349

Bringing an understanding of spatial configuration to the concept of agglomeration economies

The case of Greater Manchester

FRANCESCA FROY

UCL, LONDON, UK

ABSTRACT

In the field of economics, it is often asserted that the size and density of cities matters to economic success – larger, denser, cities with sufficient '*economic mass*' are found to be more successful. The spatial *structure* of cities and their configuration is, however, rarely discussed. This article explores the benefits of using space syntax analysis to understand how agglomeration economies work in cities, based on a case study of Greater Manchester. It is argued that the spatial configuration of cities is in fact instrumental to the operation of the 'agglomeration externalities' or economic synergies which have, since Alfred Marshall, been recognised as bringing advantage to firms in clusters of economic activity: supply chains, labour-sharing, and knowledge spill-overs. The configurational characteristics of city street networks are shown to bring together diverse economic capabilities, while also connecting firms into national and international economic flows. However, when the spatial configuration of a city changes, this can undermine its capacity to support agglomeration externalities. A series of planning changes since the 1950s have undermined the spatial configuration of Greater Manchester, so reducing the ability of the city to support cross-sector economic synergies. This may be one factor in explaining why the contemporary city has a lower productivity than would be expected, given its size.

KEYWORDS

Space syntax, industry relatedness, supply chains, labour, knowledge-spill overs

1 INTRODUCTION

Cities are increasingly being recognised as important sources of economic growth (Glaeser, 2011, Krugman, 1998, Storper, 2013). While the Covid-19 pandemic has highlighted the potential for people to live and work in more distributed settings, it is believed by many that cities will inevitably 'bounce back' because of the important advantages that they confer to human innovation and creativity (Florida et al., 2021). A long-standing assumption in the field of agglomeration economics is that it is the size and density of cities that matters to economic success – larger, denser, cities with sufficient '*economic mass*' are economically more successful (Overman et al., 2009, Ahrend, 2014). In comparison the spatial *structure* of cities and their configuration is poorly understood and little discussed. In this article it is argued that the spatial configuration of cities is instrumental to the operation of the 'agglomeration externalities' or economic synergies which have, since Alfred Marshall, been recognised as benefitting firms in clusters of economic activity: supply chains, labour-sharing, and knowledge spill-overs. This article explores the different spatial affordances (Gibson, 1979) which cities provide for these three economic processes. It focuses on Greater Manchester, which was to some extent, the "first agglomeration economy" - the city is well-known for hosting the first mass production of textiles in the 18th century which kick-started the industrial revolution. Since then, textiles production has coevolved with, and branched into, a series of industries including the chemicals sector, engineering, and financial services which remain concentrated there (see Froy, 2021). While the city is increasingly transitioning towards a knowledge-based economy, it maintains a strength in materials and materials science. Greater Manchester nevertheless "punches below its weight" in terms of the productivity that you would expect to see in a city of its size. Because of this, the city remains a focus of Government interventions to build a "Northern Powerhouse" outside of London and to support growth through the more recent "levelling up" agenda (Tomaney and Pike, 2020, Martin et al., 2021). The article suggests that the city may not be functioning spatially and economically as it once did due to planning changes from the 1950s onwards which undermined the coherence and structure of its street network.

2 THEORETICAL BASIS

What are 'agglomeration economies'?

Alfred Marshall (1890) described the multiple economic interdependences that exist between firms in places that host a concentration of industries such as Sheffield (hosting metalworking industries) and Lancashire (hosting textiles). Marshall pointed to different advantages that such clustering conferred on firms including the sharing of labour, the sharing of products in supply chains, and the existence of knowledge spillovers (see Figure 1).

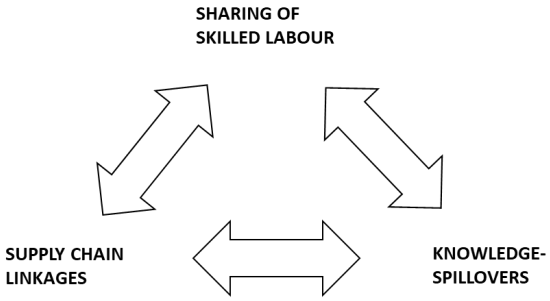


Figure 1: Industrial interdependencies which provide the foundations of agglomeration economies

Marshall's descriptions of agglomeration economies focused mainly on single sectors (defining what are today known as 'localisation economies'), whereas following the work of Jacobs, economists now also describe 'urbanisation economies' which capture, among other things, the benefits of cross-sector interdependences in large cities which host economic diversity. Duranton and Puga (2004), for example, draw on these ideas to identify the 'sharing, matching and learning' mechanisms that act as the 'micro-foundations' of agglomeration economies in economically diverse cities, although they broaden the definition of sharing to also include the sharing of public amenities and institutional structures. Recently economic geographers have also pointed out that economic diversity in cities is not random, but has a topological or network structure, with preferential relationships existing between certain economic sectors, which benefit more from the mutual sharing of skills, labour, products, and knowledge – the importance of such industry relatedness for Greater Manchester (and for architectural understandings of how the built environment supports economic diversity) is explored by the author elsewhere (Froy, 2021).

Conceptions of space in conventional economic agglomeration theories

The three agglomeration foundations or externalities described by Marshall - supply chains, labour sharing and knowledge-sharing – may seem like very different economic processes. However, they represent different ways of bringing together the same thing i.e., economic *capabilities*. The importance of economic capabilities is increasingly recognised in regional economic science, for example being central to the economic complexity analysis developed by the Harvard Growth Lab (see Hausman and Hidalgo, 2014). Their concept of capabilities incorporates a recognition that the knowledge which is important for economic growth does not just reside in people's brains, but rather is embedded in local processes, industries and – importantly - the material world. Hidalgo (2015), for example, discusses the embeddedness of economic capabilities in materials, technologies, and individual firms. However, while there is an increasing appreciation of material embeddedness in the economics literature, there is a lack of understanding, as yet, as to how the urban built environment structures how people move and interact, and hence influences how cities function. Indeed popular economic theorists such as Ed Glaeser actively argue against taking infrastructure or spatial organisation in cities seriously, arguing that '*cities aren't structures; cities are people*' (2011, p.9).

An active observer of urban economies who did on the other hand maintain the importance of urban morphology and spatial configuration was Jane Jacobs, who discussed how the 'anatomy' of streets created lively local commercial centres (see Wetmore, November 11, 2000). Nevertheless, she mainly described the importance of street network structure to economic activity at the *local* scale, writing less about how the physical structure of cities might enable or constrain economic interactions at a city-wide scale, beyond exposing the role of urban expressways in cutting off and segregating neighbourhoods (see Froy, 2018). Since then, the discipline of space syntax (and the graph analysis of other theorists such as Sergio Porta and Andres Svetsuk) has provided a sophisticated way of understanding how the spatial configuration of cities influences economic activities. However the focus to date has more often been on the *location* of economic activities than on the Marshallian agglomeration processes which so preoccupy economists, with notable exceptions including Narvaez et al (2017) and Penn et al (2018).

