Churning population?
Monitoring the London Plan
New ways of understanding London's population change

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Written and designed by Ying Wang and Michael Keith.

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Copies of this report are available from https://warwick.ac.uk/fac/soc/sociology/research/projects/isc/opencity/.

Executive summary

The last full census demonstrated that in some parts of London almost half of the people who responded to the census had moved within the last twelve months. At a fundamental level this demonstrates the limits of the decennial census as source of information and the gaps in real time data about a city like London that changes so rapidly. The ONS and senior scholars and institutions have tried in many ways to mitigate this by using diverse techniques for estimating the enumeration of the numbers people in place at different geographical scales between census years. But the volatility of the numbers define a major challenge for social policy in general and the drafting of a meaningful plan for London in particular. The 2021 London Plan was prepared, drafted, published at a time towards the end of the decennial census interval and it was adopted in March 2021 in the absence of meaningful data from the 2021 census. In this report we consider the implications of what this absence might mean and in particular how the scale of mobilities of people in the city, normally referred to as population churn might impinge on the monitoring of the plan.

'Churn' has been a longstanding interest for councils across London where the population base changes so rapidly. Understanding the numbers, nature and dynamics of changing population is central to all forms of planning, provision and responding to local people's needs. In 2022, however, these questions are not straightforward for planners and policymakers from the GLA and London councils. Traditional sources of demographic data – either from the Census that tries to map in detail every household every ten years or the ONS which provides annual estimates of population based on sophisticated projections of trend, have become less reliable since the start of the Covid-19 pandemic. Not to mention their limited capacities to pin down the exact numbers of migrants/movements over a long period, which have already been widely discussed (Lomax and Stillwell 2017). With rising levels of uncertainties, there remain some key questions regarding the scale and nature of London's population changes and residential movements that have occurred over the past decades. Answers to these questions will not only provide insights into London's population dynamics and associated socio-economic changes (e.g. changes in the housing market) but also help us to understand how London may change or develop in the future.

This report sets out to address some of the most important questions about the churning population in London. In this report, we draw on Census migration data and big data from consumer records and other sources to construct alternative ways of seeing the city in near 'real time'. In doing so, we aim to construct new ways of understanding how London's population is changing fast over the last decade and provide preliminary answers to the following questions:

- How many people live in London? How many have left post-Brexit and since the pandemic? How often do they move?
- Which parts of London are growing fastest and slowest? How does that reflect changing patterns of the housing market?
- How do we understand the changing geography of London? What are the implications for policymaking and the London Plan?

Key findings

London's churning population: Evidence from the Censuses

Census migration data provide snapshots of residential moves in and across London. They help analyse long term trends of and differences in population churn between small areas in London at certain points in time. We analysed and visualised migration patterns from Censuses conducted in 1981, 1991, 2001 and 2011. The results show significant and accelerating increases in population churn across the capital. This is especially the case for the decade between 2001 and 2010. The 2011 Census reports a massive increase in average churn rates, which rose from less than 25 per cent to more than 35 per cent, meaning that more than one-third of the London population was on the move in 2010, a year before the census date.

The greater patterns of flux and transience were not experienced by London boroughs in the same way. The Census-based analysis reveals emerging new geographies of London. We map out the distribution of churning populations and find that central London has remained to see a relatively large proportion of people moving in and out over the past three decades, in boroughs such as Kensington and Chelsea, Westminster and Camden. Churn rates in some inner London boroughs such as Wandsworth, Hammersmith and Fulham, and Tower Hamlets caught up with these high levels in the 2000s. Outer London boroughs, especially those in outer East London, have remained relatively residentially stable over the past three decades. More importantly, further analysis shows that **an increase in population churn has been observed in all London boroughs**, but disproportionately higher levels of increase in churn have been experienced by most inner London boroughs (e.g. Tower Hamlets, Islington, Lambeth and Southwark).

Despite high accuracy at local levels (e.g. borough level and below), Census migration data suffers from low temporal granularities since they are only collected once every ten years (and we are still waiting for the release of 2021 Census data in late 2022). This limitation makes Census data a less favourable data source for monitoring population changes in London, particularly in rapidly changing areas or among fast-growing population groups. This is especially the case when migration patterns had the greatest proportional changes since the 2011 Census. The 2011 Census does not consider groups that have arrived more recently, such as the Romanians and Bulgarians, let alone the effects of Brexit and the pandemic.

Other publicly available population statistics, such as population estimates and administrative data, are also insufficient due to their low spatial granularities. They either have less detailed local-level estimates or poor-quality estimates that come with substantial margins of error.

New insights on London's churning population: Evidence from consumer data

Since most publicly available statistical sources are insufficient to understand the process of population change and migration on the ground (Lomax and Stillwell 2017), we turn to a new form of big data – the 'Linked Consumer Registers (LCRs)'. Released by the Consumer Data Research Centre (CDRC), the LCRs are sourced from public versions of electoral registers, consumer registers, and land registry house sale data. The LCRs record names of UK residents at the address level in annual snapshots and is, therefore, able to capture population activities at a high spatial and temporal granularity (van Dijk and Longley 2021).

Drawing on the LCRs, the CDRC develops a new measure of population mobility – the Residential Mobility Index (RMI) to estimate population turnover across space. The RMI is a yearly estimate of the proportion of households that are different between the end of 2020 and the end of each year dating back to 1997. Drawing on the aggregation of address-level consumer data, the RMI can capture short-distance moves within local authority boundaries, which are usually under-documented in publicly available population statistics (except the Census). The RMI is a valuable source of data also because it provides a longitudinal profile of households and covers inter-censual periods when detailed pictures of local populations and their movements were hardly available from conventional statistics at small geographies (e.g. sub-borough levels). This is of paramount importance for the last decade when considering the significant but uneven impact of Brexit and Covid-19 on London's neighbourhoods (O'Connor and Portes 2021; ONS 2021).

To test whether the RMI is a reliable household estimate of residential mobility in London, we anchor it to Census migration data. The comparison demonstrates the strong correspondence between RMI 2011 and migration data from the 2011 Census, indicating that the RMI has the potential to fill in some of the gaps left by currently publicly available data. However, one should also remain cautious when interpreting RMI results. Apart from systematic biases associated with the LCRs, RMI 2001 appears to be a poor surrogate of the 2001 Census migration rates due to the mismatch between the two measures that increases with the length of time between the target year and 2020. In addition, the mismatch between the two measures is not evenly distributed; RMI estimates tend to be closer to Census estimates in more residentially stable areas.

We then carry out RMI-based analysis, revealing for the first time some findings of research understanding how London's population is changing fast over recent decades and how different parts of the city experiences such changes differently. While the Censuses point to greater patterns of flux experienced across London boroughs during the 2000s, the RMI further extends this argument. Our analysis shows that demographic changes were being felt differently by different boroughs at different moments. Inner London boroughs consistently experienced disproportionately higher levels of population churn, but their relative positions have undergone significant changes in the past two decades. **Two significant inflections are noticeable in the data which appear to correspond to consequences of the major 'shocks' of the financial crisis and the Brexit referendum.** 2008-2010 appeared to be one key moment of change when most Inner London boroughs experienced a sharp decline in their residential mobility rankings after the global financial crisis (except Greenwich, Lambeth, Lewisham and Southwark). 2015-2018 was another key moment of change when most Inner London boroughs, except Greenwich and Hammersmith and Fulham, witnessed a decrease in their relative proportions of mobile population/households. The most significant decrease in churning population was reported by some central London boroughs, such as Kensington and Chelsea, Westminster and Camden.

In contrast, most outer London boroughs started with a relatively stable population and their mobility trajectories began to diverge after 2008. Some have become new 'hot spots' of international and internal migrants since 2008, such as Newham, Merton and Harrow. Some also experienced increasing levels of residential churn, albeit such an increase did not start until the late 2010s, such as in Ealing, Enfield, Hounslow, Hillingdon and Redbridge. Some were negatively affected by the EU referendum and became less attractive to migrants after 2016, such as Barking and Dagenham. Some were less affected by the structural changes and have remained to be relatively residentially stable, such as Bromley, Kingston upon Thames and Sutton.

Further analysis at the Lower Super Output Area (LSOA) level reveals how mobilities patterns have changed over time on the ground. Longitudinal analysis show major changes in residential churn that took place across central London boroughs between 2015-17, especially in neighbourhoods across central and south Camden, Westminster and Kensington and Chelsea. At the same time, some new 'hotspots' of residential churn emerged in outer London in the late 2010s, such as neighbourhoods in north-eastern Merton and central Hounslow.

To understand these new trends and geographies of residential churn, we made some further attempts to explore the relationships between churn rates and place characteristics, among which we focused primarily on local housing market statistics. On the borough level, we found positive and statistically significant relationships between churn rates and count of sales (of both marketing and social housing) and negative and statistically significant relationships between churn rates and median price (private sales). These observations suggest that London's housing price generally hinders residential movement. However, LSOA-level analysis points out several areas where housing price is positively associated with mobility, generally in areas of particularly high house prices and those below London averages, implying a link between population churn and the two ends of the income spectrum. Some are in the central part of the city where the housing price is relatively high, such as neighbourhoods in Camden, Southwark, Kensington and Chelsea, and Wandsworth. Some are in Outer London, but still with a relatively high housing price, such as Richmond upon Thames. Others are distributed in Outer London boroughs with relatively low housing prices, such as neighbourhoods in south-eastern Newham and south Barking and Dagenham. These areas are reported to be new 'hotspots' of international migration. The exploration of the housing price-mobility relationship demonstrates the scalar effect of churn and calls for further attention to different types of residential churn (e.g. gentrification-related churn and migration-related churn), their spatio-temporal distributions and socio-economic consequences.

Policy Implications and Recommendations: Population Churn and monitoring the 2021 London Plan

1. **Democracy and community engagement: Knowing local populations**

The legitimacy of the London Plan in the eyes of the people of London depends significantly on the credibility of the claims made by City Hall and London Boroughs about the scale and pace of local change. This report has demonstrated the significant and growing role population churn plays over very short periods of time in reconfiguring the population geographies of London. As part of the monitoring of the London Plan ***we recommend that regular monitoring updates should report on these geographies of population churn to inform the implementation of the 2021 London Plan.***

2. **Development Control in London: Monitoring the London Plan, the reliability of data and challenges to development impact assessments**

Many of the technical details of the roll out of development control policies depend on estimates of the impact of development on surrounding locations. Localised development plans and masterplans across all the boroughs of the city depend in part on the local empirical evidence on which they are based to test the impact of developments on public goods such as access to open space, health and education services, forms of congestion in transport and mobility modes. All of these are rooted in estimates of both present and future populations. In short, the calculation of appropriate assessments of Section 106 contributions and impact agreements depend on meaningful population data. But we know that some parts of London are growing faster than others. We know that the age profile of different parts of London is being reconfigured, particularly in the wake of the COVID pandemic. The numbers of children per household varies rapidly through population churn, secular trends of suburbanisation and gentrification have reshaped the population profiles of different boroughs in London since the 2011 census, the relationship between multi centric commercial hubs and residential neighbourhoods across London is evolving rapidly as more people choose to work from home for at least parts of the week.

It is already the case that consultancies across the city offer services aimed specifically to minimise the contributions of major developments through challenges to the knowledge base on which impact assessments are made. Notwithstanding the first-rate attempts to estimate inter census change this is likely to increase through time if the London Plan is claimed to represent the needs of the demographic geographies of the London of 2011 rather than 2021 or later. Consequently, understanding the impacts of population churn on

London's rapidly changing residential patterns on a more real time basis is imperative for accurate, appropriate and defensible development control practice in the next decade and avoiding challenges to the London Plan as it works its way down through the city's geographical hierarchy of development control practices. In this context ***we recommend the GLA consider how population churn estimates might be used to inform the GLA monitoring of the 2021 London Plan.***

3. Capitation and budget estimates based on headcounts

The proportions of support vary greatly and have changed through time significant proportions of local government and other London Borough revenue support for the provision of local public services accrue from central government subsidies. These tend most commonly to reflect population demographics, the demand for places in schools, primary care, public health and environmental services. Globally, we are seeing an increased pressure on governments to use alternative sources for such estimations than a decennial census. We have explored tentatively the use of some sources of new data closer to 'real time' and the implications for the geographical distribution of populations across London and their rates of change in forms of population churn. Given the scale and accelerated rate of population churn over the last three decades while any conclusions should be treated carefully ***we recommend that but one element of monitoring of the London Plan should explore the possibility of using alternative data methodologies of measurement of residential populations when considering the development of London through the London Plan.***

4. Public service quality and changing landscapes of diversity

One of London's strengths is the cosmopolitan nature of the city. International migration has for centuries been central to the history of the city but this has rarely been without social, cultural and economic challenges. Longstanding academic research demonstrates that international migration generally provides greater benefits than costs to the economy. Migrants tend to come to the city schooled and skilled and tend also to be younger with high employment participation rates, meaning that they generally contribute more in taxes than they receive in support from the state. But these costs and benefits have an uneven geography, the benefits are realised at the scale of the labour market and the travel to work area, the costs accrue at the scale of residential impact. Migration benefits significantly the whole economy of London, pressures on some welfare services such as school places, GP surgeries and access to public space reflect much more localised pressures. Former policies in the United Kingdom (such as the long-abolished Section 11 programme) tended to recognise this by financial support for local authority obligations to mediate the arrival and impact of international migration related changes. But as London's population geography changes the geographies of costs and benefits of international migration change accordingly. Consequently the impact of developments in London in areas of high migration need to be assessed in the context of these dynamics in order to reflect both the costs of public goods (such as health, education and green space) as well as the economic benefits of migration for the city as a whole. A significant number of developments in London demand appropriate equality impact assessments and in this context ***we recommend that City Hall should explore how the boroughs and the 'GLA Family' could use new data sources on population churn to inform monitoring of the 2021 London Plan to understand the impact of migration on different parts of the city***.

Table of Contents

Introduction

Why is population change important

The last full census demonstrated that in some parts of London almost half of the people who responded to the census had moved within the last twelve months. At a fundamental level this demonstrates the limits of the decennial census as source of information and the gaps in real time data about a city like London that changes so rapidly. The ONS and senior scholars and institutions have tried in many ways to mitigate this by using diverse techniques for estimating the enumeration of the numbers people in place at different geographical scales between census years. But the volatility of the numbers define a major challenge for social policy in general and the drafting of a meaningful plan for London. The 2021 London Plan was prepared, drafted, published at a time towards the end of the decennial census interval and it was adopted in March 2021 in the absence of meaningful data from the 2021 census. In this report we consider the implications of what this absence might mean and in particular how the scale of mobilities of people in the city, normally referred to as population churn might impinge on the monitoring of the plan.

Making sense of population churn

'Population churn' is often used to describe the movement of population. While some define 'churn' as moves across administrative boundaries and calculate it as the sum of in- and out-migration moves divided by the total population (Camden Council, 2017), others emphasise the importance of short-distance moves within each area (Bailey and Livingston 2005). The overall churn of an area is thus described as a combination of people 'who have either moved *in* or *out* or *within* the area' (Hollis 2010:20).

Churning population influences the scale and composition of the local population and is often used as an indicator of local population dynamics (Dennett and Stillwell 2008). Studying population churn enables greater insight into the size, structure, composition of a population and the scale of population change, which has significant implications for understanding the openness and closeness of an area, as well as the permeability of its boundaries. This is vital when it comes to service planning and allocation, capitation and budget estimates, as well as democratic participation. For instance, churn will affect the number of children joining a new school, the number of patients changing general practitioners, the number of households setting up new council tax accounts, and the number of persons who are entitled to vote in elections. As an indicator of residential change, churn also affects the ability of local communities to face challenges, enhance interactions and engagement, and promote neighbourliness and social cohesion.

Population churn has a significant impact on London. The 2011 census showed that in some parts of London, almost half of the population churned in a single year before the census date. This is significantly higher than the average churn rate across the UK during the same period when 12.01 per cent of the population have changed address. More importantly, the significant impact of churn is not being felt uniformly by all London boroughs. Early evidence from London Councils suggests that, compared to inner boroughs, outer London boroughs experienced lower levels of churn but higher levels of of net inward flow in the early 2010s[1].

Existing research has documented a variety of demographic, economic, and social factors that contribute to population churn in London, such as age and life-stage transitions, family type, employment status, educational qualifications, housing tenure and ethnicity. Scholars argue that higher rates of churn are more likely to be found among people who are young adults or young children, single or lone parents, unemployed, with higher educational qualifications, private tenants, and from ethnic minority groups (Bailey and Livingston 2005; Long 1992; Musterd et al. 2016). These driving factors affect London boroughs disproportionately, creating unique spatial patterns of population churn across London. For instance, according to ONS Population Estimates, the inflow of children and young people (0-15) is more likely to happen in outer London boroughs, especially Havering, Barking & Dagenham, and Bromley. A disproportionate increase in Local Housing Allowance (LHA) claims was also found in outer boroughs, but most notably in Ealing, Brent, Barnet, Enfield, and Haringey.

Recent research also explores driving factors behind population churn and its various effects. Travers and colleagues (2007) particularly distinguish *escalator churn*, where residents whose circumstances improve move out, and *gentrifier churn*, where better-off households move into the area. Four types of churn areas were further identified by research carried out into the National Strategy for Neighbourhood Renewal (Robson, Lymperopoulou, and Rae 2009), including

- *'Escalator' areas*, where residents whose circumstances improve move out of the area and the neighbourhood becomes part of a continuous onward-and-upward progression through the housing and labour markets.
- *'Gentrifier' areas*, where better-off households move into the area. Although most in-movers come from less deprived areas and most out-movers go to similarly or more deprived areas, this may or may not entail the kind of conscious process of markedly richer households displacing markedly poorer households envisaged by much of the literature that discusses gentrification (Lees 2000).
- *'Transit' areas*, where households move in and out, to and from less deprived areas. Typically, this implies young or newly established households coming from less

[1] Source: https://www.londoncouncils.gov.uk/node/28515.

deprived areas (such as their parental home) and starting on the housing ladder with limited initial resources.
- *'Isolation' areas*, where households move in and out, to and from similarly or more deprived areas.

Although scholars and policymakers have recognised the importance of population churn and its far-reaching impacts, empirical evidence on London's churning population remains limited. Despite the many sources of statistics about migration to and from London (e.g. Mid-year population estimates, Annual Population Survey, NHS patient register and National Insurance Number registrations), there remain problems and inconsistencies in pinning down the numbers of migrants/movements and characteristics of migration due to definitional, timing, coverage, measurement, and quality differences between data sources[2]. Moreover, the Census and other publicly available statistical sources suffer from low temporal or spatial granularities. We have limited knowledge of churning populations beyond the decennial Census and limited insight into the granularities of churn, since most publicly available population data are hardly available at fine geographic scales and fail to reflect the substantial amount of short-distance moves.

To address these gaps, we introduce a new measure of population churn – the Residential Mobility Index (RMI), which derives from a 'Linked Consumer Registers' dataset drawing on consumer registers, electoral registers, and land registry data. The aim of this is to reflect the annual (dis)continuity of residence, allowing us to monitor changes in patterns of internal migration over the past decades and provide 'highly granular inventories' (Lansley, Li, and Longley 2019:1587) of local populations and their movement. We explore in this submission the potential and the possible challenges of using such data to provide new insights into the rapidly churning population across London.

The remainder of the report is structured as follows: in section two, we present existing empirical evidence on London's churning population, drawing on publicly available population statistics, primarily Census migration data. This provides a contextual framework to understand the general trends and broader patterns of population churn throughout the region. Acknowledging the limitation of Census migration data, we introduce the RMI and the 'Linked Consumer Registers' in section three. By anchoring the RMI to conventional migration data, we find strong correspondence between RMI 2011 and 2011 Census, demonstrating that the RMI has the potential to supplement conventional population statistics by capturing changing patterns of residential mobility in London at a high spatial

[2] A detailed discussion see https://migrationobservatory.ox.ac.uk/resources/briefings/who-counts-as-a-migrant-definitions-and-their-consequences/.

and temporal granularity. This is followed by RMI-based analysis in section four. We visualise the changing spatial and temporal patterns of RMI across London boroughs and LSOAs, showing how the RMI acts as a new way of understanding population change in London. The last section summarises the main findings and discusses some policy implications.

Notes on data and methodology

Population churn is 'the outcome of mobility of all types' (Scanlon, Travers, and Whitehead 2010:11). Depending on the origin and destination of the movement, at least three types of mobility can be observed in London: to and from overseas (i.e. international migration); to and from the rest of the UK (i.e. domestic or internal migration) and within the capital itself (i.e. within London movement). Domestic migration can be further divided into those moving between London and other UK regions (i.e. inter-regional flow) and those moving between London boroughs (i.e. intra-London flow or inter-borough flow). The relationship between each type of mobility and main sources of data are presented in Figure 1.

