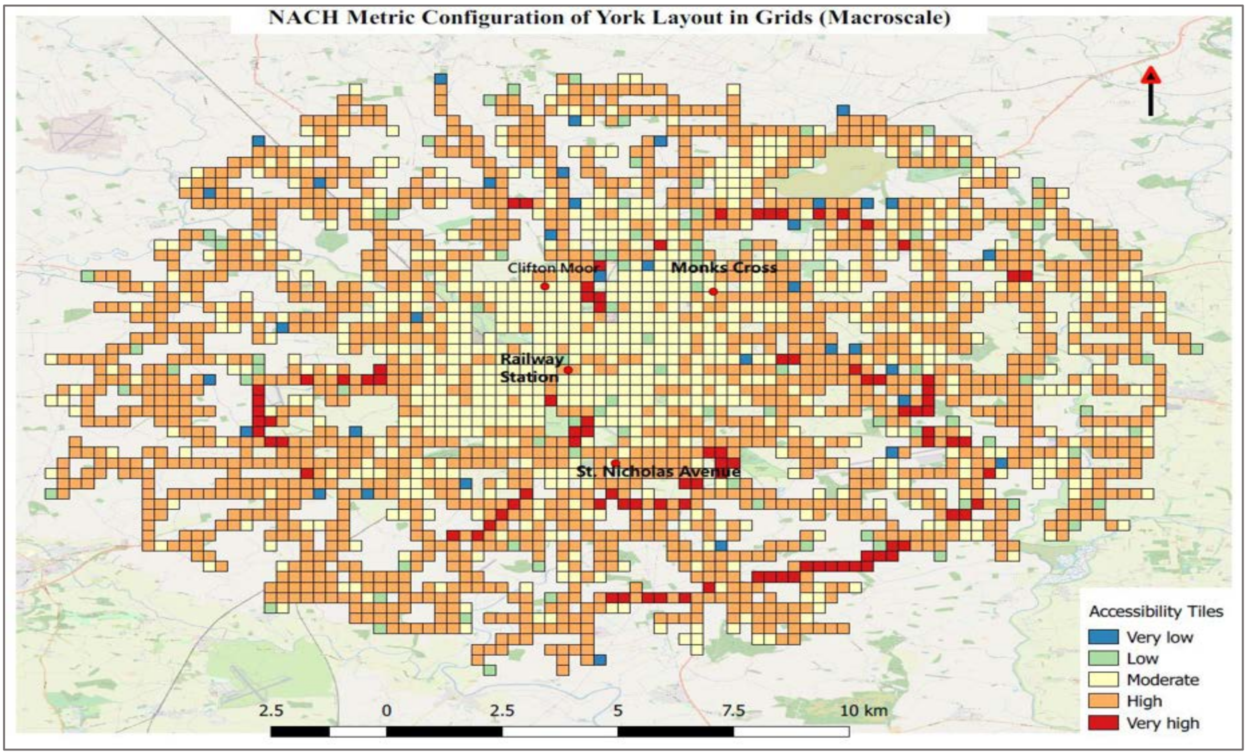
Source: Research work (2019)

4. Choice metric output at York mesoscale



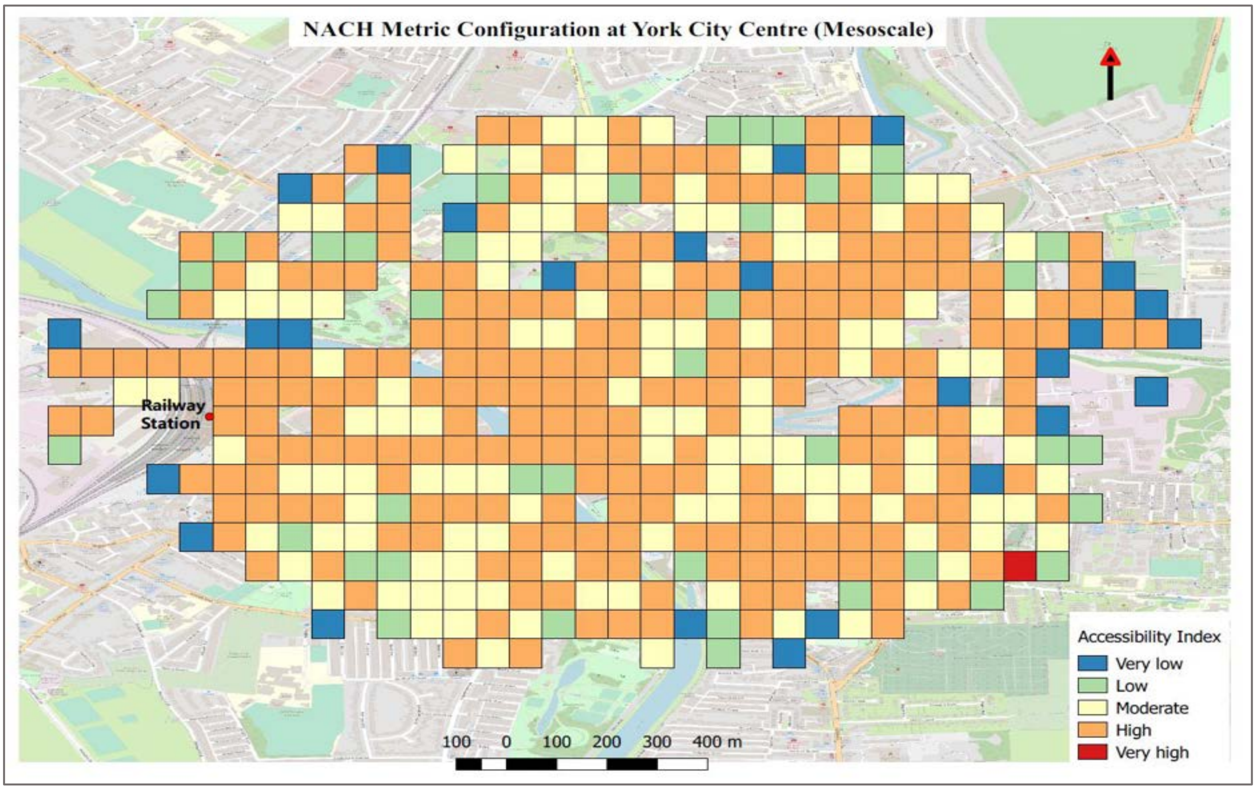
Source: Research work (2019)

5. NACH metric output at York macroscale



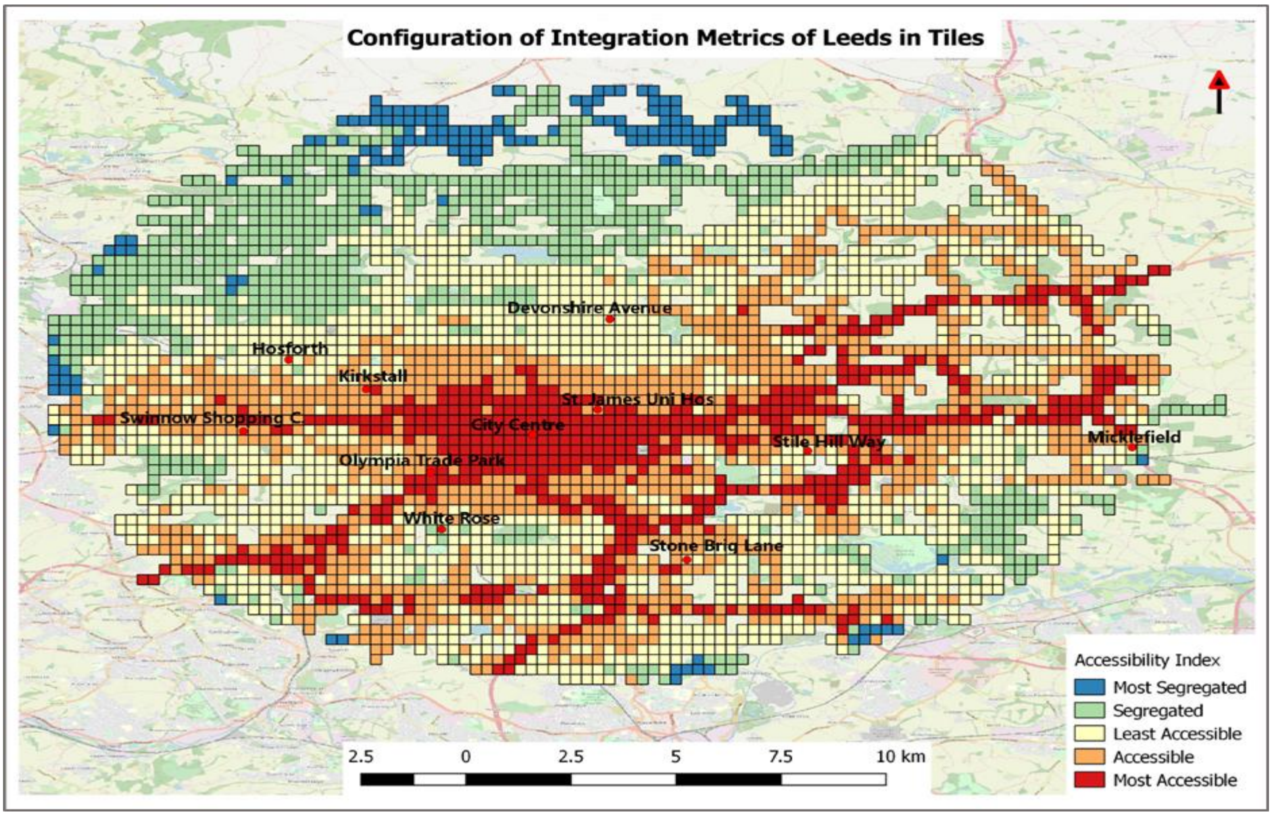
Source: Research work (2019)

6. NACH metric output at York mesoscale



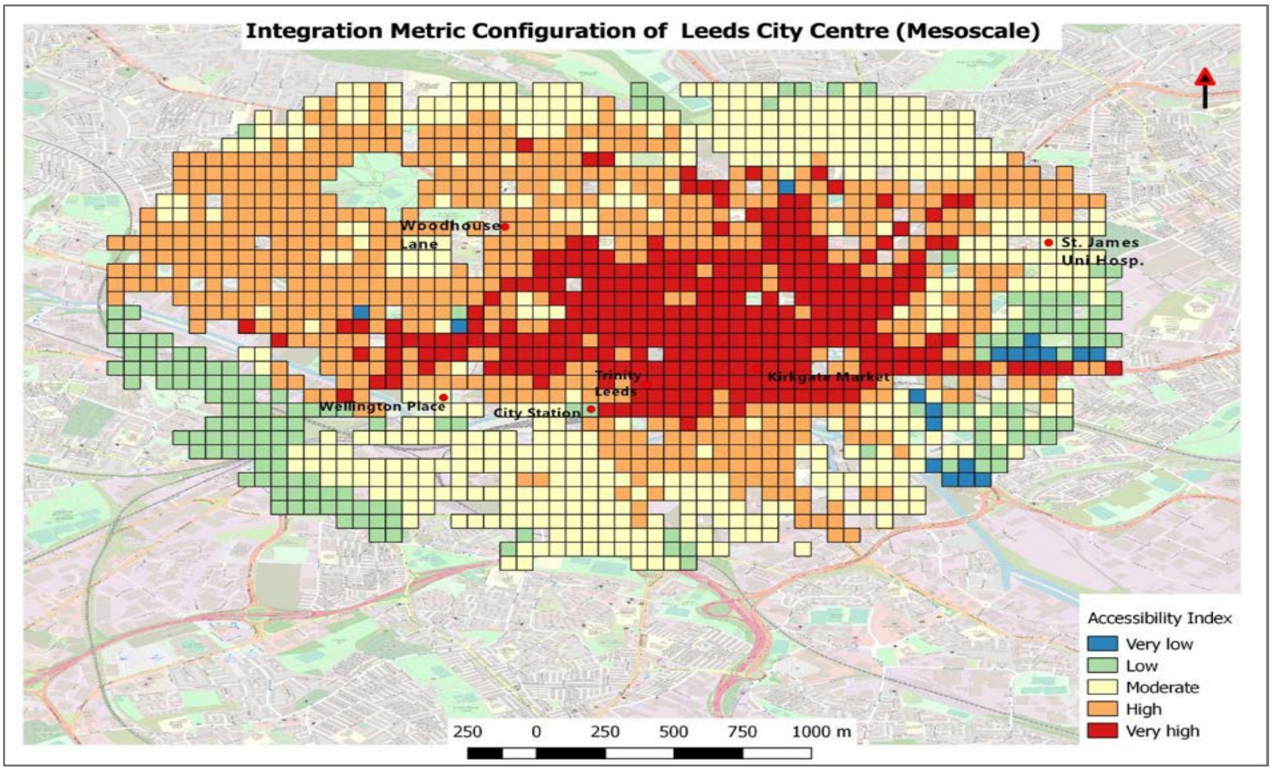
Source: Research work (2019)

7. Integration metric outputs at Leeds macroscale



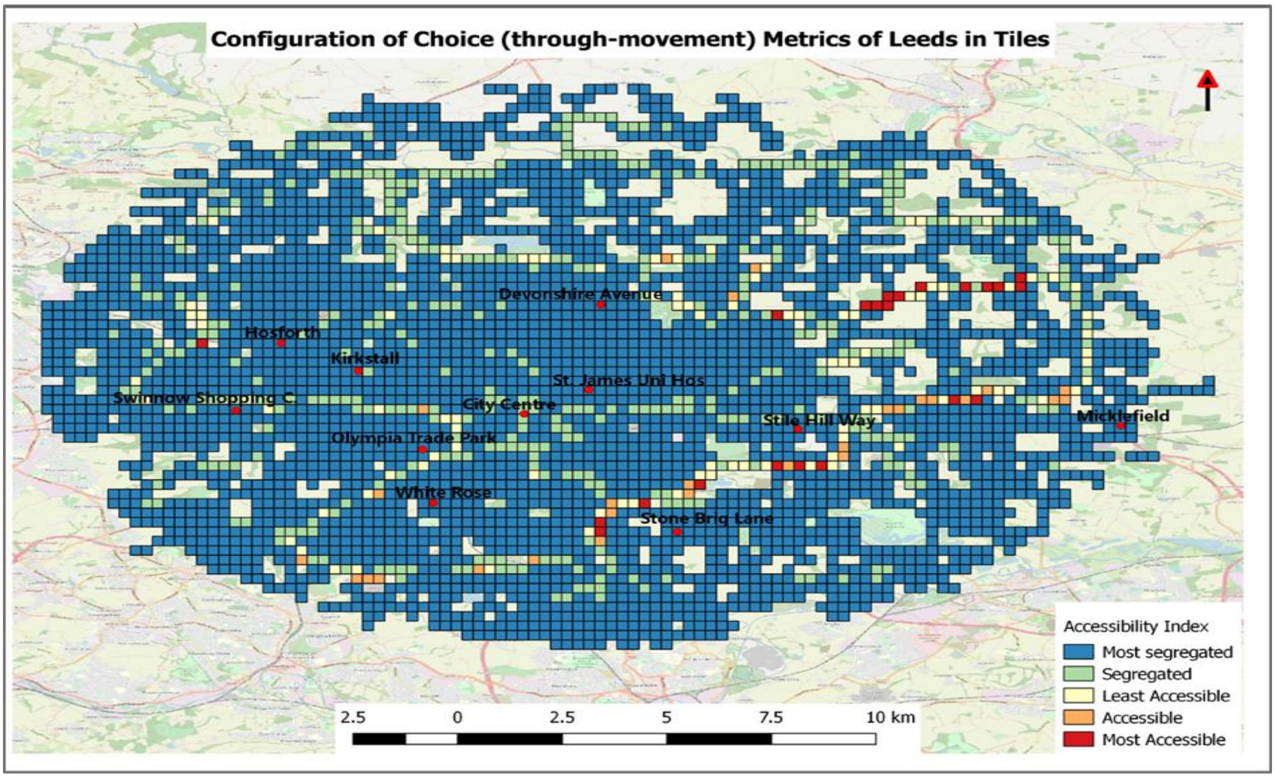
Source: Research work (2019)

8. Integration metric outputs at Leeds mesoscale



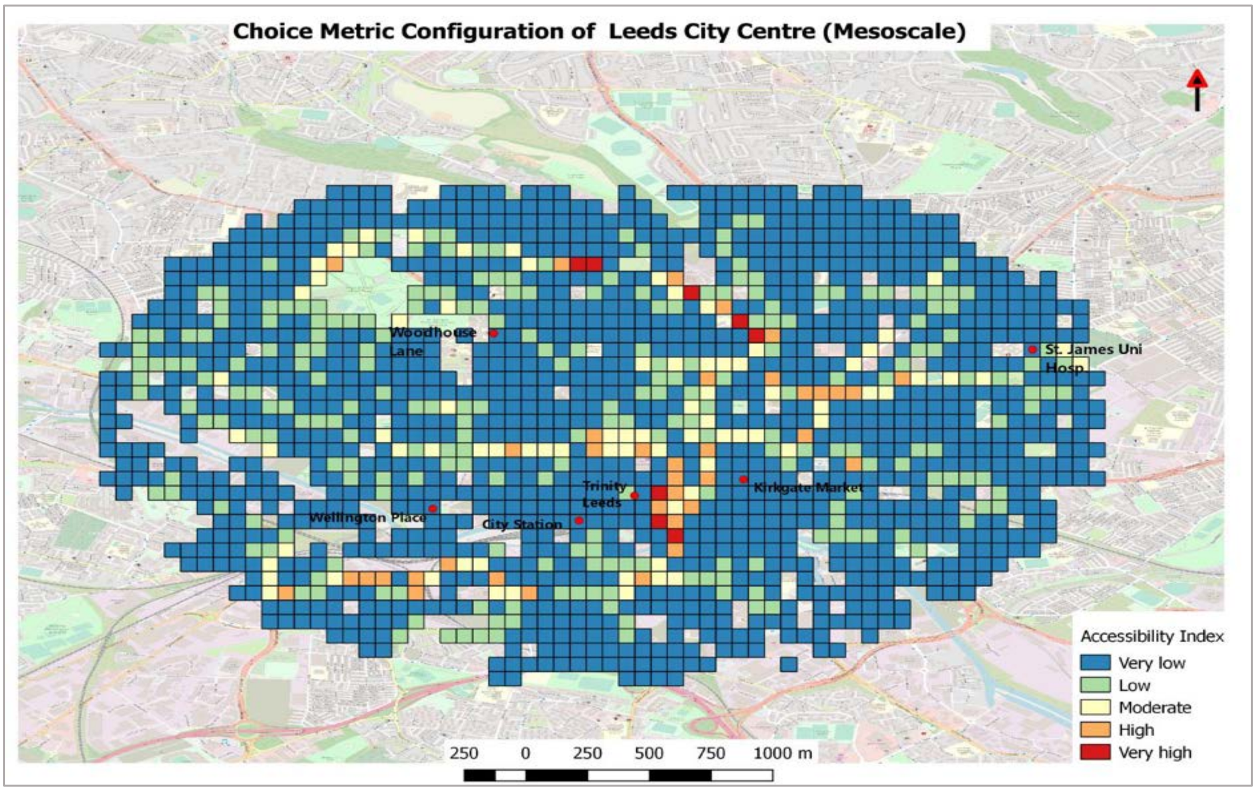
Source: Research work (2019)

9. Choice metric output at Leeds macroscale



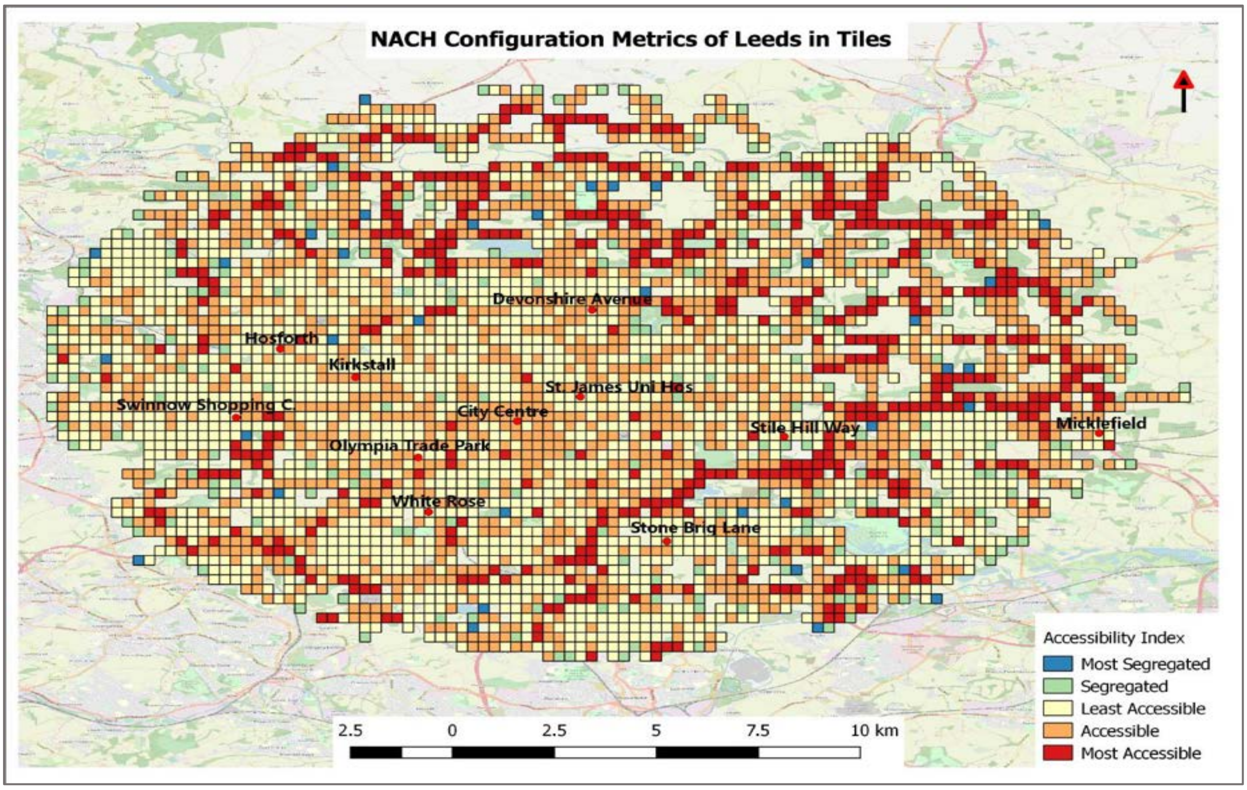
Source: Research work (2019)

10. Choice metric output at Leeds mesoscale



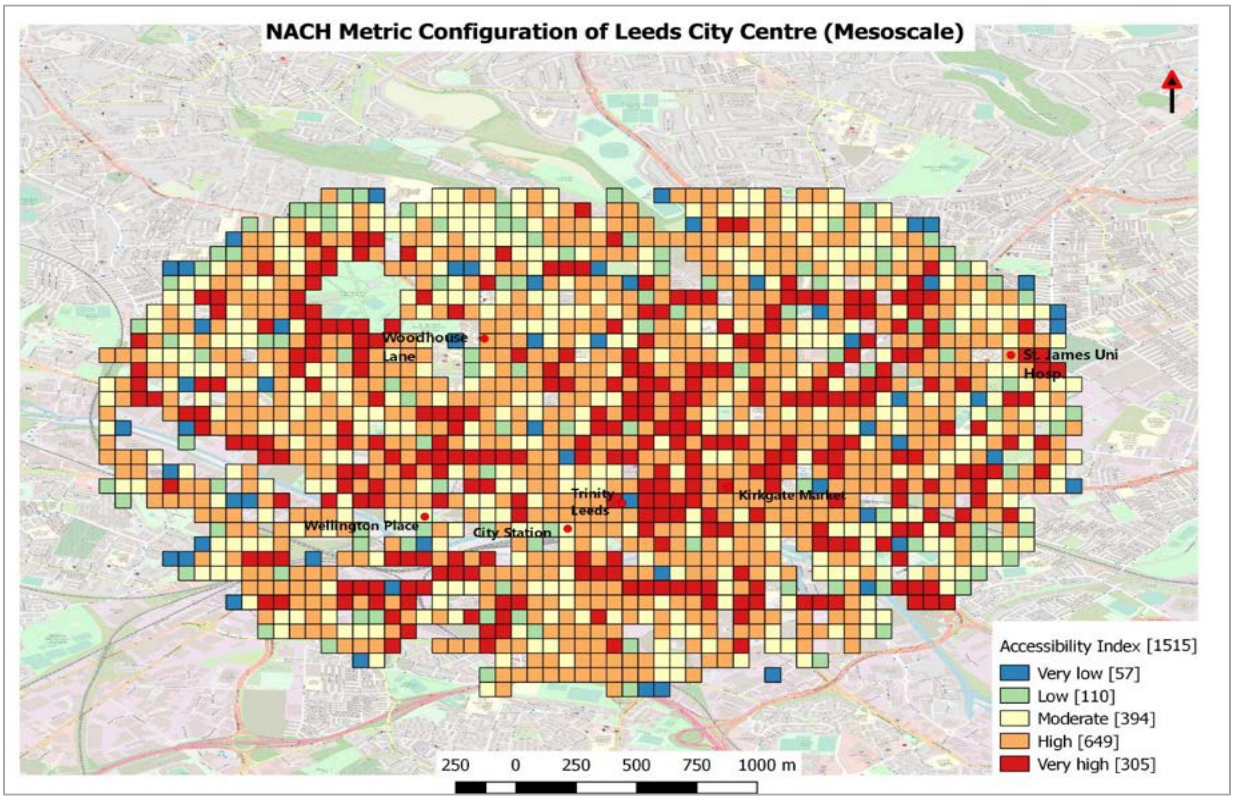
Source: Research work (2019)

11. NACH metric output at Leeds macroscale



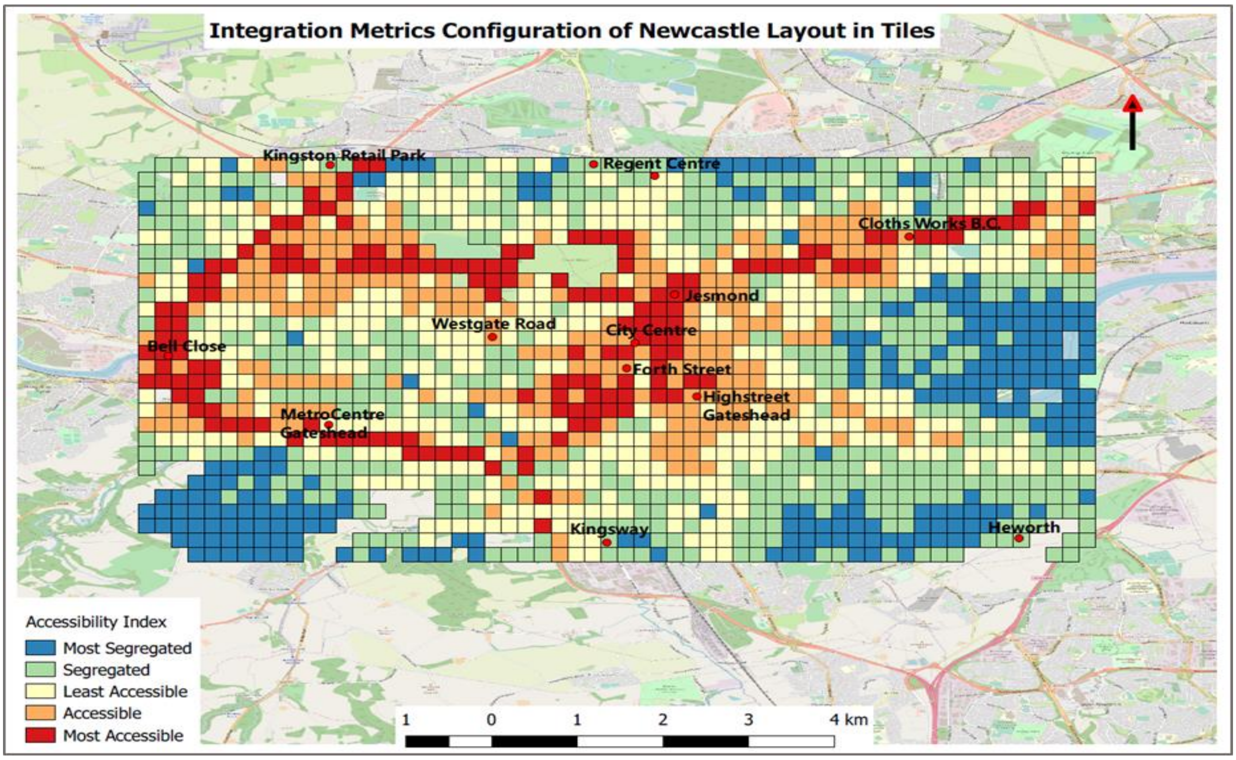
Source: Research work (2019)

12. NACH metric output at Leeds mesoscale



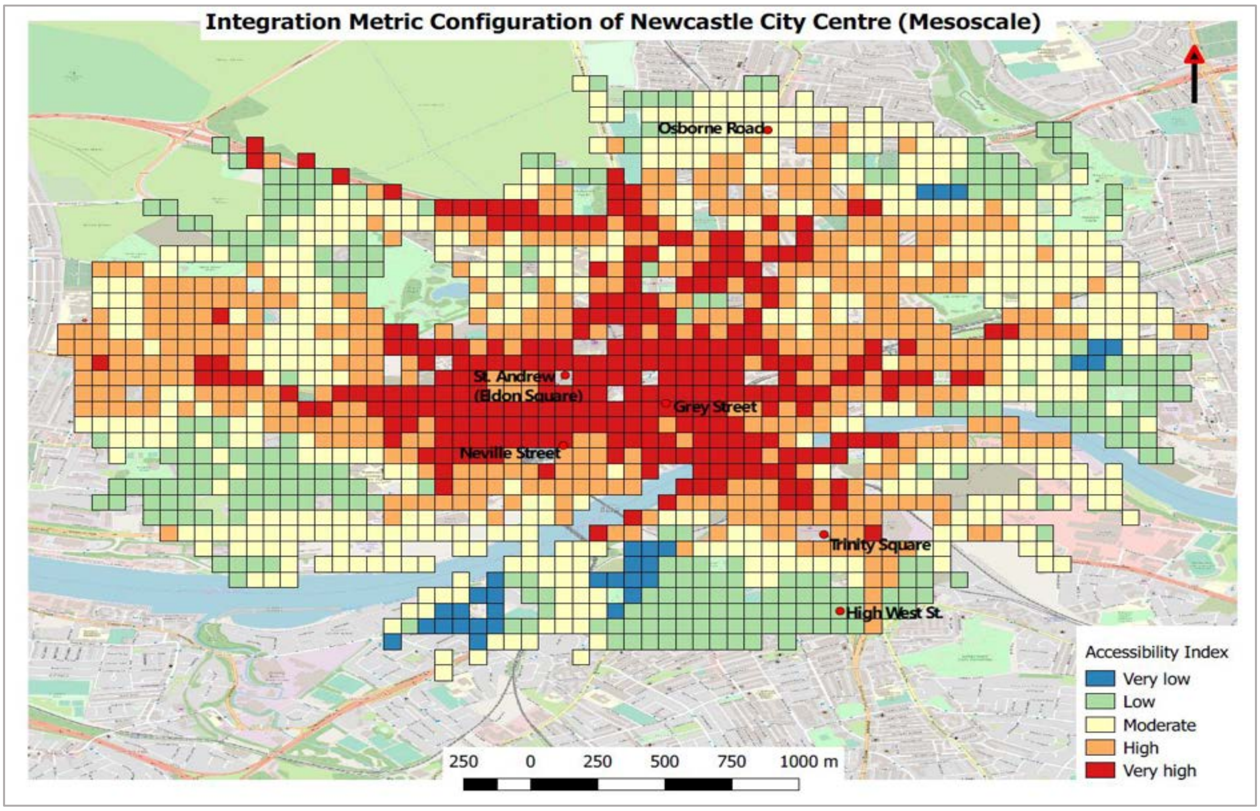
Source: Research work (2019)

13. Integration metric outputs at Newcastle macroscale



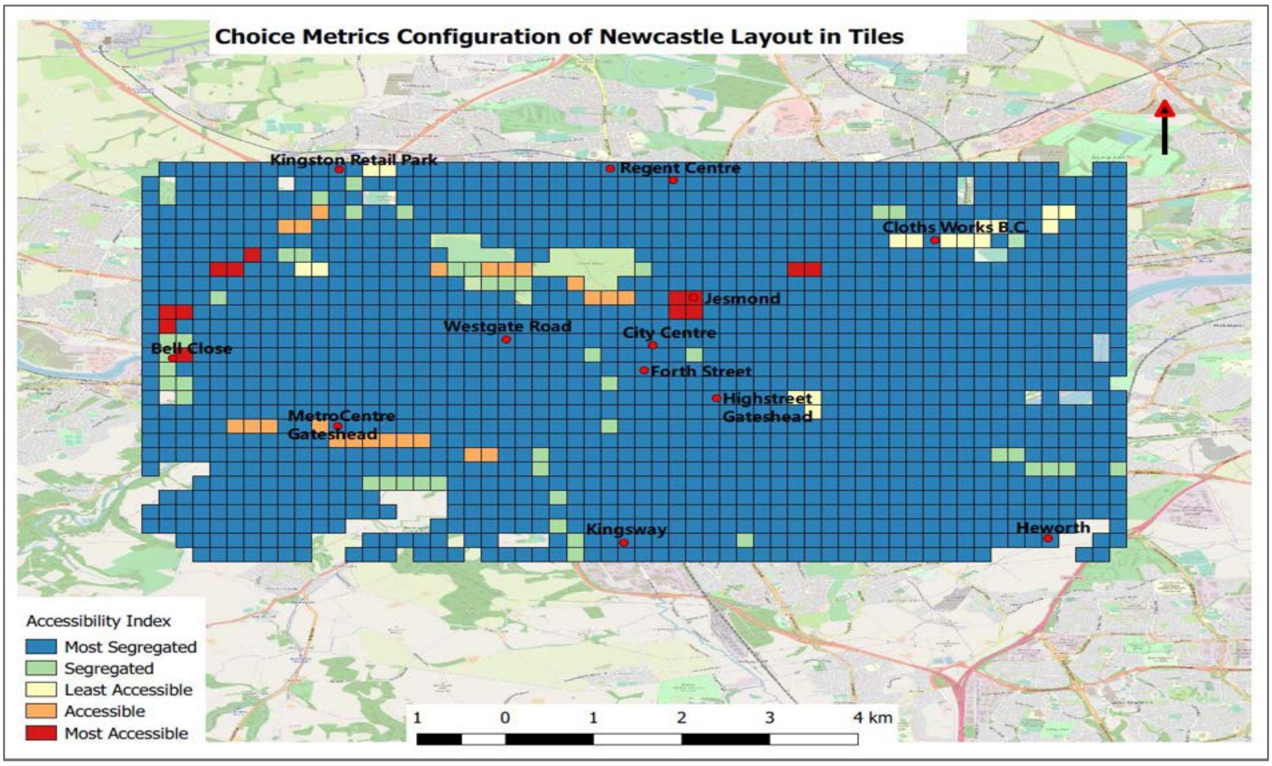
Source: Research work (2019)