3 DATASETS AND METHODS

This article is based on a wider research project which used a mixed-method approach, incorporating network analysis, mapping, interviews and historical archive research (see Froy, 2021). It partly draws on interviews with fashion-related companies based in the Cheetham Hill and Broughton areas of Greater Manchester – two fashion and accessory wholesalers (Urban Mist and Jay Trim) and three fashion manufacturers (Private White V.C., Wright Bower and Xpose). An architectural ethnography of the Strangeways area is used as a source, in addition to fieldwork in Altrincham, the Oxford Road Corridor and Media City. Space syntax analysis was carried out using contemporary and historical maps for Greater Manchester at three different stages of its history – 1850, 1950 and today. As various more specific methodologies were used, these are spelt out in more detail alongside their results in Part 4.

4 RESULTS

4.1 Spatial characteristics of 'agglomeration externalities'

The role played by street networks in supporting supply chains, labour market matching and knowledge-sharing mechanisms at multiple scales is explored in three respective sections below.

i. Supply chains – and the importance of urban 'movement economies' for goods

The first economic interdependency to be explored is supply chains. Hillier et al (1993) used the term 'movement economy' to describe the pedestrian movement that happens in cities. However, this idea can equally be applied to the circulation of products within supply chains. In all economically active cities, street networks must accommodate the circulation of materials and

goods during the production, distribution, and consumption process – from the supply of raw materials to the wholesale and retail of finished goods, and the disposal of waste (see Davis, 2020). This requires a different set of spatial affordances to that required for pedestrian movement, with backstreets, delivery systems, yards and storage spaces becoming more important. Because supply chains are often long-distance, extending far outside of cities, different forms of multi-scalar accessibility are also important to their operation – as recognised by Read (2015).

Greater Manchester has long been an industrial and commercial city, and its street system has clearly evolved to support the circulation of goods as well as people. This is visible, for example, in the named back streets which are common throughout the city, and which have functioned over the centuries to facilitate access for goods coming in and out of warehouses, factories and workshops. Many of these streets share the same name as a parallel street but they incorporate “back" as a prefix to their name – so Turner Street for example is adjacent to Back Turner Street in the Northern Quarter (see Figure 2 below). Commercial plots often stretch between the two streets, allowing their occupants to have a front-access to customers and a back-access to suppliers.

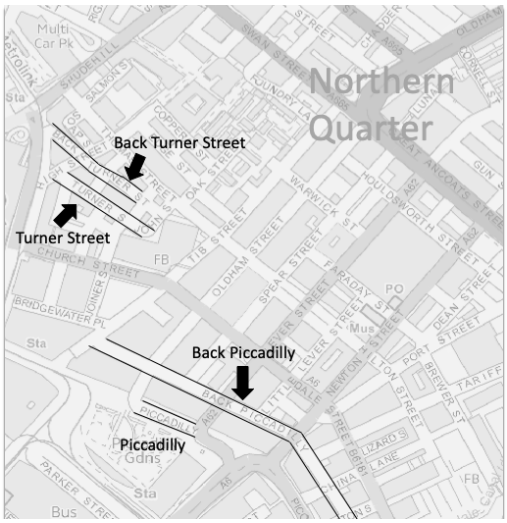


Figure 2: Back streets in the Northern Quarter in Greater Manchester as delivery routes. Source: annotations by author, based on OS data © Crown copyright and database rights [2021] Ordnance Survey (100025252) (OS). VML Raster 10km

Interestingly, these back streets are also important to production in the contemporary city. Space syntax analysis reveals that manufacturing firms in Greater Manchester are more often found on less integrated streets that are nevertheless close to key movement streets within the foreground network (see Froy, 2021) – a finding which echoes research in Cardiff and London by Narvaez et al (2014) and Scott (2015) respectively. Having a back street location which is nonetheless close to accessible foreground streets may allow manufacturers to keep production costs low due to the lower rents associated with these streets, while nevertheless preserving city-wide accessibility.

While back streets would have provided conduits for the circulation of many locally produced goods in the past, today many supply chains are in fact international. The haberdashery

wholesalers JayTrim have about 100 suppliers, ranging from very small firms to multinational corporations, of which only ten per cent are based in the UK. Indeed, several of the interviewed firms were clearly participating in global production chains, with leather bag maker Wright Bower working with an Italian company who send them materials and fittings from Belgium, which they then make up into finished bags and reexport for global distribution. The interviewed companies all seemed to take these long-distance relationships in their stride, with Jay Trim identifying that they had achieved a degree of stability in their international relationships (some of which had endured for 40 years) and because of this, their supply chain '*just flows*'. This serves to confirm Read (2007)'s point that cities bring 'the potentials of the world to hand' (p.16). Nevertheless, the companies do have to manage varying delivery times, which can have knock-on implications. The family running the fashion wholesalers Urban Mist also manufactures their own goods in China before shipping them to Greater Manchester, and they describe how bureaucratic processes such as the certification of stock and custom checks can produce delays of two to three months, interfering with their ability to produce and distribute 'on trend' fashions. It is not only upstream supply linkages that have become increasingly international, but also downstream linkages, with all the international firms now catering for markets which are either national to the UK or international. JayTrim, for example, identify that in the mid-70s, seventy per cent of their customers came from a five-mile radius, while now only ten per cent do. While companies may think nothing of maintaining long-distance relationships, this does not mean that such relationships have become materially "disembedded", rather, as Read points out, cities must provide companies with 'reach' into national and international economic flows. JayTrim, Expose and Urban Mist are based in Strangeways, an area to the north of Greater Manchester which appears to be well-set up to support such flows. This area hosts an astonishing concentration of fashion wholesalers, particularly along the parallel streets of Derby Street and Broughton Street, which sell imported clothes, bags, shoes, and fancy dress on to retailers from across the UK. At first sight the businesses appear to be retail stores, in that they advertise their wares in shop windows, however most also exhibit 'Trade only' signs.

The Strangeways area incorporates a planned grid of streets, developed since the 1950s on land which was previously an old brickworks. This grid sits between two high choice streets, Bury New Road and Cheetham Hill Road (see Figure 3) which play an important part in the city's 'foreground network'. When values for through movement (or the Space Syntax category 'choice') at a 10km radius were aggregated from local streets to Middle Layer Super Output Areas (MSOAs) in Greater Manchester, Strangeways fell into one of the top four MSOAs. The foreground network in the city functions not so much to connect Strangeways to the city centre, but rather to render Strangeways "shallow" or more accessible to national infrastructure, providing a quick route out of the city and onto the motorway system.

a. Integration (2km radius) b. Situation within the foreground network

Figure 3: Space syntax analysis of the Strangeways area of Greater Manchester. Source: building layer from OS Data © Crown copyright and database rights [2021] Ordnance Survey (100025252) OpenMap - Local. Street network extracted from Space Syntax Openmapping (https://spacesyntax-openmapping.netlify.app/#6/55.603/-3.252) amended using base map from OS Data © Crown copyright and database rights [2021] Ordnance Survey (100025252) OS VML Raster 10km.