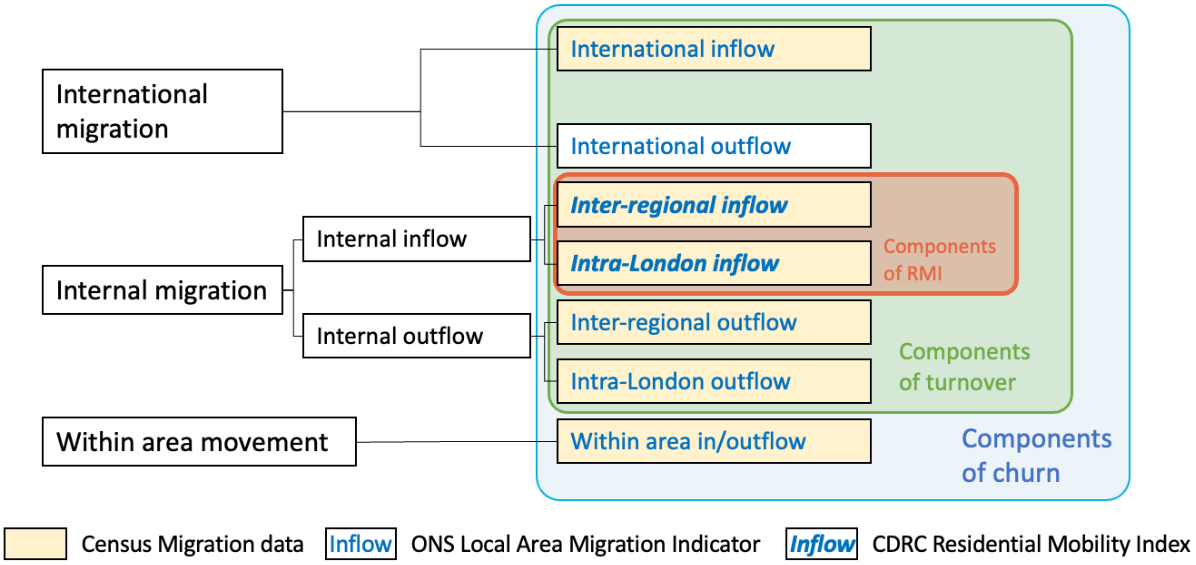


Figure 1 Types of mobility and components of churn

In this report, we define key measures of population movement as:

- *Population turnover,* which is the sum of long-term international inflow, long-term international outflow[3], internal[4] inflow and internal outflow, relative to population size (the green box in Figure 1).

[3] Census migration data do not provide information on international outflow.

[4] According to the ONS, internal migration refers to 'residential moves between local authorities and regions in England and Wales, as well as moves to or from the rest of the UK (Northern Ireland and Scotland)'. See https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/migrationwithintheuk/methodologies/internalmigrationestimatesqmi

- *Population churn*, which is the sum of population turnover and movement within the area, relative to population size. Notably, this is different from the way Camden Council used to calculate churn: 'the sum of in- and out-migration divided by the total population. Churn is 28 per cent in the year to mid-2019 but includes university student moves to and from Camden' (Camden profile, 2021)[5] (the blue box in Figure 1).
- *Residential mobility*, which is the sum of inter-regional and intra-London inflows, relative to relative to population size (the amber box in Figure 1). We will discuss this measure in detail in section three.

[5] https://opendata.camden.gov.uk/download/9m7e-5qyt/application/pdf

London's churning population: Evidence from the Censuses

In this section, we present existing empirical evidence on London's churning population, focusing on migration into, away from and within London over the past three decades (1981-2011). Drawing on publicly available population statistics, primarily Census migration data, we calculate churn rates and discuss the main characteristics of London's churning population.

Longitudinal trends

Figure 2 presents the churn rate for each London borough at four time points, 1981, 1991, 2001 and 2011, respectively. The boroughs were ranked from the most mobile one with the highest churn rate in 2011 (i.e. Westminster and City of London[6]) to the most stable one with the lowest churn rate (i.e. Bexley).

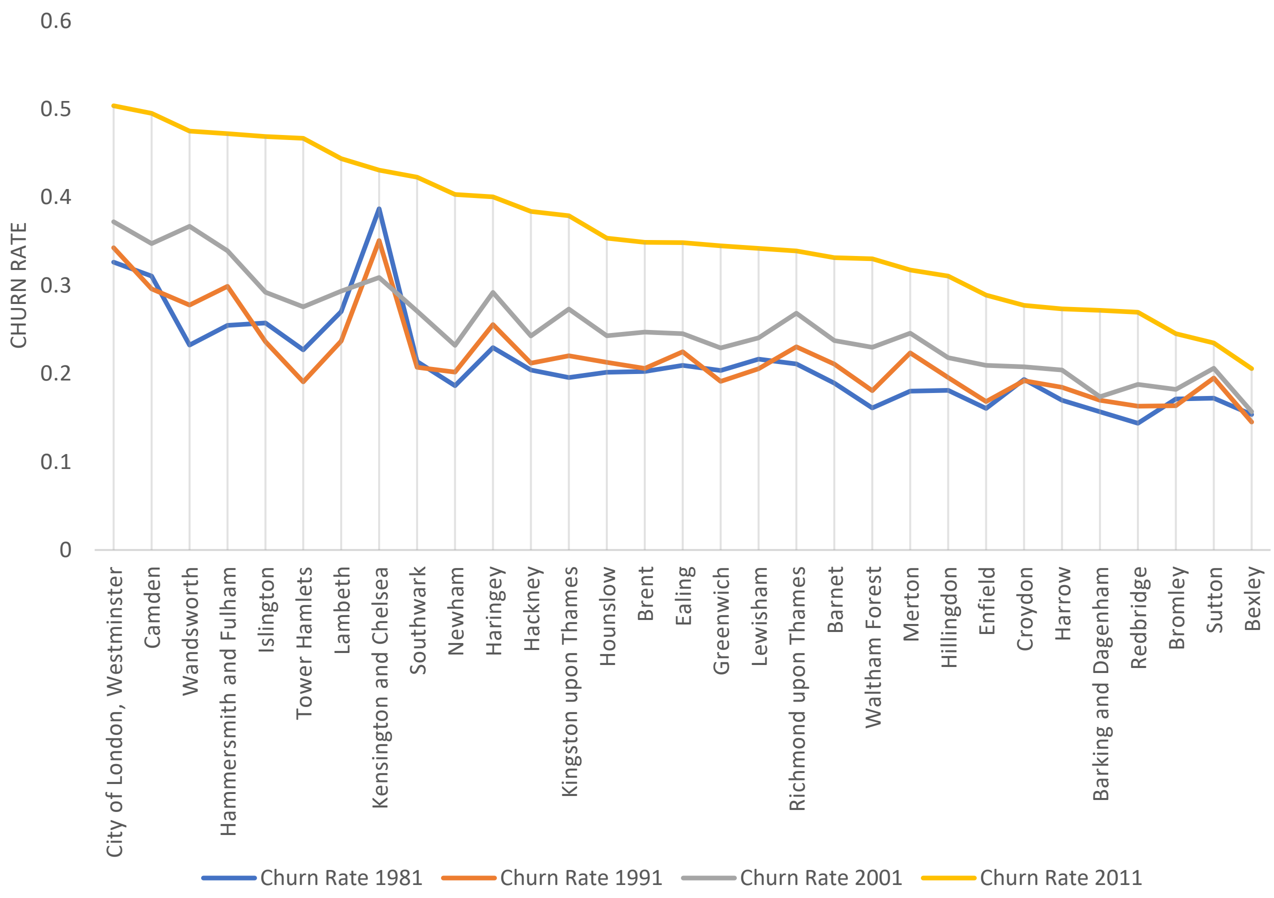


Figure 2 Churn rates by borough

[6] In residential terms the City of London is markedly different from other 32 boroughs. For the purpose of this analysis, data for the City of London is combined and presented together with Westminster.

Source: 1981, 1991, 2001 and 2011 Census.

Compared across the four Censuses, we observed a slight increase in churn rate in 2000/2001, when the average churn rate increased from 21.61 per cent to 24.95 per cent. In 2010/2011, greater patterns of flux and transience were experienced across London boroughs than a decade earlier. This led to a massive increase in average churn rates, which rose from less than 25 per cent to more than 35 per cent, meaning that more than one-third of the London population was on the move.

The increase in churn rate was also consolidated based on the rate of change, as presented in Figure 3. In figure 3 below all grey bars lie on the right-hand side of the y-axis, suggesting that all London boroughs have experienced positive changes in churn rate during 2001-2011. Most amber bars lie on the right-hand side of the y-axis, indicating that most boroughs have reported an increase in churn rate during the 1990s. The only exception was Kensington and Chelsea, which reported negative changes in churn rates. When it came to the 1980s, negative changes in churn rates have been reported by more than one-third of boroughs, including Tower Hamlets, Kensington and Chelsea, Lambeth, Islington, Camden, Greenwich, Lewisham, Bexley, Bromley, Southwark, Croydon and Havering.

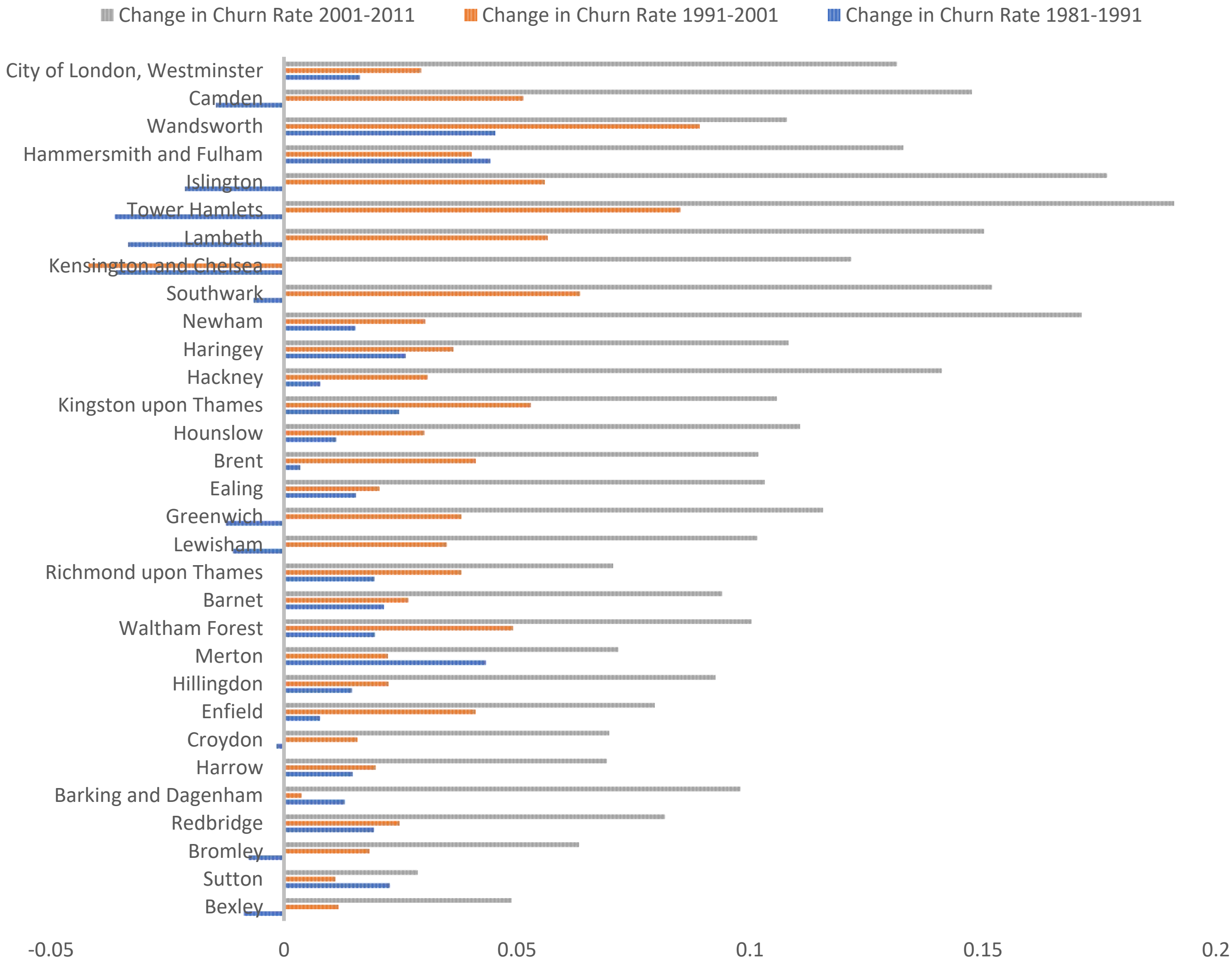


Figure 3 Change in churn rates by borough

Source: 1981, 1991, 2001 and 2011 Census.

We map out the distribution of population churn across space to explore the geographies of London's churning population. As shown in Figure 4, central London has shown a consistently relatively large proportion of people moving in and out over the past three decades, in boroughs such as Kensington and Chelsea, Westminster and Camden. In other Inner London boroughs churn rates accelerated and caught up with this pace of change in the 2000s, such as Wandsworth, Hammersmith and Fulham, and Tower Hamlets. Outer London boroughs, especially those in East London, have remained relatively residentially stable over the past three decades.

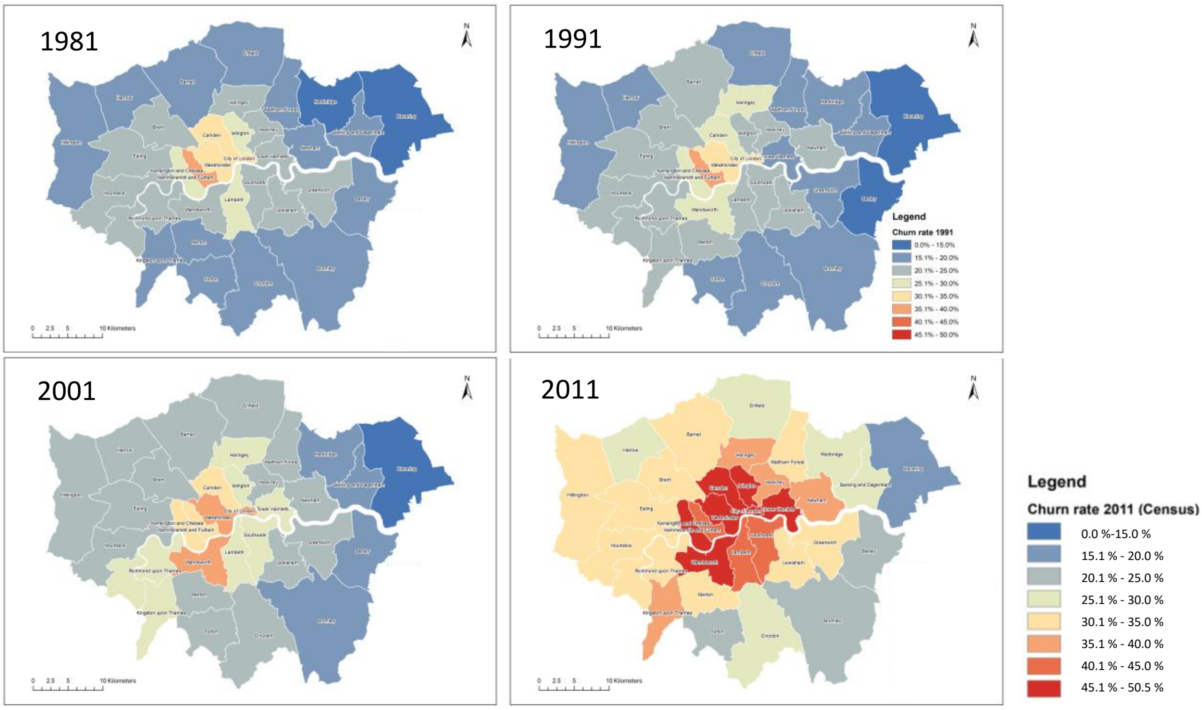


Figure 4 Distribution of churn rates by borough

Source: 1981, 1991, 2001 and 2011 Census.

Another interesting observation is that Westminster replaced Kensington and Chelsea and has become the borough with the highest churn rate in 2011. As much as 50.37 per cent of its usual population changed their addresses in 2010/11 – an incredibly high figure.

We also map out how changes in churn rates are distributed across London boroughs. The increase in population churn – as discussed earlier, was more apparent for inner London boroughs, such as Tower Hamlets, Islington, Wandsworth, Camden and Westminster. In addition, Figure 5 clearly shows that the rate of change has increased significantly during the 2000s. Compared to the first two inter-censual periods, the third inter-censual period witnessed a general increase in the rate of change (figure on the right with larger areas coloured in amber and red). Tower Hamlets replaced Wandsworth and became the borough with the largest net increase in churn rate; its change rate has more than doubled and reached 19.10 per cent during the 2000s.

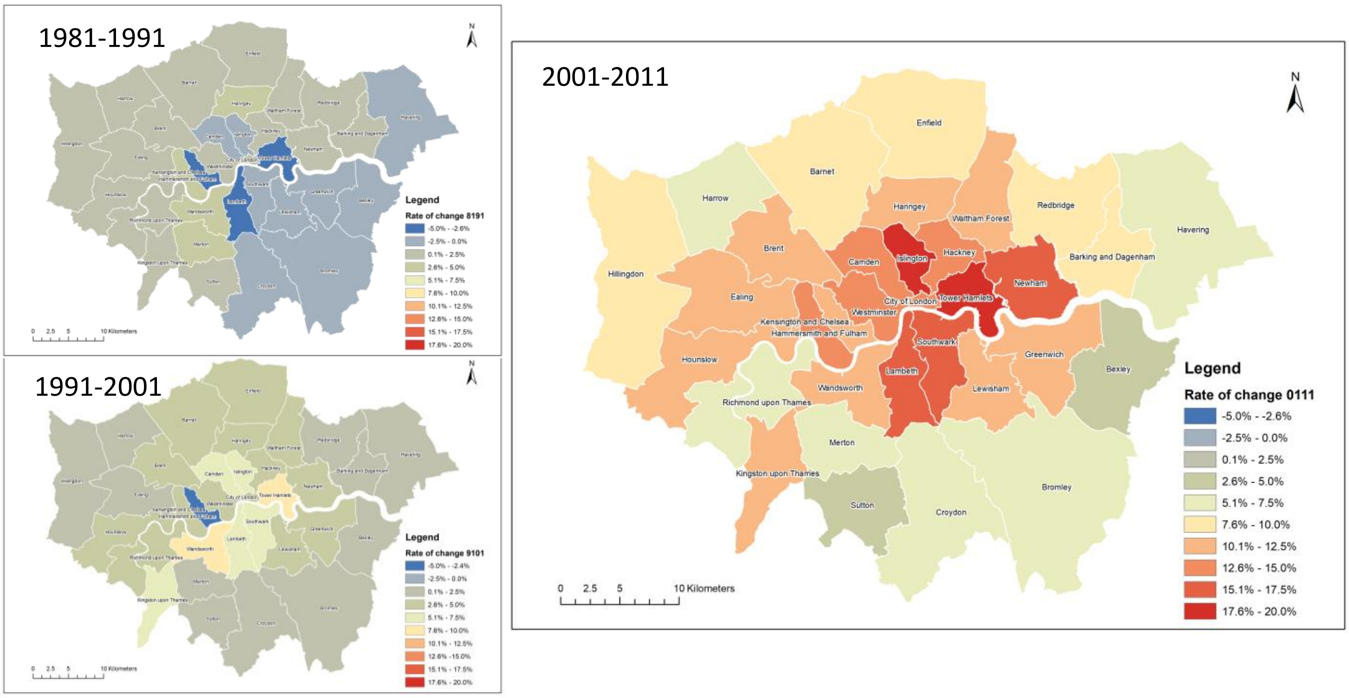


Figure 5 Distribution of change in churn rates by borough

Source: 1981, 1991, 2001 and 2011 Census.

Characteristics of London's churning population

Churning population brings major demographic, social and economic changes to London. In this section, we examine some of the main characteristics of churning populations and the changes they bring to local areas.

The first characteristic is the origins and destinations of population flows. We do not consider international immigrants here because even the UK Census does not collect information on international outflows. Figure 6 presents inter-regional flows between London and the other UK regions. Since more than two-thirds of moves in the UK were of less than 10 kilometres (Hollis, 2010), it is not surprising to see that people tend to move to neighbouring areas just outside their region and many inter-regional movements away from London had destinations in the adjacent regions, such as South East, and East. According to the 2011 Census, the greater South East attracted more than 90,000 people from London, followed by the East (55,000) and South West (20,000). The three regions were also the most popular places or origins within the UK for those moving in to the capital (South East 63,000, East 35,500, and South West 20,000).

Figure 6 Inter-regional flows between London and other UK regions

Source: 2011 Census.

Similar to inter-regional flows, the largest intra-London movements are found between adjacent boroughs (Figure 7). This is especially the case for Inner London boroughs in South London, such as between Wandsworth and Lambeth and between Lambeth and Southwark. Another interesting observation is that inner London boroughs gained more population than they lost from intra-London flows. This is indicated by the thickness of arrows pointing to these boroughs, compared to those pointing against these boroughs.