14. Integration metric outputs at Newcastle mesoscale



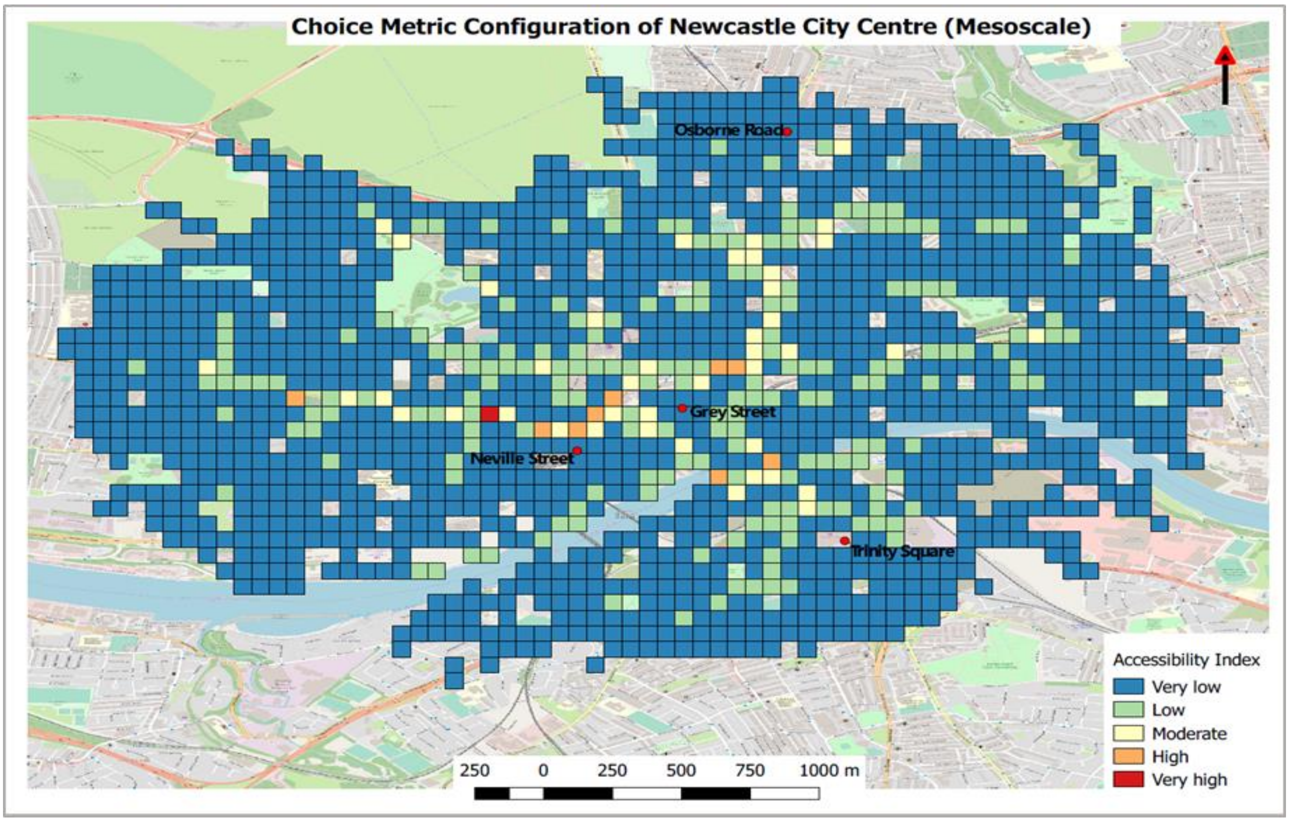
Source: Research work (2019)

15. Choice metric outputs at Newcastle macroscale



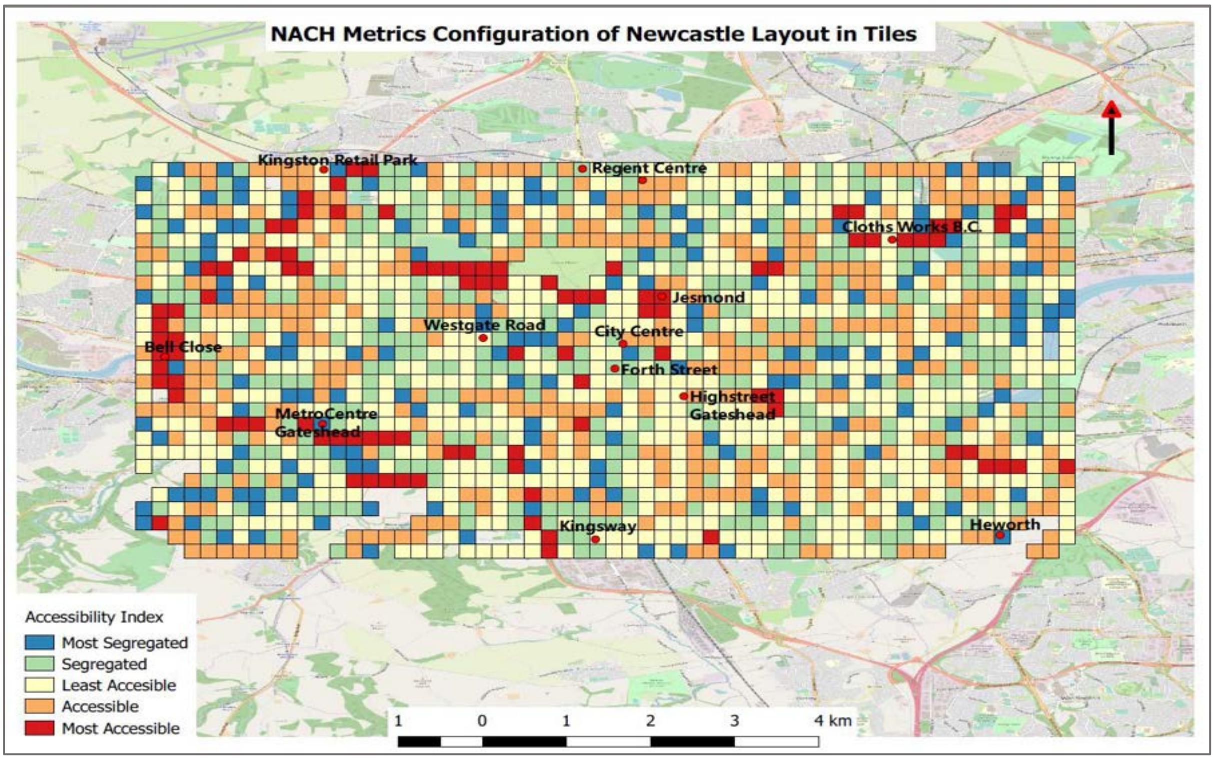
Source: Research work (2019)

16. Choice metric outputs at Newcastle mesoscale



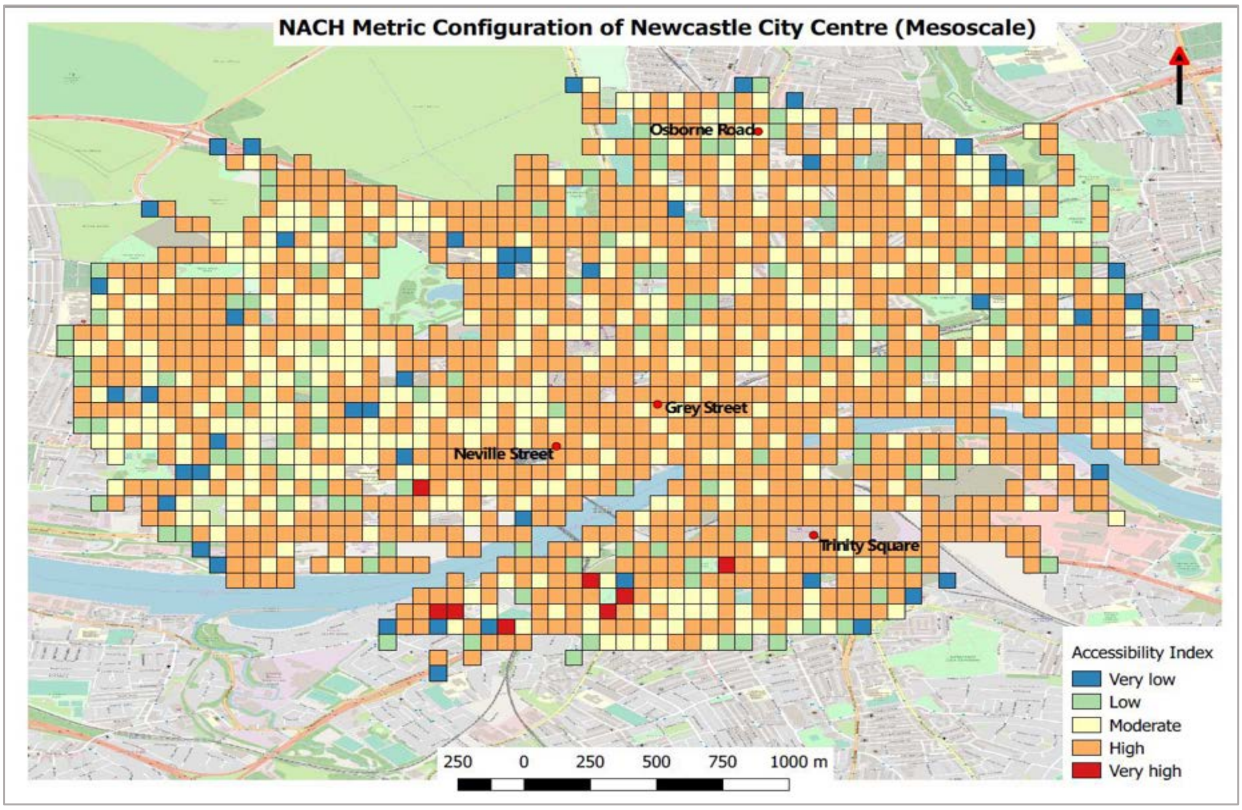
Source: Research work (2019)

17. NACH metric outputs at Newcastle macroscale



Source: Research work (2019)

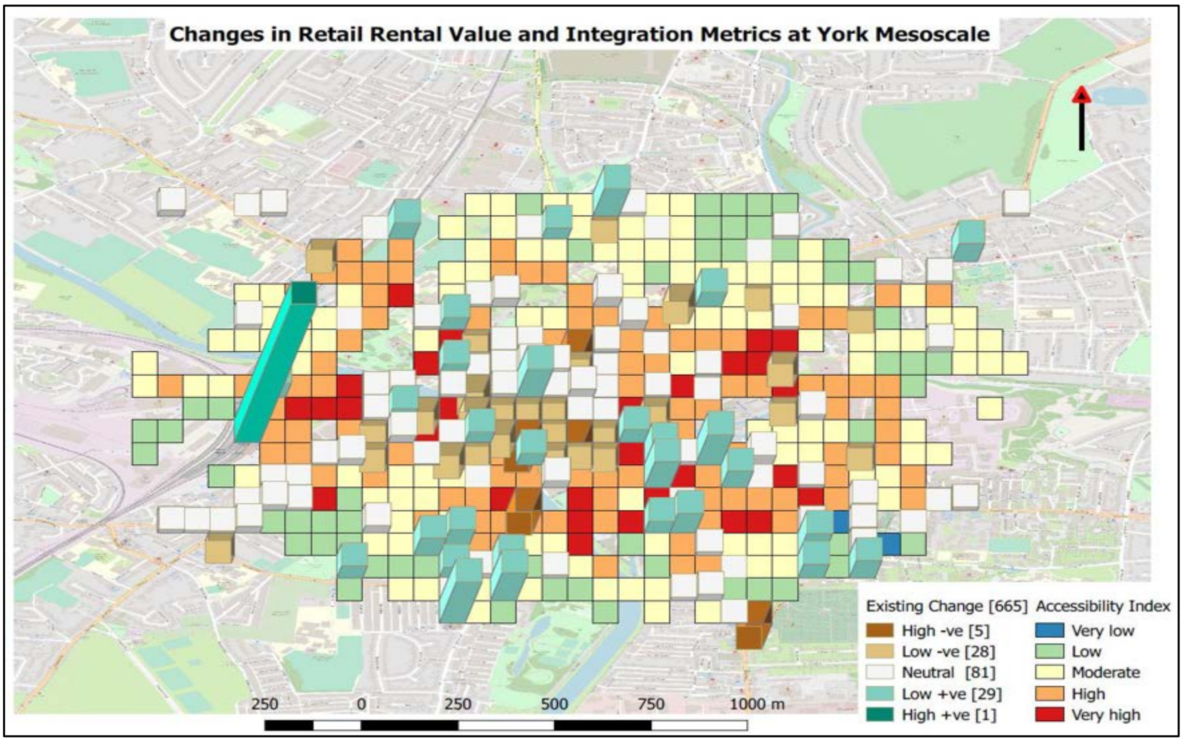
18. NACH metric output at Newcastle mesoscale



Source: Research work (2019)

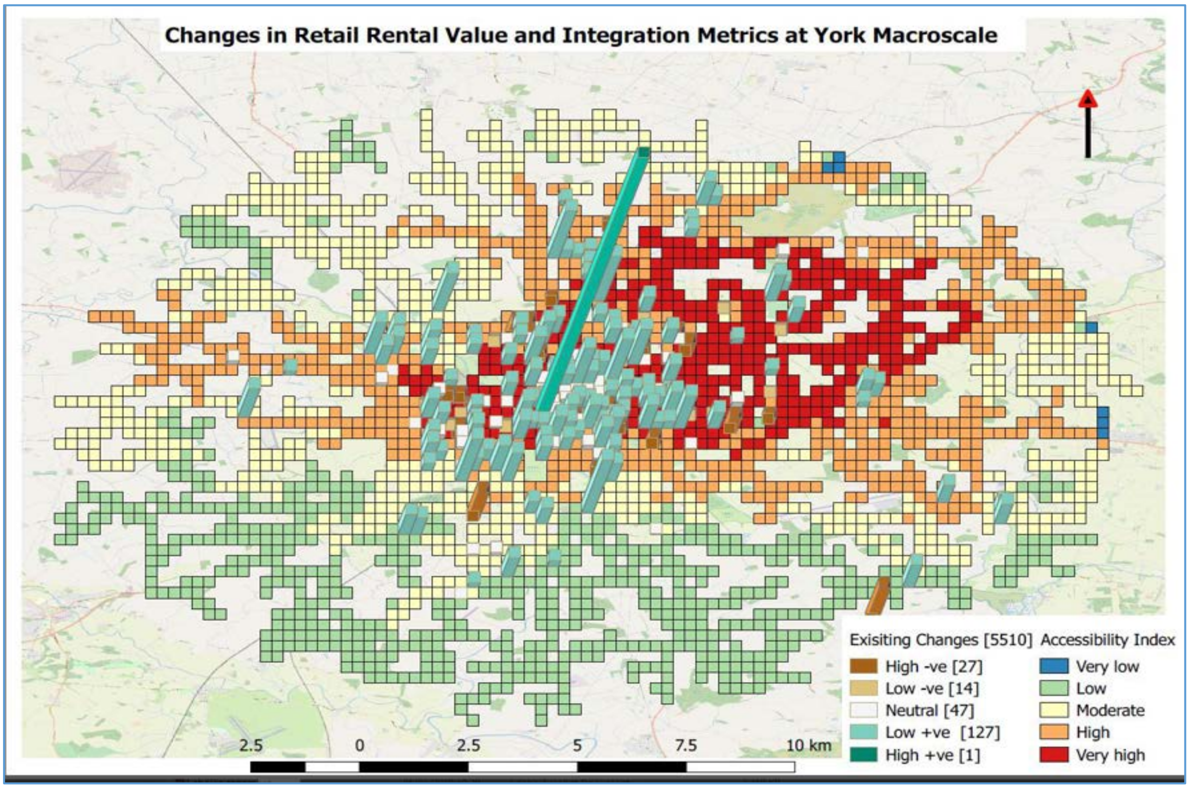
APPENDIX C: Spatial Relationship between RPM and CMP variables

1. Changes in retail rental value and Integration metrics at York mesoscale



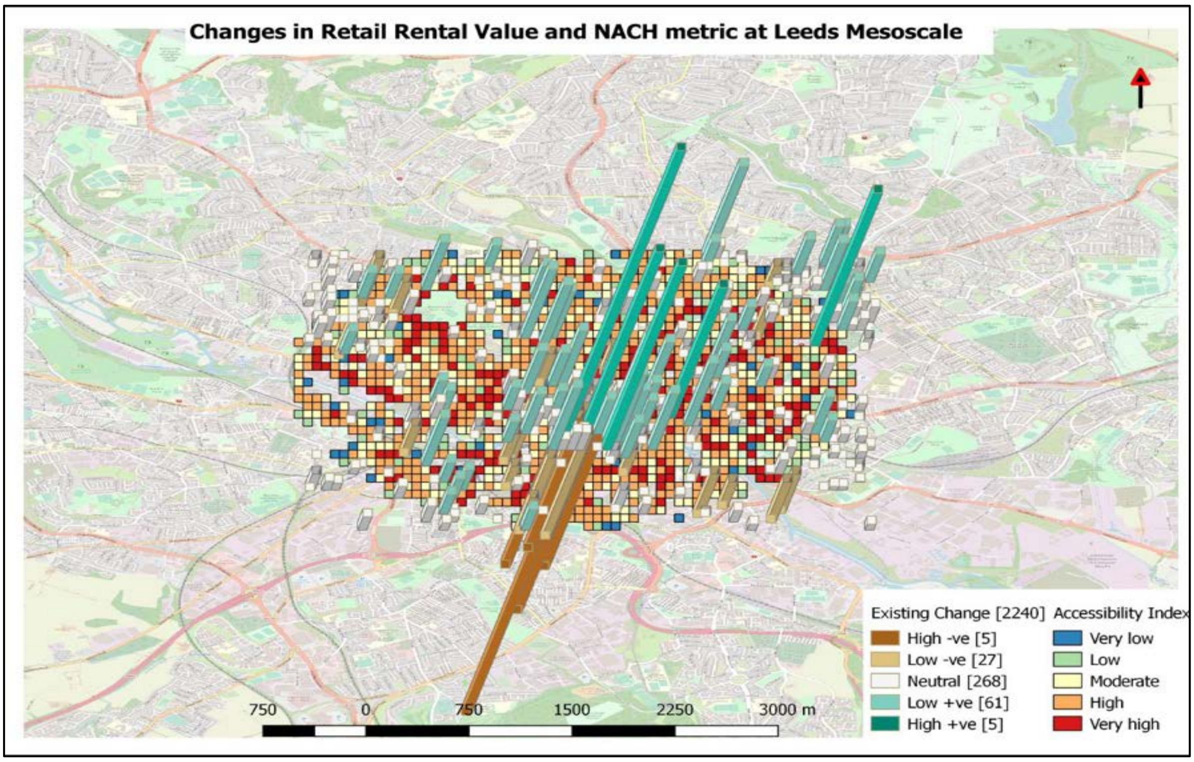
Source: Research work (2019)

2. Changes in retail rental value and Integration metrics at York macroscale



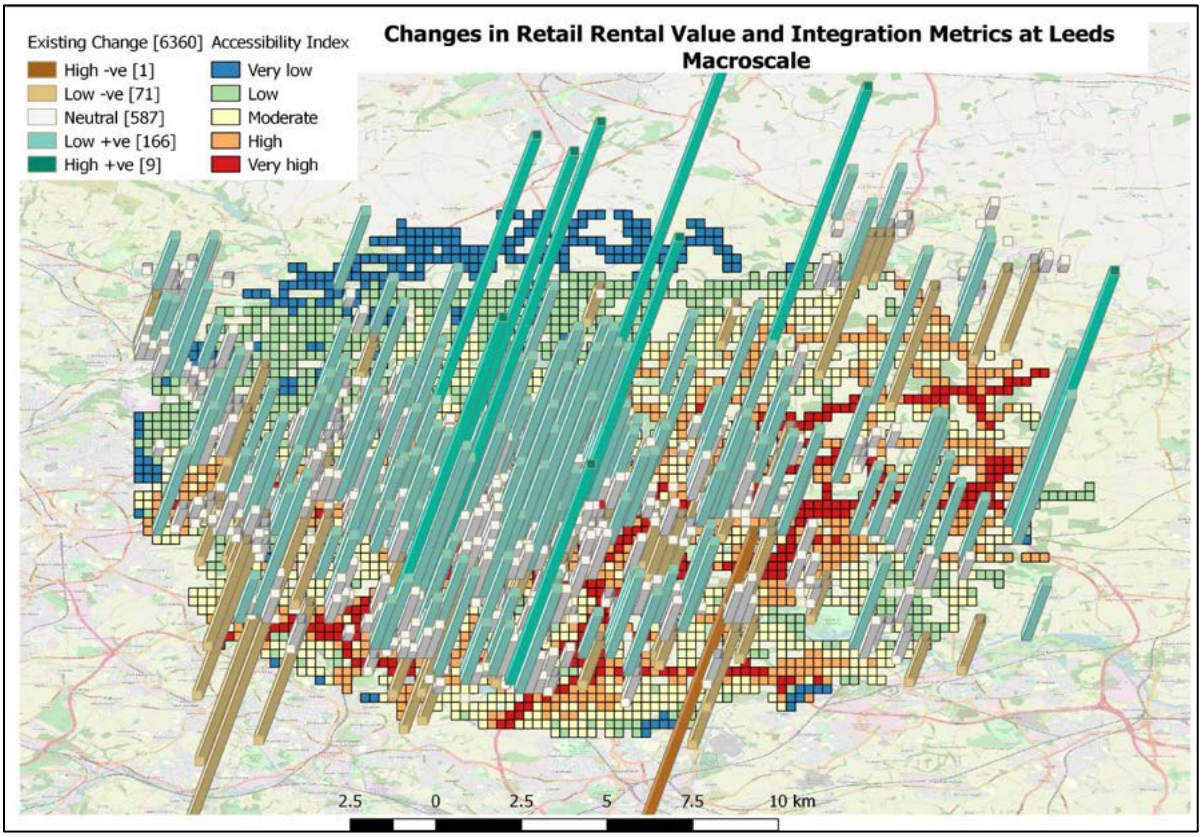
Source: Research work (2019)

3. Changes in retail rental value and Integration metrics at Leeds mesoscale



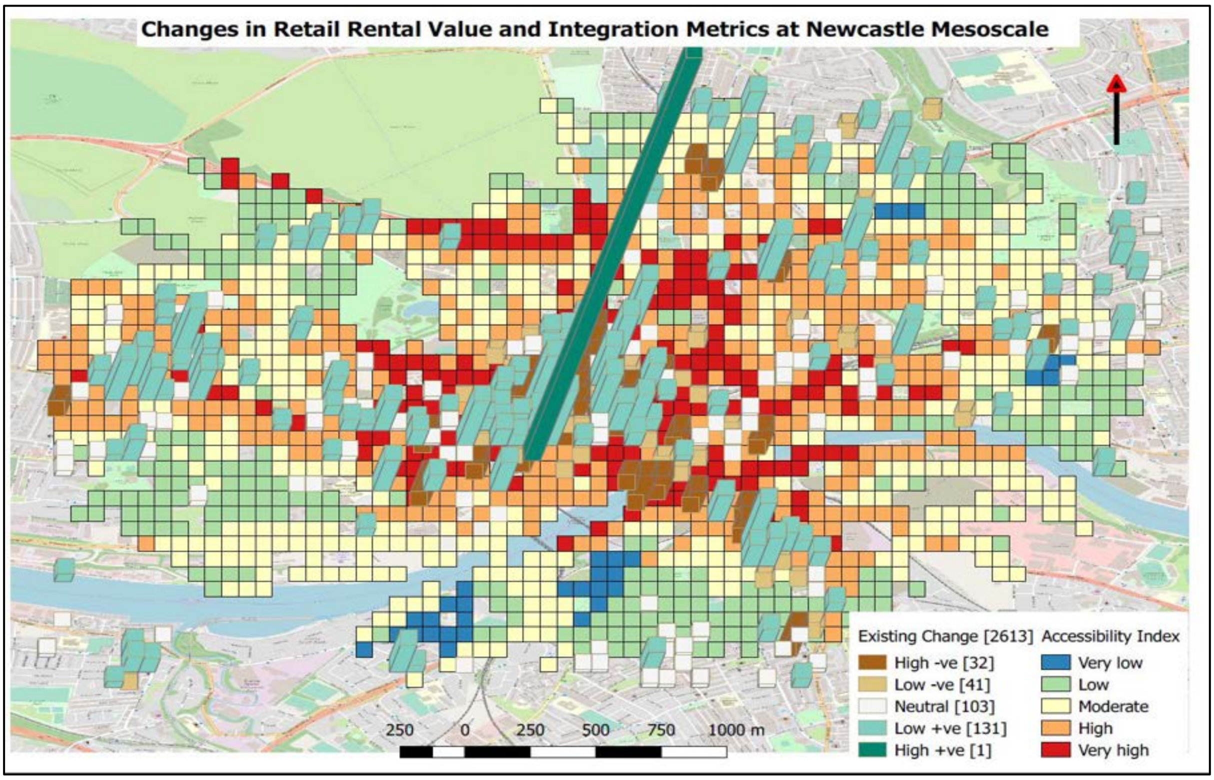
Source: Research work (2019)

4. Changes in retail rental value and Integration metrics at Leeds macroscale



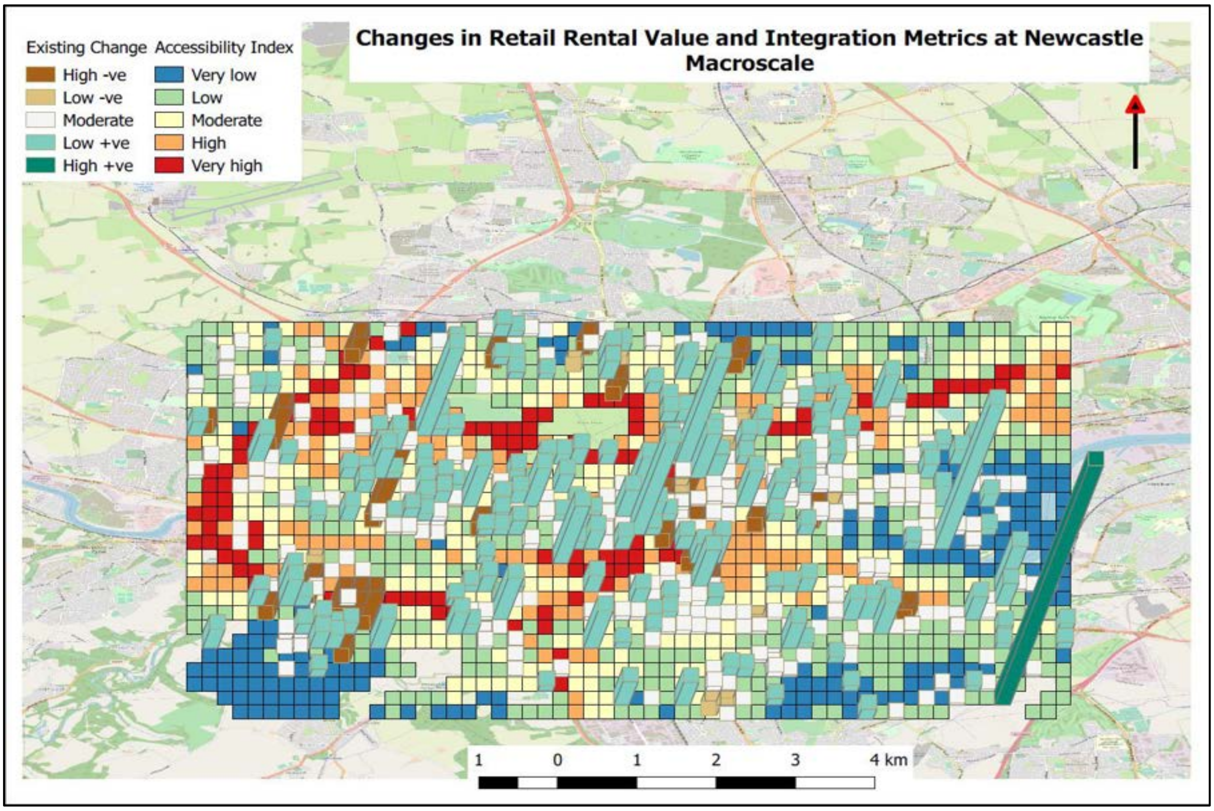
Source: Research work (2019)

5. Changes in retail rental value and Integration metrics at Newcastle mesoscale



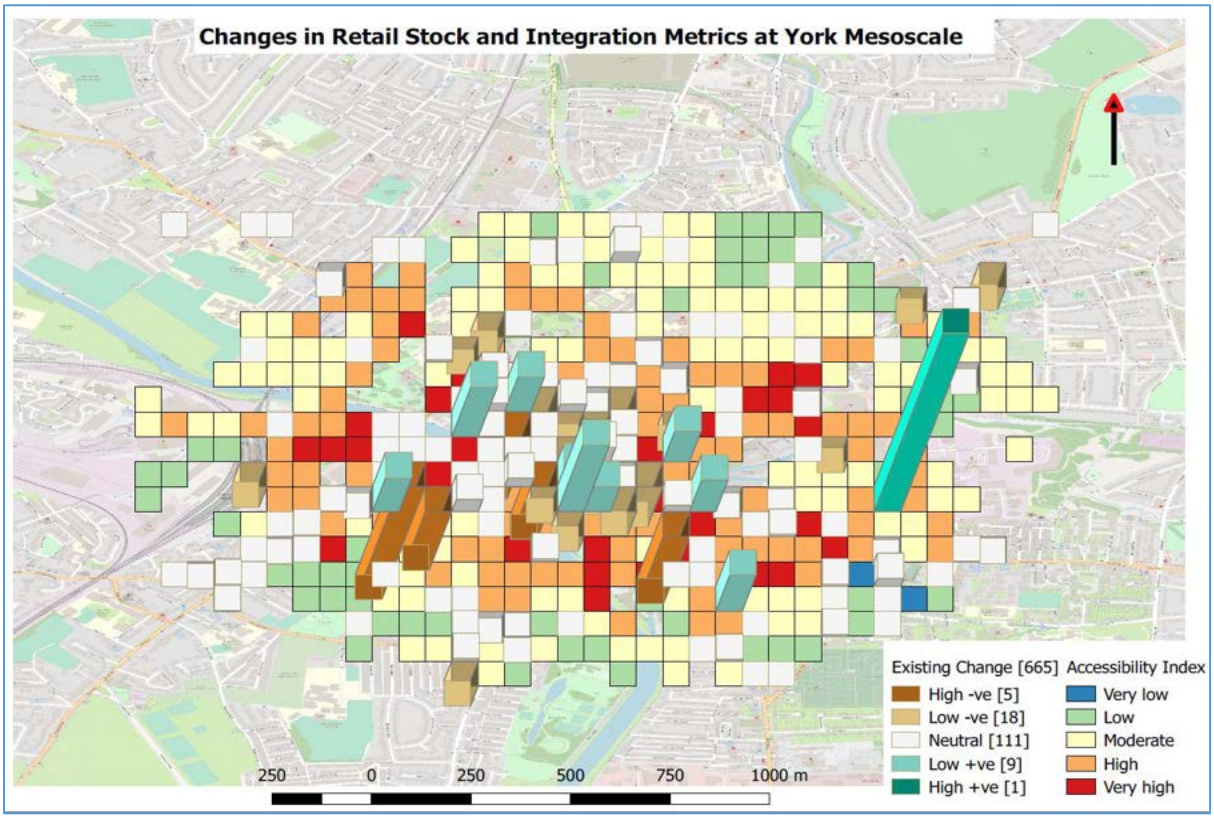
Source: Research work (2019)

6. Changes in retail rental value and Integration metrics at Newcastle macroscale



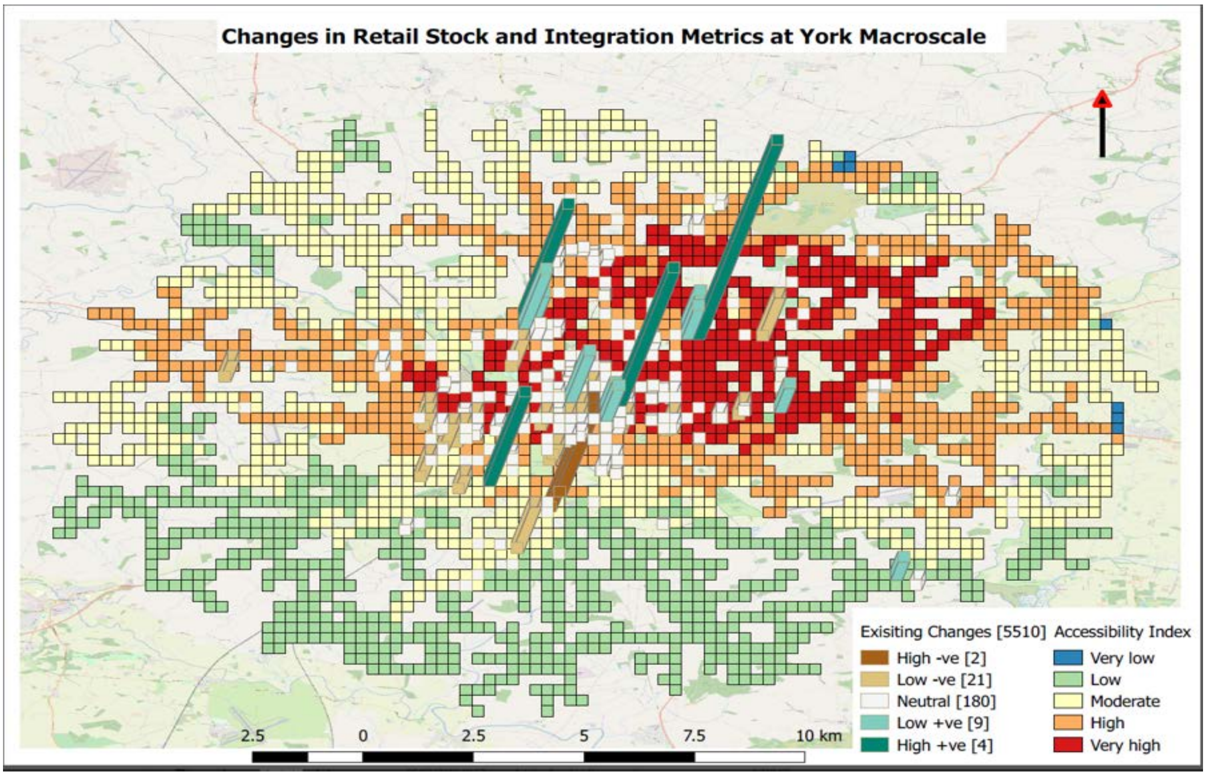
Source: Research work (2019)