Local firms take advantage of this reach and accessibility to organise multiple collections and deliveries each day. JayTrim identified that they have three carriers coming in everyday to collect their haberdashery products. They send around five hundred parcels a week while receiving ten to fifteen deliveries. The company uses a local brokering service that negotiates with delivery organisations such as FedEx, DHL, and UPS to organise both national and international deliveries. Customers also come to the area from across the UK by car, but then walk around the area to inspect the wholesale goods on offer, this having been traditionally a 'cash and carry' area. To accommodate this, Strangeways operates to some extent like a small retail centre - with wholesale shop fronts lining Derby and Broughton Streets, and the perpendicular streets between them. There are many local street intersections allowing customers to retain choice as to which wholesalers they visit as they move through the system (see Sevtsuk, 2010). Car parking spaces are arranged to avoid disrupting pedestrian flows. The area thus acts as an interface between two scales of movement – the larger-scale movement of goods in and out of the area from national and international markets (often in cars and vans), and the local movement of pedestrians seeking to purchase goods.

Another important spatial affordance which supports the operation of supply chains is storage space (Froy and Davis, 2017) – something which is again much in evidence in the Strangeways area. The local courier broker used by JayTrim and many other local firms is based in a street in Strangeways that has been sectioned off to operate as a "yard", which provides an external production, storage, and distribution space. The conversion of streets into yards was also found elsewhere in this area of Greater Manchester (see Figure 4 below), and a manufacturer in London (Mark Brearley of Kaymet) informed the author that this is an important way in which the street network is appropriated and used to support commercial activities in cities (Domenech et al., 2019).

Socks Street East, hosting a delivery firm Torah Street

Figure 4: Streets functioning as yards in Strangeways. Sources: photo of Socks Street East by Jacob Miller, second photo from Map data ©2019 Google

Local buildings are themselves also well-adapted for storage. The managers of the fashion wholesalers Urban Mist identified that the area was particularly convenient to them as it offers a rare combination of shop-style frontages onto the streets, and then deep receding warehouse spaces behind (see Figure 5). Some of these buildings are converted old factories (this area used to host waterproofing factories that are still standing) while others are purpose-built using a similar template. Given the rising importance of storage and distribution in cities, and the increasing blurring between retail/wholesale and manufacturing (see Froy and Davis, 2017) this would seem to be a useful building type for cities today.

Figure 5: Shared access to markets: street type frontages, car park courtyards and extended pavements. Sources: Froy (2021). Photos on the left-hand side of the figure taken by Jacob Miller. Photos on the right-hand side sourced from Map data ©2019 Google.

A final supply chain linkage which needs to be considered, and which requires both an accessible urban street system and storage facilities, is the disposal and reuse of waste. While many waste products are picked up by local councils, some of the interviewed firms had more sophisticated waste disposal techniques. The knitted hat maker Xpose, for example, give their acrylic off-cuts to a company from Rochdale who recycle them into bedding. Their packaging materials,

including both cardboard and plastic, are picked up by a specialist recycling firm. In the future it will be interesting to explore the spatial affordances which might support a more circular economy, and in this, cities can learn from their past. Exploring historic maps for Greater Manchester (including the GOAD fire insurance maps) reveals many historical spatial affordances which supported industrial recycling in the 19th century city, including shared materials depots and high street repair shops (see also Desrochers, 2009).

ii. Labour sharing and 'matching'

Labour sharing is the second important Marshallian factor, or economic interdependency, which confers advantages on firms that are based in cities, and which again relies on a well-configured street system. Large diverse cities are in particular celebrated for allowing the complex skills of local residents to be matched with the complex skills needs of firms (Duranton and Puga, 2003). Indeed, the term "functional labour market area" is often used to define the size and scope of cities, also incorporating patterns of commuting from a city's hinterlands. The labour market 'matching' process relies on an effective spatial organisation of not only commercial space, but also residential space.

There has been a long history of research into how Greater Manchester functions as a labour market, with a time-zone map from 1917 highlighting all the urban areas that fell within a commute time of 40-50 minutes (see Froy, 2021). Greater Manchester has been for a long time a 'commuting-based city' with many of its higher skilled and better paid workers living outside the city centre. Rodgers (1980) notes that from the 1950s onwards upward social mobility meant outward movement, with the inner-city area of Manchester – Salford – Trafford suffering a 23% population loss between 1951-71. Until recently this was reflected in local house prices in Greater Manchester, with prices decreasing the closer you got to the city centre, in contrast with cities such as Bristol, where values increase towards the centre (Law et al., 2017). The Greater Manchester Combined Authority is now tempting people back to the centre through encouraging a significant amount of residential new build, often at the cost of a loss of commercial space, particularly for small manufacturing firms.

However, some parts of Greater Manchester are more connected than others when it comes to daily commutes, reducing the extent to which their residents can make the most of living in this large agglomeration. An analysis of commuting rates between different parts of Greater Manchester today using ONS Census data found that all ten local authorities have commuting links, but these are stronger between the three centrally located authorities of Manchester, Trafford, and Salford with Wigan being somewhat of an outlier. This local authority would also seem, unsurprisingly, to be the most disconnected from the foreground network of the city (see Figures 6 and 7). Many attempts have been made to join up the ten local authorities which make up Greater Manchester into a more coherent and connected city, including the construction of internal motorways. Schlomo and Blei (2015) identify that such urban 'expressways' are important in allowing cities to "self-adjust" as they grow larger, ensuring that the urban labour

market as a whole is still accessible within an acceptable commute time. However, such roads often come at the cost of creating severance between communities (as will be discussed in part 4.2) and Hillier (1999) argues that where multiscale foreground networks work well in cities, with the incremental development of "deformed wheel structures" as cities expand, such mono-use urban roads become unnecessary. Greater Manchester relies on a number of other urban transport infrastructures to connect up its labour market, such as the local train and tram systems, although the Mayor of Greater Manchester acknowledges that these systems are at the moment far from being 'fit for purpose' (Minchin, 2021), with long commute times from one part of the city to the next being a daily challenge for many.

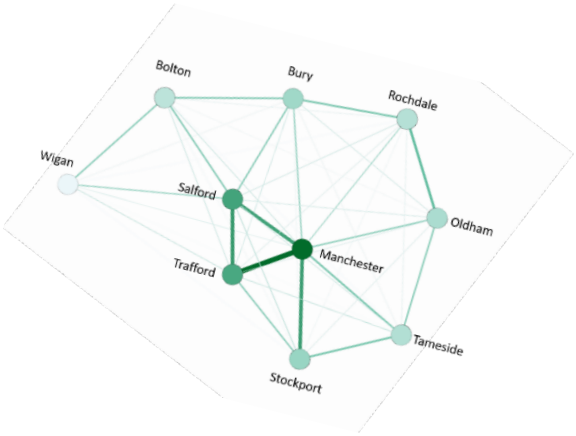


Figure 6: Commuting flows between Greater Manchester local authorities mapped as an edge-list in Gephi. Notes: The colours of the nodes here reflect their betweenness centrality. The width of the edges reflects the strength of the commuting flows. Source Froy (2021) based on ONS 2011 census data on 'Location of usual residence and place of work'. ONS Crown Copyright Reserved.