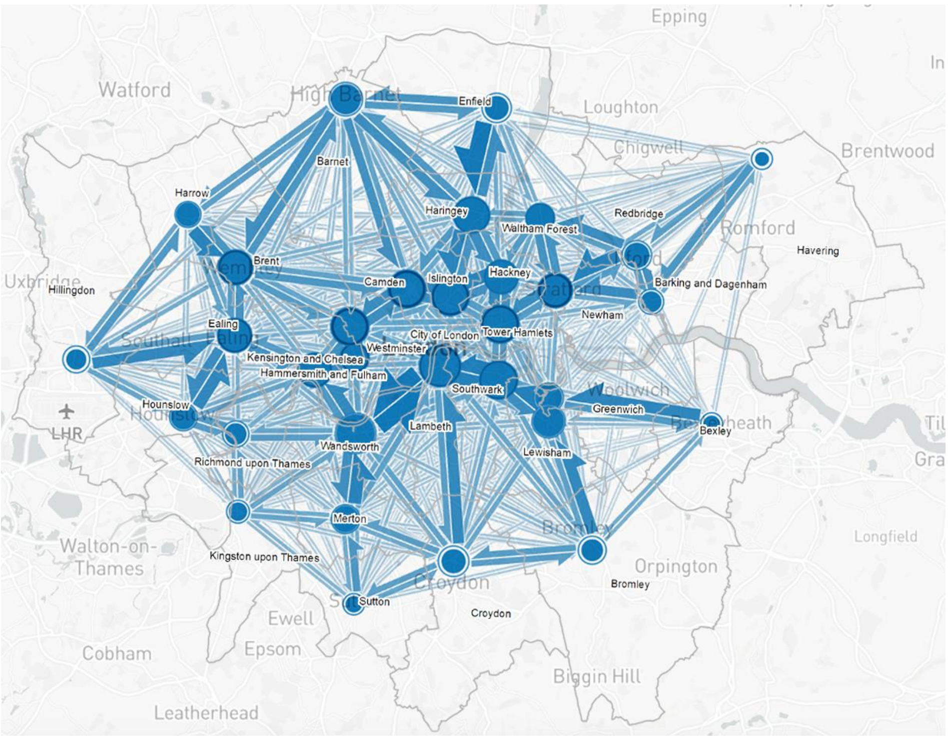


Figure 7 Intra-regional flows between London boroughs

Source: 2011 Census.

Another characteristic worth attention to is ethnicity. Figure 8 compares the ethnic compositions of Londoners, according to the 2001 and 2011 Censuses. The figure shows the number of white Londoners fell in the intercensal period, with its proportion dropping from 71.15 per cent in 2001 to 59.79 per cent in 2011. As a result, the proportion of non white ethnic minority residents in London rose from 28.85 per cent to 40.21 per cent.

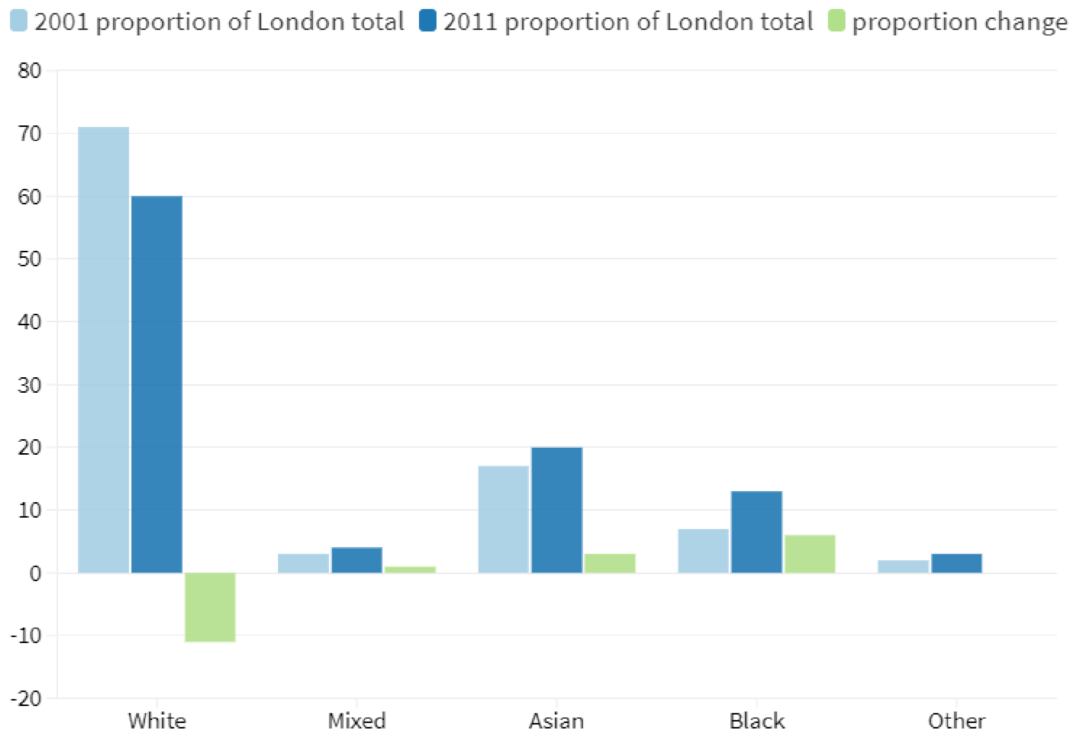


Figure 8 Broad ethnic group proportions in London, 2001 and 2011

Source: 2001 and 2011 Census.

To be more specific, the change in the White population was composed of a dramatical decrease of White British (14.90 per cent), and a huge increase in the 'Other White' group, which contains many of the eastern European migrants who have settled in London over the last decade (increased by 402,800 people, a 49.40 per cent rise). Notwithstanding this, the White British remained the largest single group in 2011. All ethnic minority groups, except the Chinese (decreased by 0.34 per cent, not shown in the figure), saw increases in their proportions (Figure 9).

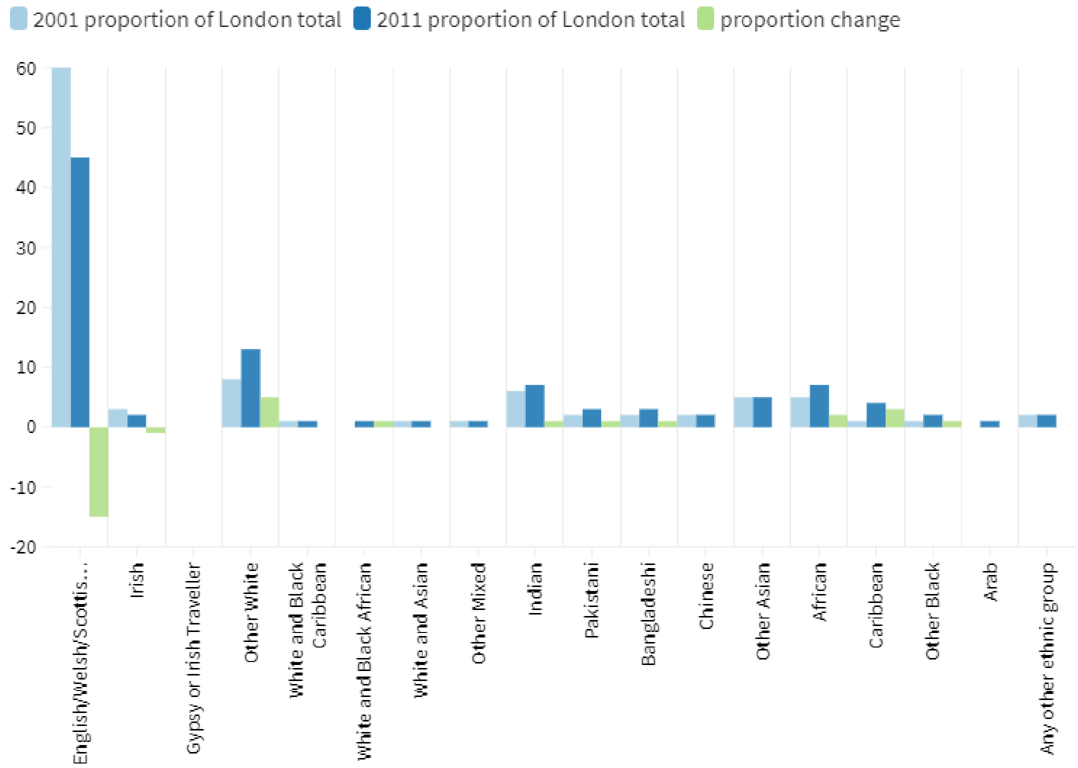


Figure 9 Ethnic group proportions in London, 2001 and 2011

Source: 2001 and 2011 Census.

Figure 10 visualises the distribution of the non-White population in London according to the 2001 and 2011 Census, respectively. The figures reveal several 'hotspots' in London where there are relatively higher concentrations of non-White residents: Newham, Redbridge, Brent and parts of Harrow, Ealing, Hounslow and Croydon.

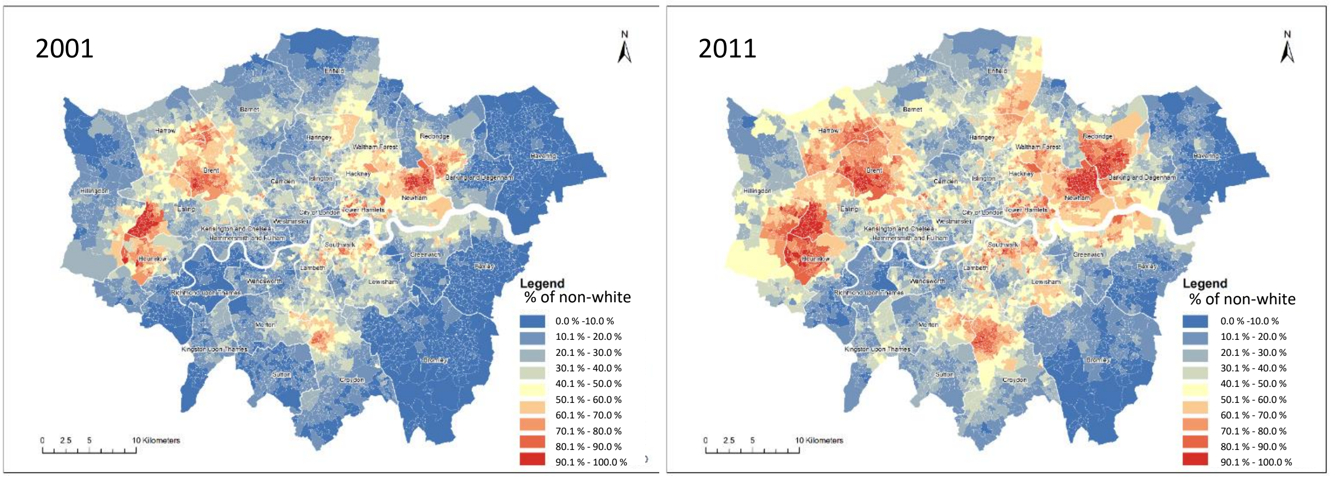


Figure 10 Distribution of other ethnic minority populations in London

Source: 2001 and 2011 Census.

We compare the two figures and present how the distribution of the non-White population has changed during the intercensal period (Figure 11). Higher changes are more likely to be found in outer London boroughs, such as Barking and Dagenham, Redbridge, Hillingdon and Enfield. In general this might appear to represent the suburbanisation of populations with family migration histories that involved settlement in London's inners cities in the 1960s-1970s. Some of these more suburban boroughs did not see large numbers of international migrants in 2001 but have also attracted considerable numbers of international migrants in the 2000s.

When comparing Figure 11 with Figure 5, it is interesting to see that areas with the greatest increase in churn (such as Tower Hamlets, Islington, Lambeth and Southwark) are not the areas with the greatest proportionate increase in ethnic minorities (such as Barking and Dagenham, Redbridge and Hillingdon).

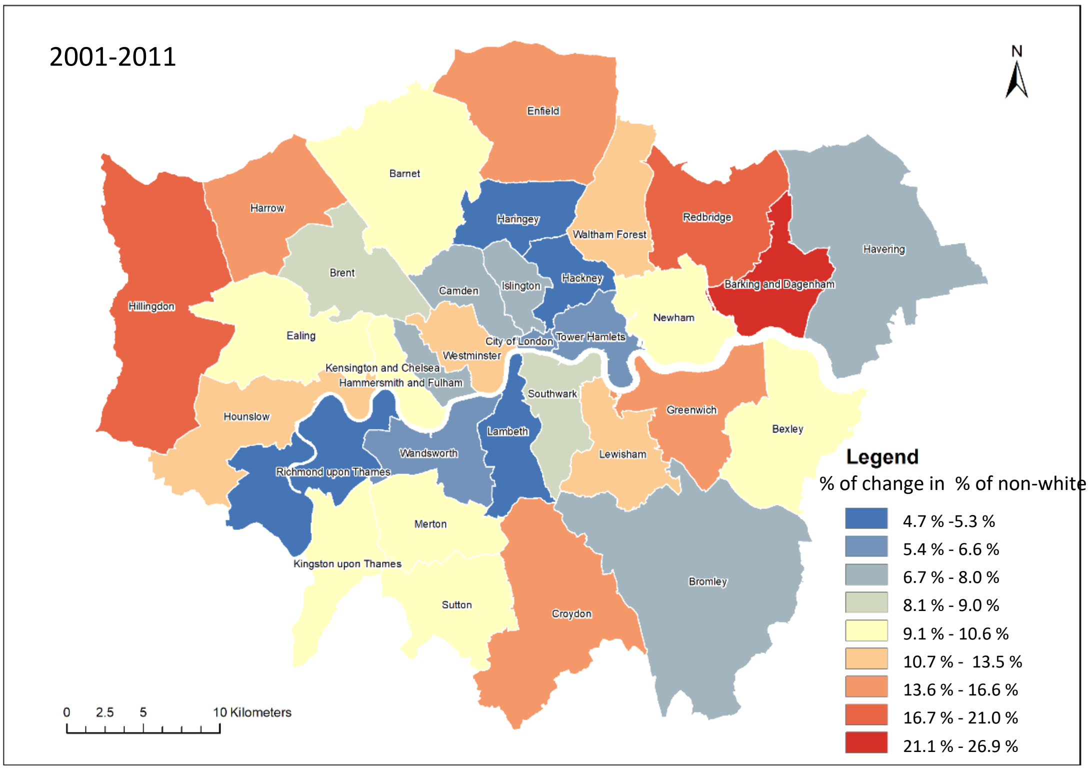


Figure 11 Change in the share of non-white population in London

Source: 2001 and 2011 Census.

Another characteristic of London's churning population is their country of birth. In the decade between the 2001 and 2011 Censuses, the UK-born population decreased by 53,500 people and as a result, the proportion of non-UK born residents in London rose from 27.14 per cent to 36.72 per cent.

Figure 12 shows how foreign-born populations were distributed across London in 2001 and 2011, respectively. In 2001, non-UK born residents were mostly concentrated in central London, particularly in Westminster, Kensington and Chelsea, and parts of Brent. In 2011, there was an increase in foreign-born citizens and an expansion of their places of residence. They were no longer confined to inner-city areas and spread out to some outer London boroughs, such as Harrow and Hounslow in the North West, and Redbridge and Barking Dagenham in the North East.

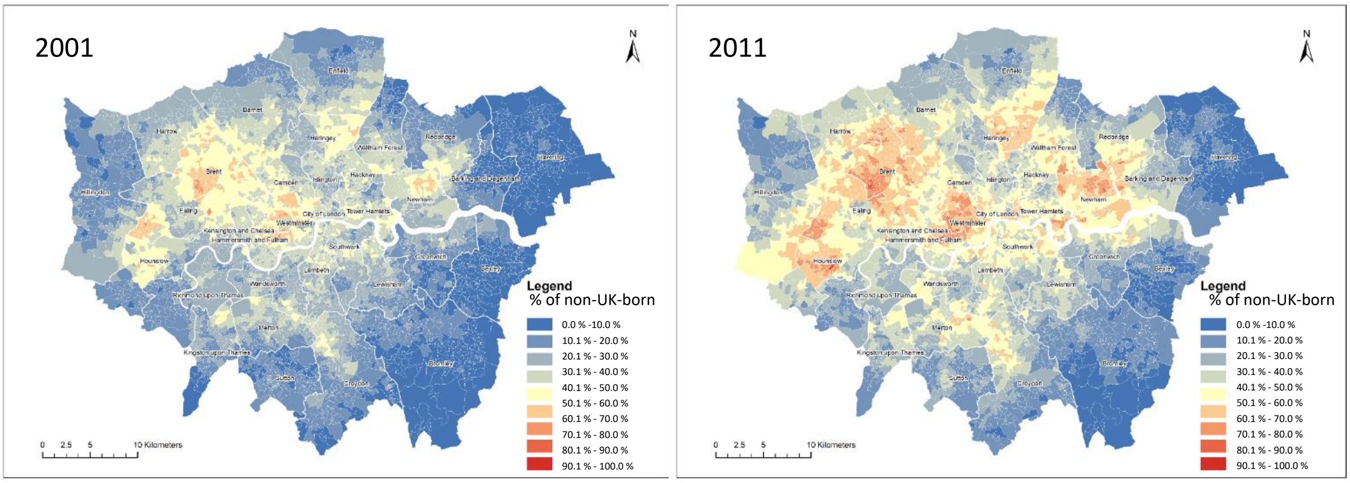
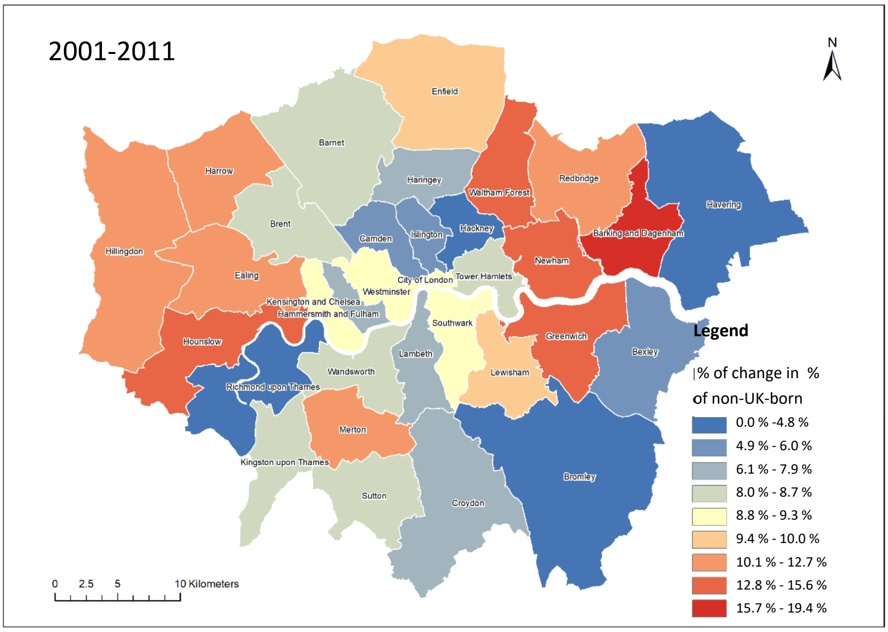


Figure 12 Distribution of the non-UK-born population in London

Source: 2001 and 2011 Census.

It is therefore not surprising to see those higher changes in the distribution of non-UK born residents were found in outer London boroughs, such as Barking and Dagenham, Newham, and Hounslow (Figure 13, top figure). Further analysis (Figure 13, bottom figure) shows that migrants from the EU countries did not account for most changes in these boroughs. This observation indicates that EU migrants did not account for most changes in the non-UK born population, at least in the popular destinations of international migrants. Instead, EU migrants accounted for most changes in Haringey and Hackney, and a large proportion of changes in Barnet, Brent, Ealing, Lambeth and Islington.