7. Changes in retail stock and Integration Metrics at York mesoscale



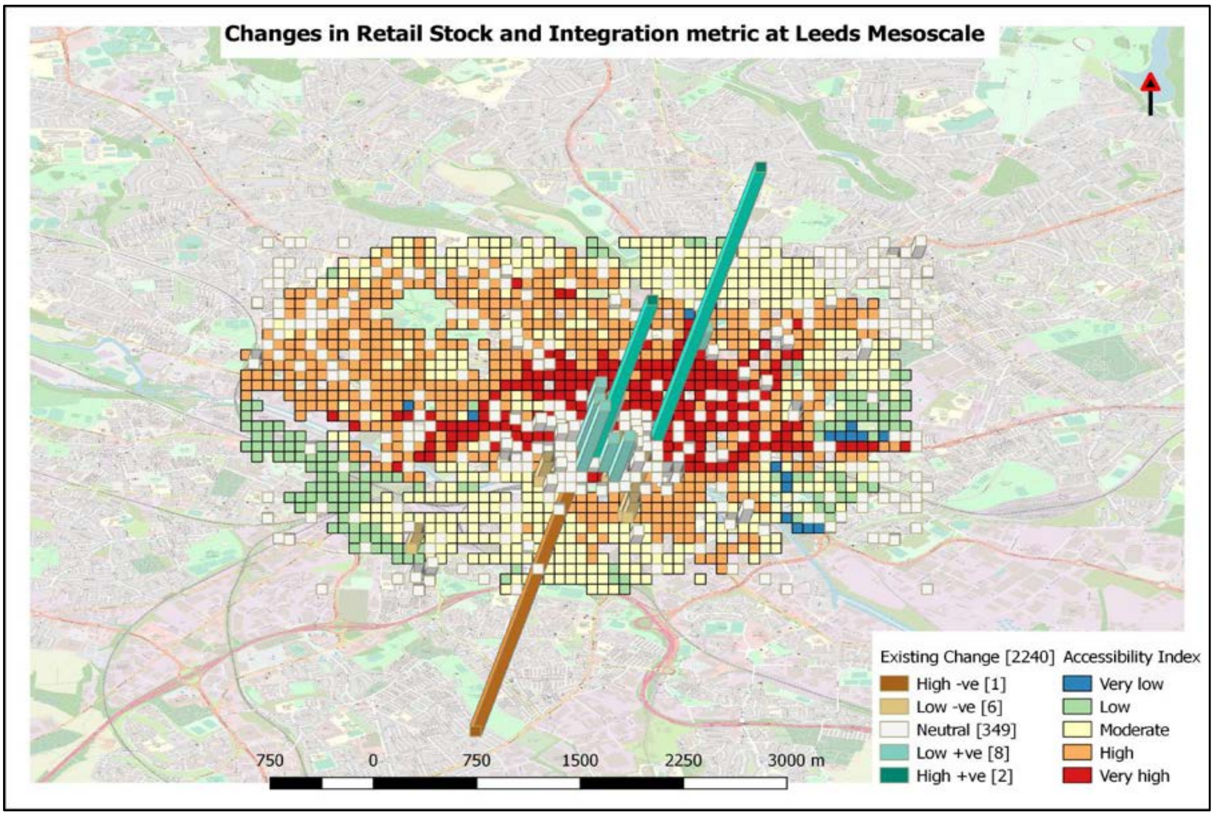
Source: Research work (2019)

8. Changes in retail stock and Integration metrics at York macroscale



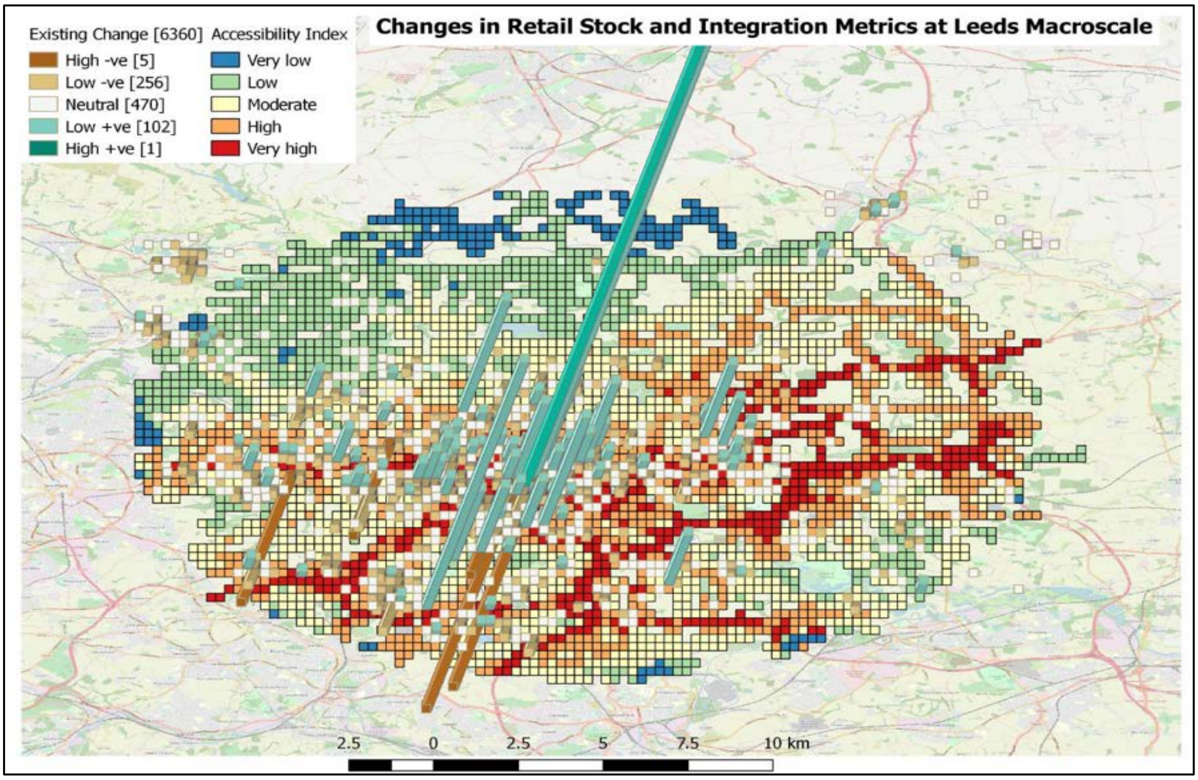
Source: Research work (2019)

9. Changes in retail stock and Intergration metrics at Leeds mesoscale



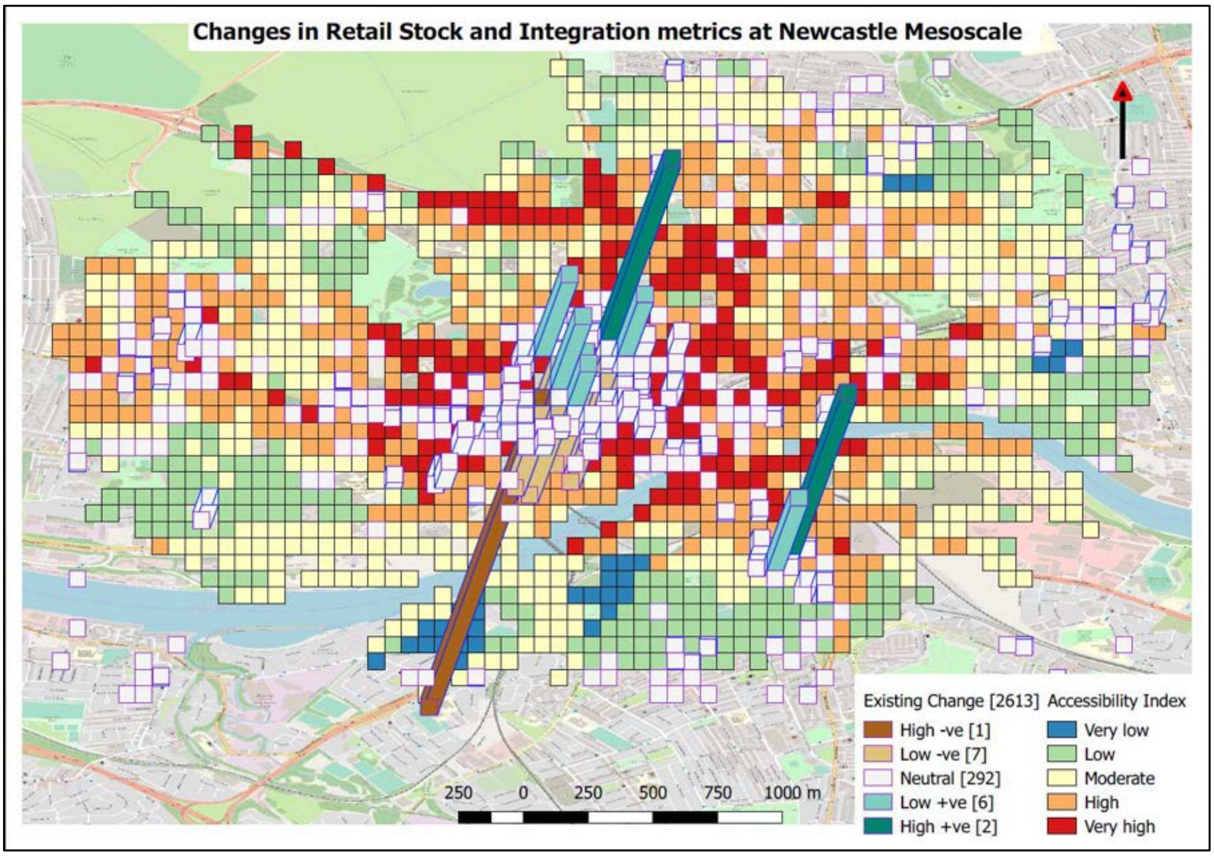
Source: Research work (2019)

10. Changes in retail stock and integration metrics at Leeds macroscale



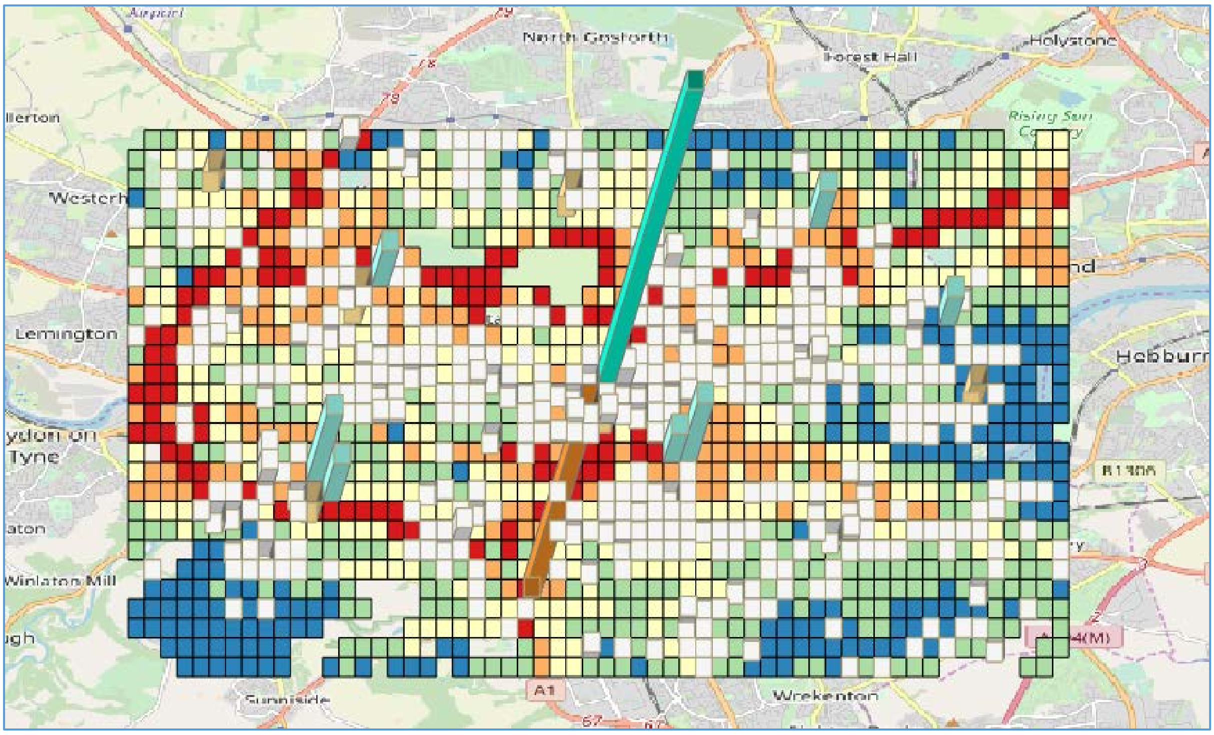
Source: Research work (2019)

11. Changes in retail stock and Integration metrics at Newcastle mesoscale



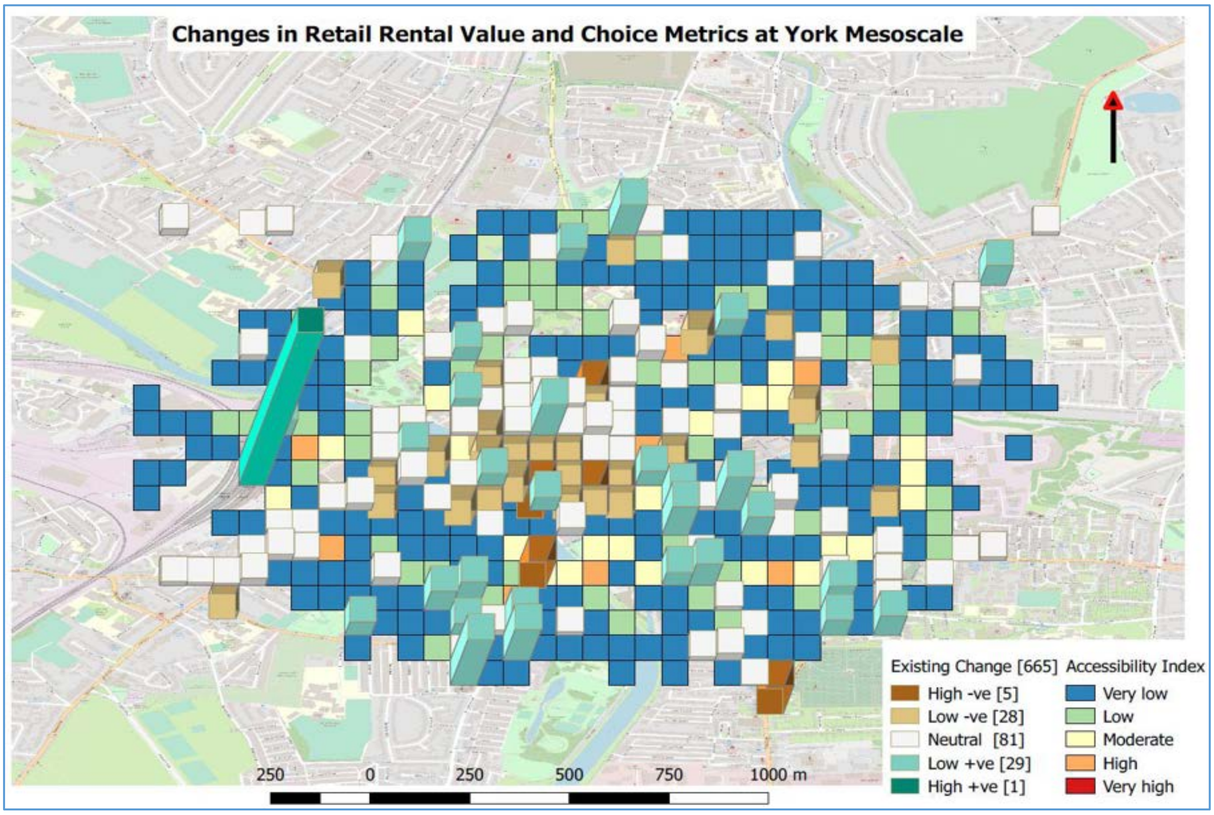
Source: Research work (2019)

12. Changes in retail stock and Integration metrics at Newcastle macroscale



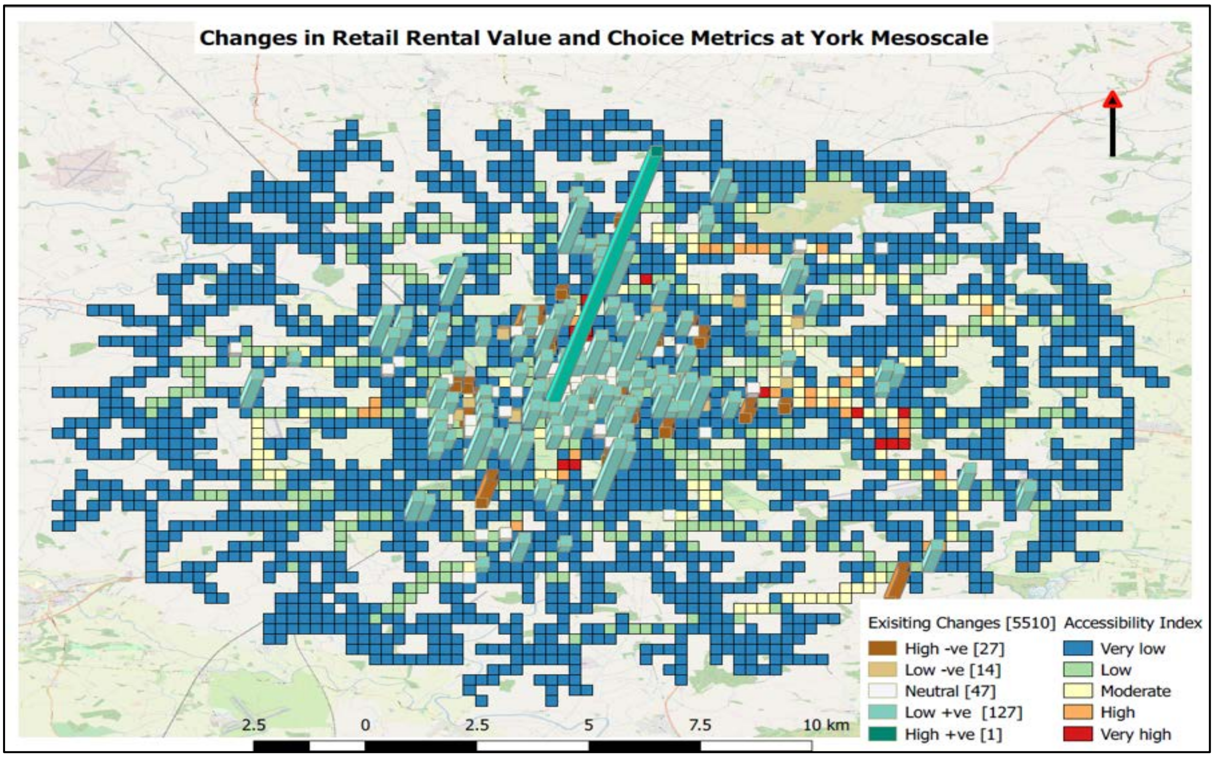
Source: Research work (2019)

13. Changes in retail rental value and Choice metrics at York mesoscale



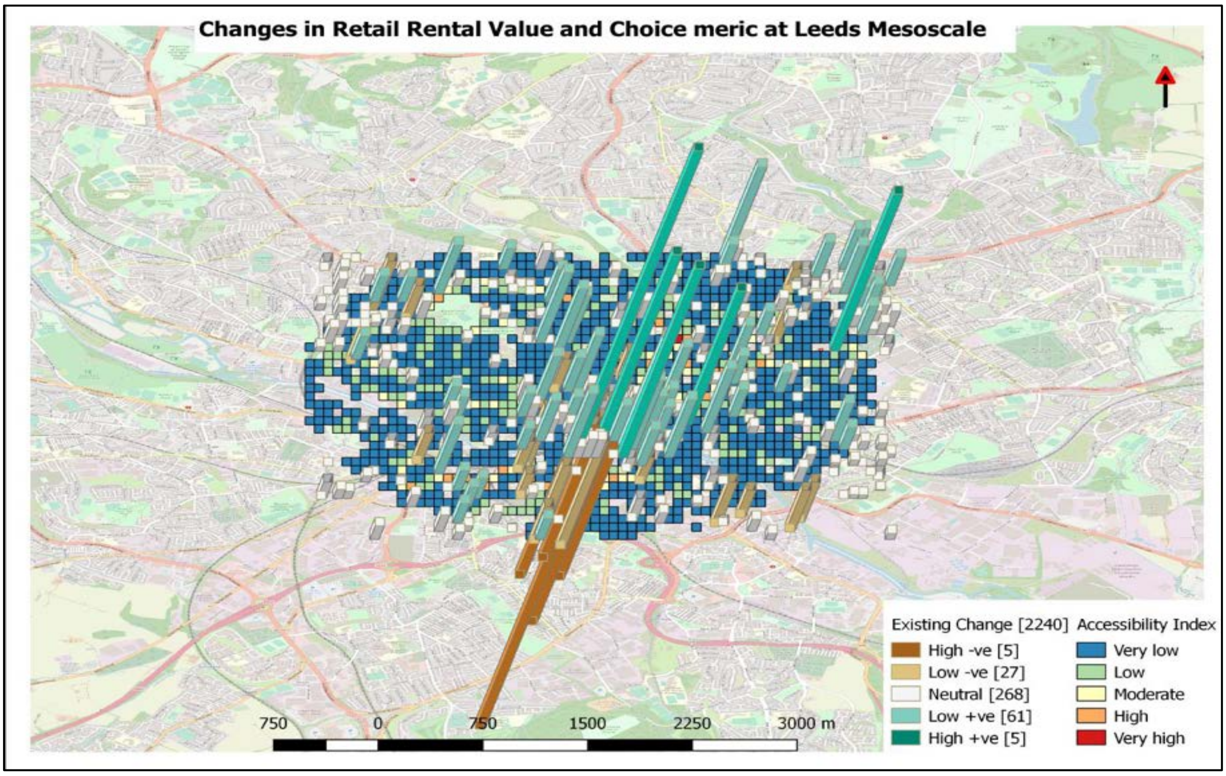
Source: Research work (2019)

14. Changes in retail rental value and Choice metrics at York macroscale



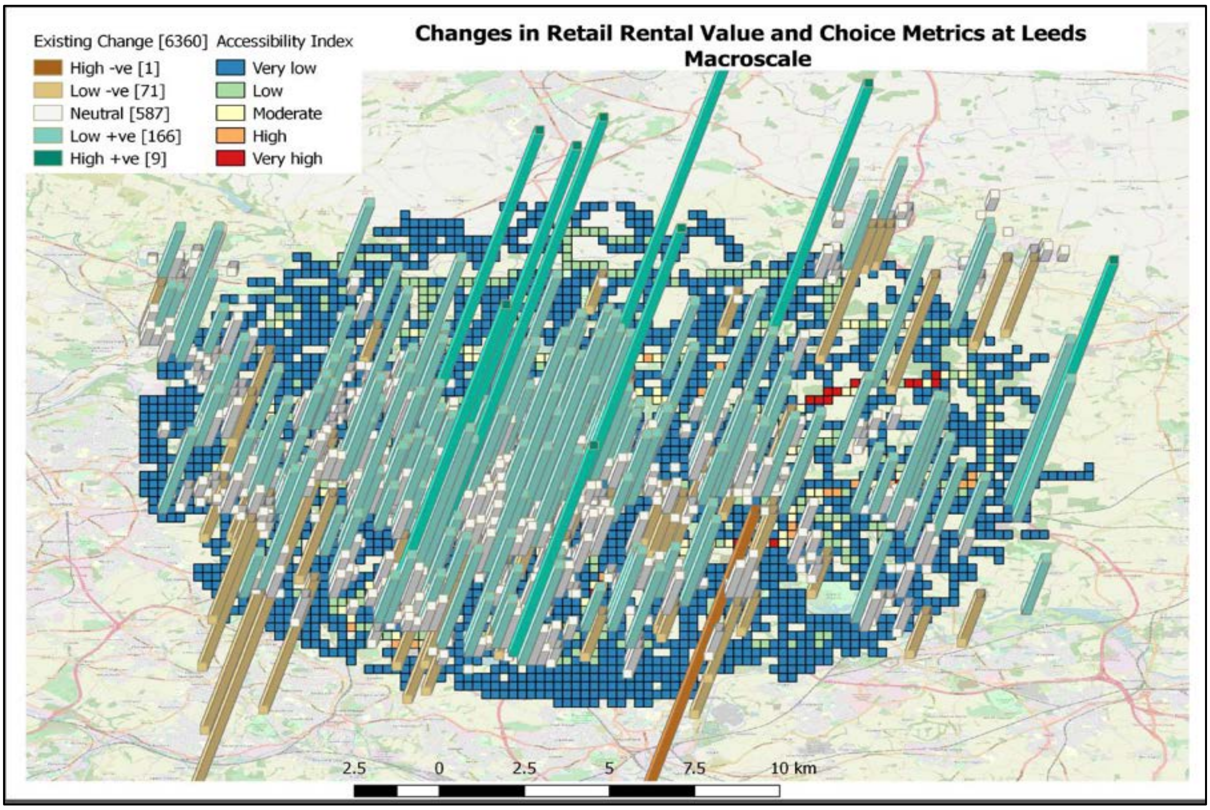
Source: Research work (2019)

15. Changes in retail rental value and Choice metrics at Leeds mesoscale



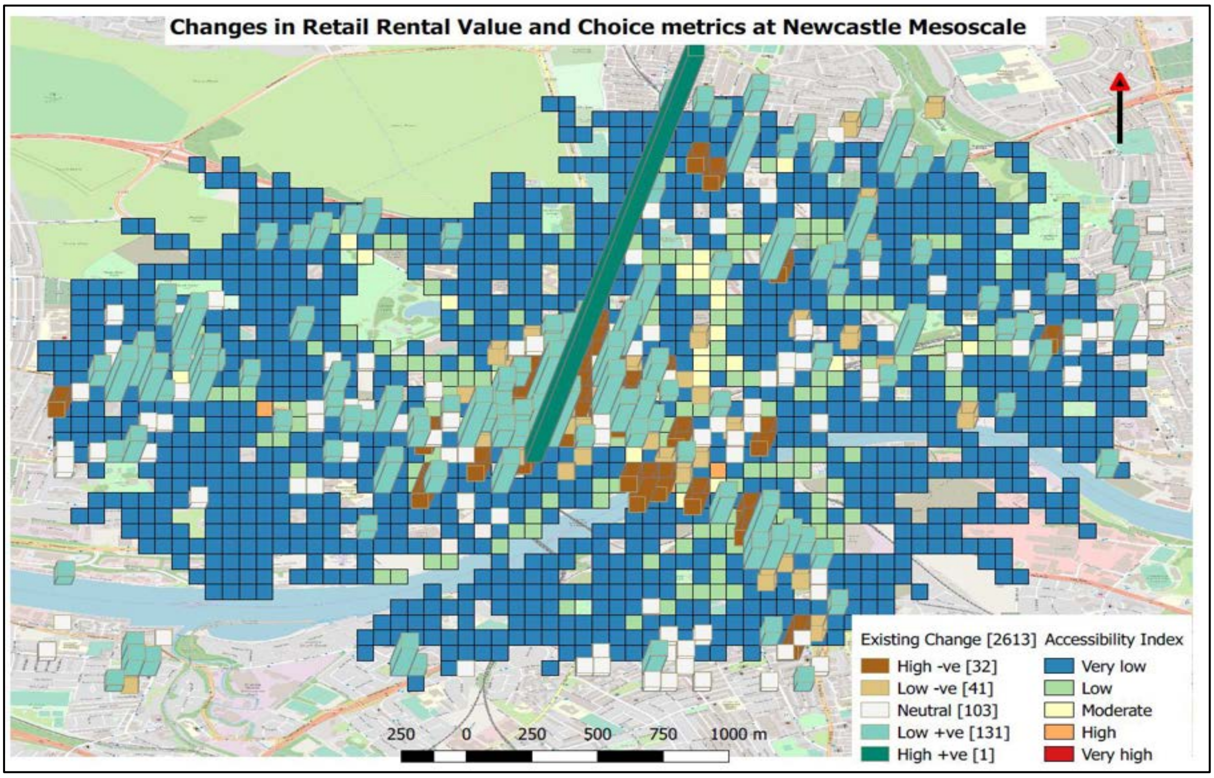
Source: Research work (2019)

16. Changes in retail rental value and Choice metrics at Leeds macroscale



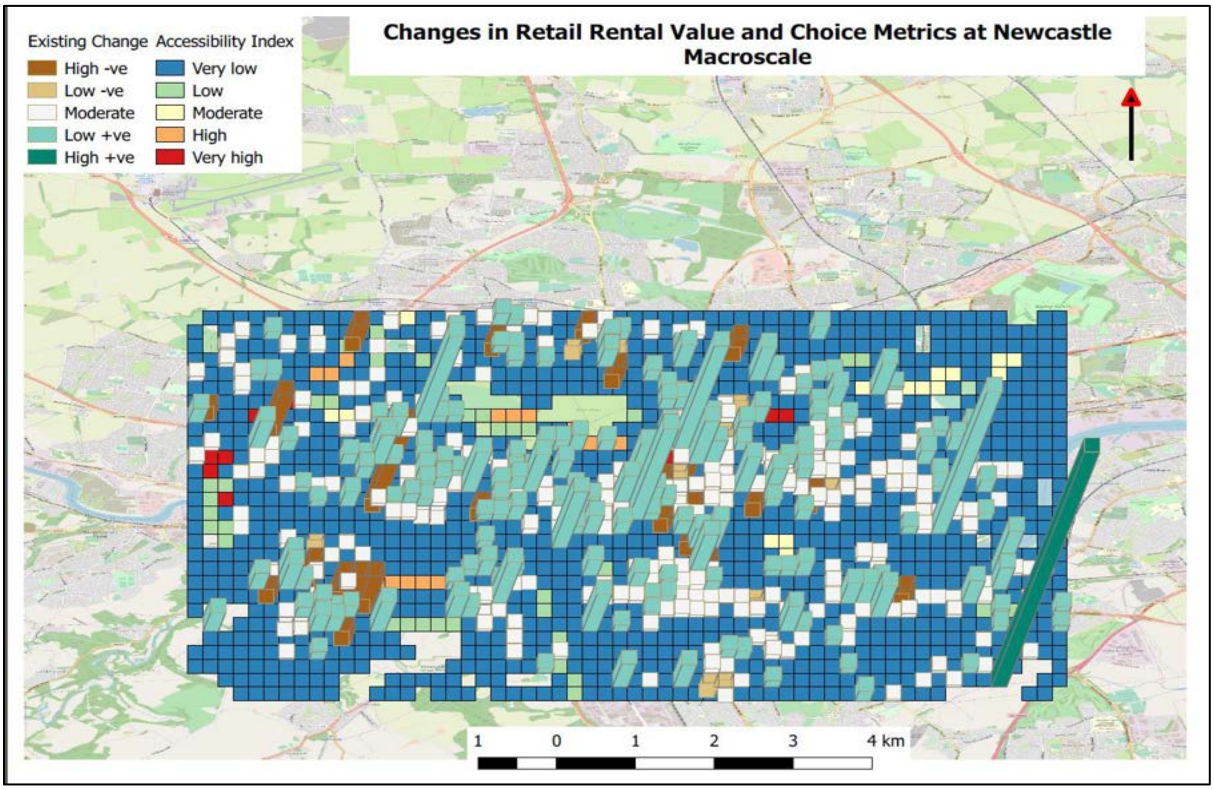
Source: Research work (2019)

17. Changes in retail rental value and Choice metrics at Newcastle mesoscale



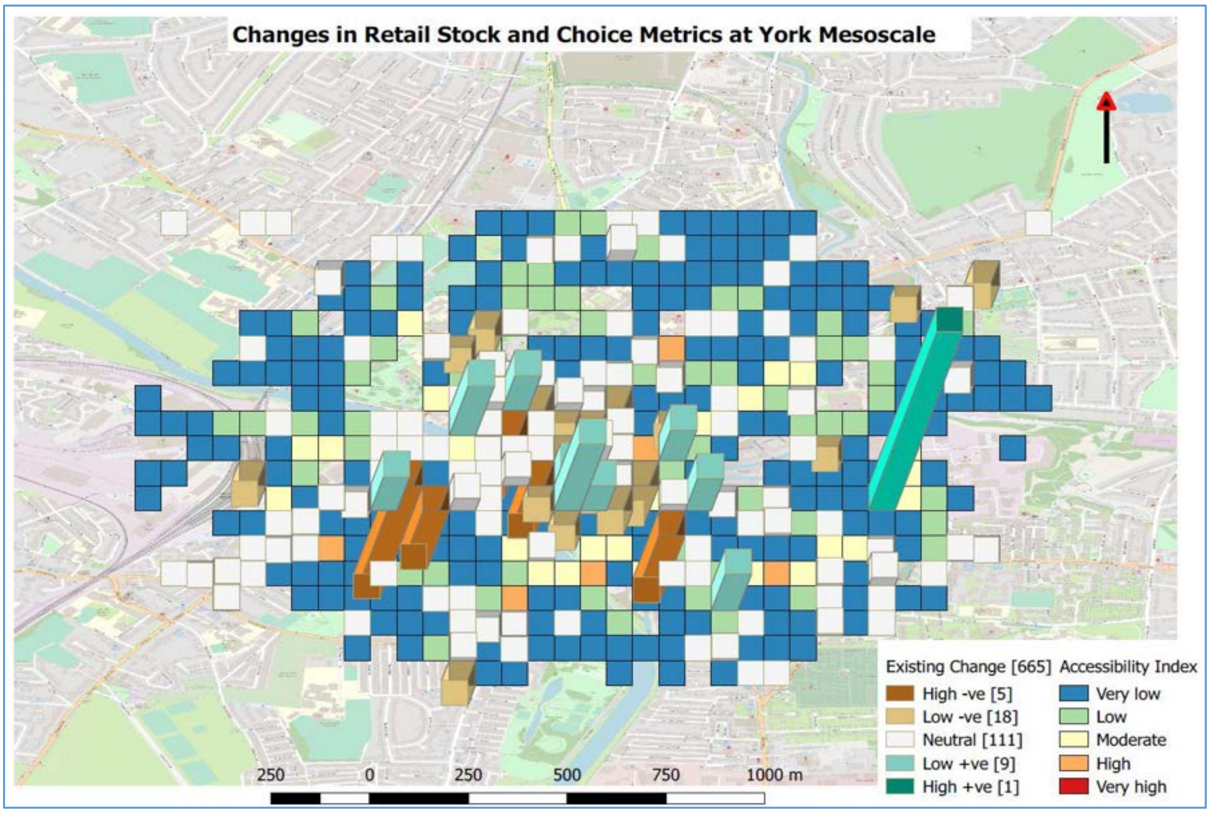
Source: Research work (2019)