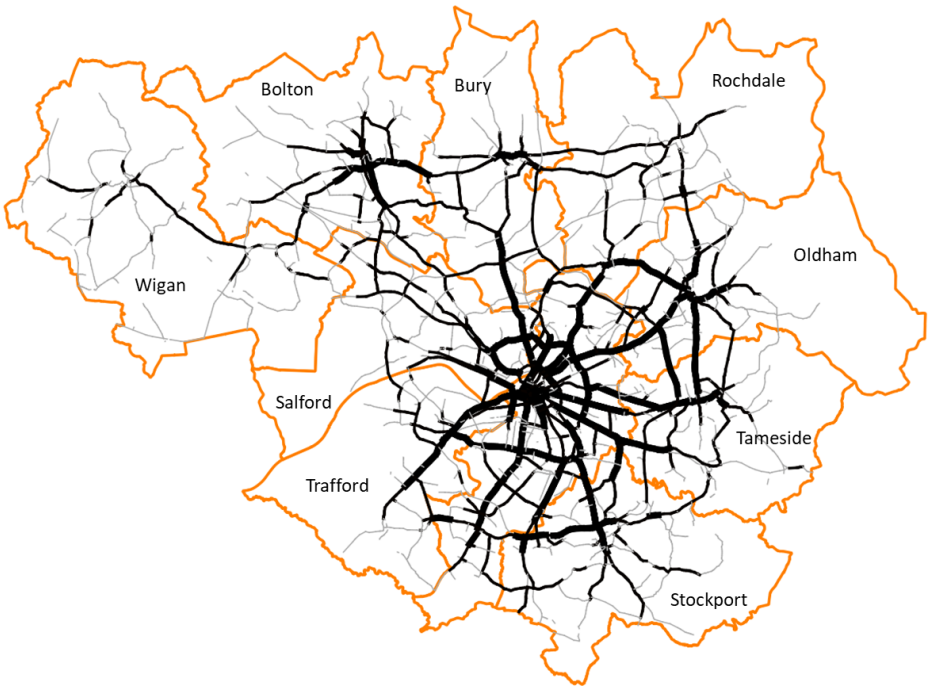


Figure 7: The foreground network of Greater Manchester and the extent to which it reaches into different local authorities. Sources: Froy (2021). This network was extracted from Space Syntax Openmapping (https://spacesyntax-openmapping.netlify.app/#6/55.603/-3.252) and amended based on an OS Data © Crown copyright and database rights [2021] Ordnance Survey (100025252), OS VML Raster 10km. Local authority boundaries are derived from the December 2017 clipped boundaries dataset downloaded from www.data.gov.uk . Contains public sector information licensed under the Open Government Licence v3.0.

Local or neighbourhood labour markets are also very important to cities, where people commute within a much smaller area. The author found that the economic sectors and industries most likely to collocate with each other at neighbourhood scale in Greater Manchester were those that are 'skills-related' (Neffke and Henning, 2013) i.e. they rely on common sets of skills from their labour force (see Froy 2021). Knowledge-based service sector firms were particularly likely to collocate, and this may mean that these industries mutually-source common local labour pools, which in turn would benefit from locally integrated streets and pedestrian accessibility. However, these economic sectors may also collocate to benefit from knowledge-spillovers - see the respective section below. In fact, there is a wide literature which suggests that industries requiring *lower* skills levels are more likely to rely on local labour markets, due to the prohibitive costs for lower income workers associated with longer commutes (see e.g. Green and Owen, 2006, Geddes, 2007). Accessibility to a relatively local labour supply was, for example, important to most of the companies interviewed for this research which specialised in wholesale and small-scale manufacturing. Mike from the waterproof coat manufacturers Private White V.C. identified that accessing local workers was in fact more important to their firm than other links within the city such as supply chains. All the companies found recruitment a challenge, particularly when it came to machining skills – with the author finding equivalent problems in a study of small-scale manufacturers in East London (Domenech et al., 2019). Because of these

challenges, Private White V.C. often resort to sourcing labour from other local related industries that are shutting down such as hosiery, bedwear and cushion factories.

There is ongoing debate about whether residential location in cities leads to labour market exclusion (see e.g. Détang-Dessendre and Gaigné, 2009, Cheshire et al., 2014, Rae et al., 2016), with prolonged local unemployment also undermining the ability of cities to successfully match skills supply and demand. A mapping of indices of employment deprivation across Greater Manchester revealed that many residents who are not in work live in relatively central areas that are close to jobs (near the main city centre, and the town centres of Ashton, Bolton, Bury, Rochdale, Oldham) in addition to in more peripheral areas (such as Wythenshawe). However, it is difficult to draw conclusions about whether these residents may still be impacted by spatial segregation without knowing more about the local spatial characteristics of these areas. Hanson (2000) highlighted how spatial segregation can be created at a very local scale through the urban morphology of post war social housing estates such as were developed in Greater Manchester post-war (as will be discussed below). Such spatial segregation can lead to social and economic segregation, particularly when people remain in such areas for generations. However, as pointed out by Vaughan and Geddes (2009), the relationship between spatial segregation and economic marginalisation is far from simple. Netto et al (2015) discuss how spatial segregation in cities is associated not only with different patterns of residence in cities, but also different movement patterns of movement – people's paths literally do not cross. Given that a significant number of jobs are accessed through informal contacts that derive in part from social mixing and encounter in cities, such lack of 'path crossing' may also undermine the sharing of information which maximises labour market matching in cities. This would be a useful focus for future research into the relationship between spatial configuration and longer term labour market exclusion in Greater Manchester, as a complement to other recent findings on deprivation and 'disconnection' (Rae et al., 2016).

iii. Knowledge-sharing

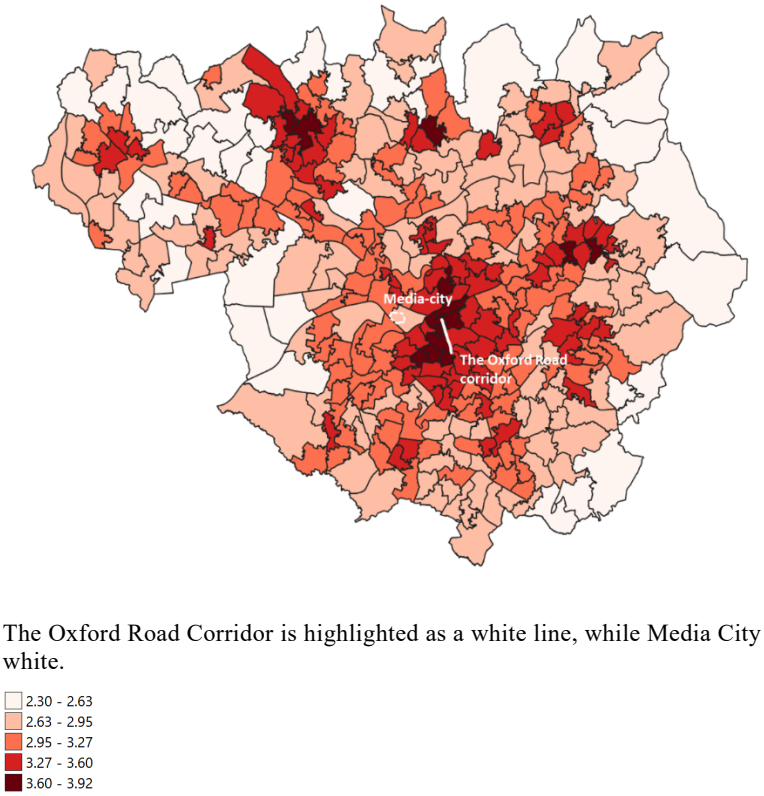
The third and last Marshallian mechanism to be explored is knowledge-sharing. Again, the street network of Greater Manchester can be seen to support knowledge-sharing and knowledge-spillovers at various scales, from the very local to the city-wide scale. As identified above, the author found that 'skills-related' industries are more often found in the same neighbourhoods in Greater Manchester, with knowledge-based services being particularly likely to collocate. There is a large literature within economic geography which suggests that knowledge sharing is most likely to occur between economic sectors that share 'cognitive proximity' (Boschma, 2005) due to being based on similar (although not identical) skills and knowledge.