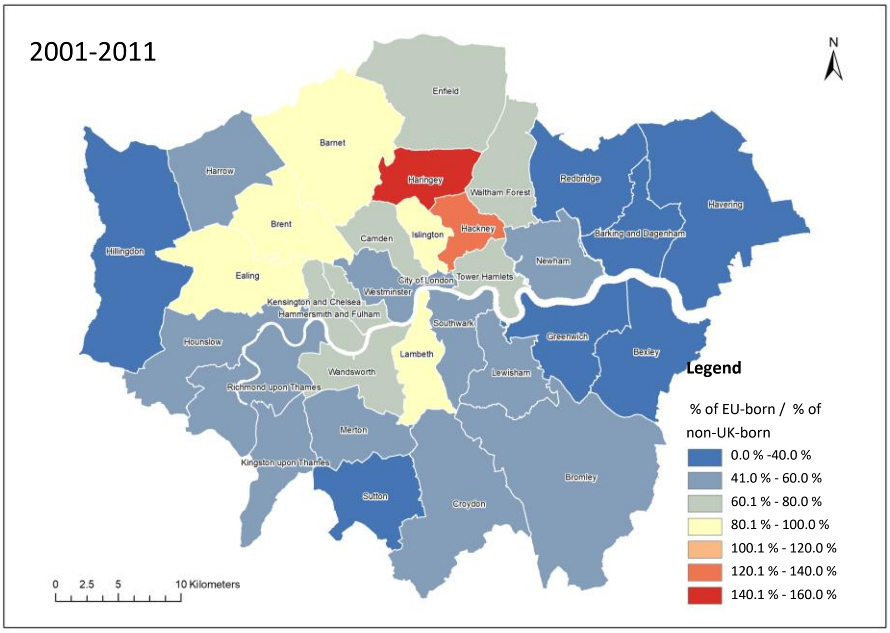


Figure 13 Change in the share of the non-UK-born population (top) and EU-born population (bottom) in London

Source: 2001 and 2011 Census.

Another effect of population movement is that migration flows have the effect of keeping London's population relatively young (Figure 14). This is because the highest inflows for both international and internal migration are found among those around 20 to 30 years old. For all other ages, net international migration has added to London's population while net internal migration has cut down London's population.

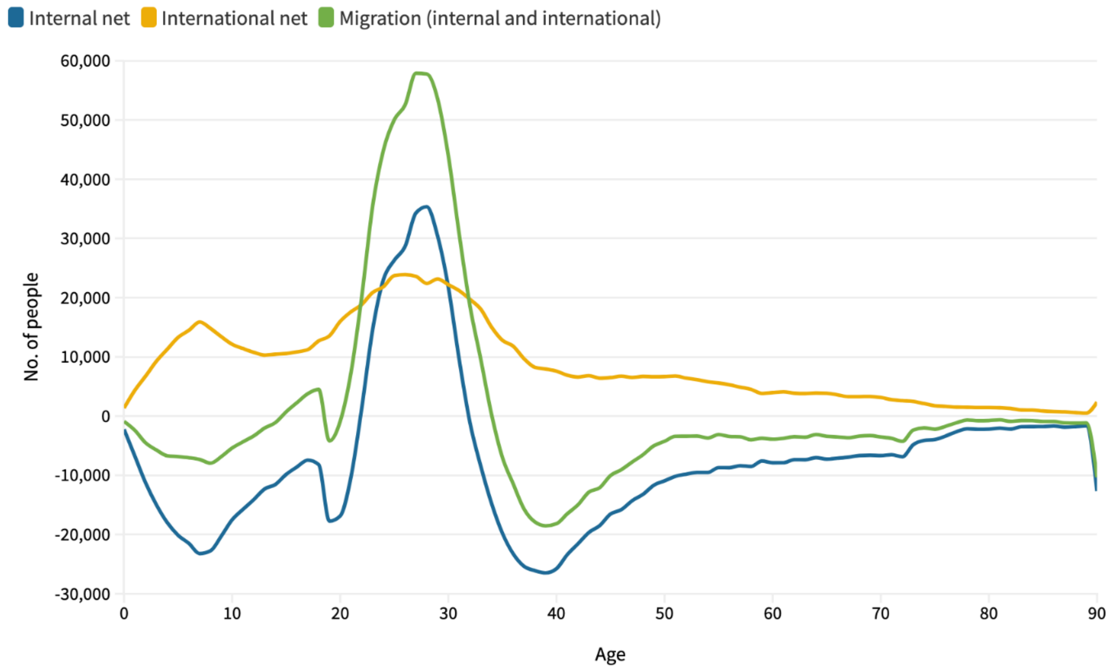


Figure 14 Churning population in London by age groups

Source: 2019 ONS population estimates.

Young migrants tend to concentrate in some parts of London. A detailed look at London boroughs (Figure 15) shows that, of all international migrants, higher proportions of juveniles and students are likely to gather in Outer London boroughs, such as Hillingdon, Kingston upon Thames and Newham.

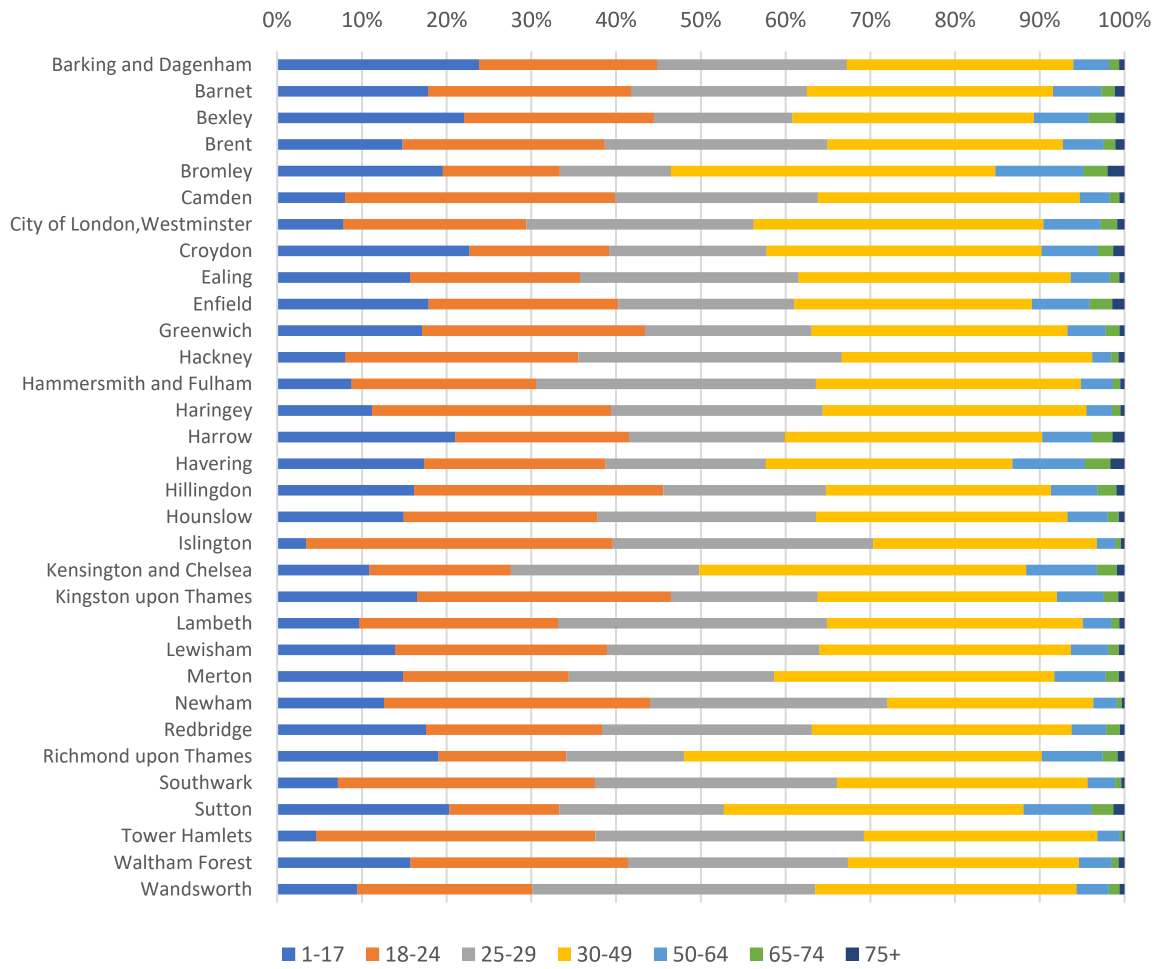


Figure 15 International inflow to London boroughs by age group

Source: 2011 Census.

We also looked at the length of time in the UK for international migrants. Figure 16 presents the areas in London that had relatively higher levels of 'newcomers' (who we define as those who spent less than 2 years in the UK) in 2011. The figure shows that while newcomers were scattered across the city, some outer London boroughs host few or almost none of them (such as Havering, Bexley, Bromley and Sutton). These boroughs are also areas with relatively lower levels of population churn.

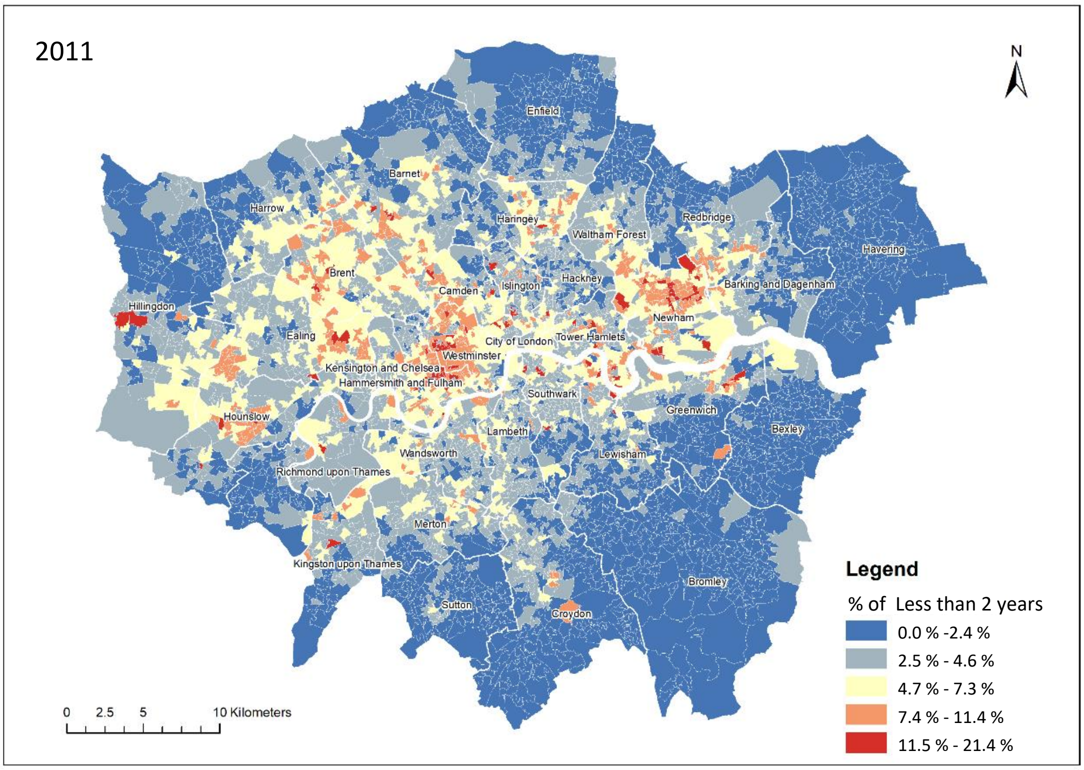


Figure 16 Distribution of new-comers (less than 2 years in the UK) in London

Source: 2011 Census.

The analysis above demonstrates that Census migration data provide snapshots of residential moves. They help analyse long term trends of and differences in population churn and turnover between areas at a point in time and are very accurate at the local level. Our analysis reveals many interesting patterns of churn and population movement in London. Among these patterns, there are two most striking ones. First, we discovered accelerated rates of change and churn across London. The 2011 Census reports significantly higher rates of churn compared to the 1981-2001 Censuses. Second, the Census-based analysis shows emerging new geographies of London. An increase in population churn has been observed in all London boroughs, but disproportionately higher levels of increase in churn have been experienced by most inner London boroughs. The rates of increase are greatest in newer areas of migration (e.g. Tower Hamlets, Islington, Lambeth and Southwark in inner London, Figure 5), rather than traditional destinations for international migrants (e.g. Barking and Dagenham, Redbridge and Hillingdon, Figure 11).

However, Census migration data are insufficient to understand the process of population change since they are only collected once every ten years (i.e. low temporal granularity). They are thus not able to reflect continuity or discontinuity of residence and do not give up-to-date information on population change. They cannot be relied upon to provide information on rapidly changing areas and/or population groups. This is especially the case when migration patterns had the greatest proportional changes since the 2011 Census. The 2011 Census does not consider groups that have arrived more recently, such as Romanians and Bulgarians, let alone the effects of Brexit and the pandemic.

Other publicly available population statistics, such as population estimates and administrative data, are also insufficient due to their low spatial granularities. They either have less detailed local-level estimates or poor-quality estimates that come with substantial margins of error. One consequence of this is that a large proportion of short-distance moves are under-documented (especially those not moving across local authority boundaries), even though these moves are the most common drivers/components of population churn[7].

Residential Mobility Index: New insights on residential Churn

The Census and most publicly available statistical sources suffer from low temporal or spatial granularities and are insufficient to understand the process of population change and migration on the ground (Lomax and Stillwell 2017). To address these gaps, new forms of data showing digital footprints of business or service delivery are repurposed to provide new insights into the rapidly changing population (Lansley et al. 2019). Here, we employ a new measure of population mobility: the Residential Mobility Index (RMI), which derives from a 'Linked Consumer Registers' dataset and captures population activities at a high spatial and temporal granularity (van Dijk and Longley 2021).

RMI and Linked Consumer Registers

Released by the Consumer Data Research Centre (CDRC), the RMI provides a household estimate of residential mobility in London, covering the period from 1997 to 2020[8]. It describes the population at large with 'big data' arising through transactions between consumers and service/good providers and administrative data from public UK electoral registers. To be more specific, datasets underlying the RMI include (CDRC, 2021)[9]:

[7] According to Dataloft Rental Market Analytics, 27 per cent of renters in the UK move less than 1 mile, and 14 per cent move within 1-2 miles. See the following link for details: https://www.dataloft.co.uk/dataloft-rental-market-analytics.

[8] Source: https://data.cdrc.ac.uk/dataset/cdrc-residential-mobility-index. The data for this research have been provided by the Consumer Data Research Centre, an ESRC Data Investment, under project ID CDRC [Project Number], ES/L011840/1; ES/L011891/1.

[9] For details on the process of how these data sources are linked, please see Lansley, Li and Longley (2019) and van Dijk, Lansley and Longley (2021).

- Public versions of electoral registers, covering the UK's adult population or nationals of an EU or Commonwealth country consent to inclusion on the Electoral Roll (both parliamentary and local government elections).
- Consumer registers[10], covering populations assenting to inclusion on the contact lists of services or goods. These include many of those who 'opt out' of the public version of electoral registers and are not eligible to vote.
- Land registry house sale data, to identify residential moves in the owner-occupied sector (for validation).

Drawing on the assemblages of the consumer and the electoral registers, the CDRC introduced the RMI as an indicator to estimate population turnover across space. The RMI is calculated based on estimating the first and last year of which a household[11] moved into and out of a property at a particular address. If not all household members joined an address in the same year, then the CDRC considers the earliest move-in date/year (Lansley et al. 2019). The estimates are further aggregated to the neighbourhood level (e.g., the LSOA level), where a yearly estimate of the proportion of households that are different to those in 2020 is calculated. This means that if 100 households were recorded in a given area in 2020, of which 90 were also there in 2016, and 85 in 2015, that area would get an RMI value of 0.10 for the year 2016, and 0.15 for the year 2015. A larger RMI denotes a higher level of residential mobility or neighbourhood turnover, or a lower level of residential stability.

RMI and Census migration data: understanding the differences

Since consumer datasets underlying the RMI are neither of known provenance nor with full population coverage, it is necessary to anchor the data to conventional data sources. Here we validate RMI with the 2011 Census, which is the only reliable source of information on local migration in the UK. Notably, the RMI is a ratio drawing on the quantitative relationship between the number of households in the base year (2020) and the number of households that remained in that area in any preceding target year. It reflects cumulative 'household difference' between the two years: the RMI of a target year takes into account all in-migration flows that happened from the target year to 2020. To make the RMI more comparable to Census migration data that measure changes in place of residence for one year, we calculated the annual RMI by subtracting the RMI of one year from the RMI of the

[10] The consumer data were originally supplied by CACI and DataTalk from 2002. Following the introduction of new GDPR regulations in 2018, they were no longer included in the RMI dataset.

[11] A 'household' is defined as a unit consisting of all residential who were estimated to be present in the same address in 2020. As such, the RMI is limited to capture residential mobility in houses in multiple occupation.

subsequent year. The new ratio generated reflects annual neighbourhood turnover in comparison to 2020.

Figure 1 (p.4) shows the comparison between components of Census-based churn rate and annual RMI. The figure suggests that the annual RMI is a limited version of the 'in-migration' component of 'churn'. The limitation could be understood in the following way: if a household moved into an area in 2018 and moved out in 2019, it would be counted as an 'in-migrating household' in the calculation of churn rate of 2018. However, this would not be included in the estimate of the annual RMI of 2018 because such a household moved out in 2019 and was longer in the study area in the baseline year of 2020.

The following figures compare annual RMI with multiple mobility rates derived from Census migration data, including churn rate, turnover rate and internal inflow rate. In general, statistical analysis demonstrates that a strong and positive correlation exists between annual RMI and internal inflow rate for the year 2011, with a correlation coefficient of 0.62 ($p<0.001$). The strong correlation suggests that, for most London boroughs, their relative levels of annual RMIs correspond to their relative levels of internal inflow.

Further analysis, as shown in Figure 17, indicates that, for most London boroughs, the absolute values of annual RMI are significantly lower than corresponding mobility rates calculated with 2011 Census data. This is not surprising given the limitations discussed above. The ratio between annual RMI and internal inflow rate is somewhere between 22.44 per cent to 50.4 per cent, with an average ratio of 35.73 per cent.

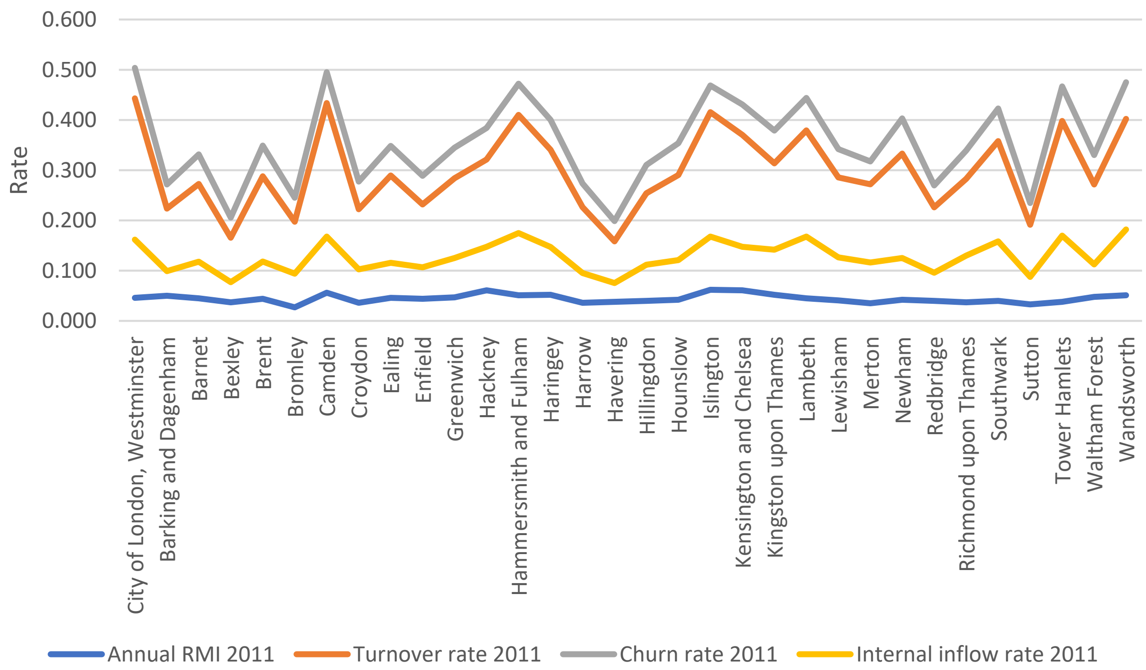


Figure 17 Comparison across annual RMI and multiple mobility rates, London boroughs, 2011 (values)

Source: CDRC Residential mobility Index (2020) and 2011 Census.

To account for the differences in measurement, we transformed the numerical values of mobility rates into rank orders, with the most residentially mobile borough ranking the highest. Figure 18 compares across multiple rankings. For most London boroughs, we found the relative levels of annual RMIs correspond to their relative levels of internal inflow. For a few boroughs, however, we observed significant differences (>10) between their annual RMI ranking and Census internal inflow rate ranking. Two boroughs – including Barking and Dagenham and Waltham Forrest, reported that their annual RMI rankings in 2011 were 'significantly higher' than the corresponding Census internal inflow rate rankings. Four boroughs reported 'significantly lower' RMI rankings, including Lambeth, Richmond upon Thames, Tower Hamlets, and Southwark.