18. Changes in retail rental value and Choice metrics at Newcastle macroscale



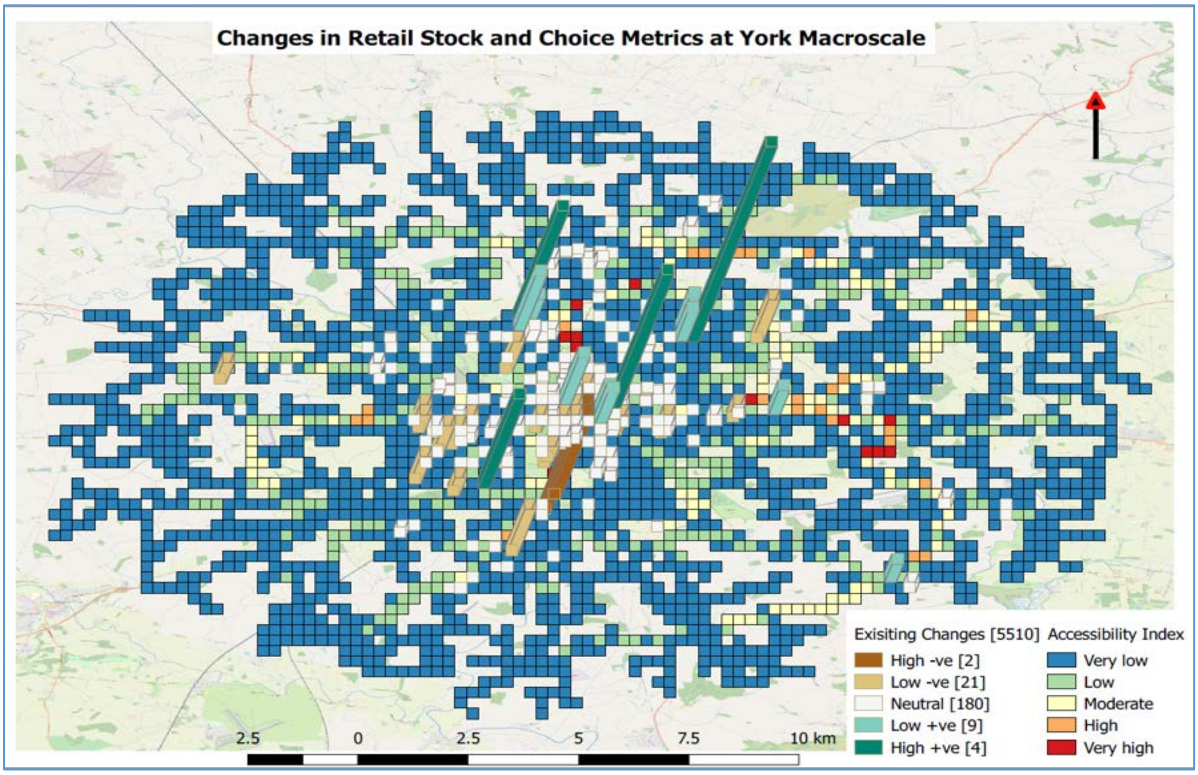
Source: Research work (2019)

19. Changes in retail stock and Choice metrics at York mesoscale



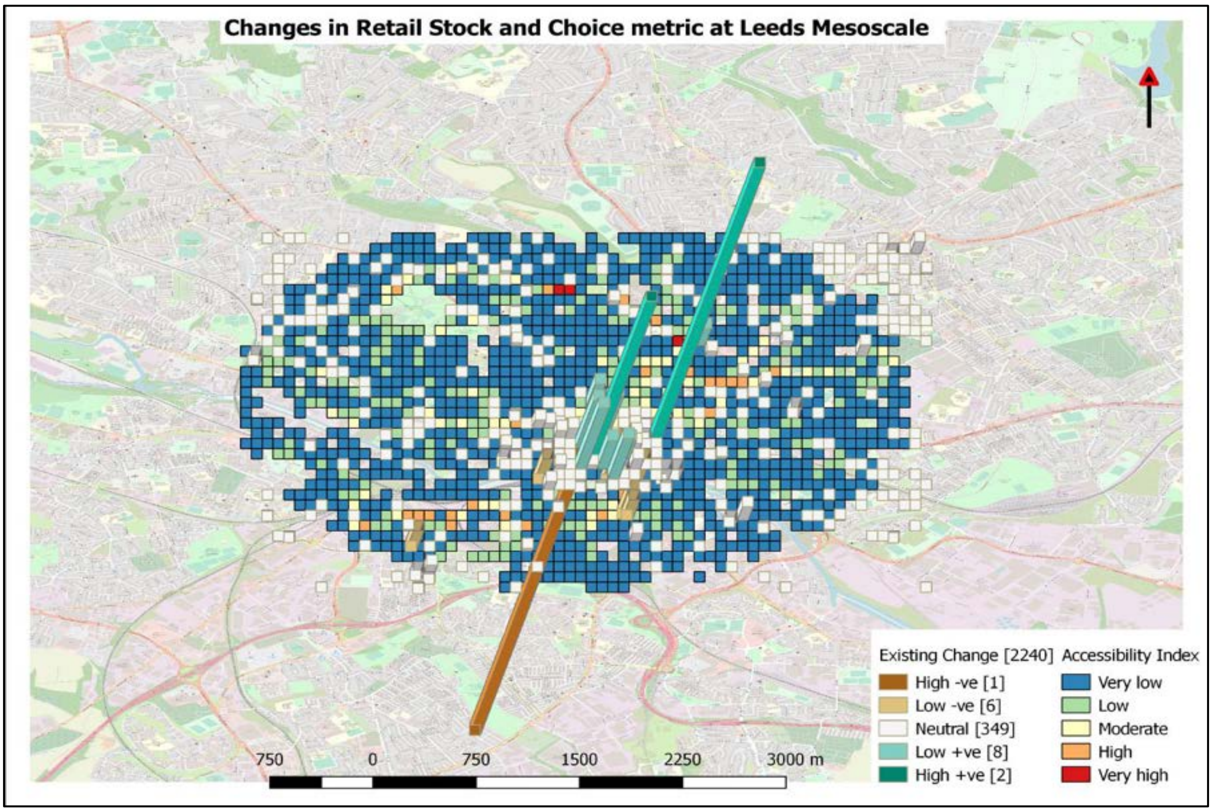
Source: Research work (2019)

20. Changes in retail stock and Choice metrics at York macroscale



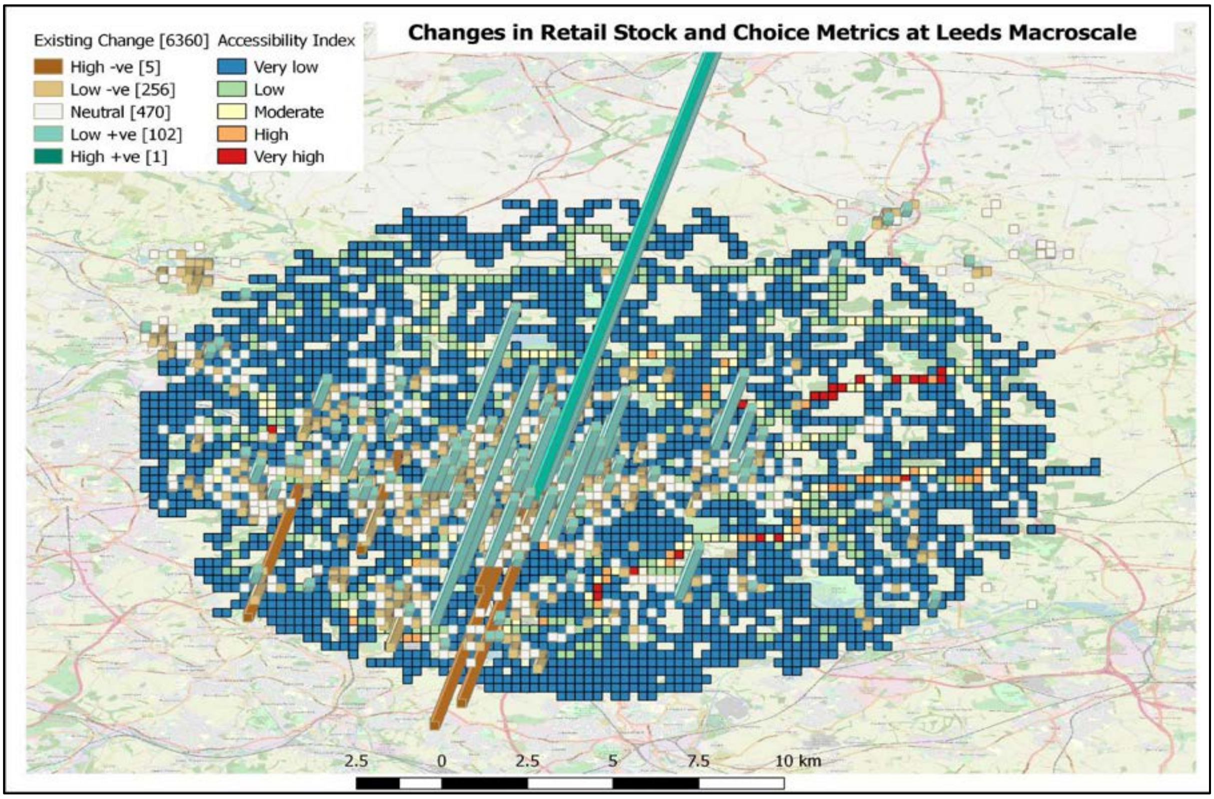
Source: Research work (2019)

21. Changes in retail stock and Choice metrics at Leeds mesoscale



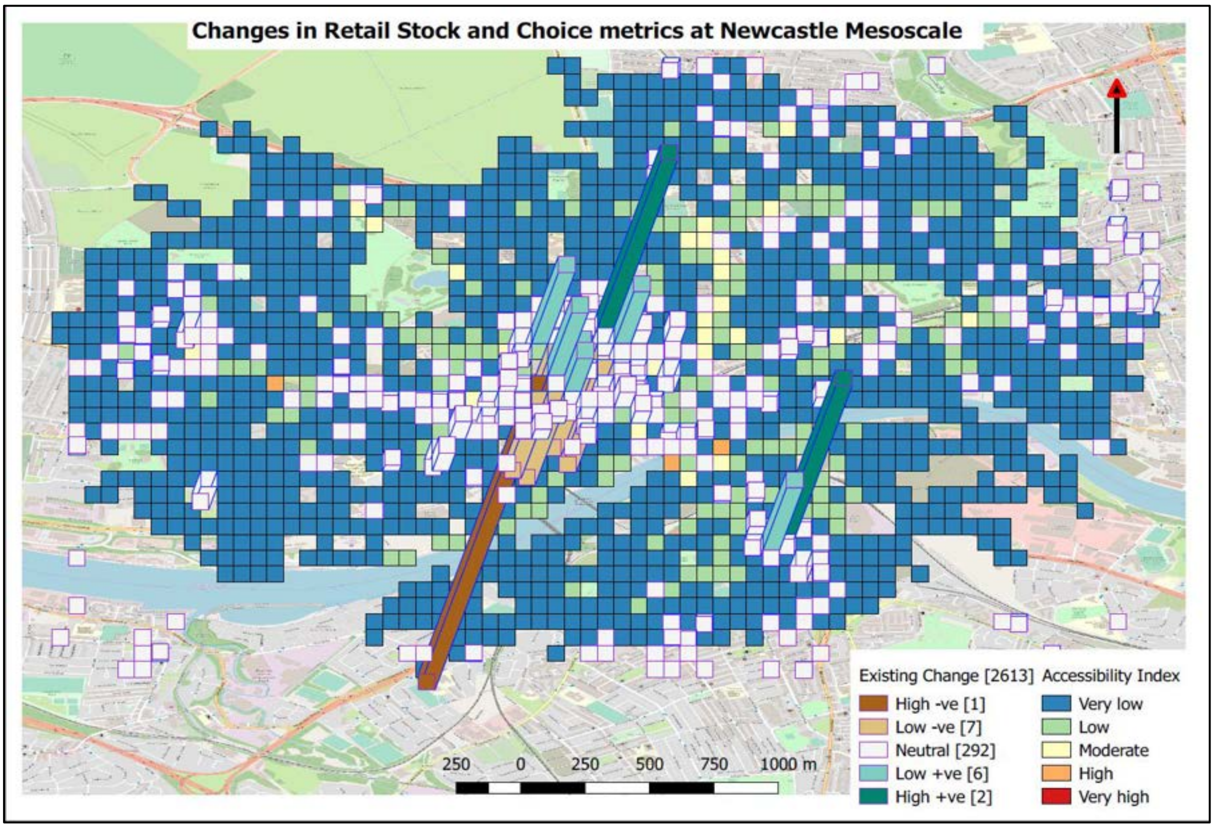
Source: Research work (2019)

22. Changes in retail stock and Choice metrics at Leeds macroscale



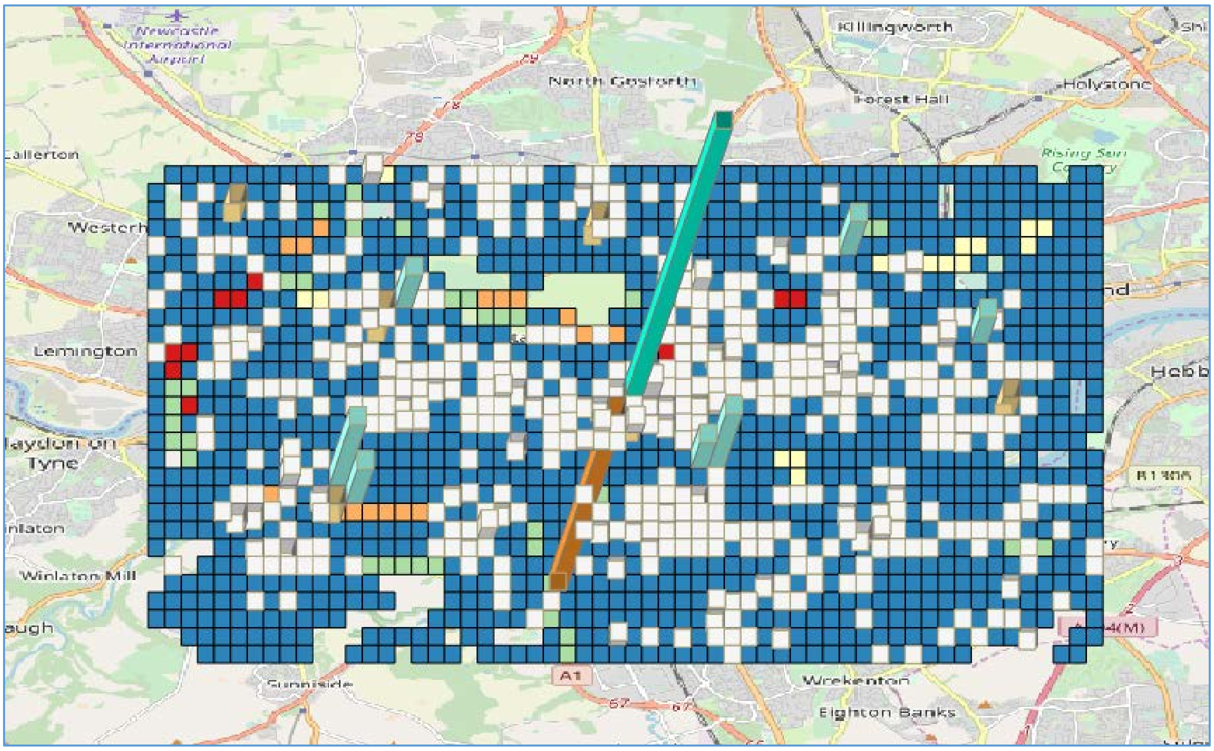
Source: Research work (2019)

23. Changes in retail stock and Choice metrics at Newcastle mesoscale



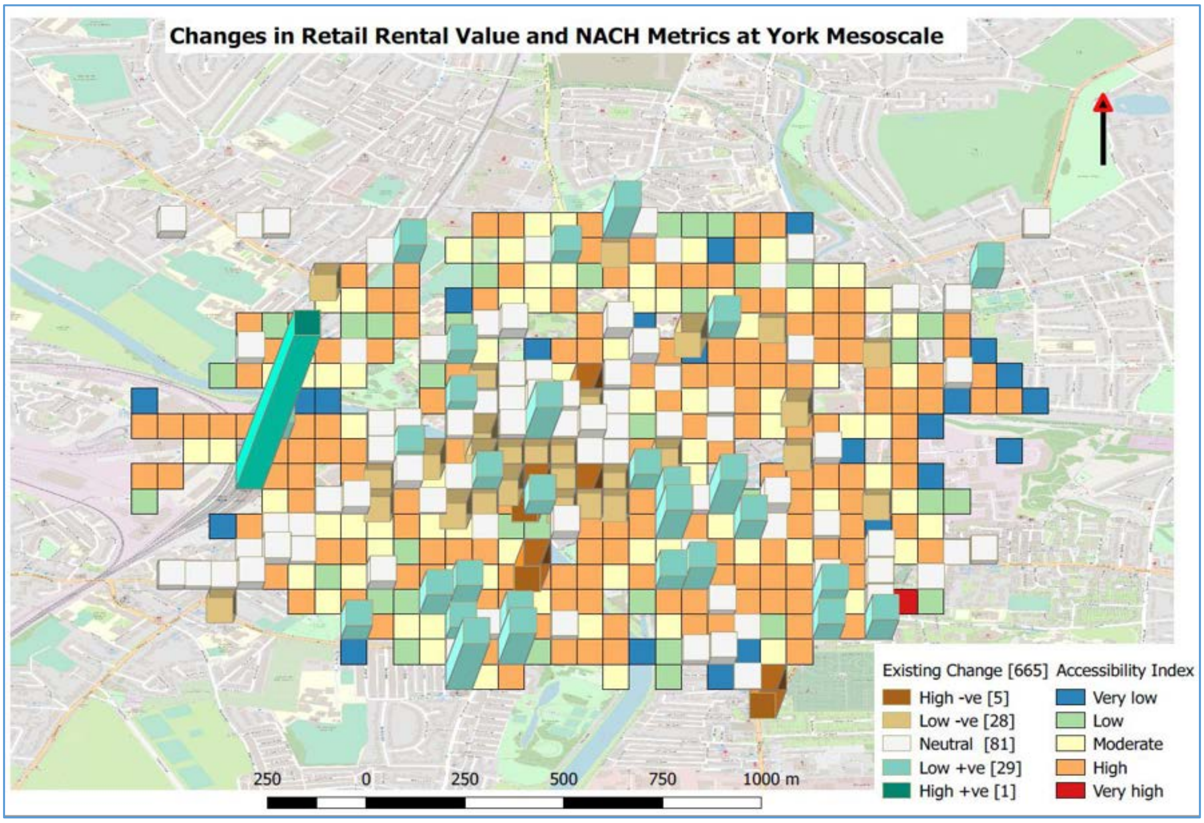
Source: Research work (2019)

24. Changes in retail stock and Choice metrics at Newcastle macroscale



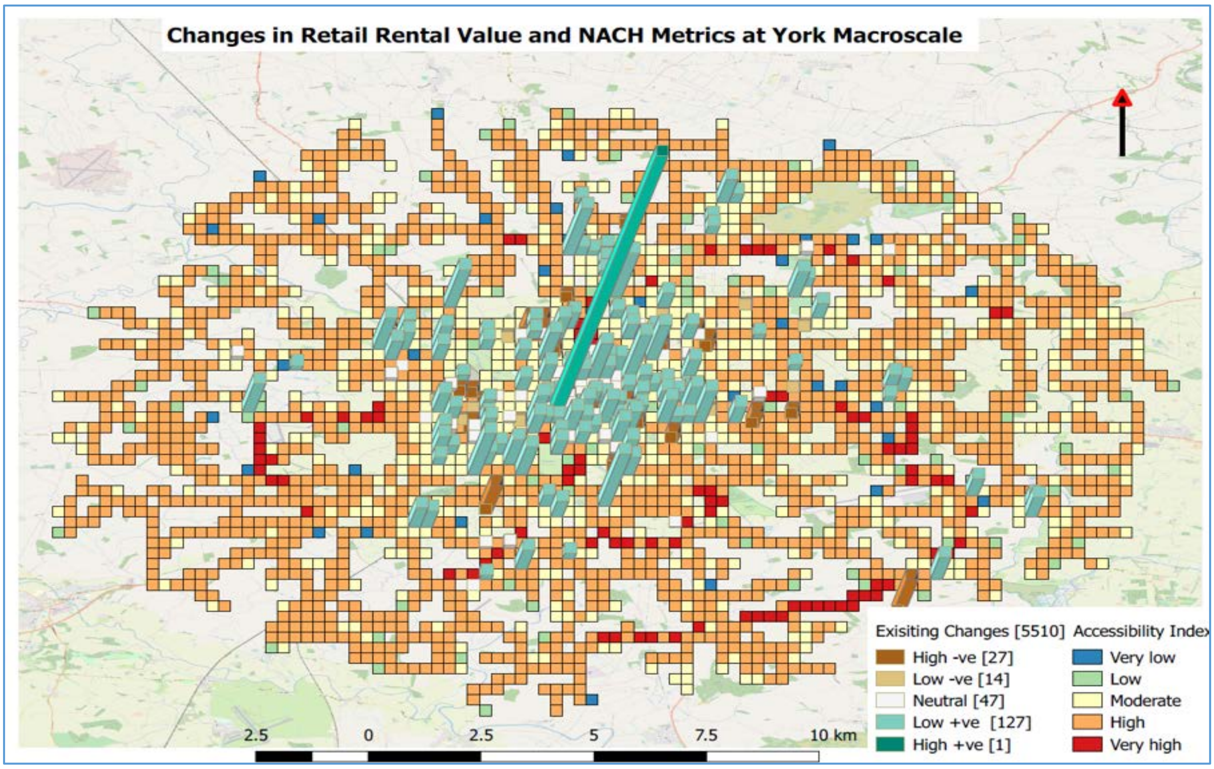
Source: Research work (2019)

25. Changes in retail rental value and NACH metrics at York mesoscale



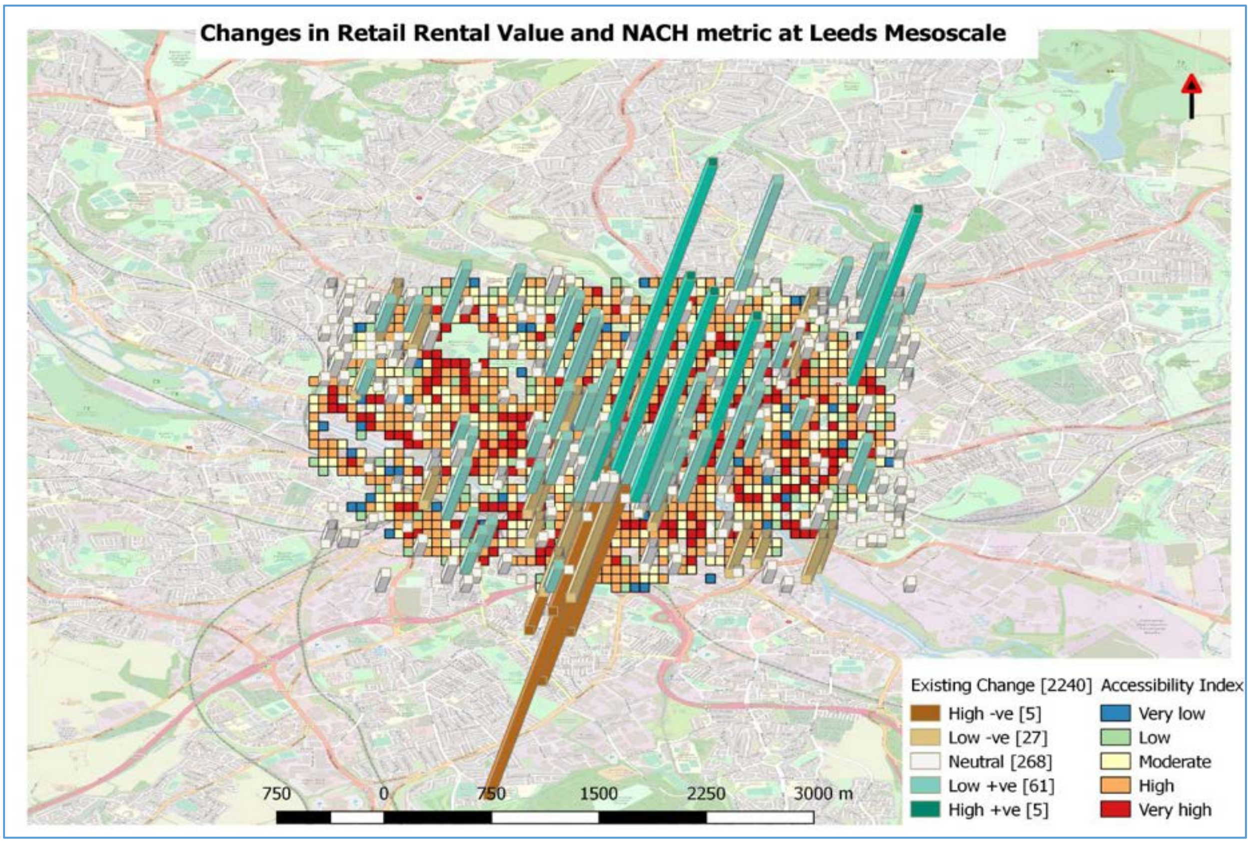
Source: Research work (2019)

26. Changes in retail rental value and NACH metrics at York macroscale



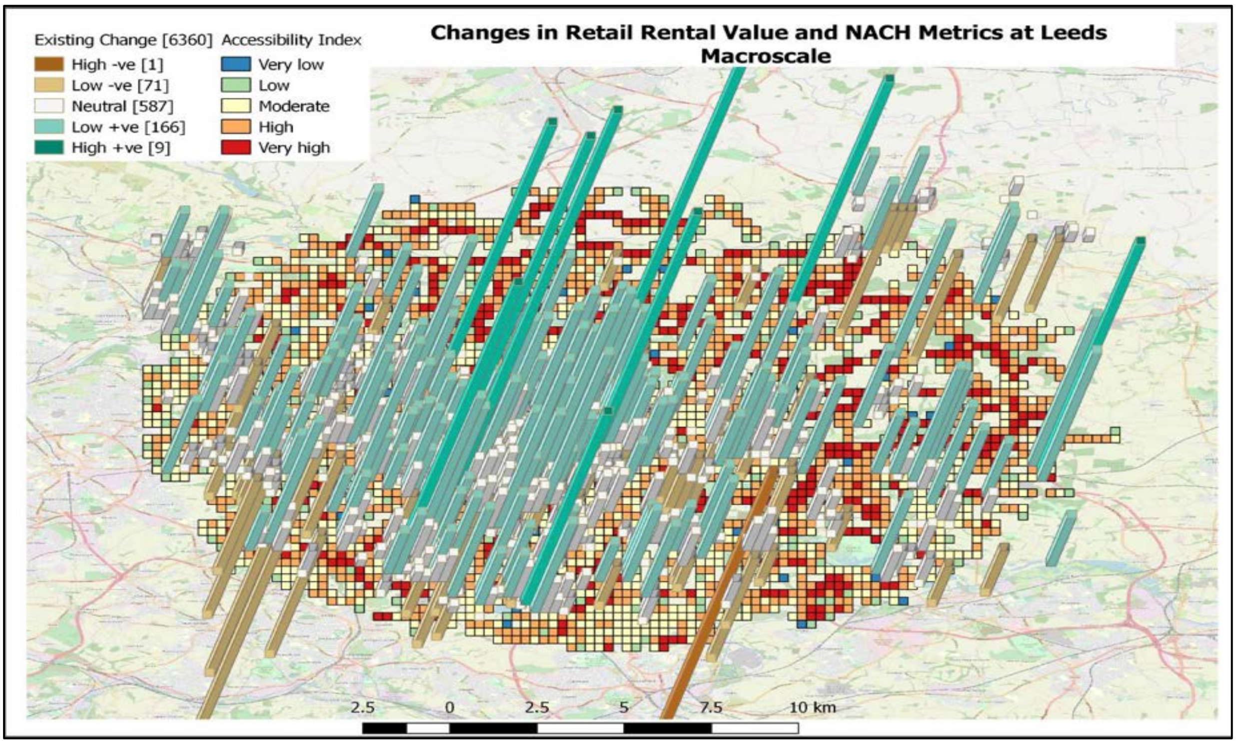
Source: Research work (2019)

27. Changes in retail rental value and NACH metrics at Leeds mesoscale



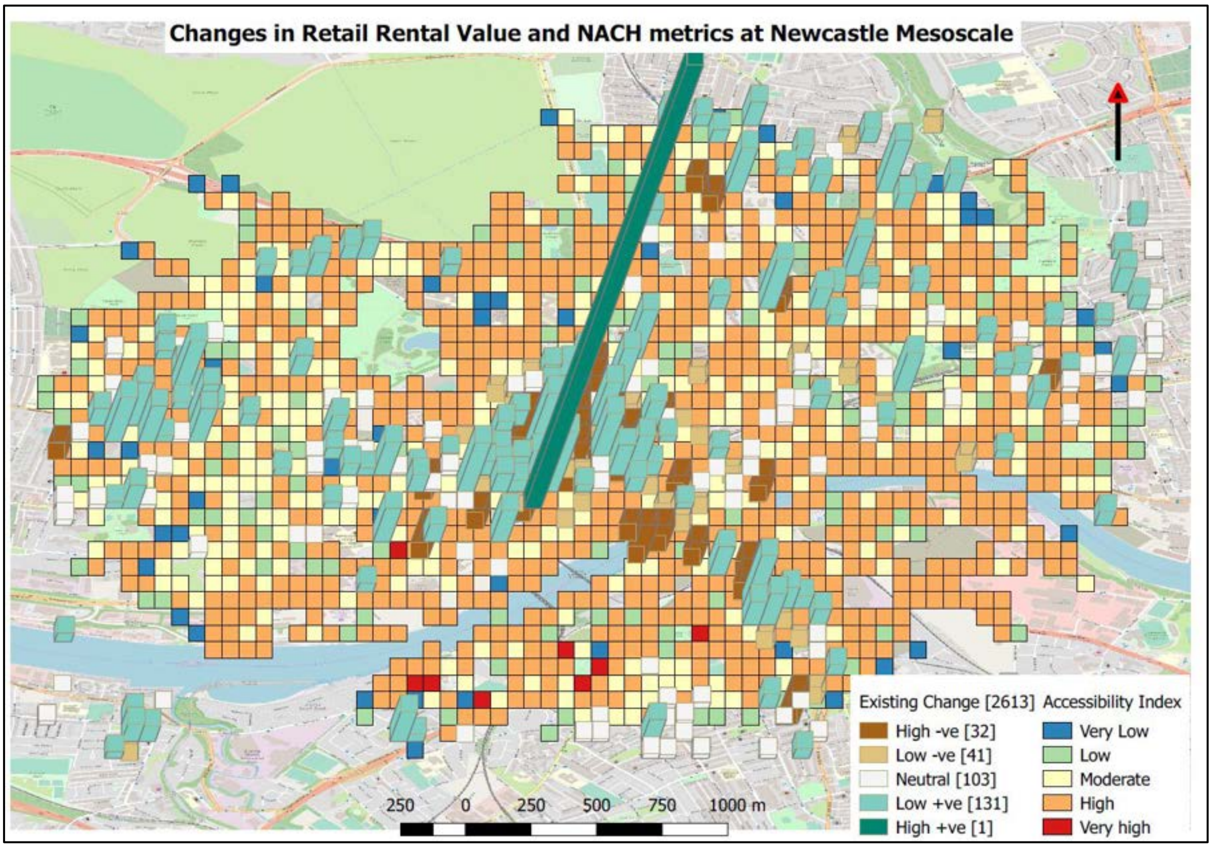
Source: Research work (2019)

28. Changes in retail rental value and NACH metrics at Leeds macroscale



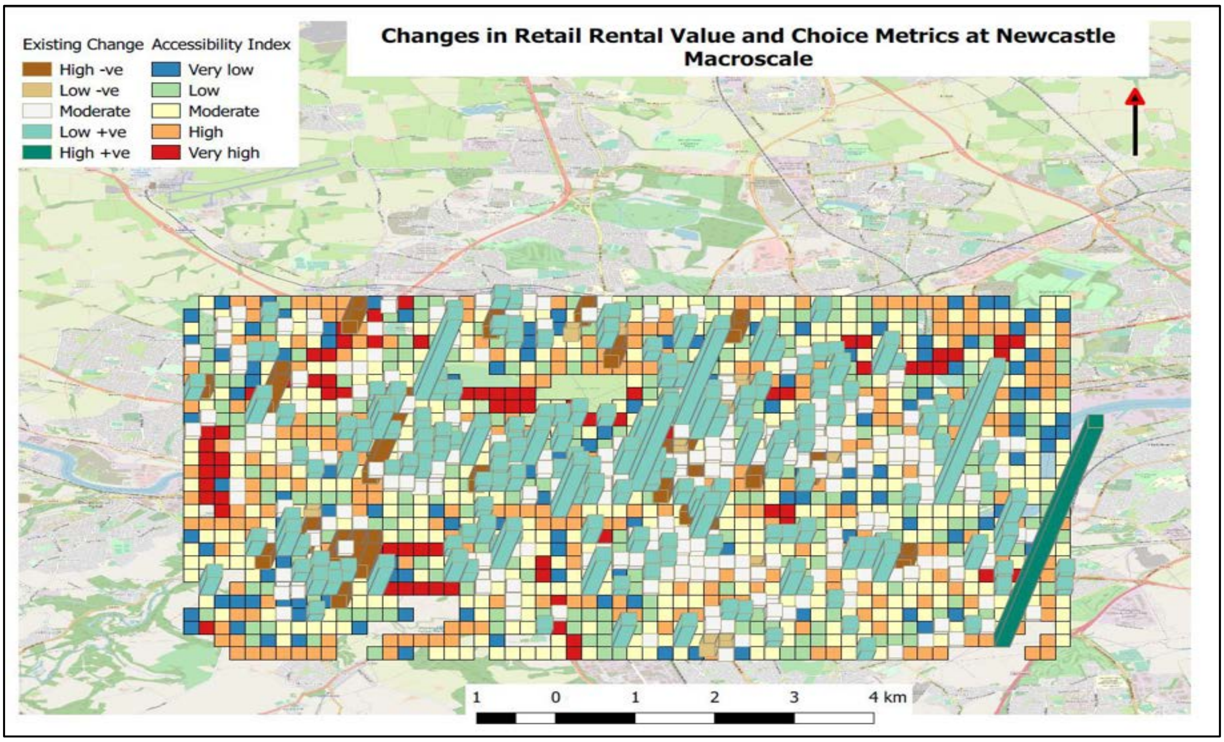
Source: Research work (2019)