Altrincham is a good example of a neighbourhood which appears to support cross-sector knowledge sharing, particularly in the knowledge-based services. It is a relatively affluent neighbourhood to the southwest of the city which has a particular concentration of '*arts,*

entertainment and recreation' and '*professional, scientific and technical*' sectors. Workers in these sectors are likely to benefit from the fact that this neighbourhood is relatively dense and locally integrated according to space syntax analysis, enhancing the possibility of both planned and serendipitous local encounters. Indeed, firms within the creative and knowledge-based services sectors in Greater Manchester are more likely to be found in streets that have higher than average integration at the 2km and 10km scale suggesting that such firms benefit from being in areas of higher pedestrian movement.

Altrincham is a buzzy local centre offering plenty of opportunities for meeting in cafes and third spaces, with Urry (2007) discussing the privilege of being in such places where knowledge gets exchanged through "playful" forms of sociability. However, in the generation of new shared applications for patents in the United States, Roche (2019) found that the density of the local street network was just as important as the number of third-spaces available for planned encounter. Social meeting places such as bars and restaurants did not provide an additional effect on patenting without network density being there at the same time – rather the street network enhanced the potential of third spaces to promote exchange. The configuration of the local street network may therefore be particularly important to the innovation potential of neighbourhoods such as Altrincham.

At the same time, Hillier (2016) points out that more generative and creative learning may in fact come not from such localised forms of encounter, but rather from encounters with people from elsewhere in the city, that offer related but "stranger" forms of knowledge – people that you did not know you needed to meet. This was a central idea of Hillier's article on the factors associated with urban creativity, which he characterised as the 'fourth form of sustainability' in cities alongside social, economic, and environmental factors. This fact, that productive knowledge-spill overs require a balance between local and global connectedness in cities, is not always recognised in spatial planning. Indeed, the priority given by urban planners to local knowledge-sharing at the expense of more global connectivity is demonstrated in historical plans for the redevelopment of the Oxford Road Corridor. Today this is a prosperous part of the city, which boasts several universities (the University of Manchester and Manchester Metropolitan University), a science park and important health care research institutions. The Oxford Road provides a linear extension out of the city centre, and space syntax analysis reveals that the road has formed an increasingly important part of both the spatial "integration core" of the city and its foreground network of streets, as the city has expanded. It also falls within the neighbourhood or MSOA which boasts the highest through movement or choice values in Greater Manchester (see Figure 8). However at one point the intention was to turn the area into much more of an inward-facing 'Learning, Medicine and the Arts precinct' by closing Oxford Road to through traffic (Wyke et al., 2018, p.170).



The Oxford Road Corridor is highlighted as a white line, while Media City to the west is outlined in white.

Figure 8: The Oxford Road corridor and Media City indicated on a map showing average choice at 2km radius for Greater Manchester MSOAs. Sources: Froy (2021). The space syntax network on which these values were calculated was extracted from Space Syntax Openmapping (https://spacesyntax-openmapping.netlify.app/#6/55.603/-3.252) and amended based on an OS Data © Crown copyright and database rights [2021] Ordnance Survey (100025252), OS VML Raster 10km.

These plans were only partly realised, but they demonstrate a lack of awareness amongst planners as to the importance of multi-scale connectivity which continues to this day – influencing, for example, the Media City development around the former docks of Salford.

The BBC was encouraged to move to Media City from its previously more central location in the Oxford Road Corridor. While Media City has been a successful redevelopment of previously derelict land, supporting considerable inward investment, the area is relatively disconnected from the rest of the city. It is served by the city's tram system but it is outside of the city's integration core and has relatively low 'choice' or through movement values at the 2km scale (as also revealed in Figure 8). While the public spaces and cafes of Media City may provide opportunities for local exchange, this area appears to operate as a separate hub, with its workers less likely to visit the city centre. This means that they are more segregated from the broader cross-sector exchange of knowledge and capabilities which occurs in the city.

Finally, while both local and global connectivity is important for knowledge-sharing, it was apparent during the interviews with companies that not all sought to be in parts of the city where they can exchange information and ideas with others. The manager of the woollen hat

manufacturer, Xpose, was pleased that Strangeways was 'out of the way' from most of the clothing and accessories manufacturers who are based in the areas of Aardwick and Ancoats as this meant that his company was less at risk of other firms poaching their customers or copying their ideas, particularly by seeing the machines that they were using (an example which underlines the embeddedness of capabilities in technologies that has been highlighted by Hidalgo and others). Werbner (1994) points out that for such small entrepreneurs, knowledge is a hard-won thing, gained over relatively long periods of time through trial and error. Volterra (2009, p.26) similarly found that in both the textiles and engineering sectors in Greater Manchester innovation was protected by making the design and manufacture process more complex and less easy to mimic. One firm relayed that, '*we try to make it as complicated as possible*'. The search for secrecy indicates that the urban fabric may also play a role in providing economic activities with refuge from information flows, in addition to the generative possibilities of encounter (see also Penn, 2018).

Common factors linking the three agglomeration externalities

The above analysis suggests that urban street networks support economic interdependencies in multiple ways. Further, broader fieldwork (see Froy, 2021) reveals that these supportive spatial affordances come together to form what Alexander (1966) would call overlapping local systems in different areas of Greater Manchester. Some urban affordances are important to only one type of economic interdependency (such as storage systems for supply chains, speed of daily transit for labour sharing, and opportunities for spontaneous encounter for knowledge-sharing). However, common to all three interdependencies is the importance of an urban fabric that supports *circulation* – of either goods, people, or ideas - which is in turn shaped by the reach provided by the multi-scale qualities of street networks. As identified at the start of this chapter, Marshall's three economic interdependences represent different ways of circulating and bringing together the same thing – *economic capabilities*. These capabilities are often seen as interchangeable by firms – with human capabilities being substituted by technologies which are again substituted by whole firms in production chains. For example, the manager of Wright Bower identified that there was flexibility in whether they used labour, a machine, or a supplier for a particular stage of their production chain for leather wallets and bags. During previous research amongst small manufacturers in East London (Domenech et al., 2019), a company manager also informed the author that a particular stage in their production process could equally be filled by a technology or a separate supplier – the decision to invest in a machine or a new supply chain relationship often came down to cost. The street network of cities can therefore be seen to play a vital role, not only in supporting pedestrian and vehicular movement, but in circulating diverse economic capabilities to support synergies and growth.