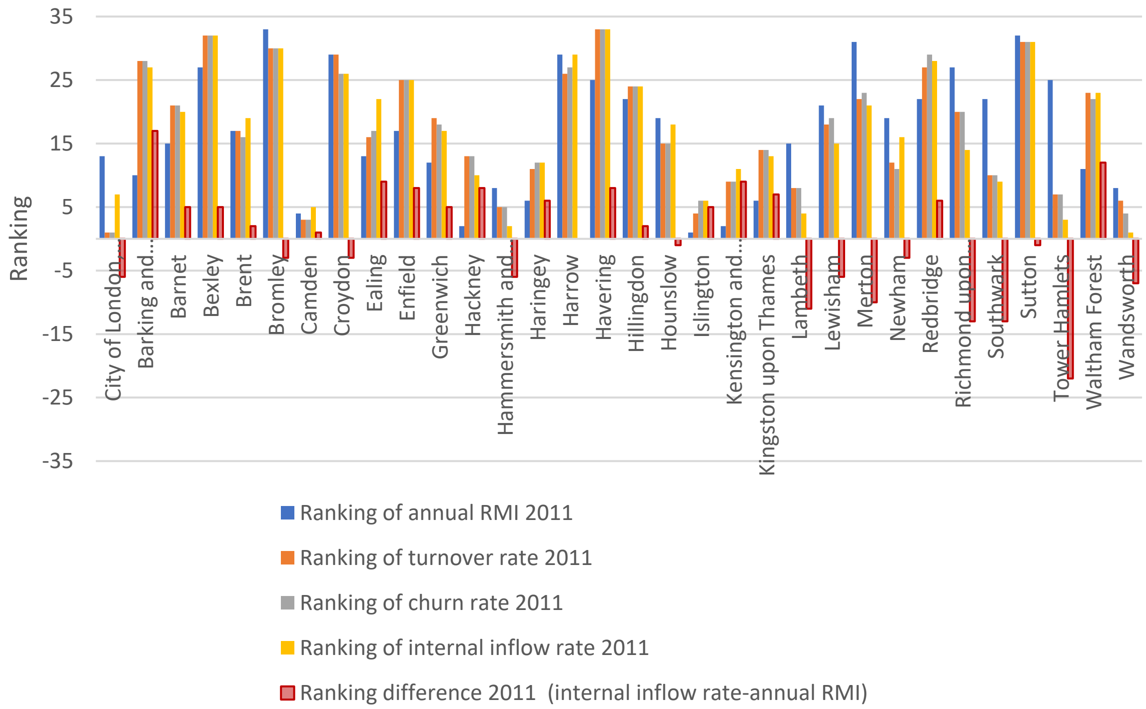


Figure 18 Comparison across rankings of annual RMI and multiple mobility rates, London boroughs, 2011

Source: CDRC Residential mobility Index (2020) and 2011 Census.

Further analysis in Figure 19 shows how differences in rankings are distributed across London boroughs. Compared to rankings of the 2011 Census migration rates, lower annual RMI rankings (i.e. negative differences, coloured in blue) were mostly reported by boroughs in Central and South London, such as Tower Hamlets, Newham, Lambeth, Southwark, Wandsworth and Richmond upon Thames. These boroughs witnessed relatively high levels of internal flow, according to the 2011 Census (see the previous discussion on p. 8). Higher annual RMI rankings (i.e. positive differences, coloured in red or amber) were mostly reported by Outer London boroughs in East and North London, such as Barking and Dagenham, Waltham Forrest and Havering. These boroughs were marked as 'low churn' with Census migration data (see the previous discussion on p. 8). These patterns indicate that RMI estimates are closer to Census estimates – both in terms of absolute values and rank orders, in areas where relatively lower levels of mobility are reported. RMI estimates tend to be less accurate where there is a relatively high level of churn.

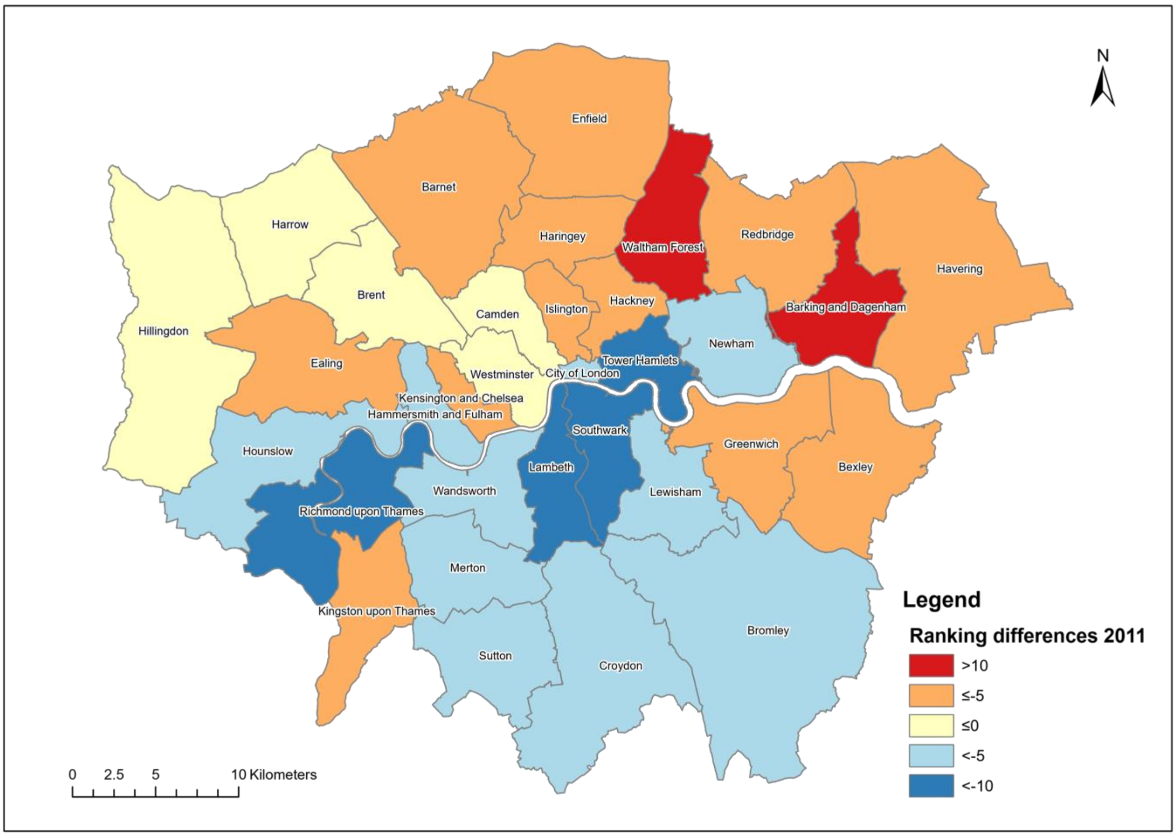


Figure 19 The distribution of ranking differences across London boroughs, 2011

Notes: Ranking difference= ranking of internal inflow rate – ranking of annual RMI. Source: CDRC Residential mobility Index (2020) and 2011 Census.

The differences between annual RMI and churn rates derived from Census migration data can be attributed to two main sources. Firstly, some of the major differences originate from the conceptual framing, relating to how RMI is defined and estimated. As discussed earlier, the RMI measures change in the number of households and reflects neighbourhood turnover occurring between the two years. This focus makes the RMI distinctive from the

Census that collects information on individual migratory behaviours. When estimating RMI, the CDRC uses a 'household' as the unit of analysis and aggregates migration/turnover patterns onto the LSOA or district level. This is different from the Census that uses 'individual' as the unit of analysis. More importantly, the RMI estimate does not consider migratory behaviours, not altering quantitative relations between the number of households in 2020 and preceding years, such as out-migration and within-area movement. This contributes to a significant proportion of the mismatch between the two data sources. Notably, the mismatch is cumulative: the longer the period between the target year and 2020, the larger the differences are likely to be between annual RMI estimates and Census estimates. This partly explains why we did not find a statistically significant relationship between annual RMI 2001 and 2001 Census migration rate ($r=0.04$, $p>0.05$).

The second source of difference relates to biases associated with the two registers underlying the RMI. Since neither electoral nor consumer data are collected for research purposes, both registers lack strict quality controls and scientific sampling frameworks. There are some widely acknowledged limitations of the two registers[12]. Apart from those who opt out of public versions of electoral registers, the electoral register is known to sufficiently under-represent the younger age groups, the non-white British population, recent movers, and those in rented accommodation (Electoral Commission, 2019). Past research has also suggested that the earlier consumer registers (2003-12) tended to under-represent the adult population relative to mid-year population estimates, and the recent consumer registers (from 2013-17) tended to overrepresent the number of adults living in the UK (CDRC 2021). These limitations make it difficult or even impossible to reconcile the differences between the RMI and Census data.

To summarise, the comparison demonstrates the strong correspondence between RMI 2011 and migration data from the 2011 Census, indicating tentatively that the RMI has the potential to fill in some of the gaps left by currently publicly available data and supplement conventional population statistics. The combination of multiple data sources at the address level enables the RMI to capture changing patterns of residential mobility in London at a high spatial and temporal granularity (van Dijk and Longley 2021). On the one hand, the RMI provides a longitudinal profile of households/adult residents of domestic properties. As a set of time-series data, the RMI is able to reflect the (dis)continuity of residence at a high temporal granularity, allowing us to monitor changes in patterns of internal migration over the past decades (e.g. between the 2011 and the 2021 Census), a period in which London

[12] For detailed discussions on population counts and distribution of data sources underlying RMI and official population statistics, including the UK Census (2011) and the ONS mid-year population estimates (2012-2019), please see van Dijk and Longley (2021).

experienced rapid population growth, as well as rapid recessions. The analysis will provide us with additional insights into temporal changes in internal migration propensities that fail to be captured by the Censuses that take place only every ten years (Lansley et al. 2019; Lomax and Stillwell 2017).

On the other hand, the RMI is a valuable source of data covering inter-censual periods when detailed pictures of the population were hardly available from conventional statistics at small geographies (e.g. sub-borough levels). Drawing on the linkage of public electoral and consumer registers grounded at the level of address/household, the RMI provide 'highly granular inventories' (Lansley et al. 2019:1587) of local populations and their movement. This is especially the case for the last decade when conventional population projections suffered from non-neglectable errors in assumptions of migration, which became an issue of increasing concern for neighbourhoods in London during and after Covid-19 (O'Connor and Portes 2021; ONS 2021).

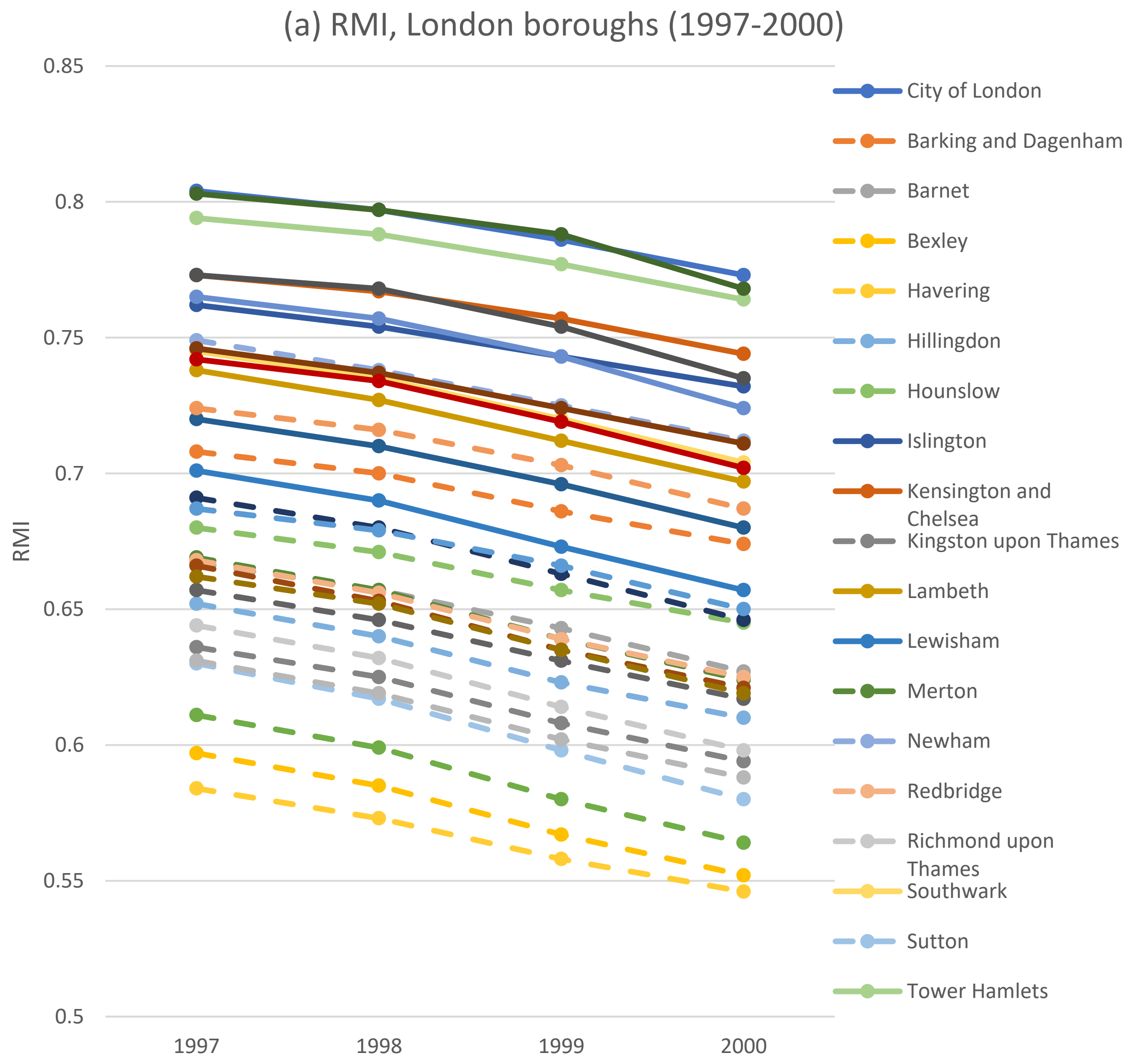
However, one shall remain cautious when interpreting RMI results due to three limitations of RMI. Apart from systematic biases associated with the Linked Consumer Registers, RMI 2001 appears to be a poor surrogate of the 2001 Census migration rates. In addition, differences in the mobility ranking are significant for some boroughs, calling for further investigations into the quality of RMI and consumer data files.

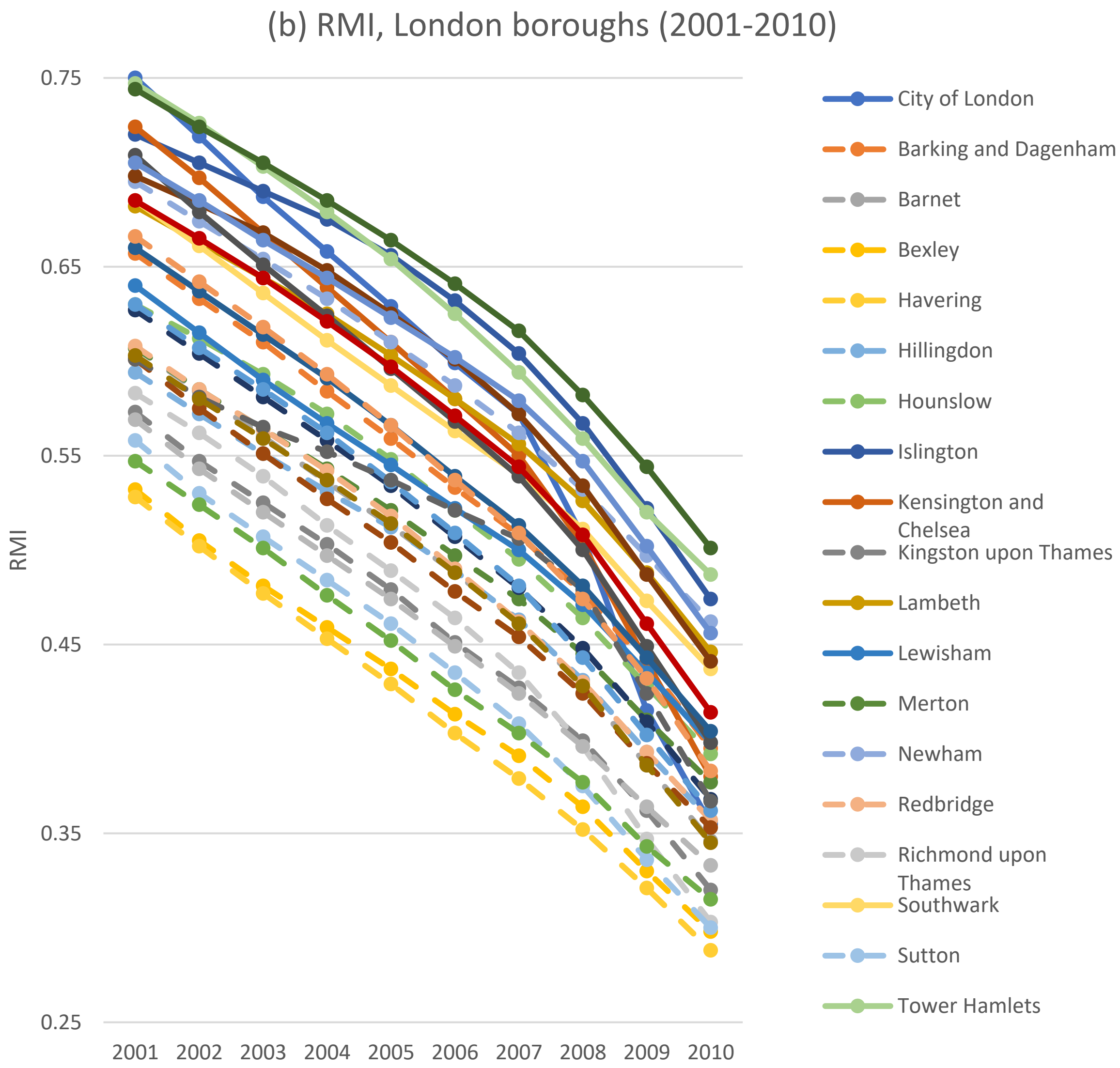
London's churning population: New insights from the Residential Mobility Index

In this section, we present RMI-based analysis, demonstrating how RMI provides new insight for understanding London's churning population. The RMI, as a set of time-series data, allows us to monitor changes in patterns of internal migration over the past two decades.

Longitudinal trends

The general trends of RMI across London boroughs from 2011 to 2019 is presented in Figure 20, providing us with additional insights into temporal change in internal migration propensities that fail to be captured by the decennial Censuses. Inner London boroughs are presented in solid lines and outer London boroughs in dash lines.


(a) RMI, London boroughs (1997-2000)
RMI
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
1997
1998
1999
2000
City of London
Barking and Dagenham
Barnet
Bexley
Havering
Hillingdon
Hounslow
Islington
Kensington and Chelsea
Kingston upon Thames
Lambeth
Lewisham
Merton
Newham
Redbridge
Richmond upon Thames
Southwark
Sutton
Tower Hamlets


(b) RMI, London boroughs (2001-2010)
0.75
0.65
0.55
0.45
0.35
0.25
RMI
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
City of London
Barking and Dagenham
Barnet
Bexley
Havering
Hillingdon
Hounslow
Islington
Kensington and Chelsea
Kingston upon Thames
Lambeth
Lewisham
Merton
Newham
Redbridge
Richmond upon Thames
Southwark
Sutton
Tower Hamlets

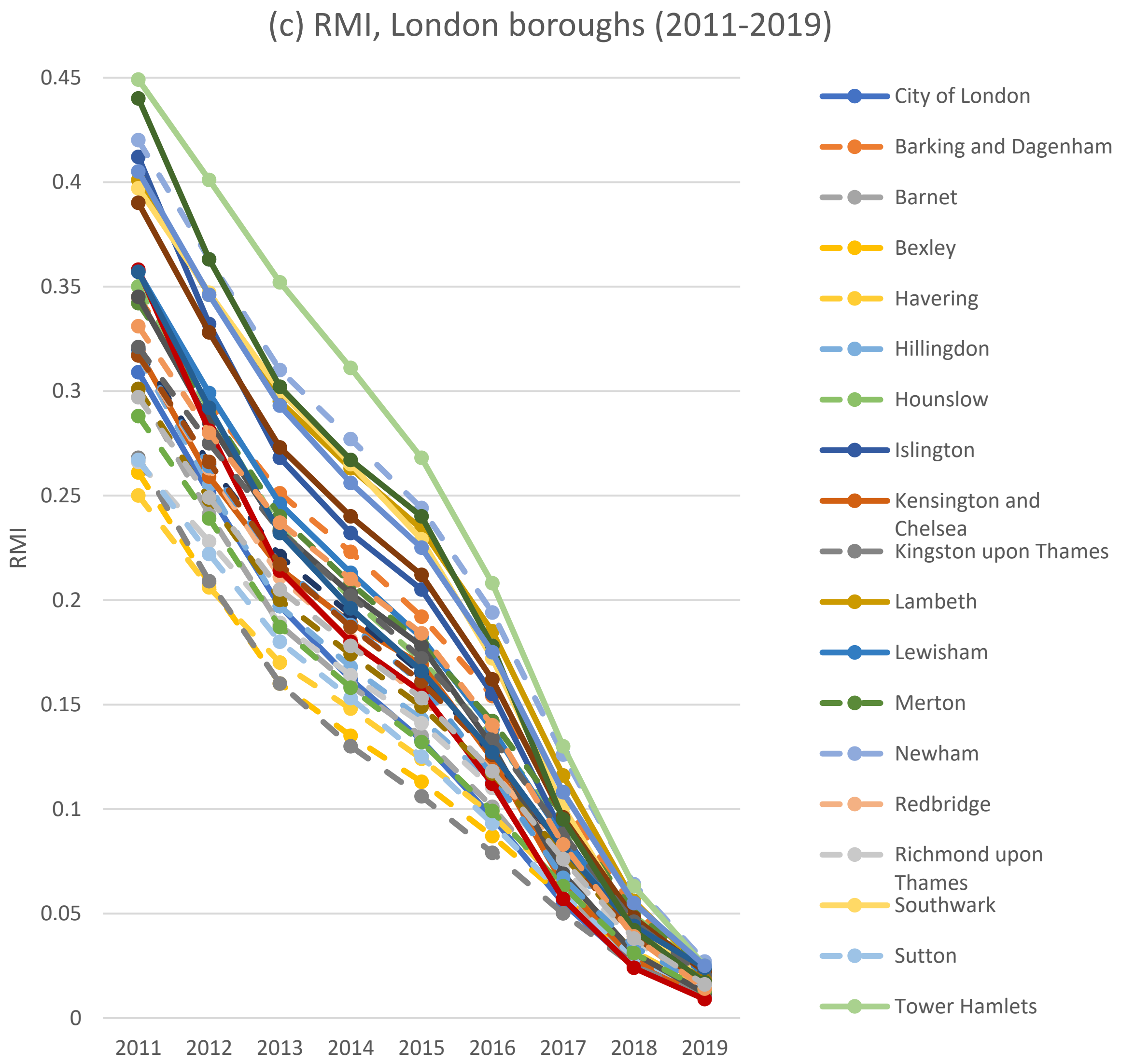


Figure 20 Residential Mobility Index of London boroughs, 1997-2019 (values)

Notes: an interactive version of RMI (1997-2019) can be found at https://app.flourish.studio/visualisation/7012934. Source: CDRC Residential mobility Index (2020).