29. Changes in retail rental value and NACH metrics at Newcastle mesoscale



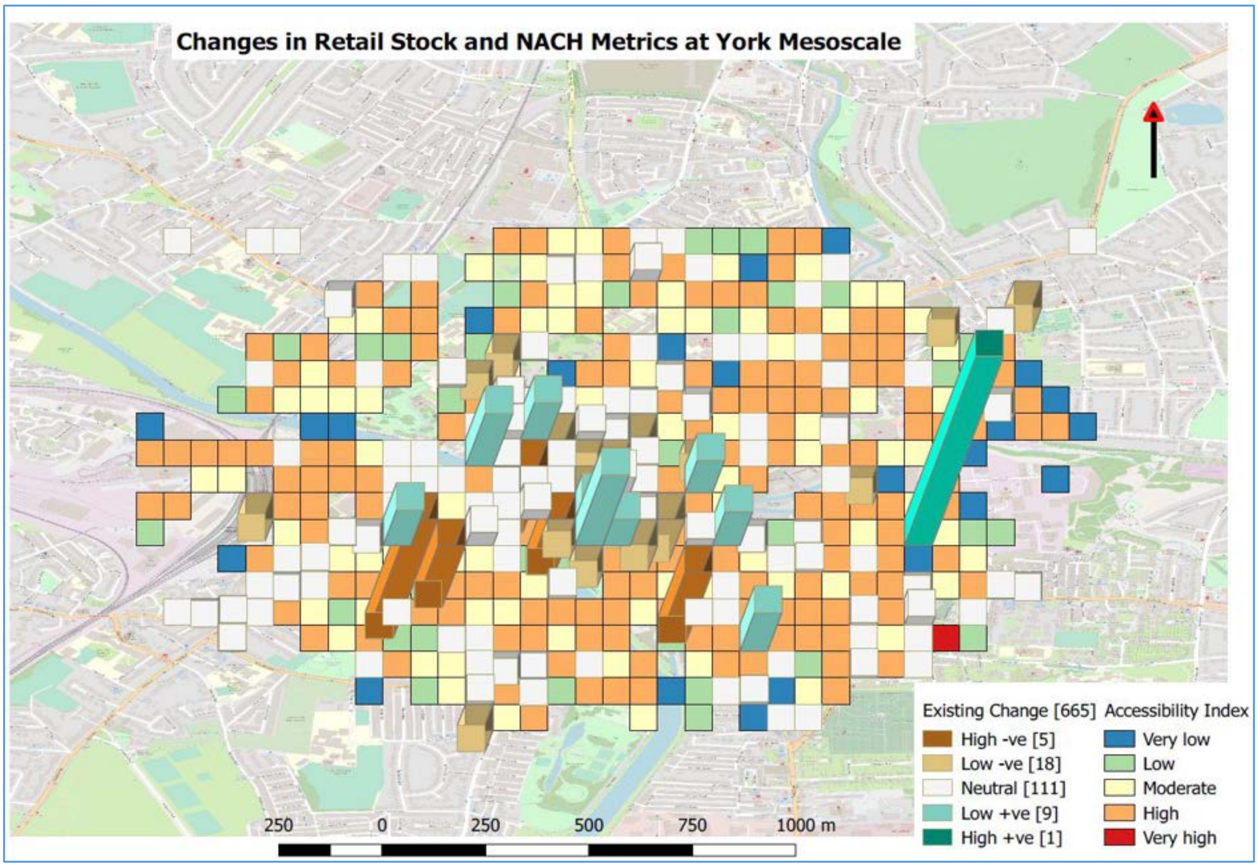
Source: Research work (2019)

30. Changes in retail rental value and NACH metrics at Newcastle macroscale



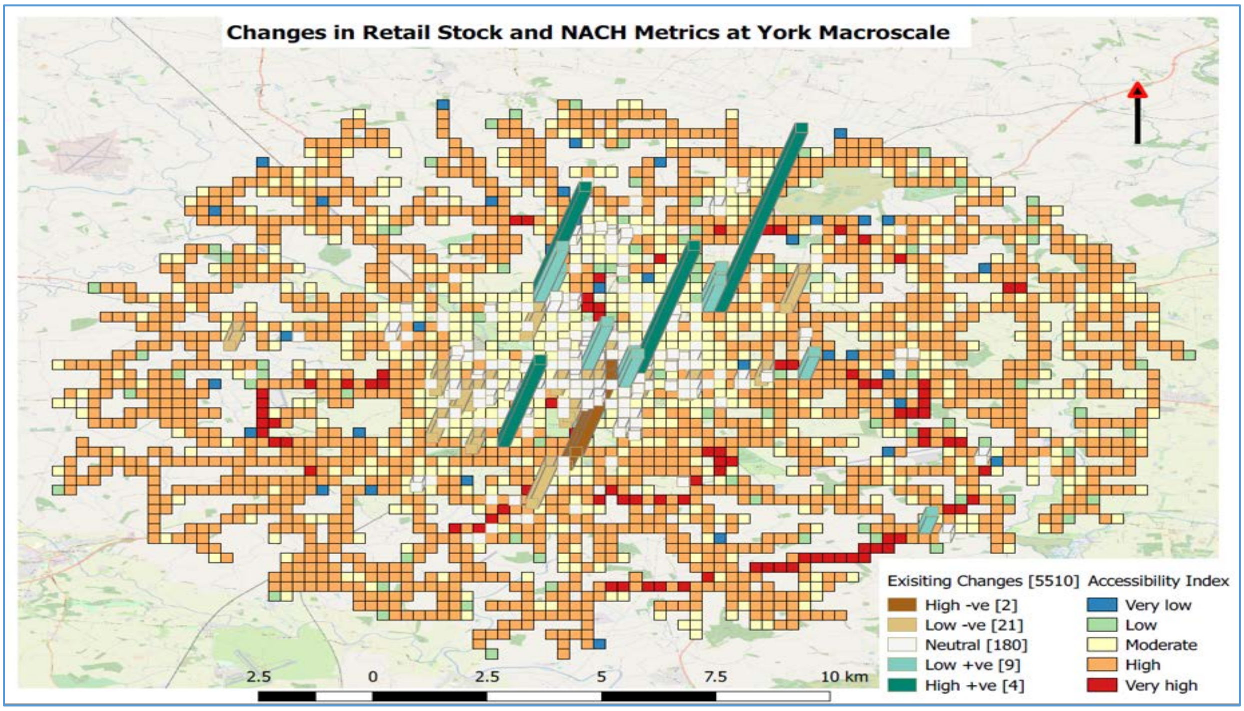
Source: Research work (2019)

31. Changes in retail stock and NACH metrics at York mesoscale



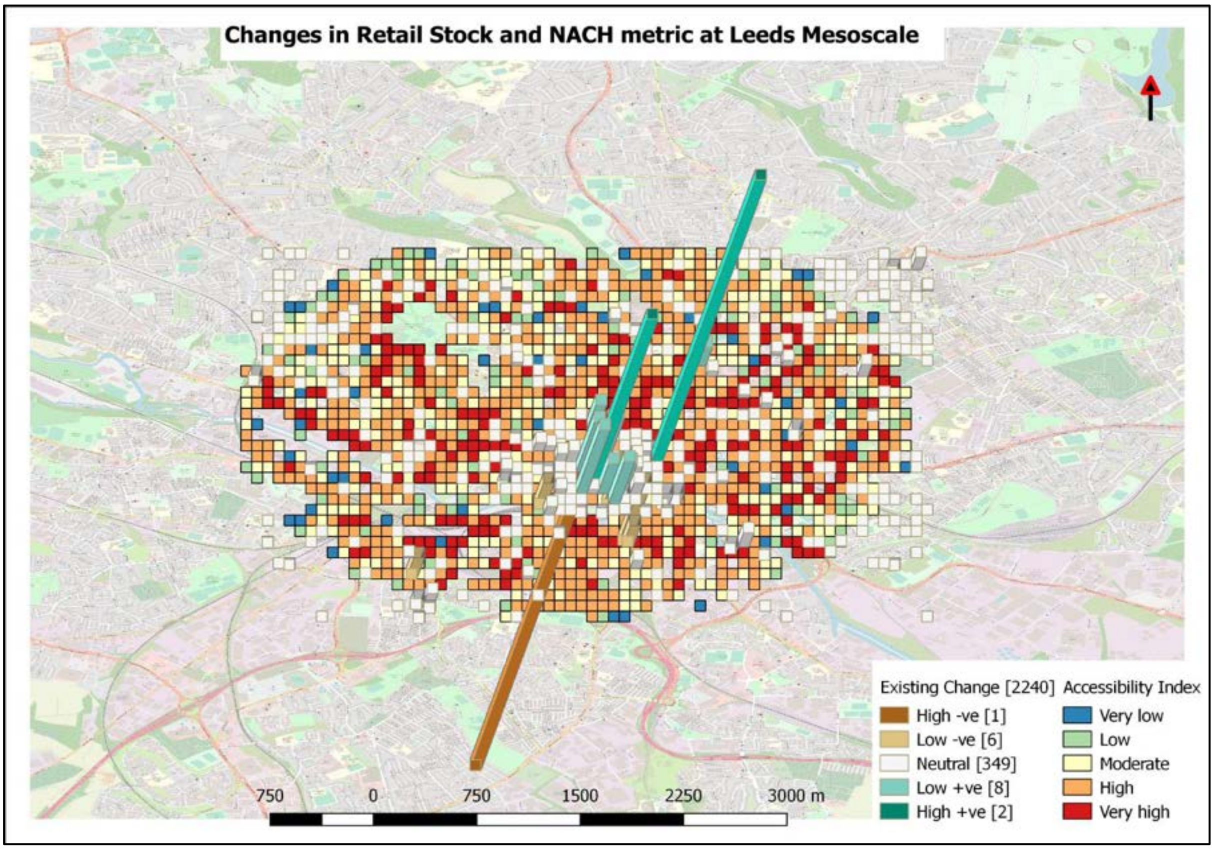
Source: Research work (2019)

32. Changes in retail stock and NACH metrics at York macroscale



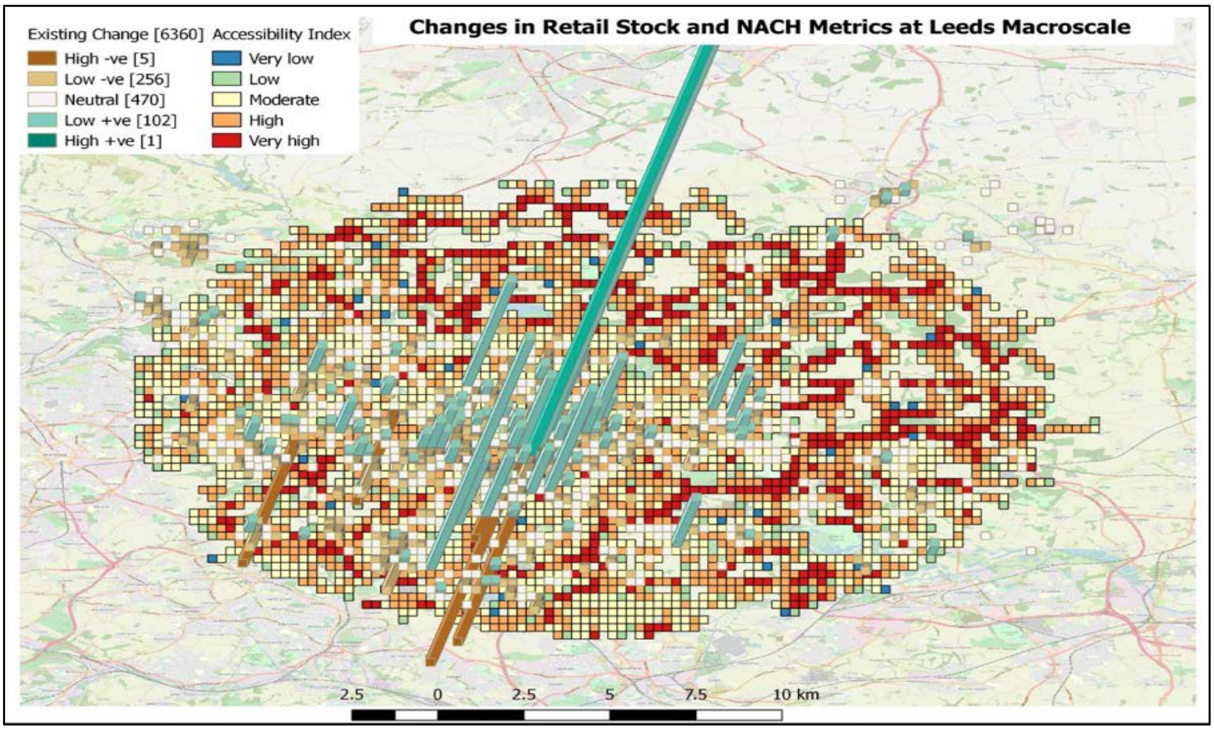
Source: Research work (2019)

33. Changes in retail stock and NACH metrics at Leeds mesoscale



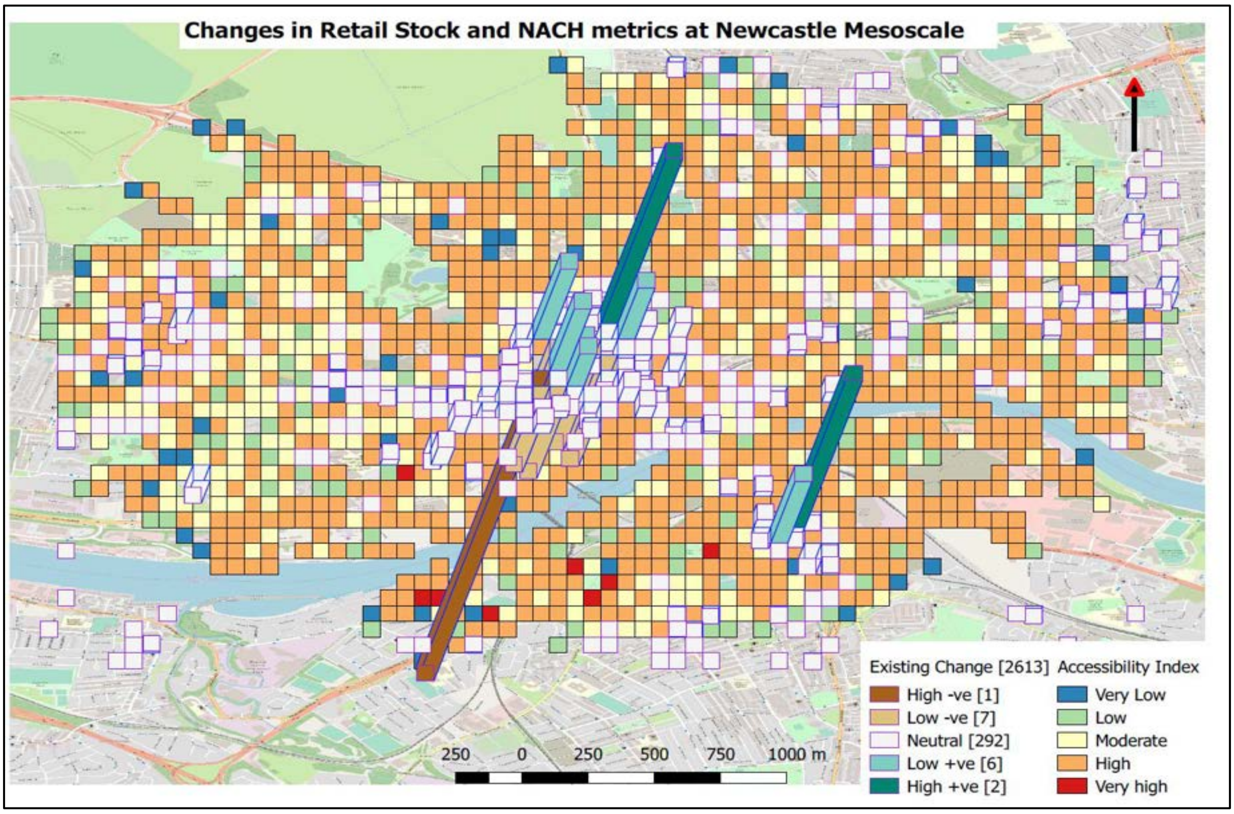
Source: Research work (2019)

34. Changes in retail stock and NACH metrics at Leeds macroscale



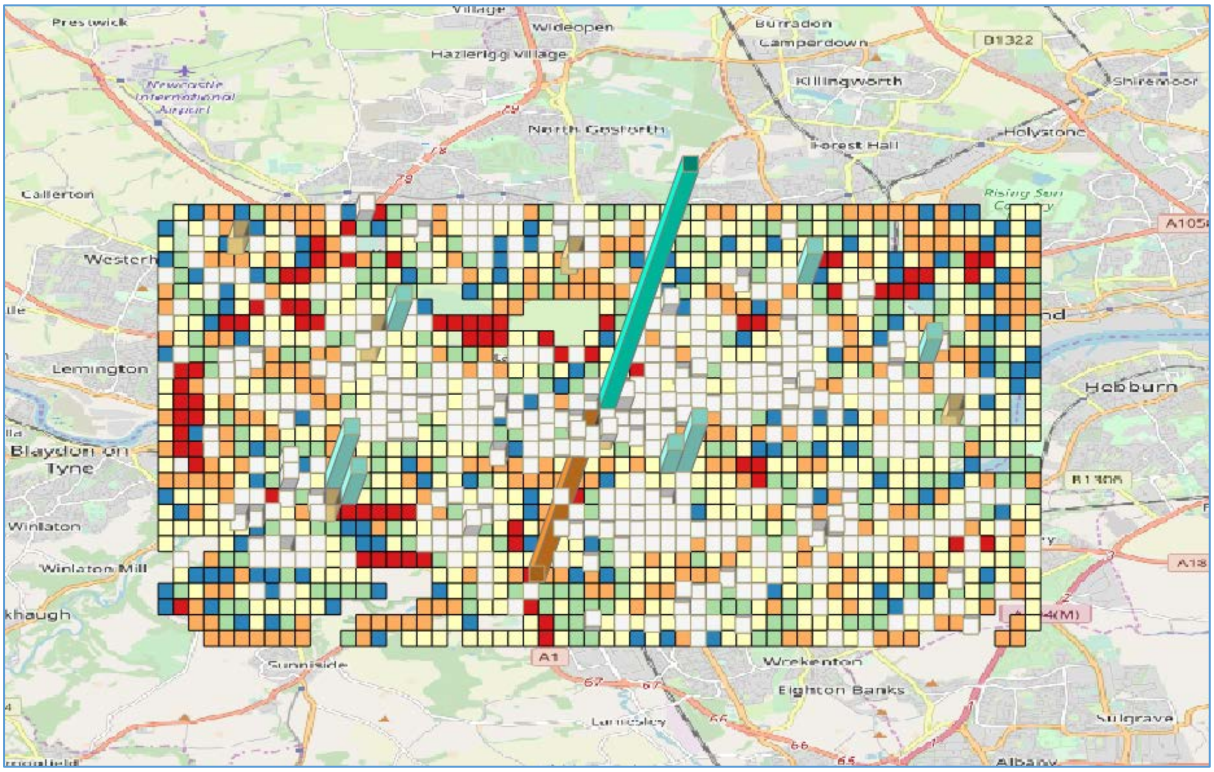
Source: Research work (2019)

35. Changes in retail stock and NACH metrics at Newcastle mesoscale



Source: Research work (2019)

36. Changes in retail stock and NACH metrics at Newcastle macroscale



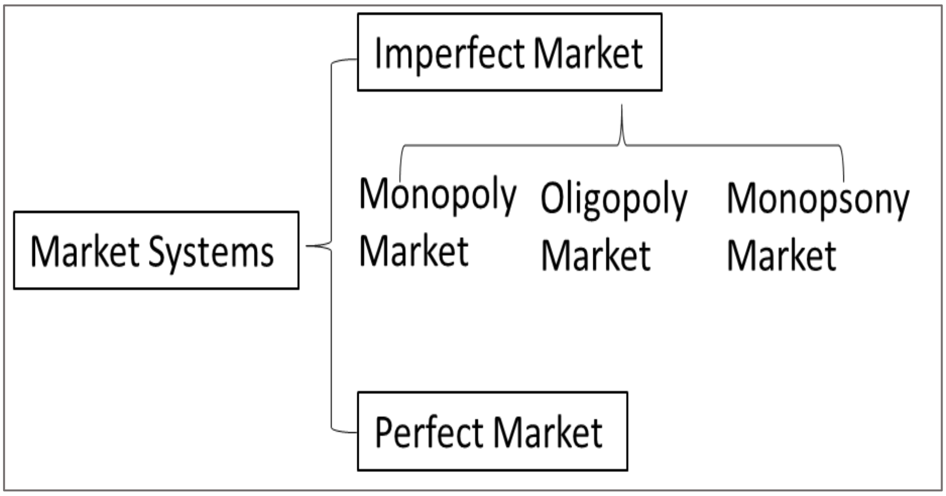
Source: Research work (2019)

Appendix D: Retail Market Competitiveness

Concepts of retail market systems: roles of shopping centres and highstreets in retail market control

Fujita (1989) broadly classified market systems based on number of market participants, similarities in goods (and services) offered and pricing control of goods and services. As such, market systems were classified as *perfect* and *imperfect (monopoly, oligopoly and monopsony)* markets as shown in Figure 1 below.

Figure 1: Categorisations of market systems



Source: Adapted from Fujita (1989)

The perfect market system is that market which allow free entry and exist of numerous market players trading the same (homogenous) products (Jowsey, 2013). It is a market system whereby there are equal opportunities to all market participants and no participant has the power to influence and manipulate prices of goods and services. Consequently, abnormal profits cannot be made by any of the market participants (i.e. sellers) at any time, as prices are determined strictly by forces of demand and supply in a perfect competition (Fujita, 1989). Fischer and

Harrington (1996) suggested that a perfect competition would produce the best possible market conditions for consumers in any given market.

Meanwhile, an imperfect market (which is the opposite of a perfect market) can be subdivided into three (3) markets as; monopoly, oligopoly and monopsony market systems (Fujita, 1989). A *monopoly market* is an imperfect market in which a market participant (i.e. seller) dominate the market and there are entry barriers for new market participants. As such, abnormal profit can be made by the sole market participant. However, an oligopoly market is similar to a monopoly market expect that there are more than one market participant. In an *oligopoly market*, there are few market players that dominate the market and as such collusive market behaviour exist (Fujita, 1989). The collusive market behaviour can lead to the few market participants operating as a single participant making them possess similar attributes with a monopoly market system. As such, abnormal profit making is also possible in oligopoly market as prices can be manipulated the few market players. Conversely, a *monopsony market* is that imperfect market that is differentiated according to number of buyers. A monopsony market has only one buyer for a particular goods and services. As such, the buyer as the significant power to control prices of goods and services making it an imperfect market.

In a typical real estate market, perfect competition between real estate markets actors do not exist. This is because real estate markets lack the capability to fulfil the key qualities (such as, homogeneity of products, normal profits making, equal opportunities among market players etc.) of a typical perfect market (Jowsey, 2011). Real estate (property) are heterogeneous in nature and market actors (e.g. property investors, developers etc.) have recoded different and abnormal profits from their interests in real estate (Fujita, 1989; Tay et al., 1999). Therefore, there are general consensus among real estate scholars (Yuo et al., 2003; Evans, 2008;

Greenhalgh, 2008; Jowsey, 2011; Bello and Bello; 2011; Kuye, 2012) that real estate markets are imperfect markets. However, the level of real estate markets' imperfection varies. The variation in imperfection of property markets influence uneven distribution of abnormal profits and incomes (or returns) from heterogeneous real property (Jowsey, 2011). Kuye (2010) and Babajide (2012) expounded that the level of imperfection in property market depend on many factors including property types, location, motives of holding interests in property by market actors, availability of technology (influencing markets information) and legal and statutory frameworks that control property markets activities among others (Babajide, 2012).

In a retail property market (particularly the investment market), it can be argued that level of market imperfection can be influenced by the floor sizes (retail stock) and types of retail property held by the investors (landlords). That is, ratio of number of investors to retail floor sizes own. This is because landlords can influence rent (income and value) and retail space allocation (including tenant mix) among other market variables (Brown, 1992; 2006). As such, the amount of floor space hold by individual landlord would ordinarily influence the level of imperfection of that retail property as the landlord controls rents, tenant mix and other market variables.

Shopping centres and Highstreets are two distinguish retail property types that exhibit different markets' imperfection characteristics. Although, shopping centres and highstreets are similar in terms of having agglomeration of retailers trading on physical retail space, they differ in terms of management, location, ownerships, space allocation and market competition systems (Yuo et al., 2003; Teller, 2007). Table 1 summarises the characteristics differences between a typical shopping centre and a highstreets.

Table 1 Characteristics differences between shopping centres and highstreets

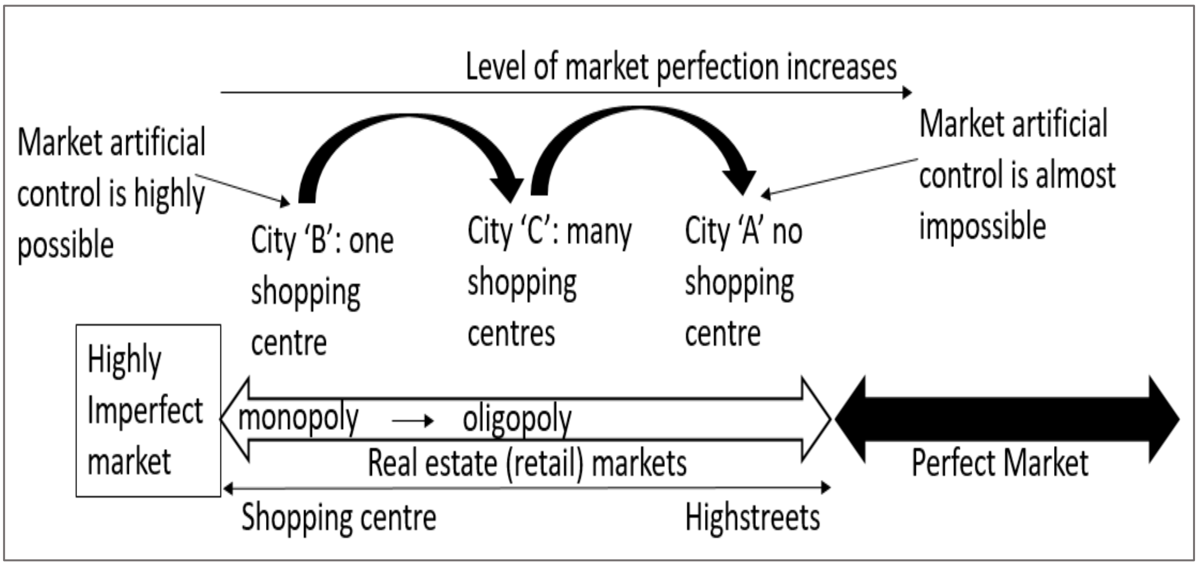
S/no	Characteristics	Shopping Centre	Highstreets
1	Management	Internal Management- centrally managed by the landlord (or shopping centre managers)	External Management- publicly managed by town centres, local authorities or Business Improvement Districts BIDs
2	Ownership	Usually owned by landlord or group of landlords	Not solely owned by anyone
3	Space allocation (Tenant mix)	Landlords or managers allocate space to tenants and therefore control the tenant mix settings. This is not always economic driven.	Space allocation on highstreets are more economic driven. Tenant mix are controlled by the market and influenced by local planning authorities
4	Market competition	Monopoly (or Oligopoly) imperfect market structure exist.	Close to perfect competition since participant are not as restricted as in shopping centres

Source: Researcher's Own (2018)

A shopping centre is an agglomeration of various retailers and commercial service providers within a well-planned, designed and managed building or a group of buildings as a unit (Yuo et al., 2003). That is, shopping centres are retail space that are owned by landlord (or group of landlord) as investment in which artificial manipulation and control by the landlord (or the shopping centre manager) is possible. A shopping centre's landlord has the power to influence tenant mix, retail space allocation to anchor (and other) tenants, spatial layout designs (that shape consumer movement) and so on (Adebayo et. al., 2018). Meanwhile, highstreets are naturally emerged retail space. Unlike shopping centres, highstreets' retail space are generally confined within the city (town) centres. Similarly, large stock of retail space are not usually owned by a single landlord in the streets highstreets. Even if a landlord dominantly own large retail floor space on the highstreets, the level of market interference on market variables (such as, tenant mix, rent etc.) on a highstreets by a landlord is usually lower than a shopping centre's landlord (Yuo et al, 2003; Bello and Bello, 2011). In other words, a typical shopping centre that is often well planned can be influenced in terms space allocation, spatial configuration, tenant mix and even rent (income) than a retail store (or group of retail stores) on the highstreets (Yuo et. al., 2003).

Consequently, market competition of a shopping centre are best described as monopoly imperfect market when a single investor owns the entire shopping centre in a given city, or oligopoly imperfect market when there are more than one shopping centres (with few landlords) within that city (Fujita, 1989). However, retail property market on a typical highstreets is less of an imperfect market when compared to shopping centres (Brown, 1990; 1992, Jowsey, 2011; Bello and Bello, 2011). It can be contended that the presence (or absence) and number of shopping centres and characteristics of a highstreets within a city spatial layouts will influence the level of market imperfection of the retail property market within that city. Figure 2 below shows the effects of shopping centres and highstreets on retail market imperfection of cities.

Figure 2: Influence of shopping centres and highstreets on cities' retail market imperfection



Source: Researcher's own (2019)

In other words, a city ‘A’ that has no shopping centre within it spatial layout will experience a more perfect market competition than city ‘B’ that has one shopping centre within it spatial layout. This is because the presence of that shopping centre in city ‘B’ implies that the shopping centre manager (or its landlord) can artificially control and influence rent, tenant mix, spatial layout within the shopping centre and make abnormal profit from owning that shopping centre (Fujita, 1989; Brown, 1992). As such, characteristics of monopoly market will exist in retail market of city ‘B’ than city ‘A’ where highstreets’ landlords do not have huge retail space to control and manipulate market variables such as rent and tenant mix (Brown, 1990; Yuo et al, 2003). Meanwhile, a city ‘C’ that has many (or more than one) shopping centres that owned and controlled by different landlords will either exhibit oligopoly retail market system or enhance market competition between the shopping centres’ landlords. This is because a pure monopoly imperfect market does not exist in such scenario. However, because business motives and strategies of landlords differ, having more than one shopping centre within a city (such as City ‘C’) will not necessary form oligopoly market system but rather increase level of perfect competition between all landlords in city ‘C’ (Grewal, 2009).

The common consensus among retail markets and urban scholars (Brown, 2006; Grewal, 2006; Stonor, 2010; Batty, 2017) is that retail space distribution within cities differ. The distribution of retail stock (including, shopping centres) within cities varies in location (in respect to position within cities) and floor sizes. Likewise, business strategies and motives (by landlords) for holding interest in a shopping centre differs (Grewal, 2001). However, the extent that the differences in quantity of retail stock (including shopping centre distribution) and ownership (within cities) influence performance of retail markets is still missing in preceding studies. Similarly, the effects of level of market perfection (or imperfection) on retail market performance within a given city is known.

This is achieved by investigating retail market performance of cities that are distinct in terms of shopping centres' and highstreets compositions within it spatial layouts. As such, three types of cities where investigated in this research. The first city do not have any shopping centre within its spatial layouts. As such, the first city is characterised as at least imperfect retail market since retail function happen only on the highstreets (as earlier illustrated). The second is a city with many shopping centres within its spatial layout and the third city has only one shopping centre within it spatial layouts. As such, the second city and third city are respectively oligopoly and monopoly retail market systems. Response to the question raised in this section will provide a better insight for stakeholders on planning, development, investment and utilization of on city retail spaces. Similarly, it is anticipated that exploring these three (3) types of cities with different retail market systems will validate outputs of the research goal that seeks to investigate influence of retail consumer movement on retail property market performance.

Appendix E: Overview of retail market performance on the three sampled cities.

This section presents basic characteristics of retail market variables for the three sampled cities. The overall changes in retail floor area, retail unit count (cluster) and retail rental value between 2010 and 2017 have been analysed and presented herein. Similarly, the changes in retail space types, namely, real shops, leisure spaces, servicing spaces and other retail warehousing (as defined in chapter 5 of this thesis) have also been explored and presented in this subsection. This is done in an attempt to execute objective 1 of the research to understand retail market components and overall statistical changes in retail market across the sampled cities.

Table 1 (below) summarises the overall performance of the retail market variables (that is, rental value, floor area and retail cluster) across York, Leeds and Newcastle between 2010 and 2017.

Table 1: Computed Overall Changes in retail rent and stock for York, Leeds and Newcastle

Sampled City	Variable	Rent (£ psm)	Floor Area (m^2)	Retail Cluster
York	∑ 2017	26,771.28	572,731.00	2,174
	∑ 2010	22,211.76	555,400.00	2,189
	Change Value	4,559.52	17,331.00	-15
	Percentage Change	**21%**	**3%**	**-0.68%**
Leeds	∑ 2017	84,371.48	1,546,717.00	8,058
	∑ 2010	78,040.55	1,474,447.00	8,058
	Change Value	6,330.93	72,270.00	0
	Percentage Change	**8%**	**5%**	**0.00%**
Newcastle	∑ 2017	42,934.36	1,114,446.00	4,462
	∑ 2010	35,192.79	1,125,034.00	4,500
	Change Value	7,741.57	-10,588.00	-38
	Percentage Change	**22%**	**-0.10%**	**-0.01%**

Source: Adapted from VOA (2017)

Table 1 shows that there are have been positive changes (of various percentages) in the demand market side [that is, retail rental value (£ psm)] across the three cities. It reveals that there have been 21%, 8% and 22% of rental value changes across York, Leeds and Newcastle respectively. Similarly, the table indicates that there are have been reluctant supply market changes [that is, retail floor area (m^2) and retail unit counts] across the sampled cities between the computed change periods. Table 1 indicates that 3%, 5% and -0.1% of changes in floor area were recorded in York, Leeds and Newcastle respectively. While the number of retail unit counts across the cities shows more restrictiveness to changes as the total number of retail unit counts manages to reduce by -0.68% and -0.01% at York and Newcastle respectively. Record from data source [that is, VOA (2017)] shows that there has not been changes in the total number of retail unit counts between 2010 and 2017. This result shows the elasticity nature of demand and supply sides of a typical property market across the three cities. That is, market situations where demand variable is elastic and react to market changes than the supply variable that is known for its inelasticity.