4.2 The changing spatial agglomeration of Greater Manchester over time

When the spatial configuration of cities becomes disrupted, this circulation of economic capabilities can be undermined, and this will be the topic of the remainder of this paper. The following findings should be of particular interest to policy makers, as there is an ongoing search for factors which explain why some cities may perform less well than expected given their size and density (Ahrend, 2014). As identified in the introduction, while Greater Manchester was an economic powerhouse at the time of the industrial revolution, today it fails to punch above its weight when it comes to productivity despite being an important second tier city in the UK with a population of 2,848,300 (Swinney, 2019, OECD, 2020). With this in mind, it is useful to trace how the spatial configuration of Greater Manchester has changed over time, and how its network structure today compares with that of the city in its economic heyday.

Space syntax theory suggests that cities can generally absorb a good deal of change without changing the principles of their layout. Hanson (1989, p.186) argues, for example, that '*the very grid itself may constitute an accumulation of strong morphological events which, taken together, produce a globally strong structure which is highly inertial and difficult to erase or destroy by local changes*'. However, there have been a series of major post-war planning changes in Greater Manchester that have been at a scale sufficient to generate wide-spread impact. The 1850s city had a strong foreground network which encouraged individuals to come in and out of the city to trade, and a network of 'griddy' background streets that hosted manufacturers, retailers, and residents alike. This would have been an important, but neglected, facilitator of the economic synergies which fuelled the industrial revolution (see Froy, 2021). The city grew rapidly due to its economic success, with much of this development taking the form of gridiron street networks, as they were relatively easy to construct at speed. Terraced residential streets became synonymous with Manchester, not least because of the television series, Coronation Street. While the speed of growth meant that buildings were not built to the best quality, the griddy nature of much of the new urban fabric provided a valuable extension to the distributed and open network density that already existed in the city centre. As the city grew, the foreground network of streets also extended coherently out into the new urban fabric. Indeed Shadwell (1906, p.66) wrote that '*in the main arteries where the tide of life runs at the full, it runs with a roar and a stir and a bustle which are not excelled by any other town, not even by New York or London itself.*

However post the Second World War, a large percentage of the griddy terraced housing was identified as 'slum property' (Wyke et al., 2018) and marked for clearance. Large areas of grid-like terraced streets were lost from many parts of the city such as Ancoats. In their place, a more hierarchical urban grain was developed, often characterised by garden suburbs (based on cul de sacs) and inward-looking social housing estates based on high-rise blocks. Rodgers (1980) describes how urban motorways were also 'ripped through' Salford and Hulme, leading to severance between communities, and ongoing problems of spatial segregation. The urban grain of the historical city was likewise lost in the centre, with Canniffe (2015, p.74) describing the

construction of the Arndale Shopping Centre as '*erasing the grain of the Victorian city in favour of a single monumental form*'. Post-war planning changes also had a strong impact on the spatial organisation of industry in the city, further implementing a zoning between industrial and residential uses which began in 1896 with the development of the country's first industrial estate (Trafford Industrial Park). While in Victorian times diverse economic sectors were closely intermingled right across the urban fabric, today there is a tendency for manufacturing firms in particular to be encouraged to locate in more segregated estates.

Such changes may have had an impact on the ability of the city to support agglomeration economies. For example, given the importance of street network density to economic interactions such as knowledge spillovers, it is perhaps concerning that network density has significantly declined in the city centre of Greater Manchester over time. While space syntax analysis of the 1850s map produced 11,464 segments, this reduced to 7456 segments in the same area within the 1950s map, and 2786 today. These changes may partly have developed organically as the city centre self-adjusted to accommodate its new role at the heart of a much larger urban system (see Hanson, 1989). However, Greater Manchester's street network has at the same time also lost configurational structure. Parts of the foreground network (comprising those streets in the system likely to host the most through movement) have been taken over by large mono-use ring roads (such as the Mancunian Way) which are not accessible to pedestrians, meaning that they do little to promote cross-city encounters. At the same time, the 'background network' (comprising the rest of the streets in the city) appears to have become increasingly fragmented and less well-distributed.

Changes to the structure of Greater Manchester are revealed by creating "star models" using a methodology developed by Hillier et al (2012). Through these models, the average accessibility of the background network (in terms of average normalised values of choice and integration) is compared with the strength of the foreground network (taking the maximum values of these variables). Mean NACH thus represents the degree to which the background network forms a continuous grid as opposed to being broken up into sub-areas. Max NACH represents the degree to which the foreground grid structures the system. When a historical comparison of the city between 1850, 1950 and today is carried out using these variables, a progressive loss of both foreground and background structure is revealed[1].

[1] Given Hillier et al (2012) point to dangers in applying normalised choice on larger urban systems that incorporate non-urban space, the analysis here focuses on a historic core (the shape of the 1850s city) and "larger core" of continuous urban fabric that exists within the contemporary boundary of the M60 motorway, including Manchester, Salford, and Trafford.

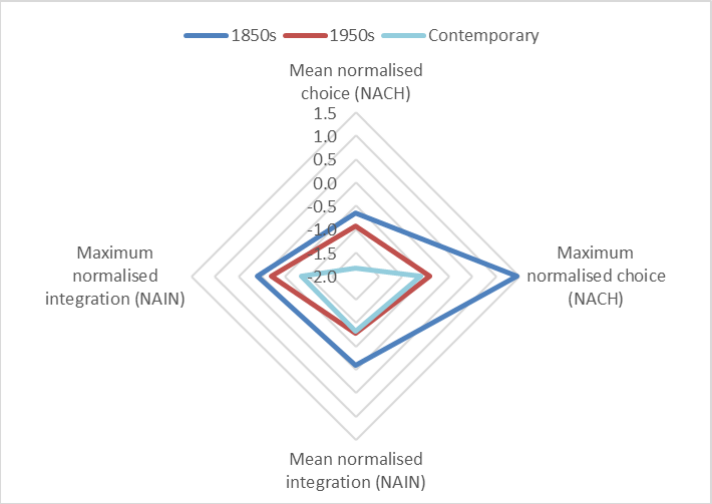


Figure 9: Changing values of the foreground and background network from the 1850s to present (within the M60 boundary). Source: Froy (2021).

The relatively weak structure of the contemporary core of Greater Manchester is confirmed when its structure is compared with other cities. The star model below in Figure 10 compares both the historic and larger core of the city with 50 other cities that Hillier et al analysed in 2012. Today's city would appear to perform particularly badly in terms of the continuity of its background system (defined by mean NACH), especially outside its historic core.