To improve interpretability, we transformed the numerical values of RMI into rank orders, with the most residentially mobile borough ranking the highest. The RMI rankings of London boroughs are presented in Figure 21.

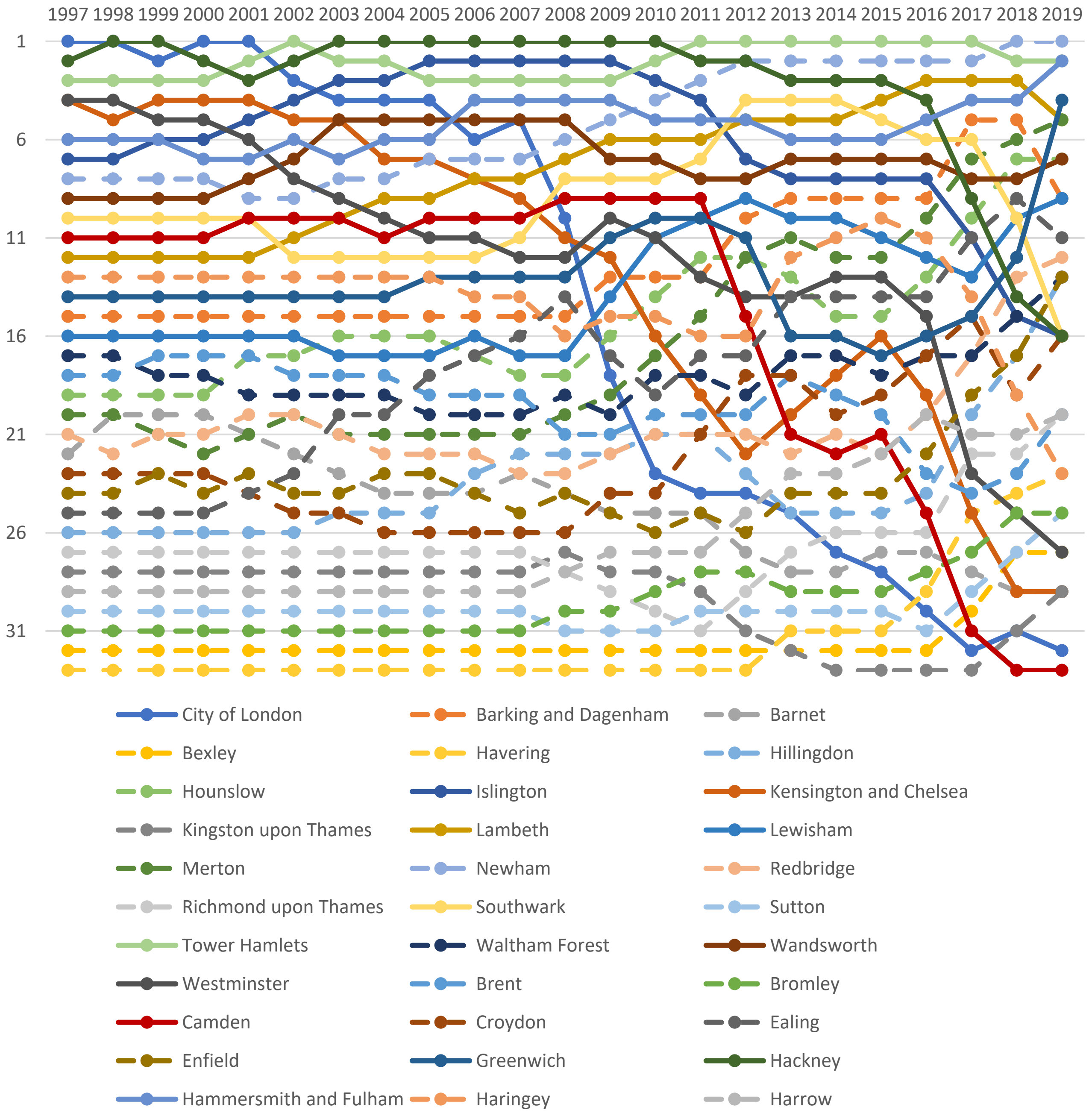


Figure 21 Rankings of Residential Mobility Index of London boroughs, 1997-2019

Notes: an interactive version can be found at https://app.flourish.studio/visualisation/7012934. Source: CDRC Residential mobility Index (2020).

According to Figure 20 (a) and (b), most inner London boroughs generally reported higher levels of RMI than outer London boroughs in the late 1990s and 2000s. This indicates, compared to their counterparts, more households in the central part of the capital were on the move and they no longer remained in the same borough in 2020.

2008-2010 appeared to be a turning point for most London boroughs. Figure 20 (b) and Figure 21 reveal the sharp difference between central London boroughs and other Inner London boroughs. Central London boroughs, such as Kensington and Chelsea and the City of London, witnessed a sharp decline in residential mobility and became more residentially stable after the global financial crisis. On the contrary, other Inner London boroughs, especially boroughs in South London, have seen a rise in the number of mobile households since the 2010s, such as Greenwich and Lewisham.

2015-2018 appeared to be another key moment for most London boroughs. As the RMI reflects in-migration, the figure suggests that most London boroughs became less attractive to immigrants after the EU referendum. This is demonstrated by the downward trends in residential mobility experienced by, for instance, Camden, Kensington and Chelsea and Haringey (Figure 21).

London boroughs' multiple mobility trajectories: an RMI-based typology

Drawing on RMI rankings, we carried out cluster analysis to explore whether and how these boroughs, each with a specific mobility trajectory, can be clustered into distinct groups that share similar mobility trajectories. This was completed with optimal matching, which generated a 'distance' matrix that records the smallest number of operations needed to match one trajectory with the other (the Levenshtein distance). We then applied this matrix in hierarchical clustering using Ward's Linkage.

Following the evaluation of diagnostics[13], we classified the 33 London boroughs into six clusters, each of which shares common characteristics over time. The six-cluster typology was created in two steps. Firstly, we classified London boroughs into three groups according to their initial RMI rankings in 1997:

- Boroughs ranked top 10 were named as boroughs with 'higher mobility',
- Boroughs occupied 11th-19th places were named as boroughs with 'mediumish mobility', and
- Others were named as boroughs with 'lower mobility'.

In the second step, we evaluated how RMI rankings changed over time, and identified four types of changes:

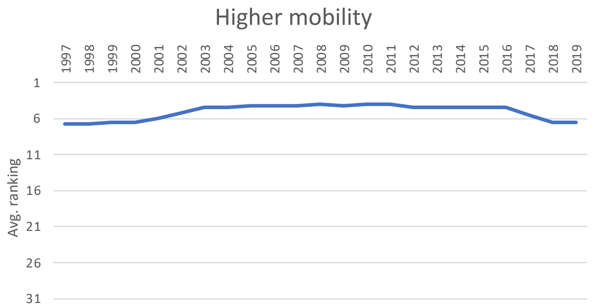
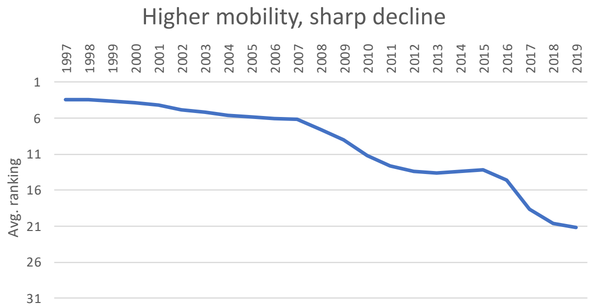
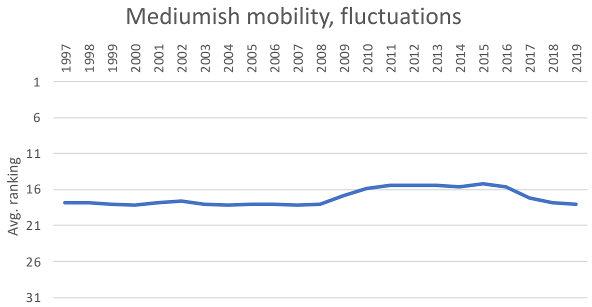
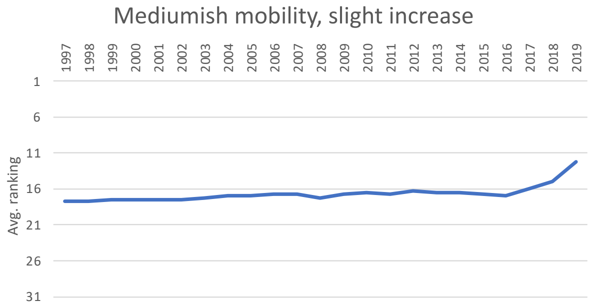
- Sharp increase (+10 change in average ranking)
- Sharp decrease (-10 change in average ranking),
- Slight increase (+5 - +9 change in average ranking), and

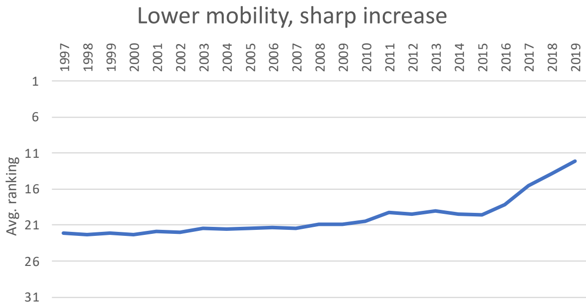
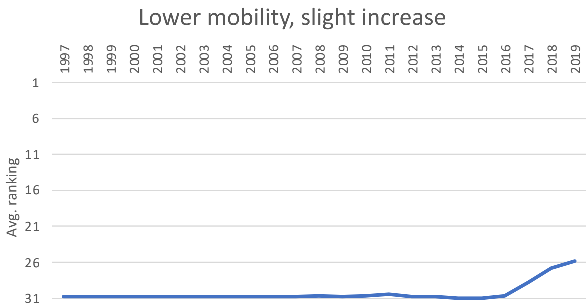
[13] A full version of the dendrogram, please see Appendices Figure A-1.

- Relative stability or fluctuation (change in avg. ranking between -5 and 5, or a mixture of positive and negative changes).

The results of this six-cluster typology and the distribution of clusters are presented in Table 1 and Figure 22, respectively.

Table 1 RMI clusters and their characteristics

Cluster no.	Main characteristics	Mobility trajectory (by avg. ranking)	Borough names
1	Higher mobility, relative stable		Islington, Newham, Tower Hamlets, Wandsworth
2	Higher mobility with a sharp decline		City of London, Hackney, Hammersmith and Fulham, Kensington and Chelsea, Westminster
3	Mediumish mobility with fluctuations		Camden, Haringey, Harrow, Lewisham, Merton
4	Mediumish mobility with a slight increase		Barking and Dagenham, Barnet, Brent, Greenwich, Lambeth, Richmond upon Thames, Southwark

5	Lower mobility with a sharp increase		Croydon, Ealing, Enfield, Hillingdon, Hounslow, Redbridge, Waltham Forest
6	Lower mobility with a slight increase		Bexley, Bromley, Havering, Kingston upon Thames, Sutton

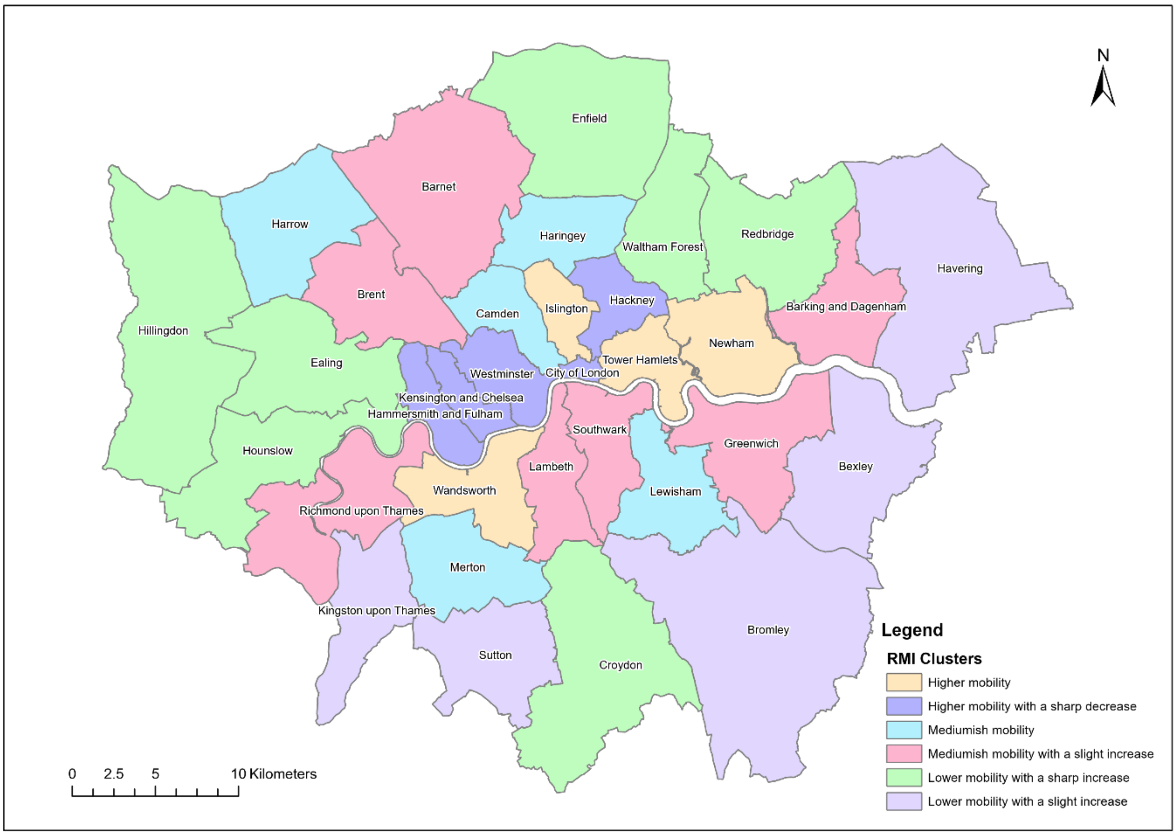


Figure 22 London boroughs coloured by RMI clusters

Source: CDRC Residential mobility Index (2020).

Cluster one: Higher mobility, relative stable

The first cluster, consisting of three Inner London boroughs (Islington, Tower Hamlets and Wandsworth) and one Outer London borough (Newham), has reported relatively higher RMI rankings over the past two decades. These boroughs all underwent large-scale urban (re)development and witnessed high levels of population churn in recent years, as reflected by the steady increase in their RMI rankings (Figure 23). Their relatively high levels of residential mobility have remained stable during the past two decades (the only exception is Islington). Unlike other central London boroughs (see discussion in cluster two), these boroughs were less influenced by the decline in mobility associated with the financial crisis and the EU referendum. Instead, two boroughs in this cluster – Newham and Tower Hamlets – reported the highest levels of residential mobility in 2019.

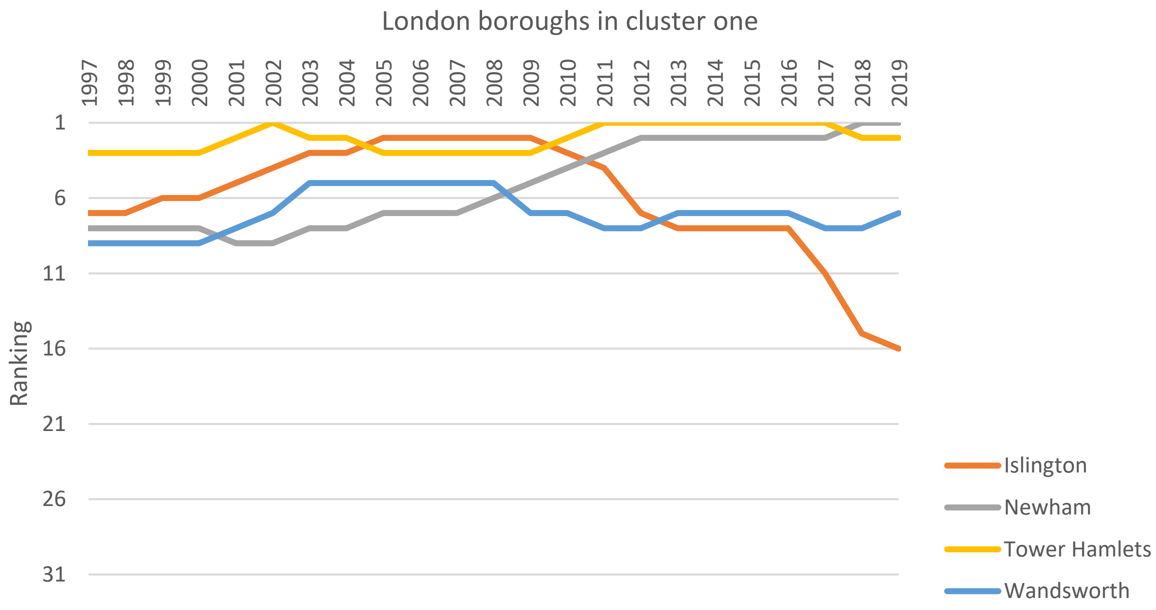


Figure 23 RMI rankings of boroughs in cluster one, 1997-2019

Source: CDRC Residential mobility Index (2020).

Cluster two: Higher mobility, a sharp decline

The second cluster has been termed as 'higher mobility with sharp decline' to describe the significant decline in residential mobility boroughs in this cluster have experienced during the past two decades. This cluster includes five central London boroughs: Hackney, Hammersmith and Fulham, Kensington and Chelsea, Westminster, and the City of London (Figure 22). Figure 24 presents evidence of heightened mobility of these boroughs in the late 1990s and early 2000s – they were all ranked among the top 6 boroughs with the highest RMI. Since the late 2000s, they have experienced two sharp declines in residential mobility. The first decline happened after the 2008 financial crisis, and the second took place after the 2016 EU referendum – as reflected by the steep decline in their RMI rankings

(Figure 24). The only exception is Hammersmith and Fulham. It has a relatively mobile population, and its RMI has been increasing since 2016.