The results from Table 1 further shows that the retail market performance of all the three cities are similar. In that, the elasticity behaviour and change pattern of demand variable (rental value change) and supply variables (floor area and retail unit counts) are the same across the three cities. However, the performance of the three investigated variables across the three cities are dissimilar. In other words, there have been positive, negative and neutral changes in the retail market variables. Consequently, further investigation on trends of changes in retail space types (namely, real shops, leisure spaces, servicing space and retail warehouse) have been conducted across the three sampled cities to understand the change pattern in retail property spaces across the sampled cities. Table 2 (below) presents changes trends in real shops, leisure space, servicing space and other retail warehousing (as defined in chapter 5 of this thesis) below.

Table 2: Changes in retail space types across York, Leeds and Newcastle

	York			Leeds			Newcastle		
	2010	2017	**Change**	2010	2017	**Change**	2010	2017	**Change**
Real shop (%)	77.2	74.9	**-2.3**	84.95	83.135	**-1.815**	86.73	83.89	**-2.84**
Leisure space (%)	12.38	14.7	**2.32**	9.11	10.41	**1.3**	8.67	11.14	**2.47**
Servicing space (%)	8.1	7.22	**-0.88**	4.64	4.84	**0.2**	3.511	3.855	**0.344**
Retail warehouse (other spaces)(%)	2.3	3.7	**1.4**	1.3	1.613	**0.313**	1.089	1.121	**0.032**

Source: Adapted from VOA (2017)

Table 2 reveals that there has been reduction in percentage of real shops across the three sampled cities despite the percentage increase in retail floor area across York and Leeds. It also indicates that leisure spaces and retail warehousing spaces (except for York servicing spaces) have experienced positive changes of various percentages. However, the leisure spaces across the three cities have experienced the highest percentage of retail space increase. In other words, the retail floor area increase across cities is an indication of increasing use (or take-up) of retail leisure spaces than real shops across the sampled cities. This is because the leisure spaces across the three cities have experienced the highest volume of retail space changes than any of the other retail space classification.

However, the distribution of servicing space across the sampled cities varies. York shows decrease in amount of retail servicing space, while Leeds and Newcastle show slight positive changes of 0.2% and 0.34% respectively. The servicing retail space appears to be the only retail class having both negative and positive changes across the cities. In other words, it is the only retail space with distinct performance between 2010 and 2017 across the study areas. Further result from Table 2 shows that retail warehouses have increased in size across the cities. The implication of this is that there have been more demand and supply of retail warehouses (and leisure space) across the three cities. In other words, the increasing demand of online retailing across these cities must have led to increase in supply and demand of retail warehousing in them. This is because increasing size of retail warehousing is an indication of increase in online retailing (Bamfield, 2013; Deloitte, 2018). The result adheres to Bamfield (2013) arguments on increase demand for retail warehouses across the UK that correlate with online retail market growth share. The direction of changes in retail space types suggest that there has been increase in online retail share across the three cities. This has led to decrease in amount of retail real shops and increase in leisure and retail warehousing. This is because the growth of online retailing can only affect real shops but not leisure retail spaces. In other words, online retail shopping is not a substitute for leisure retail space but for real shops. Consequently, number of real shops (stores) are shrinking, while, more spaces are been utilised for retail warehousing and leisure space.

Appendix F: Key published works from research

Adebayo A., Greenhalgh P., Muldoon Smith, K (2019) 'Investigating retail property market dynamics through spatial accessibility measures,' *Journal of European Real Estate Research*, Vol. 12 No. 2, pp. 155-172, Available at https://doi.org/10.1108/JERER-01-2018-0009.

Adebayo, A., Greenhalgh P., & Muldoon-Smith K., (2019) '*Investigating retail space performance through spatial configuration of consumer movement: A Comparison of York and Leeds'*. 12th Space Syntax Symposium (SSS). Beijing, China, July 2019

Investigating retail property market dynamics through spatial accessibility measures

Adejimi Alli Adebayo, Paul Greenhalgh and Kevin Muldoon-Smith
Northumbria University, Newcastle upon Tyne, UK

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Abstract

Purpose – The retail property market is constantly adopting to the continuous demand of retailers and their consumers. This paper aims to investigate retail property market dynamics through spatial accessibility measures of the City of York street network. It explores how spatial accessibility metrics (SAM) explain retail market dynamics (RMD) through changes in the city's retail rental values and stock.

Design/methodology/approach – Valuation office agency (VOA) data sets (aspatial) and ordnance survey map (spatial) data form the empirical foundation for this investigation. Changes in rental value and retail stock between 2010 and 2017 VOA data sets represent the RMD variables. While, the configured street network measures of Space Syntax, namely, global integration, local integration, global choice and normalised angular choice form the SAM variables. The relationship between these variables is analysed through geo-visualisation and statistical testing using GIS and SPSS tools.

Findings – The study reveals that there has been an overall negative changes of 15 and 22% in rental value and retail stock, respectively, even though some locations within the sampled city (York, North Yorkshire, England) indicated positive changes. The study further indicated that changes in retail rental value and stock have occurred within locations with good accessibility index. It also verifies that there are spatial and statistical relationship between variables and 22% of RMD variability was jointly accounted for by SAM.

Originality/value – This research is first to investigates changes in retail property market variables through spatial accessibility measures of space syntax. It contributes to the burgeoning research field of real estate and Space Syntax.

Keywords Street network, Rental value change, Retail property market, Retail stock change, Space syntax, Spatial accessibility

Paper type Research paper

1. Introduction

Retail activity remains one of the predominant functions of UK cities and prevailing land use of city and town centres. It involves recurrent transactions between two main market participants, namely, retailer and consumer, to effect trade. The mode of transaction between retailers and consumers continue to change as result of technological advancement, government policies and other socio-economic factors (Rhodes and Brien, 2017). Consequently, retail property markets performance indicators such as rental value, vacancy, availability, absorption rates, stock and others continue to be volatile (Vitalii and Lena, 2016). Perhaps, what will remain unchanged about retailing (in-store) is that street network will remain the connecting links through which consumer reaches retailer to effect trade on retail space (Adebayo *et al.*, 2017). Thus, connectivity of streets (i.e. spatial accessibility) remains crucial to both retailers and consumers while selecting and visiting retail property, respectively.

Preliminary studies have adopted various strategies and developed models to explain changes in commercial property market for various cities (Barras, 1994;

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Nanthakumara *et al.*, 2000; Hendershott *et al.*, 2002; Dunse *et al.*, 2010; Liang and Wilhelmsson, 2011; Astbury and Thurstain-Goodwin, 2014). Likewise, relating studies (Tsolacos and Mcgough, 1999; Ingrid, 2006; Greenhalgh, 2008; Nsibande and Boshoff, 2017) have also contributed to the understanding of how changes in property market performance indicators influence spatial decisions of market actors on development, investment and occupation of commercial property. These preceding studies have provided insights as to how changes in retail property market variables influence demand and supply of retail property within cities. However, the only tangible means through which consumers will always connect and access retail property (i.e. street network) has never been considered in the previous works. This important gap requires exigent consideration for optimum utilisation of city (retail) space as online retailing and other factors are changing the structure of retail markets, which are currently characterised by declining retail stores and increasing vacant stock among other concerning conditions (Deloitte, 2018).

This novel study took up the challenge of investigating retail property market dynamics through spatial accessibility measures of a city street network. It measures the spatial accessibility index of street network for a sampled city using space syntax's theory to compute the suppose retail consumer movement pattern on a city network. It explores and investigates how spatial accessibility metrics (SAM) explain and relate with changes in retail property market indicators within a sampled UK city network.

2. Background

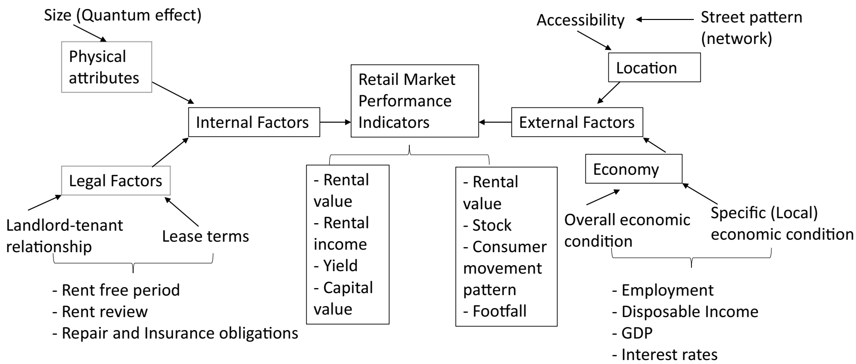
2.1 Concepts and factors influencing performance (changes) of retail property markets

The influence of retail consumers on retail market actors' decisions can be overwhelming. This is because both user and investment markets (demand) for a retail property (space) is a function of the retail consumer demand for retail goods and services (Brown, 1991; Colwell and Jackson, 2004). It is the collective individual choices of consumers that form the basis of the retail property market performance. Ordinarily, retailers (i.e. retail space occupiers) will consider latent patronage ability of retail consumers for goods and services in a local market before demanding to occupy and use the property (space) for retail purpose. Similarly, an investor will seek to invest in retail property space on the expectation that there is occupier demand for retail space with concurrent low supply of retail space in that location (Colwell and Jackson, 2004). In other words, retail consumers' demands for retail products influence decisions of user and investment retail property markets on what, where and whether to develop, invest-in and occupy a retail property (space). Considering the significance of consumer demand on retail property market performance, it is pertinent that consumer movement actions on retail space should be considered when estimating locational performance for key market decision making on development, investment and occupation of retail property. Retail property market performance on a spatial layout are measurable through the changes in market indicators (namely, rent and stock) over certain periods where noticeable market changes on that indicator is expected to have occurred (Adebayo *et al.*, 2017). Changes in any of the market indicators are expected to indicate positive, negative or neutral (no change) performance of the property market within a given spatial layout. These directional changes are useful information dashboards in making market decisions on development, investment and occupation of retail spaces.

The retail market remains one of the most dynamic property markets due to its high dependence on consumers' decisions. Retail activities continue to change because of various factors influencing retail consumers and retail market performance indicators. These factors influence the market performance (including, demand of retail products and demand and supply of retail space) across any given spatial layouts (Dixon, 2007; Evans, 2008). Wyatt (1996) categorised factors influencing property performance into external and internal factors. The external factors include location (access) and overall economic performance of the property, while the internal factors include all legal (lease terms) factors and physical attributes (such as floor sizes, building specifications among others) as shown in Figure 1.

Besides the revealed factors in Figure 1, there are other factors such as technology (online retailing), planning policies, retailers' branding and strategies that may influence retail market indicators. However, external factors, namely, economy, location and accessibility have been identified as the main influencing factor on the retail property market performance (Rhodes and Brien, 2017). This is because these external factors influence retail consumer patronage (including movement and expenditure) and overall retail market performance (Huff, 1962; Brown, 2006; Rhodes and Brien, 2017). An instance of external (economic) factor is the global economic recession of 2008 that had significant negative impacts (such as, increase vacancy rates, reductions in net rents, increases void periods, reductions in capital values among others) on retail consumer patronage (expenditure) and the overall UK property market (Astbury and Thurstain-Goodwin, 2014; ONS, 2017). On the other hand, the internal factors are more property-specific elements that are indefinable and do not reflect the overall market performance (Wyatt, 1996; Brown, 2006; Astbury and Thurstain-Goodwin, 2014). For example, building specification is of relatively less importance to retail consumers and overall market performance when compared to location and accessibility (Wyatt, 1996; RICS, 2017).

The pattern of city spatial network helps to shape retail consumer movement, which in turn plays a role in determining the distribution of retailers (stock) and performance of rental value on city space. Huff (1962) explained that accessibility distribution scores of retail space (stores) could influence retail consumers' movement patterns. He emphasised that retail spaces located on good accessible links perform better than retail spaces with poor accessible link in terms of footfall, vibrancy, rental value and demand of space. However, the extents to which accessibility index, that is, consumer movement pattern on city (retail) space will influence performance of market indicators such as rent (value) and stock is relatively unknown.



Source: Adapted from Wyatt (1996)

Figure 1.
Factors influencing retail property market performance

2.2 Concept of spatial accessibility measurement

It can be argued that accessibility index of locations within a given street network will determine retail consumer movement pattern on that city space (Huff, 1962). The concept of accessibility measurement within a city space network can generally be categorised into functional accessibility and spatial accessibility (Guers and van Wee, 2004; Reggiani, 2012; Jie *et al.*, 2017). The functional accessibility measurement involves estimating relative ease of movement from origin "O" to a destination "D" while taking into consideration deterrence factors such as costs of movement, time spent on movement and the distance travelled (Reggiani, 2012; Jie *et al.*, 2017). However, the spatial accessibility measurement solely determines the relative connectedness of places (streets) within the city spaces in relation to other places. Hence, spatial accessibility measurement does not concern itself with deterrence factors, but the interconnectivity pattern of streets while evaluating location accessibility within a city network (Baradaran and Ramjerdi, 2001; Litman, 2003). Space syntax ideologies adhere to the principles of spatial accessibility, and its configuration outputs, namely, integration and choice metrics, have been respectively identified as to-movement and through-movement potential of people within a given street network (Hillier and Hanson, 1984).

Space syntax explicitly computes accessibility indexes for streets network through spatial configuration without considering the socio-economic activities on the same city space (Batty, 2008; Giannopoulou *et al.*, 2016). However, studies have revealed that configured outputs (i.e. assigned syntactic values of street network) correlate and explain some socio-economic variables, such as property values (Chiaradia *et al.*, 2009; Law *et al.*, 2013; Muldoon-Smith *et al.*, 2015), pedestrian and vehicular movement pattern (Hillier, 1996; Peponis *et al.*, 1997) and pattern of land use distributions (Stonor, 2008) within cities. Conversely, there have been disparities among scholars' findings, especially the relationship between spatial configuration outputs and property values. For example, Muldoon-Smith *et al.* (2015) revealed that the values of commercial property (retail, offices and industrial) relate differently with integration outputs for City of Leeds. Similarly, Giannopoulou *et al.* (2016) while investigating Xanthi city in Greece revealed there were negative relationships between configured integration metrics and the residential property values of the city. Meanwhile, Chiaradia *et al.* (2009) investigated a suburb area in London and revealed there were positive relationships between the residential property values and the configured outputs of choice and integration metrics. However, a common shortcoming to all the aforementioned studies (Chiaradia *et al.*, 2009; Muldoon-Smith *et al.*, 2015 and Giannopoulou *et al.*, 2016) is that the relationship tests on variables do not consider the statistical significance of spatial configuration outputs (variables) on the property values variable. It can be contended that this unexplored relationship could shed new light on the statistical outputs in these studies. In other words, the uniqueness in property market characteristics and spatial structures of the aforementioned cities could have led to variations in results.

This research deficit provides the motivation for investigating how spatial accessibility measures (choice and integration metrics) explain the changes in retail rental value and stock within a city street network. The study explores how specific spatial accessibility index (integration and choice metrics at local and global scales) influence changes in retail rental value and supply stock within City of York's street network. Geo-spatial and statistical relationships between retail market indicators (changes in rent and stock) and spatial accessibility index (measures of "to" and "through" movement) variables were explored. This is important in establishing reliable location performance of city (retail) space for optimum decision making on occupation, investment and development of retail space.

2.3 Spatial configuration of city streets network through segment map analysis

The theory of space syntax uses graph analysis techniques to measure accessibility index of spaces (including, cities and buildings) through spatial configurations (Peponis *et al.*, 1997; Figueiredo, 2015). Spatial configuration of a given city street network is conducted using segment map analysis to assign syntactic values to spaces (or streets) by analysing complex relations between streets (while taking into account all other streets within the city network) (Hillier *et al.*, 1993). Space syntax's fundamental ideologies repose on the premise that human movements within street network follow a set of procedural rules and patterns (Hillier *et al.*, 1993; Peponis *et al.*, 2008). The procedural rule is that humans (groups of individuals) will navigate within a given street network while making the least angular turns (Hillier *et al.*, 1993; Peponis *et al.*, 2008). This ideology has been developed into computer algorithms to compute the supposed usage of a configured or designed space in terms of visibility and movement in an explicit manner (Peponis *et al.*, 1997; Jeong and Ban, 2011).

Over the years, availability of big spatial data (especially road centre line) has encouraged urban (space syntax) analysts to adopt segment map analysis over hand drawn axial maps while analysing space at city scale level (Kolovou *et al.*, 2017). The segment map analysis allows users to analyse street networks at various controlled metric radii (i.e. local configuration analysis) to reflect various modes of human movement within a given city space (Jiang, 2000). Dalton and Dalton (2009) revealed that high metric radii represent fast modes of transportations, e.g. vehicular movement, while some lower metric radii will indicate cycling or walking within the city street network. Peponis *et al.* (2008) also indicated that 400 and 800m metric radii represent 5 and 10 min walk, respectively, within a given city street network. Hillier *et al.* (2012) further explained that normalisation of configured metric variables (specifically, angular choice) can be carried out through segment map analysis within DepthMapX software tool. Hillier *et al.* (2012) explicated that normalising angular choice can be done by dividing configured choice metric values with corresponding total-depth metric values to eliminate inconsistencies associated with variations in street network patterns.

This study proposes that the manner in which a given street network is configured will influence changes (positive and negative) in retail rental values and stock within a given city space. Hence, the following propositional statements are made and further tested:

P1. The higher the accessibility indexes of streets (locations), the more the rental value changes, and vice versa.

P2. The higher the accessibility indexes of streets (locations), the more the stock changes, and vice versa.

3. Methodology

3.1 The study area

The street network of City of York in North Yorkshire, England has been chosen to pilot this experimental research. The city has rich heritage and longstanding built environment of iconic and listed buildings that annually attracts over 7 million tourists and visitors (as potential retail consumers), who spend more than £400m on retailing (VisitYork, 2017).

The rationale behind studying York is due to the monocentric landscape of the city fabric and retail distribution pattern within the city network. York is perhaps one of the few monocentric UK cities that has no large purpose-built shopping centre within its network. As such, excessive artificial control of retail property market (that is possible in shopping centres by landlords and managers) is almost impossible within City of York network. This allows for an undisrupted investigation into the city retail property market at a city network level. Similarly, the city is relatively well defined and small, both in land area, and the commercial (retail) property market size. Therefore, it is ideal to explore to pilot the developed research method.

3.2 Sources of data variables

Data used in this study have been broadly categorised into aspatial and spatial data sets. This is because the sources and processes taken in obtaining variables of aspatial and spatial data differ. Herein, the aspatial data sets are all forms of data that have been used as market indicators and were not obtained as map data. While, the spatial data have been obtained as map features data.

The aspatial data sets were obtained from valuation summary lists (2010 and 2017) of valuation office agency (VOA). The VOA holds valuation summary lists (henceforth, VOA data) for all rateable commercial (including retail, offices and industrial) properties across England and Wales for taxation purposes. The rational for using VOA data in this study (that is based on property market analysis) is not limited to the data availability, completeness, relevance and comprehensiveness (Greenhalgh and King, 2013; Astbury and Thurstain-Goodwin, 2014). The recent public release of VOA datasets provides opportunity for understanding the actual changes that have occurred in commercial property market (variables) as against predicting it. The VOA data contain commercial (retail) market indicators useful in estimating market performance on any given city's locations within England and Wales. The VOA data holds rateable values (based on market rental values as at the date of valuation), floor areas, Unique Address Reference Number (UARN), occupiers, property uses, date of valuation and property addresses for all non-residential properties in England and Wales (VOA, 2017). It is important to note that the valuation dates for 2010 VOA data is April 2008, while the valuation date for 2017 VOA data is April 2015 (VOA, 2017). The rateable values at date of valuation (that is, market values) and floor areas of retail hereditaments[1] within the City of York have been extracted from the list and used as retail rental values and stock respectively. The UARN feature serves as the common key that was used in matching records (features) of the same retail property in 2010 and 2017 data. As such, the actual locational changes in features can be established with high level of precision.

Consequently, the aspatial data variables, that is, *changes in rental value* and *changes in stock* for all (rateable) retail property within York were computed by subtracting 2010 market rent values (as at April 2008) from the 2017 market rent (as at April 2015). These variables are termed as retail market dynamic (RMD) variables in this study. Hence, the computation formula of the RMD variables is thus:

$$\text{RMD}_1 = 2017 \text{ rental value} - 2010 \text{ rental value} \tag{1}$$

$$\text{RMD}_2 = 2017 \text{ stock} - 2010 \text{ stock} \tag{2}$$

Having established the RMD variables, a database was created for the aspatial (VOA) data sets using the MS Access tool, where relevant data variables (i.e. UARN, rateable value, address, floor area, occupier, date of valuation, property type and use) were arranged in columns. This table was then exported into MS Excel tool[2] where additional columns were created for the RMD variables[3] and their corresponding geographical coordinates[4] (i.e.

Eastings and Northings). The RMD variables were then populated for all the rows (i.e. retail property/hereditament) using the above equations (1) and (2) to establish differences in rental value and stock for individual property (retail space). The data table (containing the RMD variables) was then imported into GIS (QGIS) as point features. Table I summarises the statistical description of aspatial and spatial data variables.

Meanwhile, the spatial data, i.e. the street network of York was obtained from Ordnance Survey OS (MasterMap) as a Road Centre Line (RCL). The obtained RCL was verified in the QGIS, by overlaying it on an Open Street Map layer to ascertain location precision of the data. The verified RCL data was then exported into the DepthMapX[5] where the street segment configuration analysis was conducted. The street segment analysis generated spatial configuration outputs[6] at global and local measures for integration and choice metrics. The local metrics were controlled at 800 m to represent 10 min walk of retail consumers from any location within City of York network. The choice metric was normalised by dividing the local choice metric (800 m) by total depth metrics (800 m) to solve any possible paradox in choice metric outputs as a result of the street network size and pattern (Hillier *et al.*, 2012). Hence, spatial configuration outputs[7] (i.e. the syntactic values) of *global integration, local integration (controlled at every 800 m), global choice and normalised choice (NACH)* were all obtained from DepthMapX. The syntactic values[8] of the configured York's street network were used as the SAM variables for this experimental study. The SAM variables (in table text format) were then exported into QGIS as point features and for geo-spatial analysis with the aspatial data (i.e. RMD variables).

3.3 Method of geo-spatial analysis of spatial accessibility metrics and retail market dynamics variables

Having exported both RMD and SAM variables into GIS (QGIS) as point features, all variables were integrated and geo-linked for spatial analysis. Due to the differences in nature (sources and functions) of RMD and SAM variables, the study adopted uniform system backdrop in analysing all variables. In doing so, spatial grid-squaring of the city space was adopted to allow consistent positioning of variables' values within the spatial grids. Each grid square holds unique ID that permits matching and linking of data into their respective grids (based on locational properties held by the data variables). As such, the city was divided into grid squares of 500 $\times$ 500 m (i.e. 0.25 km^2) using the vector grid tool of QGIS. The "join-attribute by location" tool in QGIS was then used to join all variables to their corresponding locations/positions within the defined city grids. The "group-stat" tool of QGIS was thereafter used to sum and average individual variables within each grid to obtain the RMD and SAM variables per grid, respectively. The average syntactic values of SAM variables are computed as the spatial accessibility index for geo-visualisation and statistical analyses in this paper. After grouping variables into grids, the SAM variable occupied a total of 1,619 city grids (tiles), while the RMD variable occupied 152 grids. As such, number of frequency count (N)[9] of SAM and RMD variables were transformed from 78,280 and 2,875 into grids of 1,619 and 152, respectively, for geo-spatial analysis purpose.

To visualise spatial relationships between SAM and RMD variables, the average value (per grid) of global integration metrics was used as the SAM variable[10]. The global integration metric was styled using the natural break classification (spectra colour) in QGIS. As such, spatial accessibility index that indicates the degree of consumer movement pattern on York city space emerged in grid tiles. The accessibility index was revealed in colour pattern, with the blue tiles indicating least accessible locations and red tiles indicating highly accessible locations. Similarly, the RMD variable was also styled and classified accordingly based on level of changes in rental value and stock. Both SAM and RMD

Table I. Descriptive statistics for RMD and SAM variables (City of York)

Basic statistics	RMD variables 2010 rent	SAM variables 2010 stock	2017 rent	2017 stock	GI	LI	GC	NACH
N	2875	2875	2875	2875	78280	78280	78280	78280
Mean	33630.08	195.72856	29243.86	159.53325	3127	95.78	2.46E + 07	3.3
Minimum	0	1	0	1	7.43	7.43	0	0.59
Maximum	1160000	7822.96	457500	7652.7	4960	693.77	1.45E + 09	5.24
Std. deviation	60562.27	499.20005	46267.784	406.84291	646.4	53.08	8.19E + 07	1.15
Median	15750	91.88	13750	72.7				
Variance	3.67E + 09	249200.69	2.141E + 09	165521.15				
Skewness	7.353	11.025	3.804	12.682				
Std. error of skewness	0.046	0.046	0.046	0.046				
Kurtosis	97.288	140.719	20.194	200.978				
Std. error of kurtosis	0.091	0.091	0.091	0.091				

Sources: RMD variables is adapted from VOA (2017) https://voaratinglistsob.core.windows.net/html/rlidata.htm; SAM variables are computed RCL outputs from DepthMapX (2018) variables were then superimposed for geo-spatial visualisation of relationships between them. This reveals visual relationships between the two variables that can indicate (accept or reject) the first and second propositional statements of this study, whether the higher the accessibility index of location, the more the rental value (and stock) changes.

However, the geo-visualisation of variables' relationship cannot suggest the level of statistical significance of SAM variables on RMD (if any). To quantify and verify the level of significance of SAM on RMD, correlation[11] and multiple regression analyses was conducted using a SPSS tool. A multiple regression model was developed to determine the *R*-square (R^2) value that determines the percentage of variation that independent variables jointly account for the dependent variable. In doing so, the study adopted the RMD variable (that is, relative[12] rental value change) as dependent variable. However, the SAM variables, namely, global integration (GI), local integration (LI), global choice (GC) and normalised angular choice (NACH), are modelled as the independent variables. The modelled multiple regression formula is shown in equation (3):

$$\mathrm{RMD} = \mathrm{a} + \mathrm{b_1 GI} + \mathrm{b_2 LI} + \mathrm{b_3 GC} + \mathrm{b_4 NACH} + \mathrm{e} \quad (3)$$

where:

RMD = Changes in retail rental value (£/m^2);
a = constant regression coefficientb_1 = coefficients of GI;
GI = global integration metrics (consumer to-movement);
b_2 = coefficient of LI;
LI = local integration metrics (consumer to-movement controlled at 800 m);
b_3 = coefficient of GC;
GC = global choice metrics (consumer through-movement);
b_4 = coefficient of NACH;
NACH = Normalised angular choice metrics; and
e = error terms.

The GI is a measure of spatial configuration that estimates how close a location (street) is to all other locations within the entire network. It is known as the to-movement metric in the field of space syntax (Hillier and Hanson, 1984). The LI is the measure of integration that has been controlled at certain metric distance (in this case, 800 m to represent every 10-min walk of consumer within the city space). While, the GC (global choice) is the measure of how likely a location (street) is to be pass through on all shortest routes from all locations to every other location within a street network (Hillier *et al.*, 1987). The GC is referred to as the through-movement metric. Similarly, the NACH value is derived from global or local choice metrics. It is computed by dividing global choice or local choice by a corresponding total depth value of street network. In this case, a local choice (at 800 m) has been divided by a total depth metric (at 800 m). All these variables (GI, GC, LI and NACH) denote spatial accessibility measures showing accessibility scores of locations based on connectivity of streets. The syntactic values of GI, GC, LI and NACH as grouped into grids in QGIS were exported into SPSS (alongside RMD variable) for statistical analysis.

4. Findings and discussions

4.1 Changes in retail rental value and stock

Table II shows the computed summaries of changes in retail rental value and stock between 2010 and 2017 for York (based on VOA data) using the stipulated equations (1) and (2). Table II indicates that there have been negative changes, both in retail rental value and retail stock within York. It reveals that there have been about 15 and 22 per cent aggregate reduction in rental value and stock respectively. This is an indication that the economic performance of the city between 2008 and 2015 reflects on the performance of the retail market indicators (that is, rent and stock). This is because the retail rental value in the 2010 VOA data must have been computed based on buoyant "pre-cash" and booming economic conditions in early 2008. Consequently, the City's retail market is yet to fully recover from the deep recession that started in the second quarter of 2008.

It is imperative to note that Table II has revealed the overall rent and stock changes; it does not indicate locations where changes have occurred within the city for market decision-making purpose. The subsequent sections present geo-visualisation outputs of locational changes in retail rental values and stock across York.

4.1.1 City of York retail rent (value) changes through geo-visualisation. Locational changes in retail (property) value within York have been ranked by matching individual property change values into the established city grids for fair distribution, visualisation and comprehension of rent changes across the city space. The rental value changes have been ranked into five classes as high negative, low negative, no change, low positive and high positive changes. These classes have been presented in colour grids as dark brown (high negative), light brown (low negative), black (no change), light green (low positive) and dark green (high positive) change as shown in Figure 2. Figure 2 shows that there have been numerous changes in retail rental value across the City of York network between 2010 and 2017. Locations (i.e. grid tiles) that have not experienced any significant rental growth or reductions are few (only three tiles) and are located at the periphery of the city network. Meanwhile, retail rental value changes within the city core are characterised by high changes. Figure 2 shows that the bulk of high negative changes have occurred within the city centre tiles, while many of the low positive rent changes are more widely distributed across the city. As such, there are many flourishing locations that have seen slight positive rental value growth, even though the overall rental value change for the city indicate a total 15 per cent reduction.

4.1.2 City of York retail stock changes through geo-visualisation. The spatial distribution of retail stock changes across the city network of York is also presented in Figure 2. The changes in retail stock have also been classified into two main classes as positive and negative changes that are represented in distinct colour columns[13] revealed in Figure 2. The purple columns (four columns) represent locations with noticeable positive stock changes within the City of York, while the orange (single) column indicates the location where there has been noticeable reduction in retail floor space. Changes (in stock) are not extensively distributed across the city network (unlike the rental value changes). The figure reveals that there are no obvious stock changes within the city centre. The reason for scant

Table II. Computed changes in retail rent and stock for York

Variable	Value	Approximate value
Σ2017 rent (£)	84078375.00	84,000,000.00
Σ 2010 rent (£)	96690035.00	97,000,000.00
Change rent (£)	−12,611,660.00	−13,000,000.00
Change rent (%)	*−15*	*−15*
Σ 2017 stock (m^2)	458682.19	460,000
Σ 2010 stock (m^2)	562743.09	570,000
Change stock (m^2)	−104060.90	−100,000
Change stock (%)	*−22.68*	*−22*

Source: Adapted from VOA (2017)

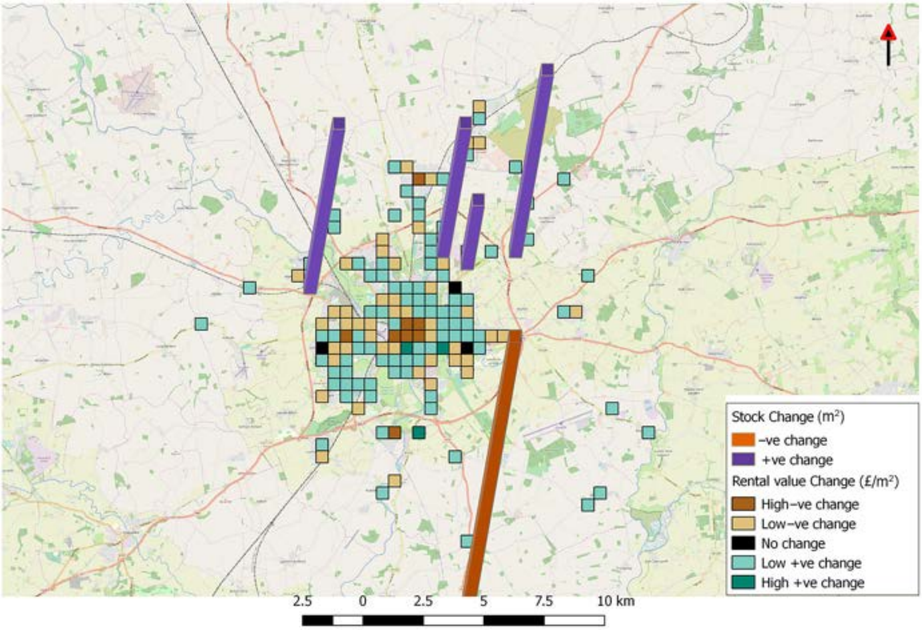


Figure 2. Distribution of RMD variables (changes in retail stock and rental value) for city of York

changes in retail stock in the city centre can be linked to the inelastic nature of supply (stock) variable in a typical property market. Also, the concentration of listed and historic buildings at city centre could have hinder retail stock changes at the city core. The main implication of this result suggests that there greater potential for stock change in peripheral areas than the city core.

4.2 Spatial accessibility indexes of City of York

Spatial accessibility index of City of York was computed in DepthMapX where all syntactic values of SAM variables were obtained. These variables were exported into QGIS (from DepthMapX) for analysis[14]. For geo-visualisation purpose, the global integration metrics was used as the SAM variable in the QGIS because of its high visual intelligibility as shown in Figure 3. The global integration metric outputs were spatially arranged into coloured grid tiles based on its embedded syntactic values obtained from DepthMapX. Each colour represents strength (index) of locations' accessibility within the city network. The order of accessibility index is such that red and orange grids represent accessible locations, while blue and green grids indicate locations with the least accessible index. As such, the spatial accessibility index of all locations within York network emerged.