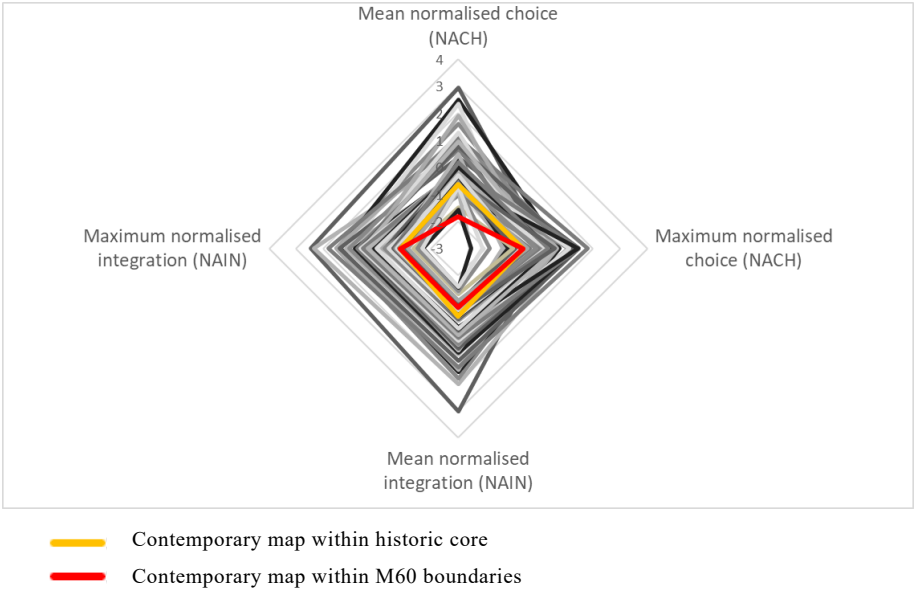


Figure 10: Comparing extracts from the Greater Manchester map with the other cities in Hillier's 2012 database. Source: Froy (2021).

Hillier (2019) more recently explored new ways of quantifying the strength and structure of foreground networks, for example considering the ability of foreground networks to 'gather together' the rest of the urban fabric into a coherent structure. In Greater Manchester, the ratio of the size of the foreground network (which Hillier here defined as those streets having NACH over 1.4) to the size of system that it structures has become less positive over time. The 1.4+

foreground network within the M60 motorway today gathers together nearly 43 times as many segments as itself. In comparison, the 1.4+ foreground network of London (taking to consideration the area within the North and South circular roads) gathers together 27.53 as many segments as itself, with many American cities having a value of under 20 (see Froy, 2021).

As noted above, a key factor in the configurational changes which have happened in Greater Manchester is the development of higher speed roads that create regional and national connectivity. This may have helped to speed up some commute times (as per Schlomo's theory of the self-adjusting city) and improve some access to national and international supply chains. Indeed, the city is well integrated into the UK street network as analysed using Space Syntax Ltd's Openmapping resource[2]. However, this does seem to have come at the expense of a loss of multiscale connectivity in the city street network. The author used the Openmapping resource to compare the multiscale connectivity of Greater Manchester with other UK "core cities"[3] – Birmingham, Bristol, Leeds, Liverpool, Newcastle, Nottingham, Sheffield – and London (Froy, 2021). The Openmapping street network for the UK was "cookie-cut" with the functional urban areas for the core cities as defined by the OECD/EU in 2018. The top ten percent of values for choice and integration at various radii was identified for the whole space syntax network of England and Wales, after which the percentage of the street network which fell within these values in each core city was analysed. The results are set out in Table 1 below, with the results for Greater Manchester, Birmingham and London being shown alongside the average for all the examined cities.

Table 1: Comparing the structural characteristics of Greater Manchester with other UK core cities

	Birmingham	**Greater Manchester**	**London**	**Average for UK core cities and London**
	% of street network	% of street network	% of street network	% of street network
Potential through movement (choice) at different scales				
2KM	18	22	24	18
10KM	27	27	28	25
100KM	13	16	15	13
Combined local and regional potential through movement				
2KM and 10KM	15	17	20	14
2KM and 100KM	6	9	10	6
Integration				
2KM	17	31	36	25
10KM	46	49	68	34
100KM	10	69	58	27

Source: Froy (2021).

[2] https://spacesyntax-openmapping.netlify.app/#6/55.603/-3.252
[3] https://www.corecities.com/cities

Greater Manchester has similar percentages of the street network that fall within the top 10% of streets for each radius to the other urban areas, in general outperforming the other core cities. However, it performs slightly worse than London when it comes to the percentage of streets that have high betweenness centrality at multiple scales, combining local accessibility with city-wide, and region-wide accessibility. Most noticeably, however, Greater Manchester has a much higher proportion of streets that are highly integrated at the 100km scale than the other cities (see the cell shaded in orange). While this national and regional connectivity is clearly important to the city's logistics, wholesale, and distribution industries, the dominance of regional and national through roads that are less accessible to pedestrians may be diminishing the extent to which urban movement flows produce "by-products" such as opportunities for encounter – the movement system becomes more focused on simple movement between origins and destinations.

5 CONCLUSIONS

This article has explored the value of bringing an analysis of spatial configuration to the concept of 'agglomeration economies'. It draws on a larger research project (Froy, 2021) which has revealed that the economic functioning of cities is not all determined by size and density – spatial configuration is also important in bringing together economic capabilities at multiple scales. Urban economies are shaped by multiple underlying structural potentials, involving not only patterns of spatial depth and proximity within street systems, but also economic forms of proximity and interdependency. This article has built on the idea of the 'movement economy' to explore the many different spatial affordances which cities provide for the operation of supply chains, labour sharing and matching, and knowledge-spillovers. The findings have implications for the discipline of economic geography, given that they underline the importance of spatial configuration to urban prosperity, a factor which is often missed in economic geography research. This research may also help shed light on why some cities go into decline over time and become economically 'left behind' – with changing spatial configuration albeit being only one factor among others. The article also indicates the importance of future space syntax research which continues to explore how street networks support the circulation not only of pedestrians, but also of goods and ideas.

REFERENCES

Ahrend, R. 2014. What makes cities more productive? Evidence on the role of urban governance from five OECD countries. *OECD Regional Development Working Papers.* OECD Publishing, Paris.

Alexander, C. 1966. A city is not a tree. *Design Magazine,* 206**,** 46-55.

Boschma, R. 2005. Proximity and innovation: a critical assessment. *Regional Studies,* 39**,** 61-74.

Canniffe, E. 2015. The morphology of the post-industrial city: the Manchester mill as 'symbolic form'. *Journal of Architecture and Urbanism,* 39.

Cheshire, P. C., Nathan, M. & Ooverman, H. G. 2014. *Urban economics and urban policy: challenging conventional policy wisdom,* Cheltenham, Elgar.

Davis, H. 2020. *Working cities: architecture, place and production,* Abingdon, Oxon and New York, Routledge.

Desrochers, P. 2009. Does the invisible hand have a green thumb? Incentives, linkages, and the creation of wealth out of industrial waste in Victorian England. *Geographical Journal,* 175**,** 3-16.

Detang-Dessendre, C. & Gaigne, C. 2009. Unemployment duration, city size and the tightness of the labour market. *Regional Science and Urban Economics,* 39**,** 266-276.

Domenech, T., Froy, F. & Palominos Ortega, N. 2019. The Maker-Mile in East London: Case study report. Brussels: Cities of Making

Duranton, G. & Puga, D. 2003. Micro-foundations of urban agglomeration economies. *NBER Working Paper Series.*

Duranton, G. & Puga, D. 2004. Micro-foundations of urban agglomeration economies. *Handbook of regional and urban economics.* Elsevier.

Florida, R., Rodriguez-Pose, A. & Storper, M. 2021. Cities in a post-COVID world. *Urban Studies***,** 00420980211018072.

Froy, F. Is new work really built from old work? And if so, what does this mean for the spatial organisation of economic activities in cities? Jane Jacobs 100: her legacy and relevance in the 21st century 2018 Netherlands. TU Delft.