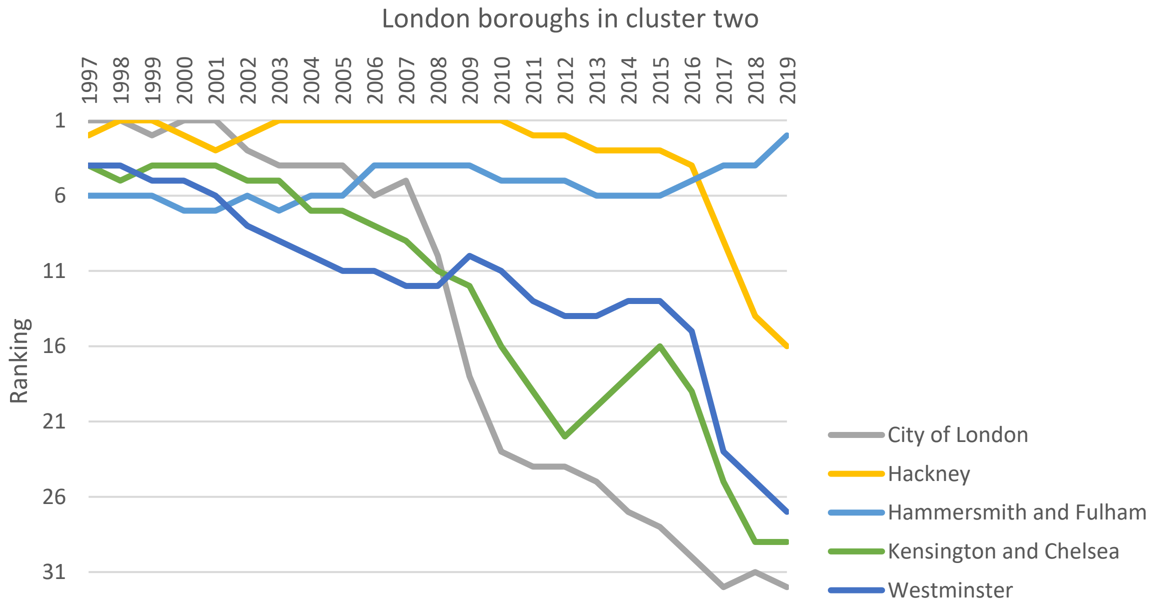


Figure 24 RMI rankings of boroughs in cluster two, 1997-2019

Source: CDRC Residential mobility Index (2020).

Cluster three: Mediumish mobility, fluctuations

The third cluster to emerge from London boroughs is titled 'mediumish mobility with fluctuations'. It contains two boroughs from Inner London (Camden and Lewisham) and three from Outer London (Haringey, Harrow and Merton) (Figure 22). These boroughs reported relatively medium levels of residential mobility before 2008 and were ranked between the 10th and 30th amongst all London boroughs in terms of RMI (Figure 25). Since 2008, mobility trajectories have begun to diverge: Lewisham, Merton and Harrow reported increasing numbers of households that have moved home and no longer remained in the borough by the end of 2020. In the meantime, however, the mobility rates of Camden and Haringey have generally decreased. In Camden, the steep decrease in residential mobility started as early as 2011. Its mobility rate has continued to decline after a short revival in 2014/15 – which shares some similarities with central London boroughs in cluster two. In Haringey, the relative decline in residential mobility happened much later; its mobility rate started to drop in 2016 after the EU Referendum.

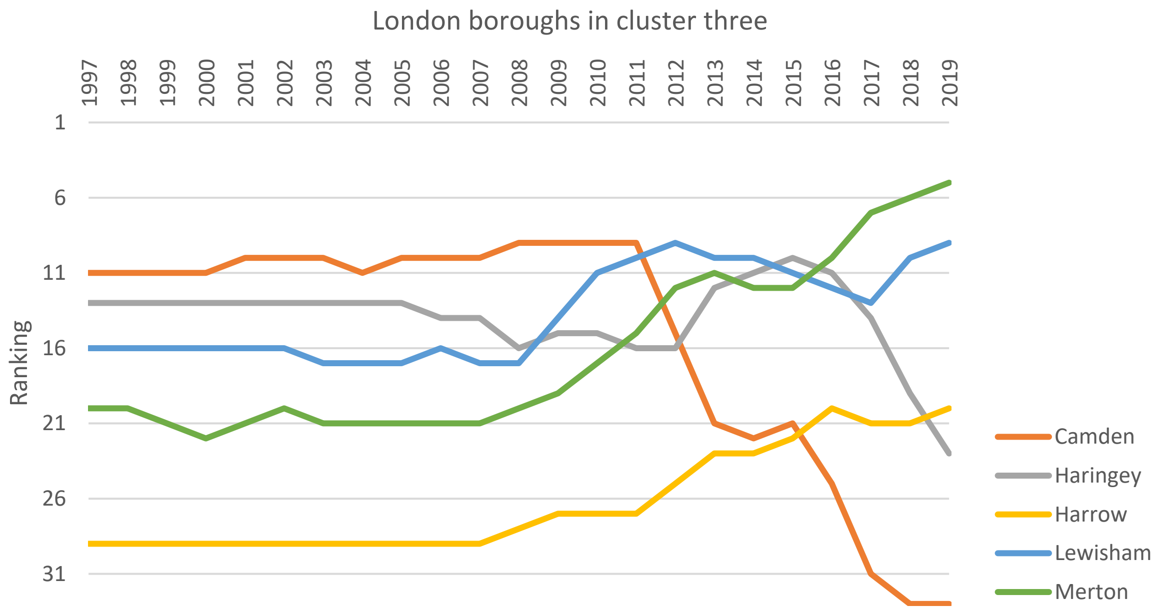


Figure 25 RMI rankings of boroughs in cluster three, 1997-2019

Source: CDRC Residential mobility Index (2020).

Cluster four: Mediumish mobility, a slight increase

Boroughs in cluster four, including three from Inner London (Greenwich, Lambeth and Southwark) and four from Outer London (Barking and Dagenham, Barnet, Brent, and Richmond upon Thames), reported general upward trends in their RMI rankings (except Barnet,). This is especially the case for the three Inner London boroughs. They experienced steady increases in the relative proportion of mobile population/households after the 2008 financial crisis (Figure 26), when most Inner London boroughs became more residentially stable – as discussed in clusters two and three. The second turning point – the 2016 EU referendum – played different roles for different boroughs in cluster four. For some boroughs, there has been a sharp decrease in residential mobility since 2016-17, such as Southwark, Lambeth and Barking and Dagenham. For other boroughs, however, a rise in mobility was observed, especially in Greenwich.

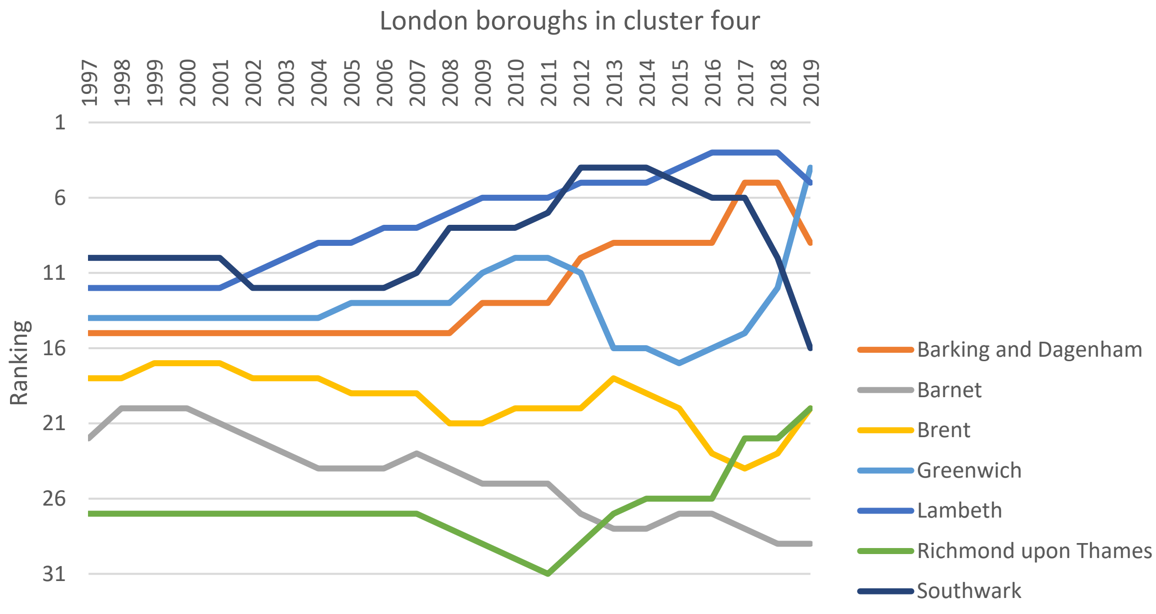


Figure 26 RMI rankings of boroughs in cluster four, 1997-2019

Source: CDRC Residential mobility Index (2020).

Cluster five: Lower mobility, a sharp increase

Cluster five consists of seven Outer London boroughs, including Croydon, Ealing, Enfield, Hillingdon, Hounslow, Redbridge, and Waltham Forest, most of which are in North London (the only exception is Croydon). These boroughs have very similar mobility trajectories, which are characterised by relatively lower levels of residential mobility in the late 1990s and early 2000s, followed by the first wave of increase in the late 2000s, and the second wave of increase in the late 2010s (Figure 27). The two waves of increase in the RMI made boroughs in cluster five distinctive from other boroughs whose mobility rates were negatively influenced by the financial crisis and/or the EU referendum (e.g. boroughs in cluster two).

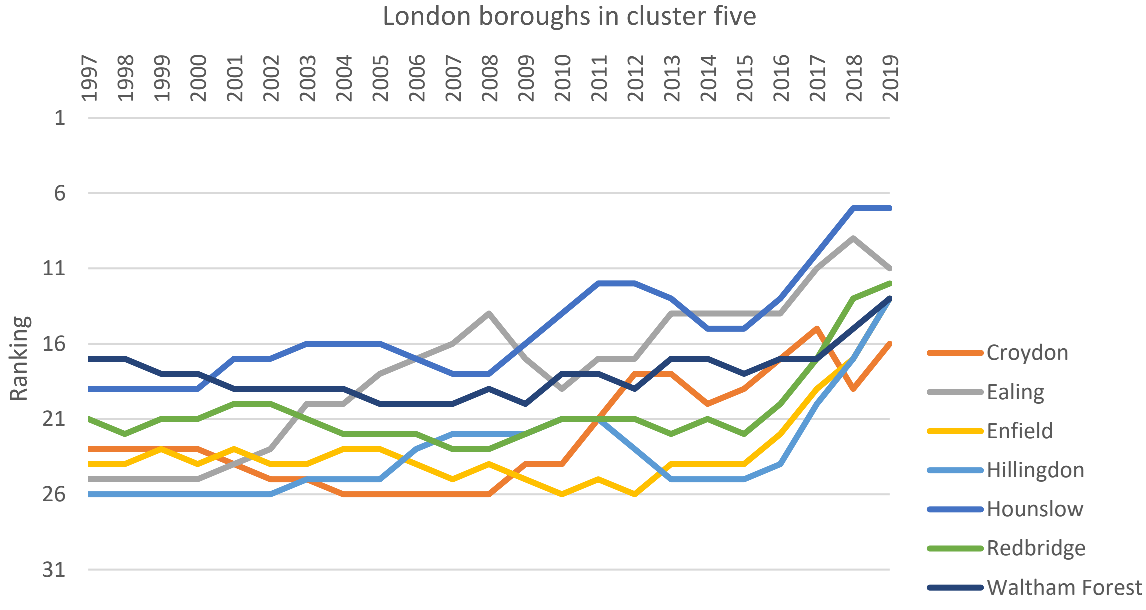


Figure 27 RMI rankings of boroughs in cluster five, 1997-2019

Source: CDRC Residential mobility Index (2020).

Cluster six: Lower mobility, a slight increase

The other five Outer London boroughs are organised in cluster six, including Bexley, Bromley, Havering, Kingston upon Thames, and Sutton. Although boroughs within this cluster also reported slight increases in residential mobility – particularly in the late 2010s, they are differentiated from those in cluster five by experiencing constantly low levels of residential movement (Figure 28).

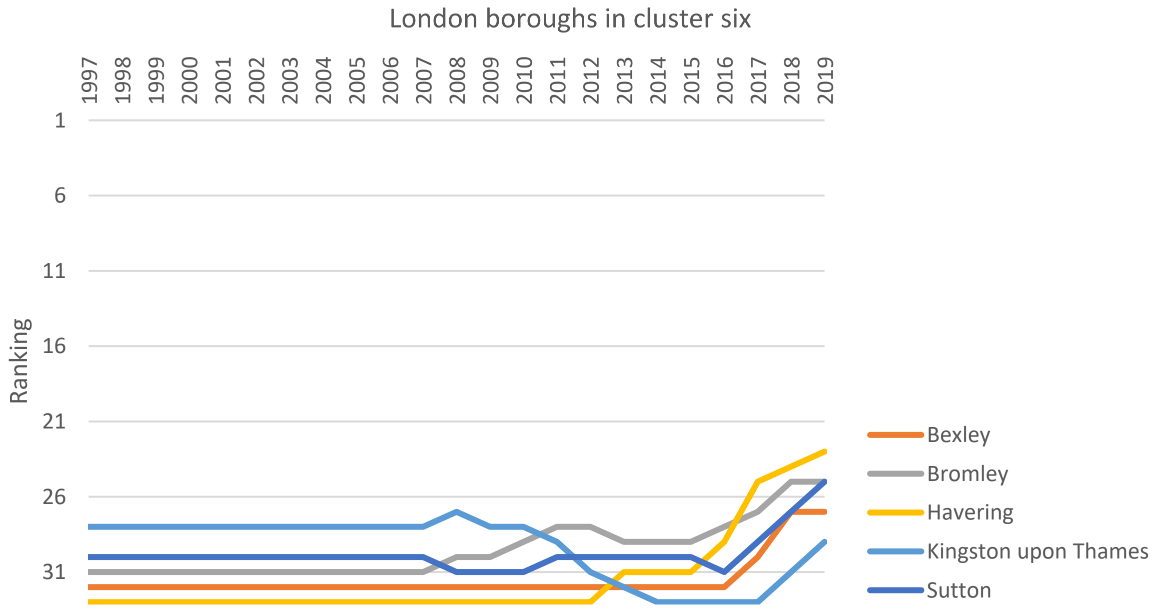


Figure 28 RMI rankings of boroughs in cluster six, 1997-2019

Source: CDRC Residential mobility Index (2020).

RMI at the Lower Super Output Area (LSOA) level

The London Borough is still a scale that is too coarse to understand in full mobility patterns on the ground. Figure 29 below shows the distribution of households that moved houses across more granular LSOA boundaries between each target year and the end of 2020. The RMI values are presented for London LSOAs at five time points: 2011, 2013, 2015, 2017 and 2019. The green colour means an LSOA has a relatively high level of residential mobility (e.g. fewer households have stayed until the end of 2020), compared to the average level of residential mobility in London. The brown colour indicates an LSOA has a relatively low level of residential mobility or more stable households.

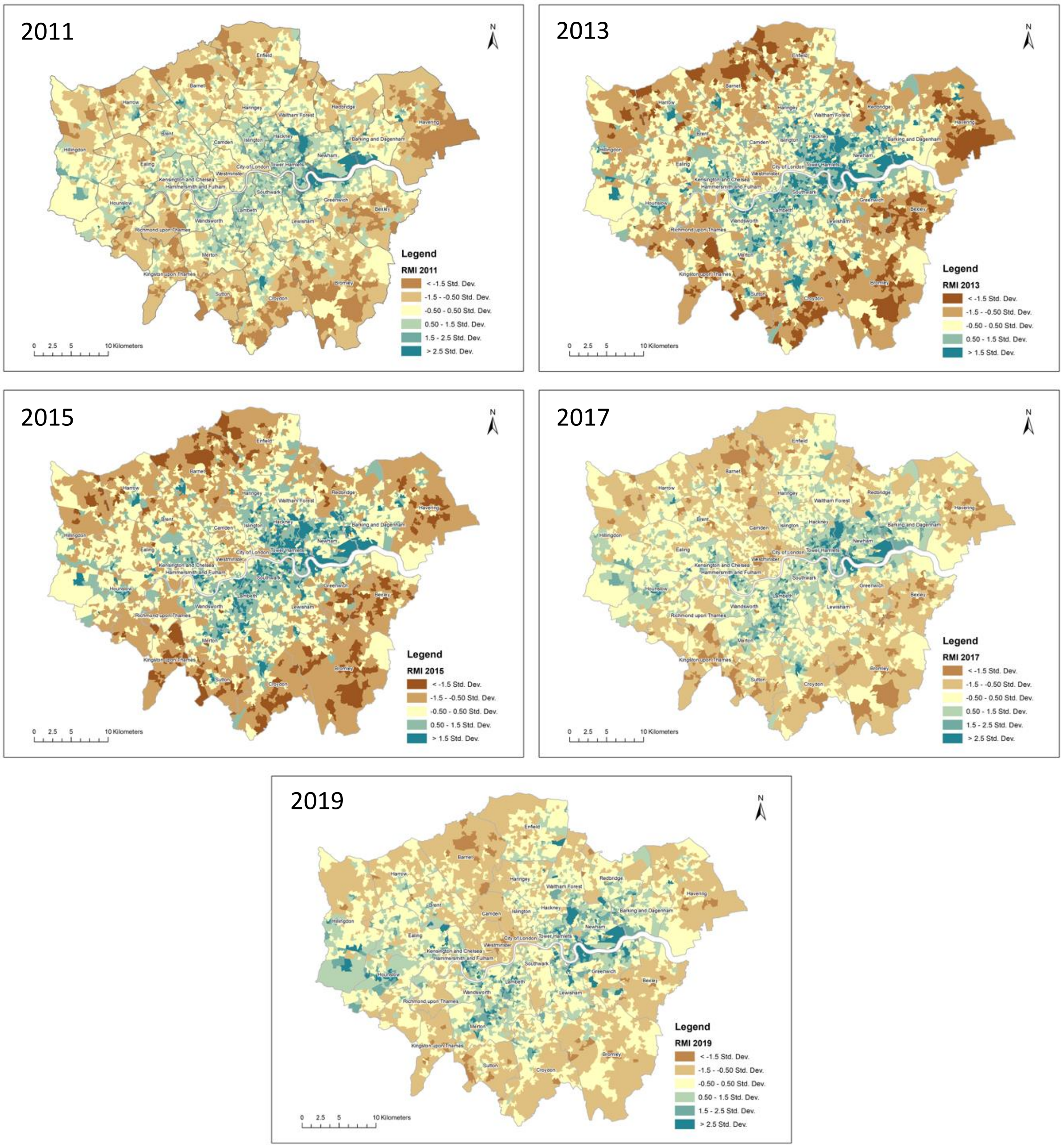


Figure 29 Residential Mobility Index, London LSOAs (by standard deviation)

Source: CDRC Residential mobility Index (2020).

In general, residentially mobile neighbourhoods were mostly found in Inner London, such as those in Westminster and southern parts of Hackney, Islington, and Tower Hamlets. Such patterns also 'spilt over' to some adjacent Outer London boroughs, such as neighbourhoods in south-western and north-western Newham. Residentially stable neighbourhoods were distributed widely in the outer suburbs, such as Havering, Bexley, Bromley and Sutton.

When we compare the five figures, what can be clearly seen from Figure 29 is that magnificent changes in residential churn took place across central London boroughs between 2015-17, especially in Camden, Westminster and Kensington and Chelsea. In the meantime, some new 'hotspots' of residential churn emerged in outer London in the late 2010s, such as neighbourhoods in north-eastern Merton and central Hounslow.

RMI and London's housing market: an exploration

Existing research in the UK has identified a variety of personal characteristics that influence mobility propensities, such as age (Bailey and Livingston 2007), life events (such as childbirth, union formation and dissolution) (Boterman 2012), and socio-cultural preferences (Musterd et al. 2016). Place characteristics, which are also believed to play equally, if not less, significant roles in shaping mobility patterns (Lomax and Stillwell 2017), have received less attention. In this section, we focus on local housing market statistics and examine their relationships with churn rates. By doing so, we aim to answer some key questions around population churn and gentrification, such as are people on the lower rank of the income scale more likely to move (likely to be gentrification-related churn) or is this not necessarily the case (likely to be migration-related churn)? These questions will be explored from a spatiotemporal perspective, in which we analyse and visualise the spatially and temporally varying relationships between churn rates and housing statistics.

The remaining part of this section is divided into two parts. In the first part, we focus on the borough level, employing longitudinal regression models to explore whether and how London's residential mobility can be explained by the characteristics of its housing market. In the second part, we delve deeper into the LSOA level. We adopted Geographically Weighted Regression (GWR) models to explore how the relationship between housing price and mobility varies across space and time in London.

London housing market statistics

The stock of housing in London includes private and social housing. The former group contains privately owned and occupied properties (51.5 per cent), as well as privately rented accommodation (26.7 per cent), and the latter group (22.7 per cent) consists of accommodations rented by local authorities and private registered providers (PRP)[14]. Properties sold at a discount to the market level, such as properties sold under the Right to Buy scheme, are also included in these statistics. For each tenure type, count of sales/rents and prices paid are recorded for each borough from 2015 to 2019[15], generating the following sets of variables:

- *Count of annual residential property sales and their median price*, including those of existing and newly built properties. These variables are derived from the house price

[14] Household tenure in 2019. Source: GLA, 2020, Housing in London 2020.