The accessibility index tiles in Figure 3 depict the likelihood of retail consumer movement within the city's street network based on space syntax principle. The interpretation of this is that locations (tiles) in red and orange colours are the most accessible locations for retail consumers, while the green and blue tiles are locations are the least accessible locations for retail consumers. Figure 3 clearly indicates that the city core (dominated by red and orange tiles) is the most accessible part of city, while the north-western part of the city is the most segregated part of the city. This implies that locations

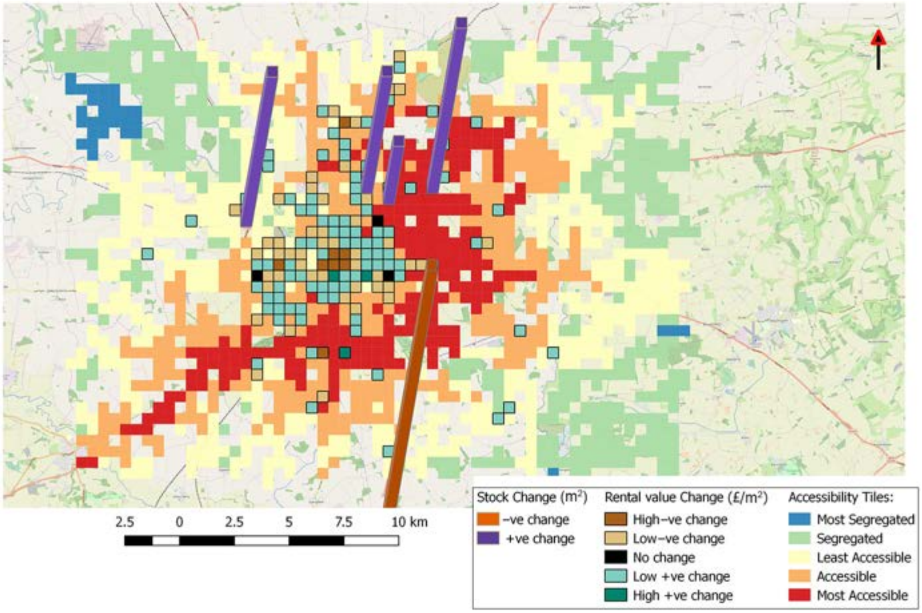


Figure 3. Spatial accessibility and changes in retail stock and rent (RMD) for city of York

(with high accessible index) will experience the greatest retail consumers' movement when compared with other locations within the city network.

4.3 Spatial and statistical relationships between spatial accessibility metrics and retail market dynamics variables

The spatial relationship between variables of RMD (i.e. rental value changes and stock changes) and SAM (i.e. the global integration metrics) is obvious in the Figure 3. The figure reveals that many of the retail properties are located in places with good accessible indexes (i.e. red and orange tiles) since these are locations that retail consumers can have easy access to. It further indicates that both positive and negative (high) changes in rental values have occurred in locations with good accessibility index, while locations with least accessibility index have experienced slight positive and negative changes in rental value. Likewise, it shows that the large negative stock change (downward column) has occurred on one of the highly accessible tiles, while many of the positive stock changes (upward columns) are found within good accessible locations. This suggests that locations with high accessibility index are more subject to retail market changes than locations with low accessibility index. In other words, accessibility index can also contribute to volatility of retail market indicators.

However, because locations with no rental value changes are also situated on good accessibility tiles, it can be contended that the changes in RMD variables and SAM index are moving toward the same relative direction but not at a constant rate. The spatial relationship between RMD and SAM variables, thus, indicates that a monotonic[15] relationship exist more than a linear relationship. Hence, Spearman's correlation coefficient is more appropriate in testing relationship between RMD and SAM. Table III shows the matrix output of Spearman correlation test between all the SAM and RMD variables.

Table III affirms that there are spatial relationships between SAM (global integration metrics) and RMD (changes in rental value and stock) variables. It reveals that all variables are significantly correlated at 0.01 significant level. The global choice metric is the least significant variable to both changes in rental value and stock with coefficients of 0.065 and 0.271, respectively. While the global integration metric shows the highest significance to both changes in rental value and stock at 0.086 and 0.362 coefficients, respectively. The retail stock change variable shows a stronger relationship with the SAM variables than the rental value changes, as initially suggested in the spatial relationship output of Figure 3. Nevertheless, changes in retail rental value within York have shown positive and significant correlation with the SAM variable. Thus, the study affirms "the higher the spatial accessibility index of City of York, the more changes in both retail rental value and stock within City of York network".

This implies that spatial accessibility measures of space syntax (despite not considering socio-economic and other factors) still influence and relate with RMD variable within the City of York. The study further explored the potential to establish the percentage of the variance in RMD (changes in relative rental value) variable that the SAM variables collectively explain. This was done by exploring the *R*-square of the developed multiple regression model in equation (3). Table IV reveals the regression results (estimates) and *R*-square value between RMD and SAM variables.

Table IV shows the output model of equation (3) that seeks to estimate the percentage of RMD variability that SAM variables (namely, global integration, local integration at 800 m, global choice and normalised choice) jointly explain. The empirical result presented in the result table reveals that NACH metrics, local integration metrics and global integration metrics are significant determinants of changes in retail rental values in York. This implies that computation of through movement (that is, choice metric) at global city scale is irrelevant to changes in York retail rent as previously suggested in the Spearman correlation result. Furthermore, in consideration of the entire variables fitted into the model equation (3),

	NACH	Global choice	Global integration	Local integration	Change_RV	Change_stock
NACH	1	0.685**	0.962**	0.973**	0.080**	0.355**
Global choice		1	0.726**	0.699**	0.065**	0.271**
Global integration			1	0.943**	0.086**	0.362**
Local integration				1	0.080**	0.360**
Change_RV					1	0.171**
Change_Stock						1

Notes: **Correlation is significant at the 0.01 level (2-tailed); $N = 1622$

Table III. Spearman's rho corrrelation coefficient

Variables	Regression coefficient	Beta coefficient	*t*-value	sig.
Constant	98.233		−0.712	0.477
NACH	1.831	−0.739	−4.846	0.001*
Global choice	0.000	−0.080	−2.938	0.103
Local integration	0.026	0.291	3.732	0.000*
Global integration	0.002	0.751	5.228	0.000*

Notes: $R = 0.470$; $R^2 = 0.221$; R^2 adjusted = 0.200; Std error = 2973.032; $N = 152$

Table IV. Regression results (estimates) between RMD and SAM variables the result table reveals that the R-square is 0.221. The interpretation of this is that the SAM variables jointly account for 22.1 per cent of the variation in RMD within the City of York. In other words, 22 per cent of RMD variability are explained by the spatial accessibility index computed based on space syntax theory. Embedding the regression coefficient model into equation (3) implies that:

$$\mathrm{RMD} = 98.233 + 0.002\,(\mathrm{GI}) + 0.026\,(\mathrm{LI}) + 0.000\,(\mathrm{GC}) + 1.831\,(\mathrm{NACH}) \quad (4)$$

While the study does not aim to establish the fitness of the above regression model, it does demonstrate that consumer–to–movement (GI and LI) variables at global and local scales are significant SAM variables on RMD variable. The study recognises that there are other spatial configuration metrics (such as, total depth, node counts, other local controlled metrics of choice and integration) that can be fitted into the model to enhance R-squared result and consequently the model. It is important to state that the developed model has only incorporated integration and choice at local (controlled 800 m) and global scales to represent retail consumer movement index on City of York network. Similarly, there are other possible factors asides SAM variables that can contribute to explaining RMD variability within the sampled City of York.

5. Conclusions and recommendations

Analyses conducted in this study reveal there have been positive and negative changes in retail rental value and stock variables across different locations within City of York between 2010 and 2017. Many of the changes in retail rental values are widely distributed in an uneven pattern across the city, while changes in stock have been confined to limited locations within the city network. The aggregation of changes is negative for both changes in retail rental value and stock. The study further established that there are spatial and statistical relationships between spatial configuration outputs of SAM variables and the RMD variables (as measured by changes in retail rental value and stock). The higher the SAM values, the more the changes (positive and negative) in the RMD variables. The developed regression model in the study suggested that the SAM variables (NACH, global choice, global integration and local integration metrics) jointly account for 22 per cent of RMD variability within City of York network, even though the global choice metric is the least significant variable of SAM on RMD.

This study recommends application of space syntax techniques and tools to retail property markets to assist stakeholders (such as, retailers, retail property owners, city planners and real property developers) when making spatial related decisions within any given city. Spatial configuration outputs that compute accessibility index of streets network should be used as an effective tool in making varieties of decisions, for example, site selection for retail development, site suitability for retail store locations, downsizing and or closing of retail store branches, changing use of property space, among other retail property development, investment and occupation decision tasks. While this research focuses on retail property market within York's street network, the developed research methods are applicable on any given city space and property types (including, residential, offices and industrial) assuming similar data exists. The study recommends applying this research method across other city space network and property types to further explore relevance of spatial configuration outputs on real property markets.

Finally, the study recommends that the space syntax society (specifically, the software developers) take additional steps in establishing a straight-forward tool that is capable of integrating socio-economic datasets into DepthMapX. Such steps will further broaden applications of space syntax in property and city space analyses.

Notes

1. Retail hereditaments are all rateable retail property (spaces) in the VOA data. Effectively, they represent units of property.
2. This was because the VOA data set is very large data and cannot be fully opened in MS Excel.
3. RMD variables are computed changes in rent and stock
4. To georeference RMD variables for geo-spatial analysis, addresses (and postcodes) of all the retail hereditaments were converted into Eastings and Northings (i.e. X and Y coordinates) using doogal software app.
5. DepthMapX is a space syntax tool for spatial (street) network analysis
6. The spatial configuration outputs contain syntactic values of integration and choice metrics for all the RCL/street segments.
7. It is important to note that the spatial configuration outputs (that is, generated syntactic values) from DepthMapX are accompanied with spatial coordinates (Eastings and Northings). This allows the configuration outputs to be exported into QGIS for geo-spatial analysis.
8. Syntactic values are generated/computed figures from DepthMapX software after street segment analysis. All the street segments (that is, RCL) within a defined a network is assigned syntactic values of integration, choice and NACH. The size of the considered network can be controlled by the user of DepthMapX, say, by 400 or 800 m or any other chosen distances. When such controls are implemented, the software calculates syntactic values base on the controlled distance rather than computing syntactic values base on the entire street network. Calculations done based on the entire street network is called global measurements (say, global integration or global choice), while the controlled distance calculations are called local measurements (say, local integration).
9. N is the frequency or counts of RMD and SAM variables as shown in the descriptive statistics Table I.
10. This is because global integration metrics are more visually intelligible than other (correlated) SAM metrics.
11. Spearman rho correlation was chosen over Pearson correlation test because variables (SAM and RMD) have been summed and grouped per grid before the correlation test. As such, a straight line relationship is not expected.
12. Relative rental value is the rent per unit square meter.
13. Column indicates extent of stock change in that location.
14. Analysis with other datasets (rent and stock) is not possible within DepthMapX.
15. In monotonic relationship, the variables tend to move in the same relative direction, but not necessarily at a constant rate.

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About the authors

Adejimi Alli Adebayo is currently a PhD researcher in the Department of Architecture and Built Environment at Northumbria University Newcastle, UK. His research focuses on enhancing performance of retail space through geo-spatial analysis of urban big data. He currently holds a Btech degree in Estate Management, MSc degree in International Real Estate (with distinction) and MSc degree in Remote Sensing and GIS. Adejimi Alli Adebayo is the corresponding author and can be contacted at: adejimi.a.adebayo@northumbria.ac.uk

Paul Greenhalgh is an Associate Professor in Real Estate Economics, Head of Subject: Built Environment and founder of the URB@NE research group and R3intelligence consultancy. He is a Chartered Surveyor and member of Commercial, Planning and Development and Valuation Professional Groups. His field of expertise is the analysis of commercial property markets, and he is widely published both in academic and professional circles. Paul is currently involved in research and consultancy projects that model the impact of spatial interventions to inform future urban growth and real estate investment strategies.

Kevin Muldoon-Smith's research and teaching combines real estate adaptation, international finance and public policy, in which he is widely published in academic and professional circles. He uses quantitative and qualitative methods to examine how the structures of local commercial real estate markets interact with international stimuli and contemporary public policy to (re)produce the urban built environment. He is also interested in cross-fertilising the typically econometric practice of real estate with contemporary theories seen in social sciences, particularly the blending of post-structural interpretations of society with recent socio-institutional examinations in real estate.

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Investigating retail space performance through spatial configuration of consumer movement: A Comparison of York and Leeds

Adejimi Adebayo[1]; Paul Greenhalgh[2]; Kevin Muldoon-Smith[3]

ABSTRACT

Spatial layouts help to shape retail consumer movement, which in turn plays a role in determining the distribution of retailers and performance of retail space on city network. Spatial configuration can be understood through street segment analysis, computing to-movement (integration) and through-movement (choice) metrics within a given set of connecting street networks, making it possible to assign syntactic values to individual street segments (space). In this paper, such syntactic values for the cities of Leeds and York have been established to indicate a spatial accessibility index that can be used to understand potential human (consumer) movement on spatial layouts. Other studies have established relationships between computed syntactic values and ranges of socio-economic activities, including land uses and urban value distributions. However, little is known about how configured (movement) metric outputs relate to changes in retail space's rental values (as proxy for retail space performance) across different city network scales. In response, this study investigates the relationship between retail space performance and consumer movement patterns (CMP) within sampled spatial layouts. The CMP are defined as spatial configuration metric outputs of integration, choice and normalised angular choice (NACH) metrics, computed at macro (city) and meso (city centre) scales. Street segment analysis on spatial layouts at city (macro) and city-centre (meso) scales were computed using DepthMapX tool to obtain the CMP variables. The computed syntactic values of CMP variables were then exported as point features into QGIS for analysis with the retail space performance within the sampled spatial layouts. Rental value data for years 2010 and 2017 were obtained from the Valuation Office Agency VOA datasets for York and Leeds. The two datasets were linked through a common key variable (Unique Address Reference Number) to compute rental value changes using MS Access and MS Excel tools. The rental value change table was also exported as point features into QGIS for geospatial analysis with the computed syntactic values of CMP variables. To achieve this, the study utilises vector grid (developed at 500m X 500m at city scale, and 200m X 200m at city centre scale for both cities) to a create uniform platform for all variables per grid. The relationship outputs between variables were investigated at macro city scale and meso city-centre scale for the two cities. The study reveals that there are variations in relationships between retail space performance and computed movement syntax across different scales of spatial layouts. The variables exhibit significant positive relationships at mesoscale (city centre), while variables exhibit weak correlation at the macroscale (city) for both cities. It further reveals that the integration (to-movement) metric has the most significant impact on retail space performance, with the through-movement metric having the least impact across all spatial layouts. On this basis, the study conclude that integration metric has the capability of signalling future of retail space (rental value) performance at city mesoscale layouts.

KEYWORDS

Retail space, consumer movement, rental-values

[1]Adejimi Adebayo, Department of Architecture and Built Environment, Ellison Place, Northumbria University Newcastle UK NE1 8ST, adejimi.a.adebayo@northumbria.ac.uk
[2]Paul Greenhalgh, Department of Architecture and Built Environment, Ellison Place, Northumbria University Newcastle, UK NE1 8ST, paul.greenhalgh@northumbria.ac.uk
[3]Kevin Muldoon-Smith, Department of Architecture and Built Environment, Ellison Place, Northumbria University Newcastle, UK NE1 8ST, k.muldoon-smith@northumbria.ac.uk

1. INTRODUCTION

Spatial configuration of spatial layouts can calculate accessibility index of city space by estimating syntactic values of choice (through-movement) and integration (to-movement) through street segment analysis. Preceding studies by Chiaradia, et. al. (2009), Law et. al. (2013), Muldoon Smith et. al. (2015) and Giannopoulou et. al. (2016) using spatial configuration techniques have investigated and corroborated the relationships between spatial accessibility (computed through spatial configuration technique) and distribution of rental values of various real properties across different cities. However, it is unclear how the configured accessibility metrics (i.e. integration and choice) relate and contribute to changes in urban rental value. This study argues that a clear understanding of this will be useful in estimating future performance of urban land value.

Of all urban land uses, retail is the one that most relies on accessibility to prosper and survive. Locational performance of retail space can help understand the future trends of city retail spaces. Cities, through connected streets, serve as the permissible link that enable physical transactions between retailers and their consumers. The pattern of spatial layouts helps to shape retail consumer movement, which in turn plays a role in determining performance of city space (Adebayo et al., 2017). Accessibility index of a city retail space contributes to the understanding of retail market performance because it signals potential flow of consumer movements and footfall (Huff, 1962; Curtis and Sheurer, 2007). Ordinarily, performance of retail market on city space are measurable through computation of changes in retail market variables (such as, rental value, floor area, retail clusters, retail diversity etc.) within a given location. The direction of changes in property market indicators over time would indicate trends in retail market performance in that location. Meanwhile, accessibility index of city space (unlike retail market variables) are measurable through street segment analysis (Peponis et. al., 2008). This study utilises changes in retail market variable (namely, rental value) and spatial accessibility index computed through spatial configuration to investigate retail space performance across sample spatial layouts. It focuses on investigating the influence of consumer movement pattern (CMP) variables (computed through street segment analysis) on locational changes of retail rental values over two dates, when changes in rental value are expected.

The CMP of connecting streets are computable through spatial configuration of Road Centre Line (RCL) as input data using DepthMapX tool. In doing so, all individual street segments of the RCL are assigned syntactic values. The assigned syntactic values depend on the spatial characteristics of the RCL data that makes up the street segment network (Jiang and Claramunt, 2002; Jeong and Ban, 2011; Kolovou et. al., 2017). Consequently, changes in network size in turn changes the assigned syntactic values of the street segments in a consistent pattern (Figueiredo, 2015). In other words, the syntactic values of a street segment '*A'* computed at a city macroscale, is not the same for the same street segment '*A'* when computed at the city centre mesoscale. The syntactic values of a configured street segment network computed through DepthMapX include metric variables of connectivity, choice, integration, total depths and others. Studies by Chiaradia, et. al., (2009) and Law et. al. (2013) indicated that choice and integration metrics are spatial accessibility variables that are capable of signalling flow of human movement within a given street network. Hillier et. al. (2012) developed normalised angular choice (NACH) metric to regularise inconsistencies associated with variations in spatial characteristics of input (RCL) data. Despite the applicability of integration, choice and NACH metrics (herein, CMP variables) to retail consumer movement and accessibility index, there is vague understanding about how CMP variables influence retail space performance. Meaning the impact of CMP variables on changes in retail rental values on cities are relatively unknown. This study explores potential application of these variables on retail property markets to understand future performance of retail rental value across city spatial layouts. This is attained by investigating variables at mesoscale (city centre) and macroscale (city) boundaries for two UK cities, namely, York and Leeds.

2. DATASETS AND METHOD

The spatial layouts and retail market variables (2010 and 2017 rental value) of Leeds and York at macroscale and mesoscale boundaries form the basis of this investigation. The logic for investigating these cities at different boundary scales is to strengthen the confidence level of possible relationship between variables. The two variables investigated are CMP (i.e. spatial accessibility metrics) and changes in rental value of retail space (otherwise known as retail market variable RMV). The two variables were sourced, processed (differently), before geo-linking in GIS for spatial investigation.

The CMP herein, are defined as spatial configuration metric outputs of integration (to-movement), choice (through-movement) and normalised angular choice (NACH) metrics, computed at macroscale (city) and mesoscale (city centre) boundaries. The input data for CMP (that is, RCL) were sourced from Ordnance Survey OS - MasterMap ITN data. The data was converted in stages to drawing layer (dxf format), axial map and segment map before running angular segment map analysis in DepthMapX. On completion, an additional layer column was created for NACH metric. The NACH layer was then computed using:

'Log value (Choice) + 1/ Log value (Total depth) + 3' … (Hillier, et. al., 2012).

As such, all the required CMP variables (integration, choice and NACH metrics) were obtained from DepthMapX tool. These variables were then exported as point feature (CSV format) for geospatial analysis with retail market variable in GIS (QGIS).

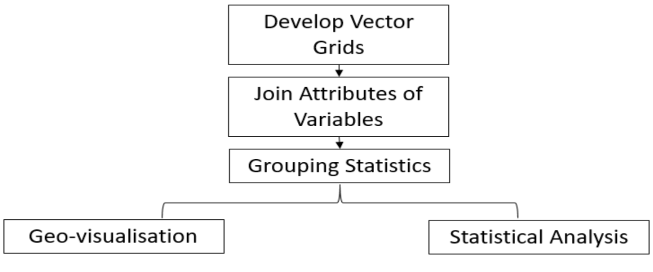
Meanwhile, the retail market variable across the sampled layouts were obtained from VOA's valuation summary list (henceforth, VOA data). The VOA data for 2010 and 2017 were processed in MS Access and MS Excel. The Doogal app was utilised in obtaining geographic (XY) coordinates of retail space addresses, while the Unique Address Reference Number (UARN) was used to link similar retail space before computing locational rental value changes between 2010 and 2017 using:

'2017 rental value – 2010 rental value = changes in rental value'

The resultant table comprises UARN, 2017 rental value, 2010 rental value, changes in rental value and XY coordinates (as the columns) and retail spaces (as the rows). The table was then exported as point features (CSV format) into QGIS for geospatial analysis.

Geospatial analysis of the two main variables (that is, CMP and RMV) were conducted on vector grids to understand locational performance of variables. In doing so, all the sampled spatial layouts were divided into vector grids before transposing values (CMP and RMV) into their respective grids. Performance index of spatial accessibility and changes in rental value are visualised and analysed by location. This technique should enhance application and understanding of space syntax (street segment analysis) in the field of real estate that understands property markets as a locational entity and not streets. Hence, three (3) basic steps were taken in GIS (QGIS) to analyse and visualise relationships between CMP and RMV performance on sampled cities. These three steps include, developing vector grids, joining attributes of variables to the grids and grouping statistics of variables per grid before conducting geo-visualisation and statistics analysis as shown in Figure 1 below.

Figure 1: Steps in geo-visualising and analysing relationships between CMP and performance of retail space variables.



Source: Authors' concept (2019)

2.1 Developing vector grids

One of the reasons for developing vector grids was to create a uniform location backdrop for all variables (CMP metrics and RMV) for geospatial analysis. As such, all the sampled spatial layouts are divided into vector grids. Each grid was assigned unique ID and spatial coordinates to represents retail location on the sampled city space. The total number of grids within spatial demarcations of macroscale boundaries for Leeds and York are 6,360 and 5,510 grids respectively, while the total number of mesoscale grids for Leeds and York are 2,240 and 665 respectively. This indicates that Leeds's spatial layout has a larger land area than York. Nevertheless, the total areas per grid at macroscale and mesoscale for the two sampled cities were equally defined at 115,000m^2 and 7,200m^2 respectively. Table 1 below shows attributes (including number and areas of grids) across spatial boundaries at mesoscale and macroscale of York and Leeds.

Table 1: Vector grid components of sampled spatial layouts

Attributes	York		Leeds	
	Mesoscale	Macroscale	Mesoscale	Macroscale
Area (m^2) per grid	7,200	115,000	7,200	115,000
Number of grids	665	5,510	2,240	6,360
CMP nodes*	4,177	81,558	15,869	209,639
RMV nodes*	1,173	2,189	2,459	8,058

*Nodes are the number of processed point features. It represents number of street segments and retail space units for CMP and RMV respectively

Source: Authors' own (2019)

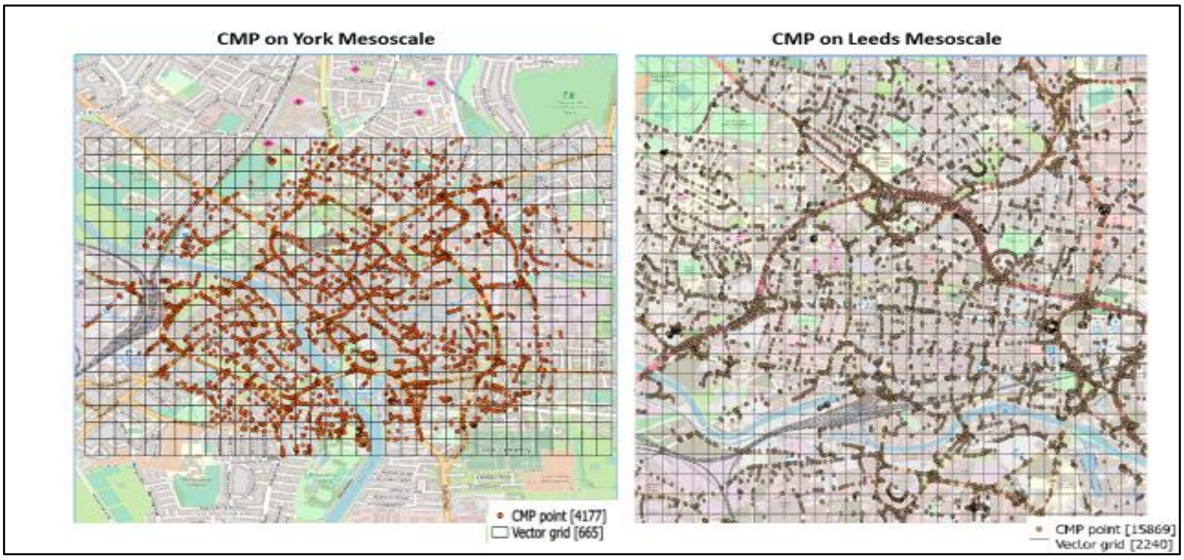
Table 1 reveals that both cities are different in terms of retail space and street segment compositions. Consequently, numbers of the processed point features of CMP (street segments) and RMV variables for Leeds at mesoscale and macroscale are more than that of York's spatial demarcations. The point features of both variables were then transposed onto the developed vector grids for further analysis.

2.2. Joining attributes of variables:

Having established vector grids for all the sampled spatial layouts, all variables were joined to the vector grids as point feature. This was done by using the *join-attribute-by-location* tool of QGIS. The ID of the points variables (CMP and RMV) were discretely joined with the developed grid ID as join vector layers. As such, geographical locations of all variables in points were established. The distribution of CMP nodes depict the street segment network on each sampled layouts while the RMV points reveal the concentration pattern of retail space across all spatial layouts. The defined mesoscale boundary for York has been defined based on the existing historical city centre wall structure (having about 2km radius from the centre), while the Leeds mesoscale was defined by 2km radius away from a chosen[4] city centre point. The macroscale boundaries for both York and Leeds have been defined by 10km radii measure from the chosen city centre points.

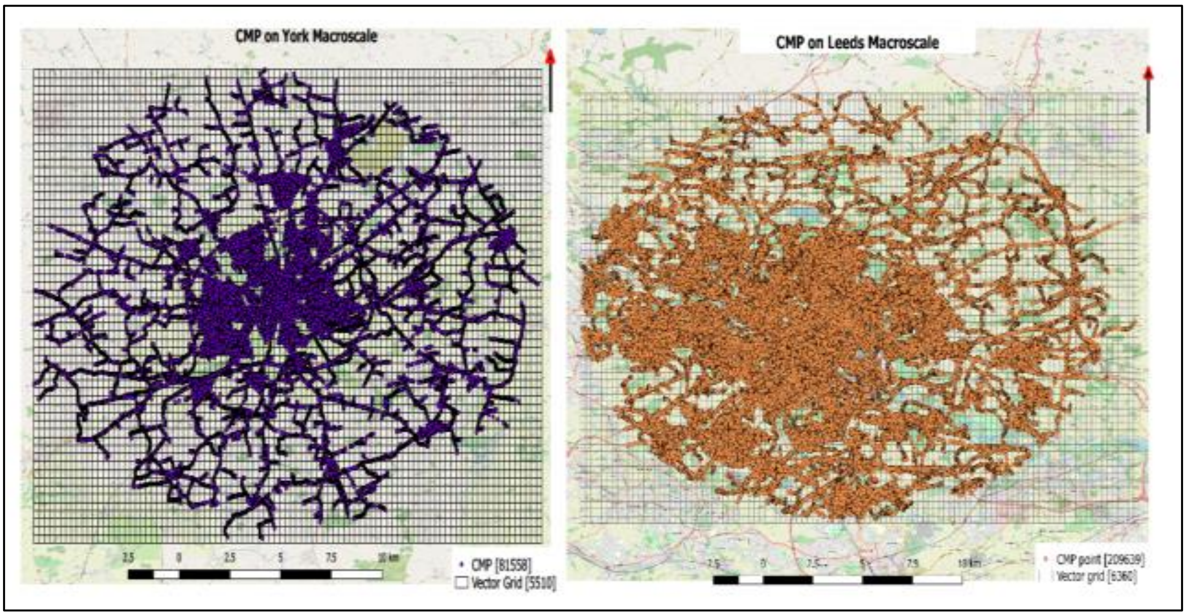
Figures 2 and 3 present comparisons of CMP points features distributions at mesoscale and macroscale boundaries as defined in this study for Leeds and York respectively. Each of these points holds corresponding syntactic values for CMP variables that is required for further geospatial investigation of relationships between variables.

Figure 2: Comparing of CMP points distribution on mesoscales of York and Leeds.



Source: Authors' own (2019)

Figure 3: Comparing of CMP points distribution at macroscale of York and Leeds



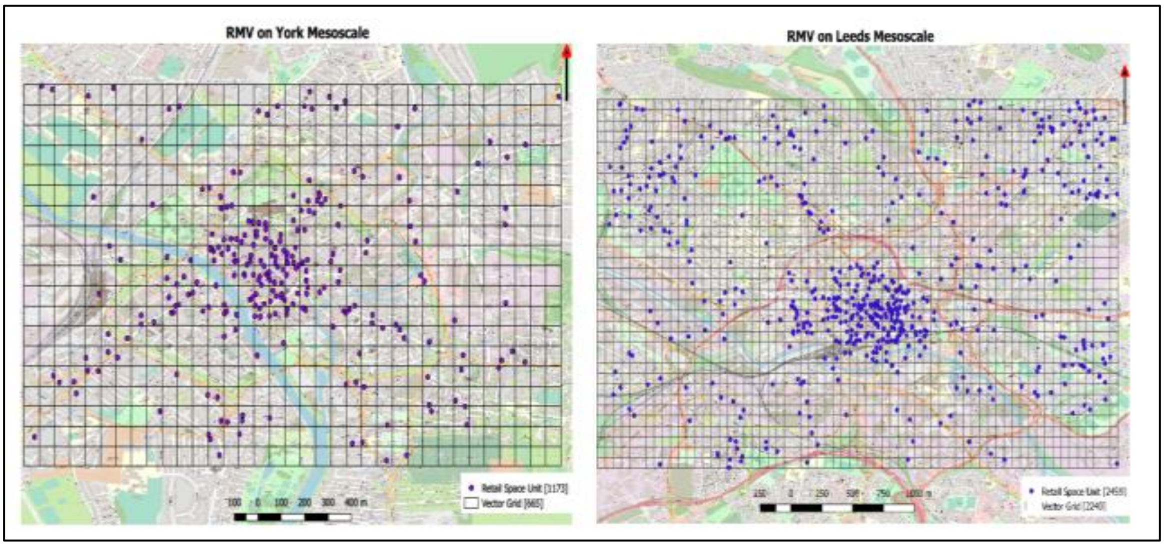
[4] The chosen centre point for Leeds is the ancient city museum

Source: Authors' own (2019)

The figures (2 and 3) above represent initial stage of computing the corresponding syntactic values within the CMP layers into the vector grids for geo-visualization and statistical relationship analysis with RMV. Similar procedures were taken in joining attributes of RMV across all the defined spatial boundaries after establishing changes in rental value per retail space using a common key (that is, UARN). While a point in CMP variables represents a street segment, a point for RMV represents a retail space unit. Herein, a retail space unit is defined as all retail space within a defined VOA address. As such, performance of RMV have been established based on the location that the retail space unit exist within the vector grids.

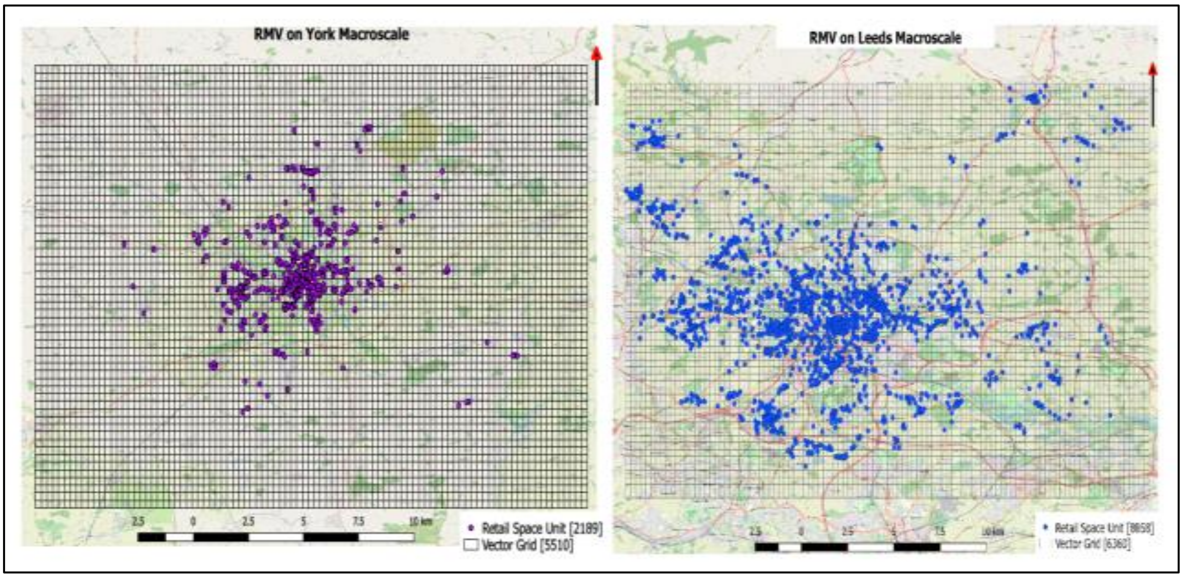
The Figures 4 and 5 respectively shows the comparisons between distribution of RMV points for York and Leeds at mesoscale and macroscale boundaries. Each of these points holds corresponding values for RMV that is required for geospatial investigation of relationships between variables.