Froy, F. 2021. *'A marvellous order': how spatial and economic configurations interact to produce agglomeration economies in Greater Manchester.* PhD, University of London.

Froy, F. & Davis, H. 2017. Pragmatic urbanism: London's railway arches and small-scale enterprise. *European Planning Studies,* 25**,** 2076-2096.

Geddes, I. 2007. *The housing forms and urban morphology of poverty areas in the London borough of Islington.* MA in Housing Studies, UCL.

Gibson, J. J. 1979. *The ecological approach to visual perception,* Boston, MA, Houghton Mifflin.

Glaeser, E. 2011. *Triumph of the city: How urban spaces make us human*, Pan Macmillan.

Green, A. E. & Owen, D. 2006. *The geography of poor skills and access to work*, Joseph Rowntree Foundation.

Hanson, J. 1989. *Order and structure in urban space: a morphological history of the City of London.* PhD Thesis, University of London.

Hanson, J. 2000. Urban transformations: a history of design ideas. *Urban Design International,* 5**,** 97-122.

Hausman, R. & Hidalgo, C. A. 2014. *The atlas of economic complexity: mapping paths to prosperity,* Cambridge, MA, The MIT Press.

Hidalgo, C. A. 2015. *Why information grows: the evolution of order, from atoms to economies,* UK, Penguin Books.

Hillier, B. 1999. *Space is the machine. a configurational theory of architecture,* Cambridge, Cambridge University Press.

Hillier, B. 2016. The fourth sustainability, creativity: statistical associations and credible mechanisms. *In:* Portugali, J. & Stolk, E. (eds.) *Complexity, cognition, urban planning and design.* Switzerland: Springer International Publishing.

Hillier, B. Structure or: does space syntax need to radically extend its theory of spatial configuration? 12th Space Syntax Symposium, 2019 Bejing.

Hillier, B., Penn, A., Hanson, J., Grajewski, T. & Xu, J. 1993. Natural movement: or configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and Design,* 20**,** 29-66.

Hillier, B., Yang, T. & Turner, A. 2012. Normalising least angle choice in Depthmap and how it opens up new perspectives on the global and local analysis of space. *Journal of Space Syntax,* 3**,** 155-193.

Krugman, P. 1998. What's new about the new economic geography? *OXFORD REVIEW OF ECONOMIC POLICY,* 14**,** 7-17.

Law, S., Penn, A., Karimi, K. & Shen, Y. The economic value of spatial network accessibility for UK cities: A comparative analysis using the hedonic price approach. *In:* HEITOR, T., SERRA, M. & PINELO SILVA, J., eds. Proceedings of the 11th International Space Syntax Symposium, 2017.

Marshall, A. 1890. *Principles of economics,* London, Macmillan and co.

Martin, R., Gardiner, B., Pike, A., Sunley, P. & Tyler, P. 2021. Levelling Up Left Behind Places: The Scale and Nature of the Economic and Policy Challenge.

Minchin, J. 2021. Is Greater Manchester's public transport network fit for purpose? Available from: https://www.intelligenttransport.com/transport-articles/130507/andy-burnham-greater-manchester-transport/.

Navarez, L., Davis, H., Griffiths, S., Dino, B. & Vaughan, L. The spatial ordering of knowledge economies: the growth of furniture industry in nineteenth-century London. *In:* Heitor, T., Serra, M. & Pinelo Silva, J., eds. Proceedings of the 11th International Space Syntax Symposium, 2017 Lisbon. Instituto Superior Technico.

Navarez, L., Penn, A. & Griffiths, S. 2014. The spatial dimensions of trade: From the geography of uses to the architecture of local economies. *ITU J. Fac. Archit,* 11**,** 209-230.

Neffke, F. & Henning, M. 2013. Skill relatedness and firm diversification. . *Strategic Management Journal,* 34**,** 297-316.

Netto, V., Soares, M. P. & Paschoalino, R. 2015. Segregated networks in the city. *International Journal of Urban and Regional Research*.

OECD 2020. Enhancing Productivity in UK Core Cities: Connecting Local and Regional Growth. Urban Policy Reviews, OECD Publishing Paris.

Overman, H. G., Gibbons, S. & Tucci, A. 2009. The case for agglomeration economies. *In:* REVIEW, M. I. E. (ed.). Manchester, UK.

Penn, A. 2018. The city is the map: exosomatic memory, shared cognition and a possible mechanism to account for social evolution. *BUILT ENVIRONMENT* 44**,** 162-176.

Rae, A., Hamilton, R., Crisp, R. & Powell, R. 2016. Overcoming deprivation and disconnection in UK cities. York: Joseph Rowntree Foundation.

Read, S. 2015. Cities as infrastructures of diversification and homogenisation: constructing multiformal spaces in Paris and Shenzen. *New Diversities,* 17.

Read, S., Bruyns, G., Van Den Hoogen, E. & Plomp, M. Constructing metropolitan landscapes of actuality and potentiality. 6th International Space Syntax Symposium, 2007 Istanbul.

Rocme, M. 2019. Taking innovation to the streets: micro-geography, physical structure and innovation. *Review of Economics and Statistics*.

Rodgers, H. B. 1980. Manchester revisited: a profile of urban change. *In:* WHITE, H. P. (ed.) *The continuing conurbation: change and development in Greater Manchester.* Farnborough: Gower.

Scott, F. 2015. High street productivity *In:* VAUGHAN, L. (ed.) *Suburban urbanities: suburbs and the life of the high street.* UCL Press.

Sevtsuk, A. 2010. *Path and place: a study of urban geometry and retail activity in Cambridge and Sommerville.* PhD Thesis, Massachusetts Institute of Technology.

Shadwell, A. 1906. *Industrial efficiency: a comparative study of industrial life in England, Germany and America,* London, Longmans, Green, & Co.

Shlomo, A. & Blei, A. 2015. Commuting and the productivity of American cities: how self-adjusting commuting patterns sustain the productive advantage of larger metropolitan labour markets. *Working Paper 19.* Marron Institute of Urban Management.

Storper, M. 2013. *Keys to the city: how economics, institutions, social interaction, and politics shape development,* New Jersey, Princeton University Press.

Swinney, P. 2019. Three things that Andrea Leadsom should know about how to address the UK's productivity problem. [Accessed 15/08/2019.

Tomaney, J. & Pike, A. 2020. Levelling up? *The Political Quarterly,* 91.

Urry, J. 2007. *Mobilities,* Cambridge, UK, Polity Press.

Vaughan, L. & Geddes, I. 2009. Urban form and deprivation: a contemporary proxy for Charles Booth's analysis of poverty. *Radical Statistics*.

Volterra 2009. Innovation, trade and connectivity.

Werbner, P. 1994. Renewing an industrial past: British Pakistani Entrepreneurship in Manchester. *In:* BROWN, J. M. & FOOT, R. (eds.) *Migration: the Asian Experience.* Basingstoke: Palgrave Macmillan.

Jane Jacobs - Speech at the National Building Museum after receiving the Vincent Scully Prize, November 11, 2000. Directed by WETMORE, J. Z.

Wyke, T., Robson, B. & Dodge, M. 2018. *Manchester: mapping the city,* Edinburgh, Birlinn Ltd.