Figure 4: Comparing of RMV points distribution at mesoscale of York and Leeds



Source: Authors' own (2019)

Figure 5: Comparing of RMV points distribution at macroscale of York and Leeds



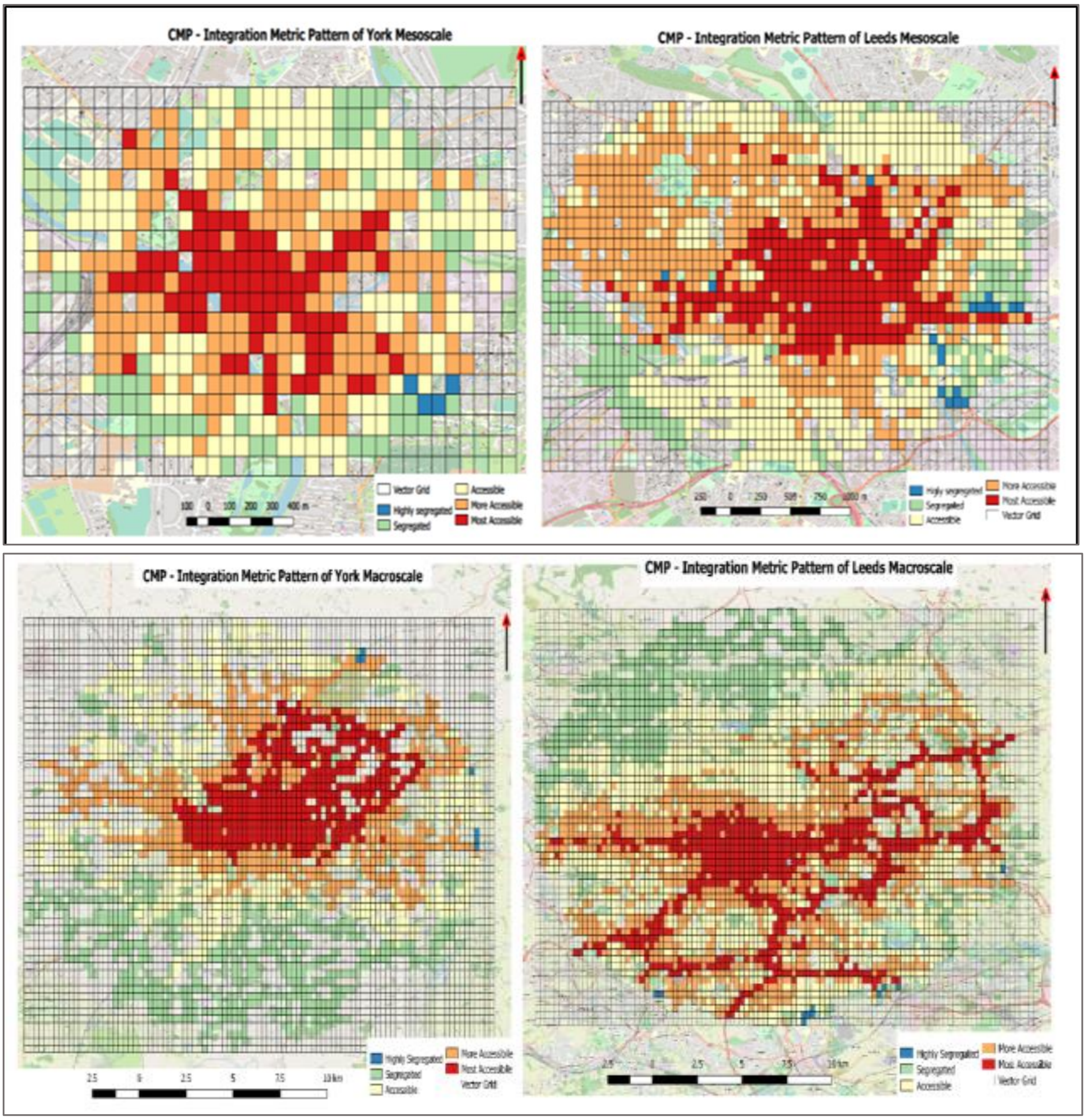
Source: Authors' own (2019)

These figures have shown that retail space distributions across the two cities at both mesoscale and macroscale are uneven just as the CMP points (street segment). Similarly, the unit (point) distribution of CMP is more than the point distribution of RMV across all sampled layouts. Meaning that estimating relationship between these different variables at any given layouts will require locational evaluation of variables rather than considering all variables within the sampled network. This study therefore took additional steps in computing index statistics of variables per grid for further analysis.

2.3 Grouping Statistics

A group-stat tool in QGIS was utilised to compute sum and average variables per grid. The CMP variables (integration, choice and NACH) have been computed by averaging total syntactic values of street segment (points) per grid, while the RMV per grid were summed-up. The logic behind averaging CMP variables and summing RMV is to obtain the average accessible index per grid and the total retail rental value changes per grid. The group stat values of CMP and changes in rental value are visualised by styling all variables in suitable colour formats. An inverted spectral colour format was adopted in styling CMP variables to maintain uniform colour standard with the traditional street segments analysis output in DepthMapX. Where red and orange street segments indicate most integrated (that is, most accessible) and blue and green indicating segregated (least accessible) locations. Figure 6 shows an example of a CMP grid pattern comparing of accessibility index (using integration metrics) between York and Leeds at mesoscale and macroscale.

Figure 6: Comparing accessibility index of York and Leeds at mesoscale in QGIS

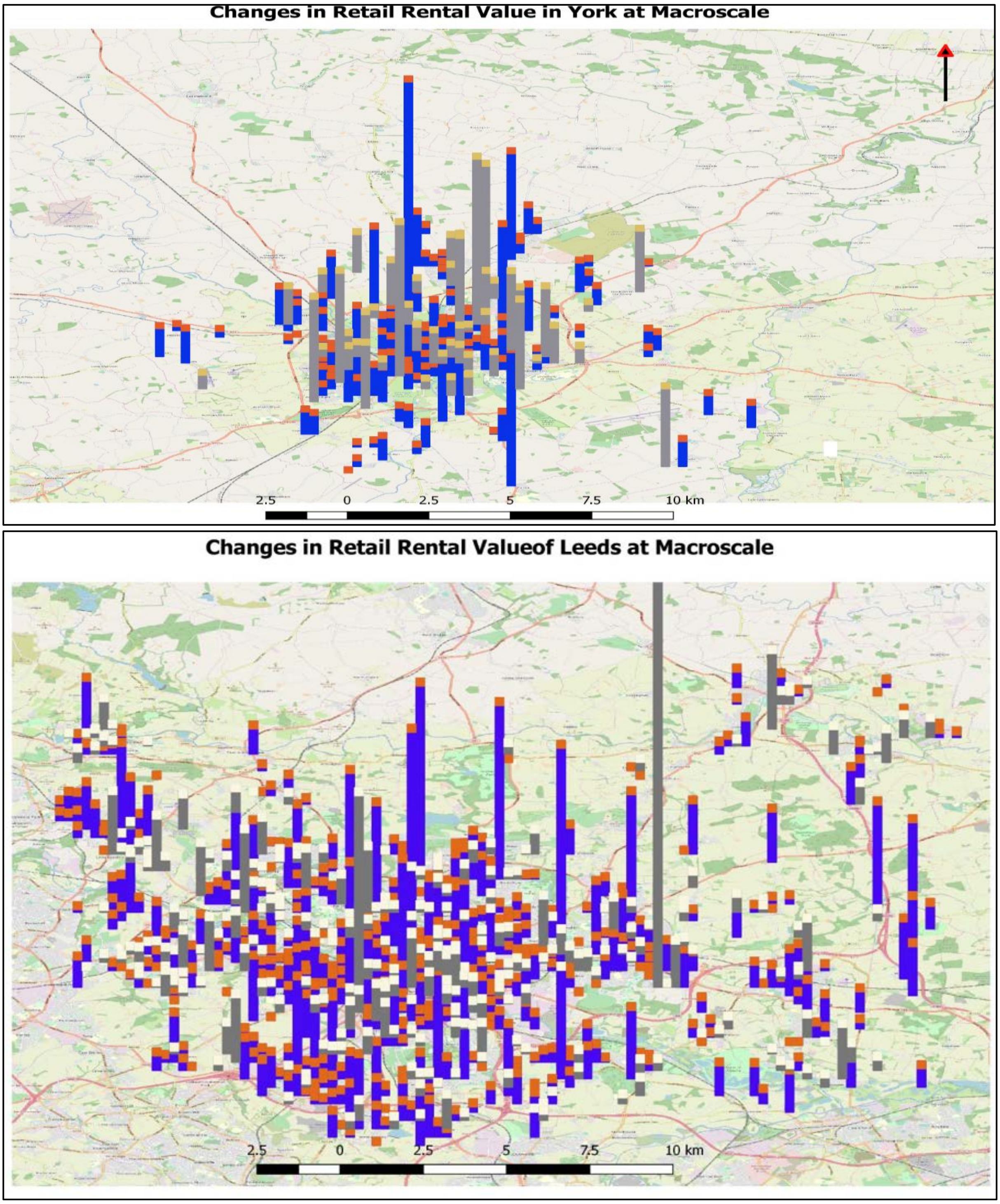


Source: Authors' own (2019)

The grid pattern output in Figure 6 styled in QGIS maintain the same trends with integration metric outputs of computed street segments on DepthMapX. Figure 6 reveals that configuration of integration metrics outputs of Leeds and York layouts are consistent in revealing centrality of spatial layouts as the most accessible part of the two cities. In other words, the integration metric output indicate centrality and accessibility pattern of the sample spatial layouts.

Meanwhile, the changes in retail rental value across all the sampled layouts have been computed and visualised using distinct colour columns to represent extent of positive and negative rental value changes. The heights of the columns show the extent of retail rental value changes. While the blue and grey columns represent positive and negative changes respectively. Figure 7 show the changes in retail rental value for York and Leeds at macroscale.

Figure 7: Distribution of RMV (changes in retail rental value) in York at macroscale scale.



Source: Authors' own (2019)

Similar procedures were taken in computing retail rental value changes at mesoscale for York and Leeds. The Figure 7 shows that changes (negative and positive) in retail rental value across these two cities occur haphazardly and do not follow uniform pattern. These results suggest that factors influencing changes in retail rental value are more of locational based than the overall city. To understand the spatial relationship between these changes and CMP, this study overlayed all changes in retail rental value on their corresponding spatial accessibility tiles. Details of relationship between variables can better be visualised in a motion interface in GIS (which cannot be presented on this paper). However, snapshots (maps) of relationship between CMP and RMV at both macroscale and mesoscale for York and Leeds have been presented in the subsequent result section of this paper.

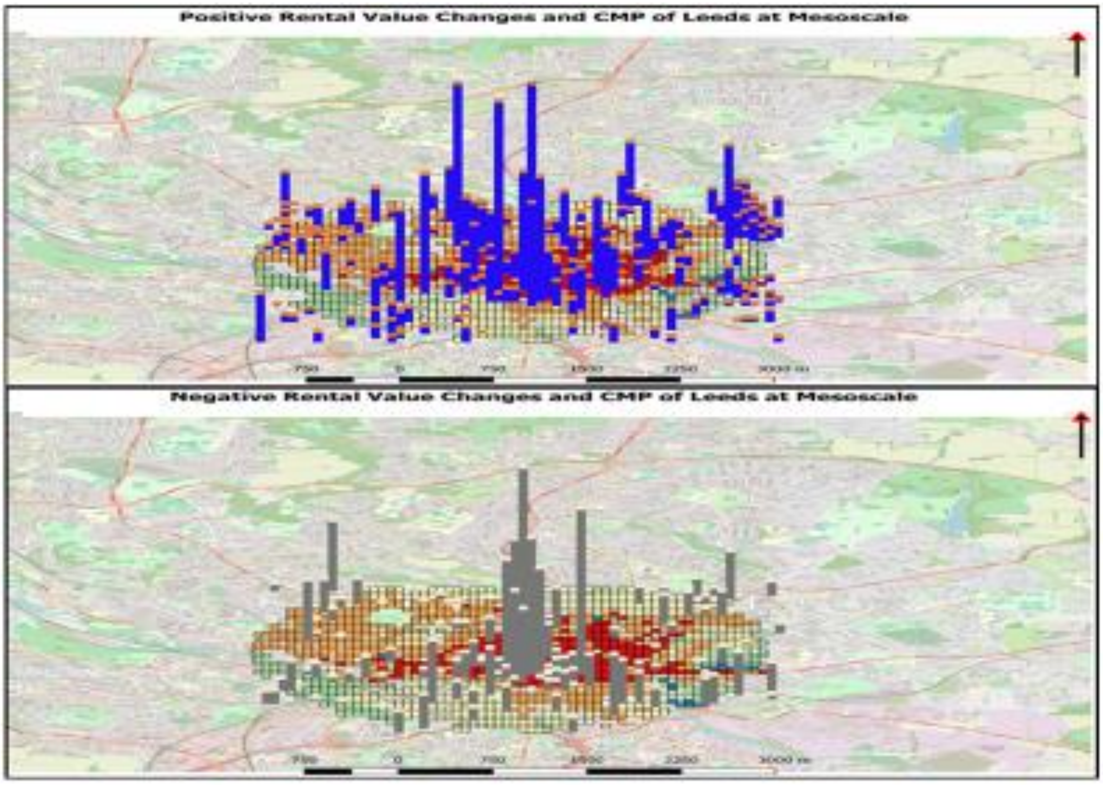
3. RESULTS: GEO-SPATIAL AND STATISTICAL ANALYSIS OF VARIABLES

While visualising the relationships between CMP and changes in retail rental value, global integration metrics have been adopted as CMP variable. This is because of the high visual intelligibility of global integration outputs when compared with other CMP layers such as, choice and NACH metric outputs. However, the study adopted all the CMP variables (that is, integration. choice and NACH metrics) in the statistical analysis to determine the contributory effects of CMP variables on changes in retail rental value (that is, performance of retail space) across all sampled layouts using scatter diagrams. Sections 3.1 and 3.2 respectively present results of visualization and statistical analyses of relationships between changes in retail rental value (RMV) and CMP across sampled layouts.

3.1 Visualisation of variables and spatial relationships

The spatial visualization of relationship between CMP and RMV at mesoscale and macroscale for York and Leeds have computed by overlaying variables using symmetric grid patterns. The adopted technique allows for detailed relationship investigation of variables at different scale boundaries. For example, relationship between positive (or negative) changes in retail rental value and CMP can be explored at different scales and locations within a given sampled city. This enhances visualisation of relationship between retail locations performances and configured spatial accessibility index. An example of relationship between positive and negative retail rental value changes and configured accessibility index for Leeds at mesoscale is presented in Figure 8 below.

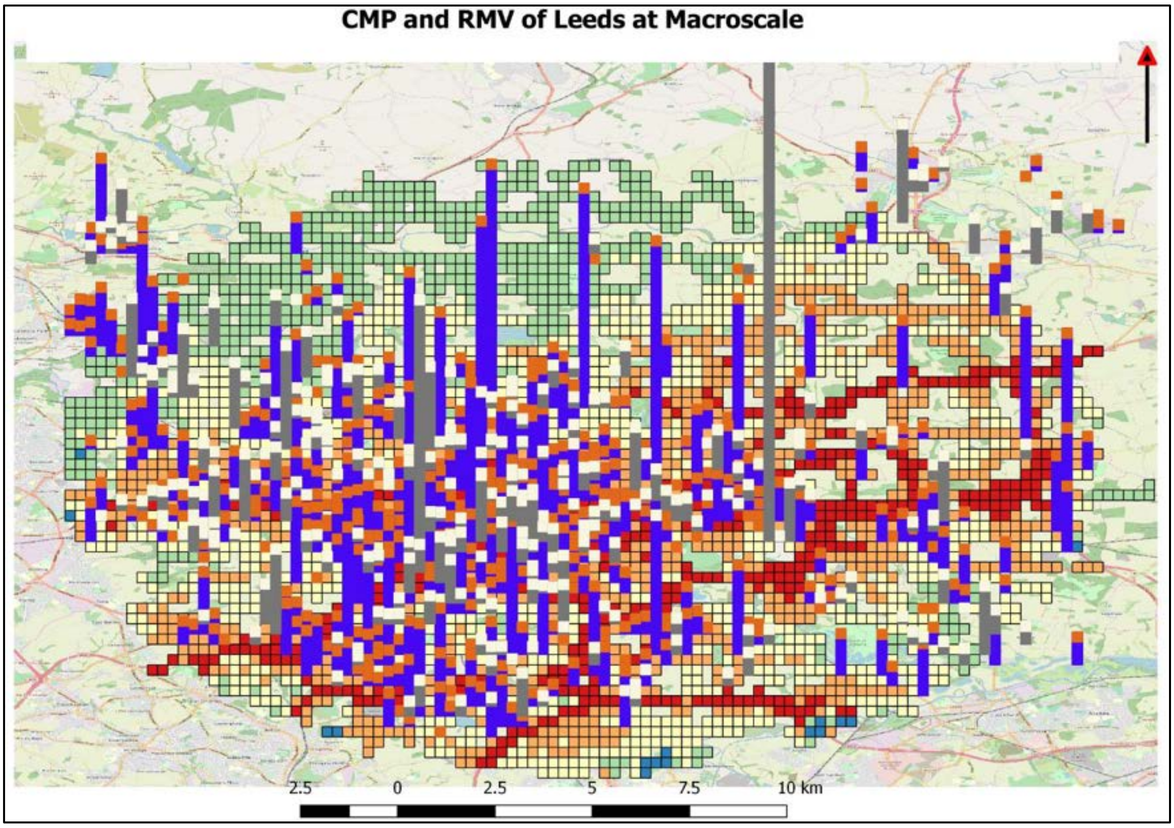
Figure 8: Spatial relationship between retail rental value changes (positive and negative) and CMP at Leeds mesoscale



Source: Authors' own (2019)

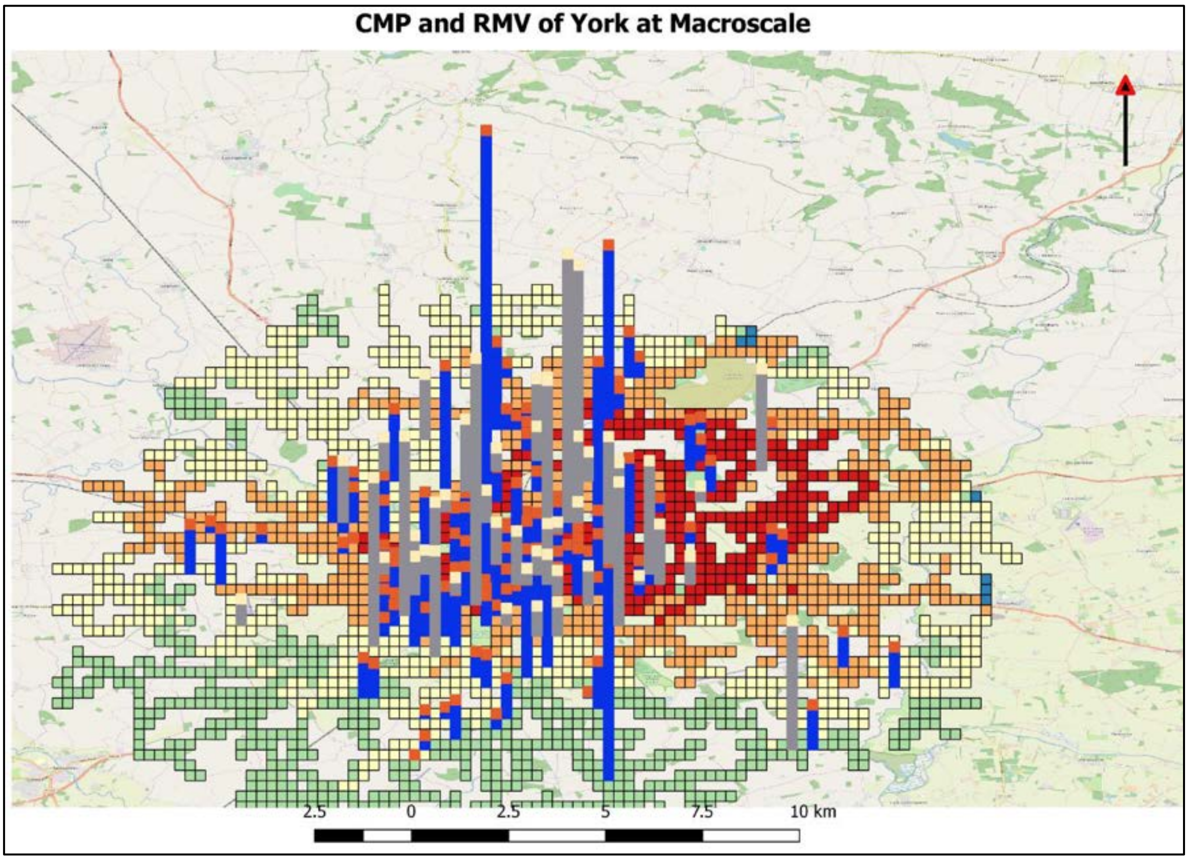
Figure 8 clearly shows that the negative rental value changes on Leeds mesoscale cluster more within the city centre, while the positive changes within the same spatial layouts are unevenly distributed. Figure 8 shows that the method of visualising relationship between RMV and CMP can be enhanced at smaller scale boundaries while revealing different types of changes. Nevertheless, comparison of relationship between the variables have been explored and presented at macroscale levels for York and Leeds. The study presents relationship between overall changes in retail rental value and CMP at macroscale for Leeds and York in Figures 9 and 10 respectively.

Figure 9: Relationship between Overall Changes in Retail Rental Value (RMV) and CMP at Leeds Macroscale



Source: Authors' own (2019)

Figure 10: Relationship between Overall Changes in Retail Rental Value (RMV) and CMP at York Macroscale



Source: Authors' own (2019)

The purple and grey columns in Figures 9 and 10 reveal the extents of positive and negative changes in retail rental value respectively on both cities. While pattern distribution of retail spaces across the two cities vary, the pattern of rental value changes also changes across the city macroscales. The figures show that distribution of retail rental value do not perfectly align with the configured integration output layer at the macroscale level. The spatial relationship between variables at the mesoscale (example), appear to show stronger relationship than variables at the macroscales. In other words, the relationship between configured accessibility index and changes in retail rental value becomes obscured as the scale boundary of analysis increases. Nevertheless, the result from Figures 8, 9 and 10 show that locations with good accessibility (red and orange tiles) have more rental value changes (both negative and positive) than segregated locations (blue and green tiles) across all scales for the two cities. This suggests that accessible locations (with potential high consumers' patronages) experience more changes in retail rental value than segregated locations on the two cities. In other words, the more accessible a city location, the greater the possibility of retail rental value changes.

However, the accessibility tiles at this level, has simply been estimated using the integration metric. To further understands the impact of other CMP variables (that is, choice and NACH) on changes in retail rental value, this study has conducted statistical analysis on variables across all sampled layouts. This was necessary to quantify the relationship between CMP and changes in retail rental value at mesoscale and macroscale for Leeds and York spatial layouts.

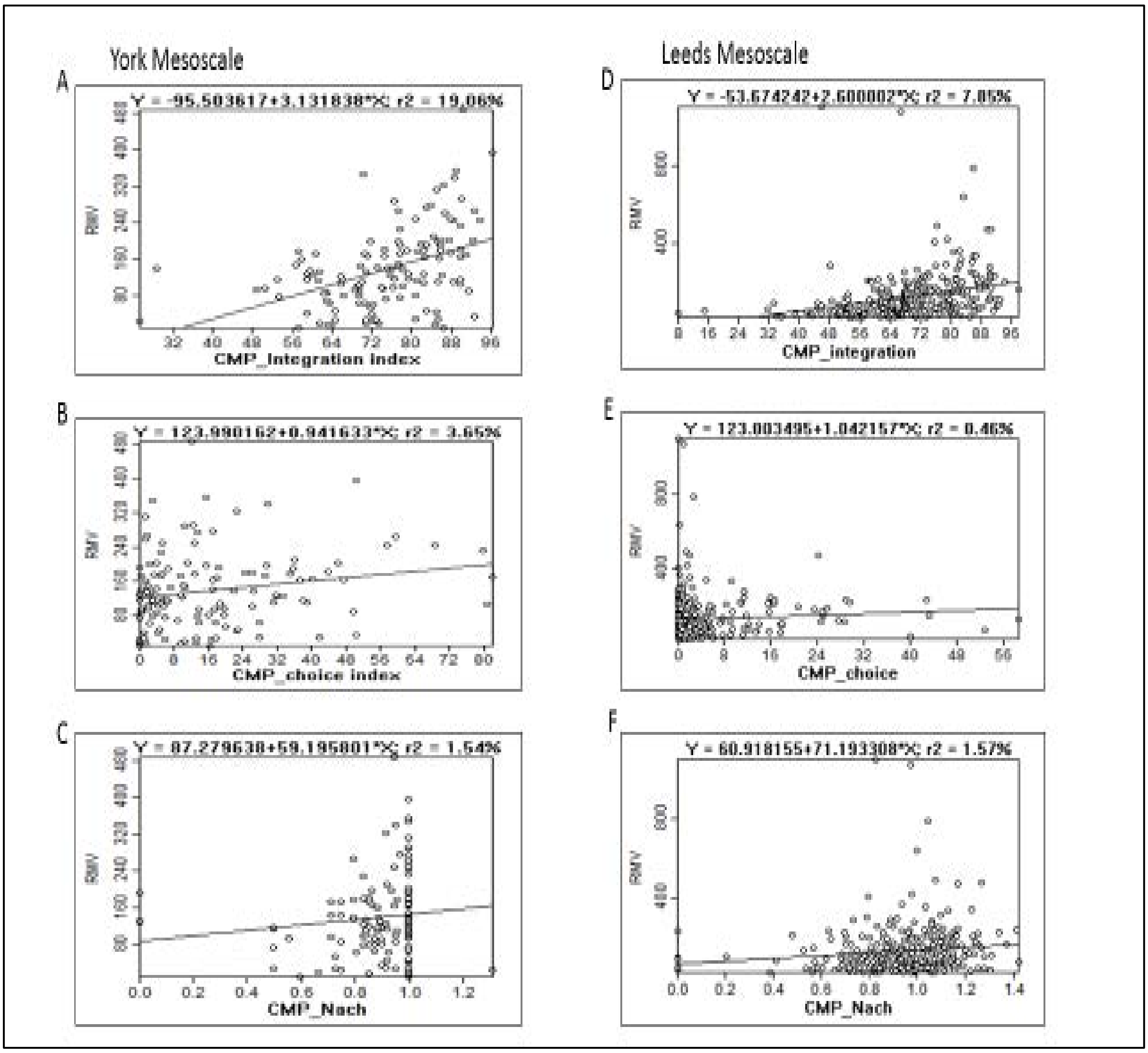
3.2 Statistical Analysis of Variables

Statistical analysis of variables are presented in scatter diagrams that show the correlation and regression outputs of group stat values of all variables at mesoscale and macroscale for York and Leeds. The logic behind this is to analyse contributory effects of CMP variables on changes in retail rental value. This study contends that establishing relevance of CMP variables on changes in retail rental value across sampled layouts will signal the most relevant CMP variables that can be adopted in modelling future performance of retail space (that is, future locational changes of retail rental value, assuming correlation exists between variables).

3.2.1. The Scatter Diagrams

A scatter diagram is a statistical tool utilised in running both correlation and regression analyses between two (or more) variables at a glance. Although this study does not focus mainly on correlation and regression analyses per se, it is assumed that computing correlation and regression analyses at various spatial scales and cities will indicate the most relevant CMP variables on retail rent changes. This is done by computing scatter diagrams showing overall relationships between variables at mesoscale and macroscale for York and Leeds. The changes in retail rental value (RMV) and CMP variables represent the independent and dependent variables respectively. As such, scatter plot diagrams showing relationships between RMV and CMP_ integration, RMV and CMP_ choice, and RMV and CMP_ NACH at mesoscale and macroscale for the two sampled cities are computed. Figure 11 compares the relationships between RMV and CMP variables (that is, integration, choice and NACH) at mesoscale for York and Leeds. Figures 11a, 11b and 11c respectively reveal the relationships (correlation and regression) between RMV and CMP_ integration, RMV and CMP_ choice, and RMV and CMP_ NACH at York mesoscale. While Figures 11d, 11e and 11f show the relationship between RMV and CMP_ integration, RMV and CMP_ choice, and RMV and CMP_ NACH at Leeds mesoscale.

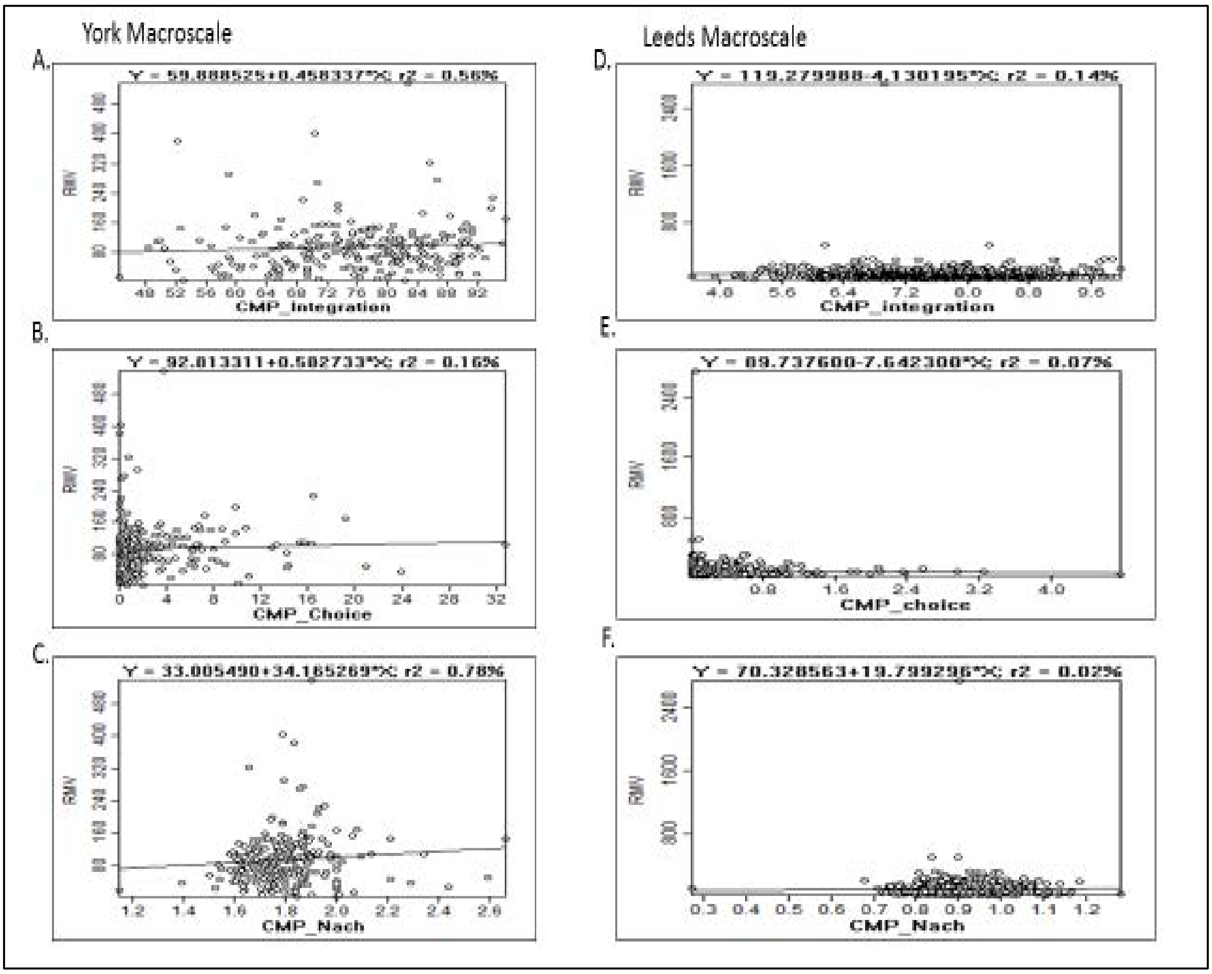
Figure 11: Comparing Statistical Relationship between RMV and CMP variables for York and Leeds at Mesoscale



Source: Authors' work (2019)

The figures (11a, 11b and 11c) in Figure 11 have shown that there are positive relationships between RMV and all the tested CMP variables. Nevertheless, the relationship between RMV and CMP_ integration indicates the strongest with 19.06% variability (as shown in figure 11a). Meanwhile, Figures (11d, 11e and 11f) showing relationships between RMV and CMP variables for Leeds at mesoscale have also indicated positive relationships but at lesser degrees when compared with outputs from York mesoscale. The comparison between York and Leeds at mesoscale reveals that relationship between variables (across all independent variables) are stronger at York mesoscale than Leeds mesoscale with the CMP_ integration variable showing highest variability and significance on changes in retail rental values for both cities. This suggests that CMP_ integration variable (that is, to-movement metric) has the highest contributory effect on changes in retail rental value in both cities at mesoscale. To validate this presumption, further analysis testing were conducted on the sampled cities at macroscale boundaries. Figure 12 shows comparisons of relationships between RMV and CMP variables at macroscale for both cities.

Figure 12: Comparing Statistical Relationship between RMV and CMP variables for York and Leeds at Macroscale



Source: Authors' own (2019)

Similar to Figure 11, Figure 12 has shown that there are variations in relationship outputs between RMV and CMP variables. Relationships between RMV and CMP variables at macroscale reveal that there are weak or no relationship between variables. This result shows the huge differences in variables (CMP and RMV) index across the cities at macroscales. In other words, it indicates that size of spatial boundaries thus influence relationship outputs between variables (in this case, RMV and CMP). This result corroborate existing visual relationship (in Figure 8, 9 and 10) that show that there are stronger relationships between variables at mesoscale than it is at the macroscale. Nevertheless, the CMP_ integration variable maintains it highest contributory effects on changes in retail rental value at Leeds macroscale as shown in Figure 12. While the CMP_ NACH shows the highest contributory effects on changes in retail rental value at York macroscale at about 0.78% variability compare to 0.56% of CMP_ integration. However, the CMP_ choice metric has maintained the least contribution to RMV variability in both cities at both scales.

4. CONCLUSIONS

This paper has introduced a new perspective of space syntax (spatial configuration) into the field of real estate, urban planning and other urban studies that do not traditionally recognise street networks but locations within cities. This study reveals that retail market performance and street components varies across cities. Hence, spatial relationship between changes in retail rental values and CMP variables varies across sampled spatial layouts in consistent pattern. The study has also shown that spatial extent (boundaries) of sampled layouts do affect relationship outputs of variables (in this case, CMP and RMV). As such, locational analyses of property market variables is highly recommended rather than conducting relationship analyses at citywide scales. Similarly, adopting the developed method of visualising relationships between RMV and CMP will widen applications of spatial configuration (space syntax) in the field of real estate that understands property market performance in terms of locations and not streets. This is because retail market performance judgements can be tied to consumer movement actions for property market actors to understand. As such, key real estate decisions such as, investment, development and occupation of retail space within any given city layout can be explored. This should enhance highest best use of city (centre) resources when adopted.

Further investigation in this study has shown that changes in retail rental values (that is retail space performance) across cities do not follow a uniform pattern. However, configuration of CMP through integration measure shows consistency in revealing the centrality and accessibility patterns of the entire sampled layouts.

The integration metrics has shown the highest level of significance to changes in retail rental value across most of the sampled layouts. That is, locations with high integration value have greater potential of changing rents than locations with low integration values. It is based on the statistical and geo-visualisation analyses that this paper recognises the potential of CMP_ integration in signalling future locational performance of retail space. Similarly, while this study has not distinguished between the types of retail rental value changes that integration metric influence, there is also potential to investigate how integration metrics relate and determine positive or negative changes in retail rental value. Further researches should be carried out to explore how integration metrics explain rental value changes at mesoscale and microscale (neighbourhood) analyses. Finally, this study has only focused its analyses on retail property (space) at macroscale and mesoscale. The developed methodology is applicable on all property types (e.g., residential, offices, leisure, industrial etc.) that require accessibility to function. The same developed method can also be deployed for microscale (neighbourhood) property market analysis (assuming similar datasets are available). Hence, spatial accessibility and performance of all property markets at all spatial scales can be explored using the developed techniques.

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