[15] Count of sale and average median housing prices are available for every LSOA from 1996 to 2020.

statistics for small areas (HPSSAs) published by HM Land Registry[16] and are available at both borough and LSOA levels.

- *Count of annual private rents and their median monthly rents*. These borough level variables originate from ONS private rental market summary statistics[17], calculated using data from the Valuation Office Agency.
- *Count of total Local authority dwelling sales/transfers*. This borough level variable is derived from Local Authority Housing Statistics (LAHS) released by the Ministry of Housing, Communities & Local Government (MHCLG)[18]. We also calculated *the mean price paid for LA dwellings* by dividing the sum of selling price by total LA dwelling sales. NB: no median price for LA sales is currently available.
- *Count of LA dwellings let and monthly rents*. The first variable originates from LAHS and is the calculated total for lettings of local authority-owned dwellings, including dwellings let to new tenants, to existing tenants and through mutual exchange. The second variable is calculated from Local authority average weekly (social and affordable) rents data published by the MHCLG[19]. These variables are available at the borough level.
- *Private registered providers (PRP) dwelling stock and monthly rents*. Both variables are calculated from housing data released by the MHCLG: the first variable from dwelling stock and tenure data[20] and the second variable from PRP average weekly rents data[21]. These variables are available at the borough level.

Figure 30 presents an overview of patterns and trends of London's housing stock. The figure suggests that, in the private sector, the housing stock has kept growing during the past 11 years (2009-2019) and annual housing transactions reached their peak in 2014 before starting to fall in the late 2010s. The PRP sector has also experienced a slight expansion in the past decade. Its stock grew from 357743 properties/units in 2009 to 413268 properties/units in 2019. However, the stock owned by local authorities has shrunk during the same period. The number of households living in social housing each year has fallen by over one third since 2009, from 22040 to 16241. The decline of new social housing tenants

[16] Source: https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/numberofresidentialpropertysalesfornationalandsubnationalgeographiesquarterlyrollingyearhpssadataset06
[17] Source: Private rental market summary statistics in England - Office for National Statistics (ons.gov.uk)
[18] Source: Local authority housing statistics open data - GOV.UK (www.gov.uk).
[19] Source: https://www.gov.uk/government/statistical-data-sets/live-tables-on-rents-lettings-and-tenancies
[20] Source: https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants
[21] Source: https://www.gov.uk/government/statistical-data-sets/live-tables-on-rents-lettings-and-tenancies

is more significant; in 2019, 9565 households new to social housing moved to LA-owned properties in London, a figure that has decreased from 18200 in 2009 (analysis not shown here). Regarding the sales/transfer of LA-owned dwellings, 1833 transactions were completed in 2019, among which 1435 were sold through the Right to Buy (RTB) scheme. This followed the continuing downward trend since 2014/15 when RTB sales reached their most recent high of 4087[22].

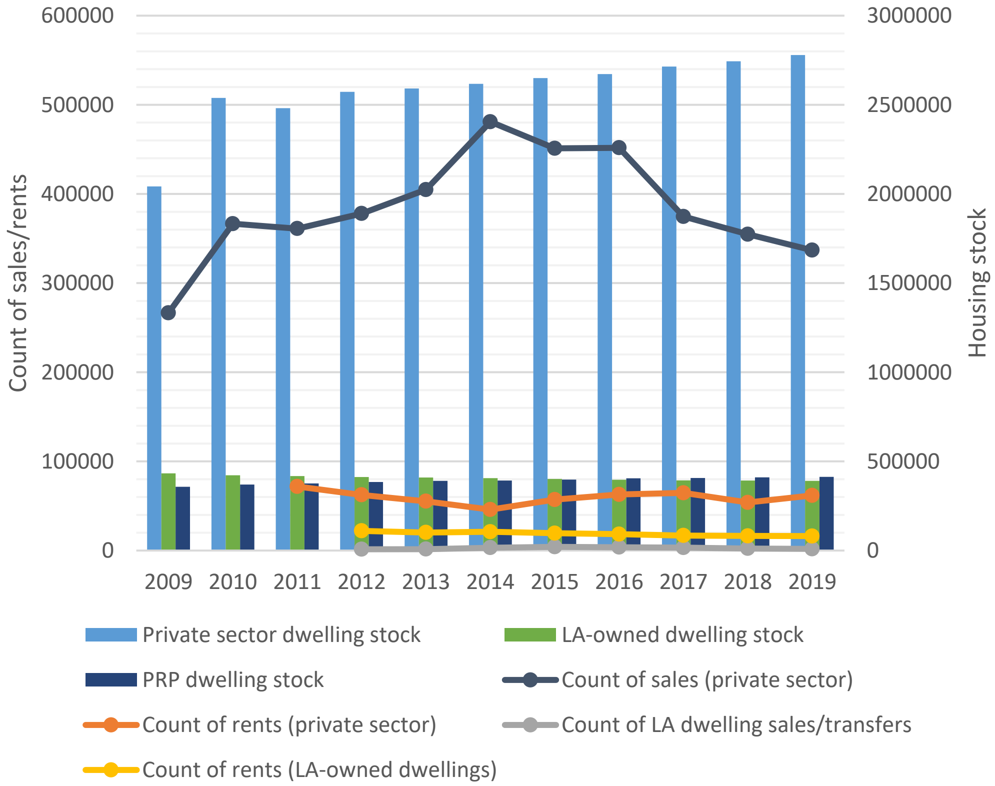


Figure 30 An overview of patterns and trends of London's housing stock (2009-2019)

Figure 31 shows how the total counts of sales and average median prices in the private sector evolved in London from 1996 to 2020. To make prices more comparable across time, we inflated the housing prices to 2020 prices using the inflation calculator provided by the Bank of England[23]. The figure reveals a general increasing trend in housing prices and residential transactions from 1996 to 2007. This was followed by a 6-year crash in London's housing market following the financial crisis, as demonstrated by the sharp decline in residential transactions and housing prices. Inflated housing prices recovered to the pre-crisis level in 2013 and have continued to grow until 2016-17. This was again followed by a decrease in both volumes of transactions and median housing prices. While median housing

[22] For more information on RTB sales from 1980 to 2019, please see table 2.18 in GLA's Housing in London 2020 report.

[23] https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator

prices witnessed a slight increase in 2020 (but has not reached their most recent high in 2016), the annual number of completed residential property transactions has continued to decline during the COVID-19 pandemic.

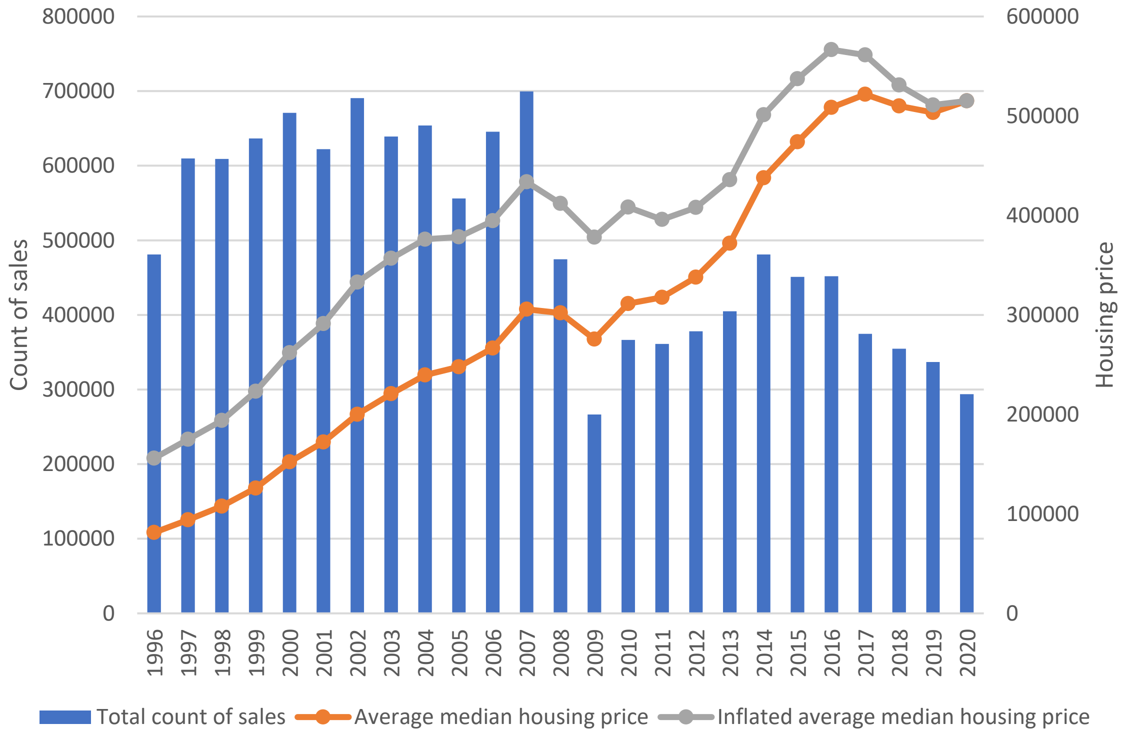


Figure 31 An overview of total counts of sales and average median housing prices in London (1996-2020)

Figure 32 presents the distribution of LSOAs with varying levels of residential transactions in 2000, 2005, 2010 and 2015, respectively (classified by standard deviation). Compared to the average level in London, higher levels of residential transactions happened in Inner London boroughs, especially those in North London and the London borough of Wandsworth. A few neighbourhoods scattered in the suburbs also witnessed higher levels of residential transactions, such as those in the south-eastern part of Newham, south-eastern part of Richmond upon Thames, the southern part of Kingston upon Thames, and western part of Hillingdon. Such a pattern has remained relatively stable during the past two decades, except the fact that residential transactions in central London (e.g. Westminster, Kensington and Chelsea, and Camden) have gradually decreased since 2010.

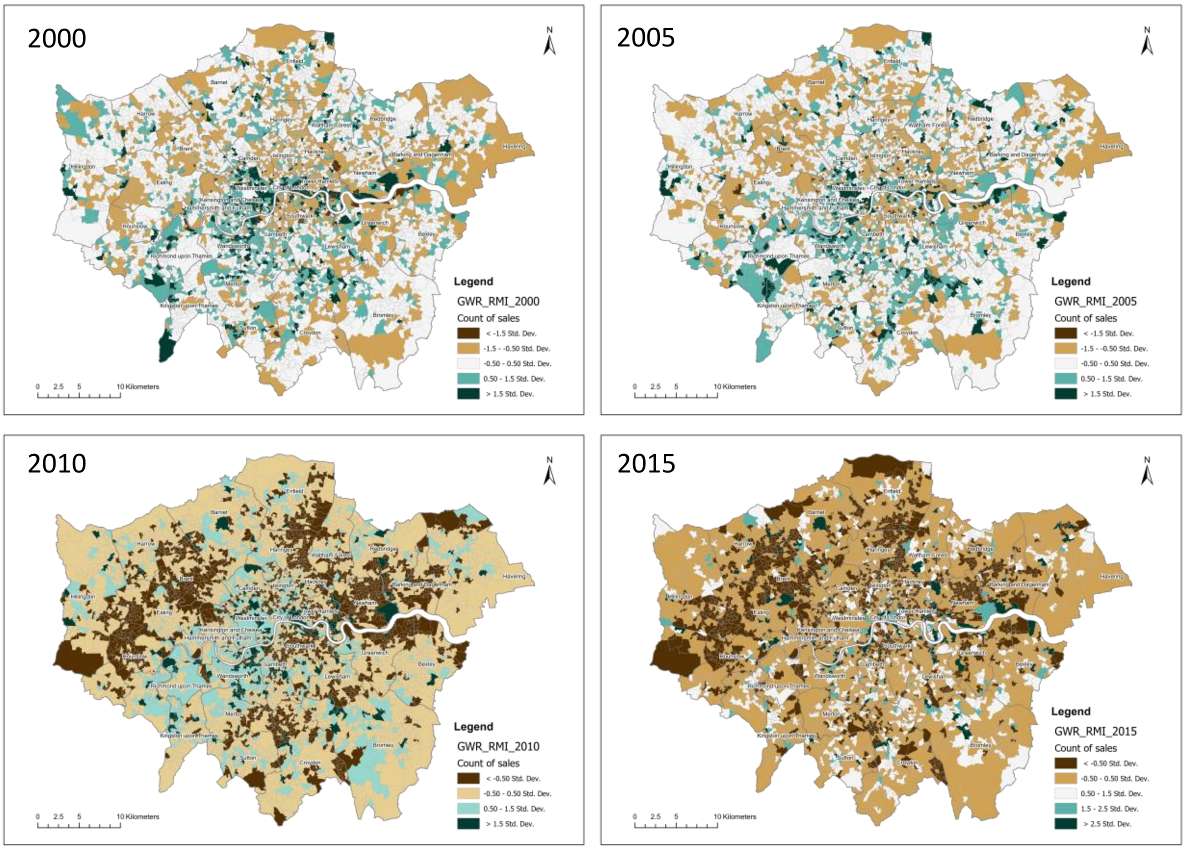


Figure 32 Count of sales, London LSOAs (by standard deviation)

Figure 33 below presents the spatial distribution of median housing prices (in their natural logarithm form) in 2015. Since the patterns have remained stable over the past two decades, figures for 2005, 2005 and 2010 are not presented here. The figure reveals several 'hotspots' where the median price paid for a property was much higher than the London average. The major 'hotspots' were in Central London, spanning across Westminster and Kensington and Chelsea, and spreading to some North London neighbourhoods, such as those in North Camden, as well as in central Barnet and north-west Enfield near the Green Belt. Another group of 'hotspots' were discovered in South West London, such as neighbourhoods in the western part of Richmond upon Thames, north-western part of Merton and north-eastern part of Kingston upon Thames.

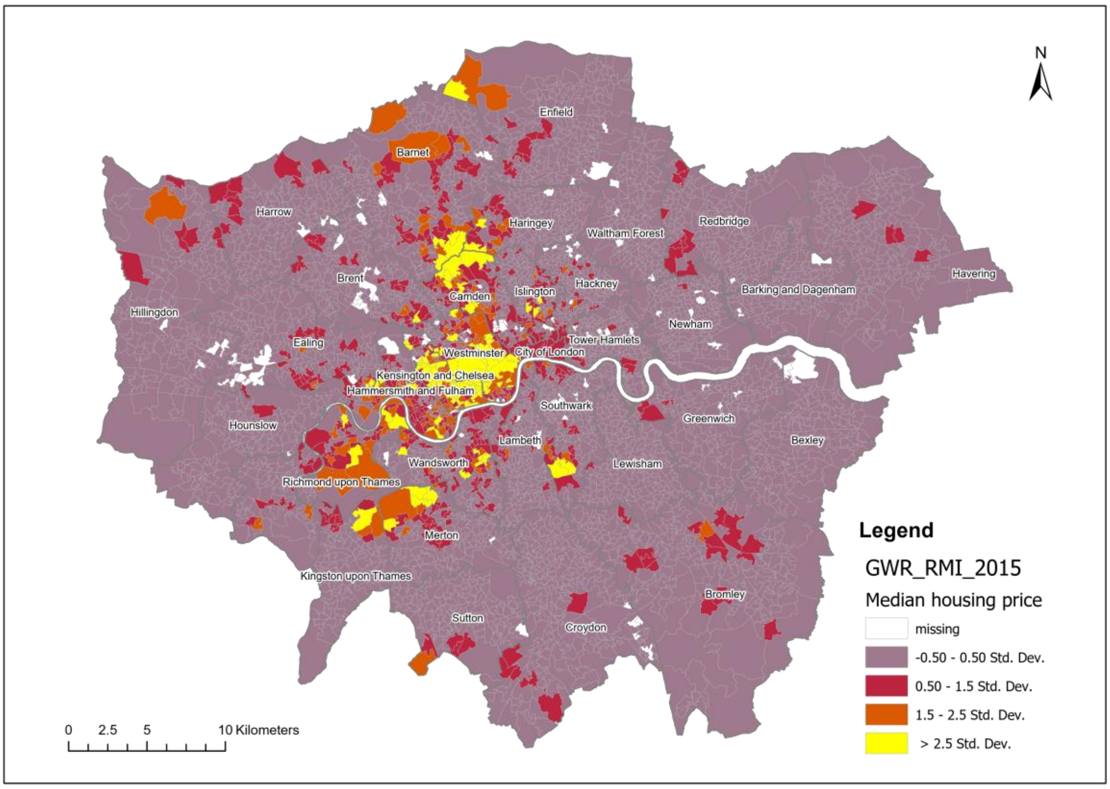


Figure 33 Median housing price, London LSOAs, 2015 (by standard deviation)

Explanatory variables

Previous works on London's housing market have identified at least two groups of variables relating to housing market performance (Fotheringham, Brunsdon, and Charlton 2003; Fotheringham, Crespo, and Yao 2015):

- Structural attributes of the property, such as floor area, type/tenure and date of construction (newly built or existing property)
- Socio-economic attributes of the neighbourhood in which the property is located, such as rate of employment, and transport accessibility

Since structural variables of properties are hardly available at borough/LSOA levels, we include neighbourhood socio-economic variables in the models. The *Index of multiple deprivations (IMD)* measures an area's relative level of deprivation[24]. The seven sub-domains of the IMD cover a wide range of areas that were found to be related to residential mobility, including income (Clark, 2005), employment (Böheim et al., 2002), education and skills training (Schaake et al., 2014), health and disability (Morris et al., 2018), crime (Keelsn et al., 2005), barriers to housing and services (Saghapour and Moridpour, 2019), and living

[24] Source: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019

environment (Jones, 2015)[25]. The indicators for each domain are presented in decile, calculated by ranking all LSOAs in England from the most deprived (lowest score) to the least deprived (highest score) and dividing them into ten equal groups. A higher score means an LSOA is less 'deprived' in each area of interest, for instance, an area with fewer residents in receipt of income support, more highly educated people, or a lower crime rate. These components are included with different weights and compiled into a single score for borough-level analysis.

In addition, some demographic factors were also included in the model, including the number of usual residents, the number of households, and population density. Summary statistics for all variables in the year 2019 can be found in the Appendices (Tables A-1 and A-2).

Borough level analysis: a longitudinal linear model

We began with borough level analysis. We fitted a longitudinal linear regression model to the RMI data to explore whether there are any correlations between the RMI and housing statistics discussed above, controlling for demographic factors. Notably, a very strong correlation was found between monthly median rents of private accommodation and median sold prices of market housing ($r=0.93$, $p<0.001$). The former variable was thus excluded from the regression model to avoid providing redundant information and causing the problem of multicollinearity.

The results are presented in

Table 2. Statistically significant relationships are found between RMI and the following housing market statistics: count of sales (private), median housing price (private), count of sales (LA), count of rents (PRP), and median monthly rents (PRP). This suggests that the residential mobility patterns of London's boroughs can be modelled with local housing market characteristics.

To be more specific,

Table 2 reveals a negative relationship between RMI and the median price paid to purchase a property from the market. The model suggests that a £100k increase in property price is likely to lead to a 1.58 per cent decrease in RMI. The table also shows that RMI is positively associated with counts of sales of market housing and council housing. This indicates that

[25] Details on how each domain/indicator was constructed can be found on p.16 (figure 3.2) of the following Technical Report: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833951/IoD2019_Technical_Report.pdf

the more properties sold – either by private owners or local authorities, the higher levels of residential churn a borough is likely to experience. More importantly, the coefficient of the latter relationship is 32 times higher than that of the former, suggesting that the sale or transfer of LA-owned properties play a relatively more important role than market housing in affecting residential mobility.

Regarding rental statistics, it is perhaps surprising that no statistically significant relationships are found between RMI and count of private rents, or between RMI and monthly LA rents/count of LA rents. This indicates that renting neither a private accommodation nor a council home has a statistically significant impact on a borough's churn rate. Instead, rental from private registered providers is likely to influence a borough's churn rate. However, unlike housing sales, an increase in PRP monthly rents is related to an increase in churn rate and an increase in the count of rents is associated with a decline in churn rate (albeit its coefficient is very small). These observations demonstrate the distinctive 'pusher' role played by private registered providers; a £100 increase in monthly PRP rents is likely to result in a 3.4 per cent increase in churn rate.

Table 2 Longitudinal linear model predicting London residential mobility index

Variables	Coef.	Std. Err.	z	P>z	[95 per cent Conf. Interval]	
London housing market statistics						
Count of sales (private)	1.12E-05***	1.67E-06	6.73	0.000	7.97E-06	1.45E-05
Median price (private sales)	-1.58E-07*	7.81E-08	-2.02	0.044	-3.10E-07	-4.51E-09
Count of rents (private)	-3.87E-06	5.38E-06	-0.72	0.472	-1.4E-05	6.68E-06
Count of sales (LA)	0.00037***	5.92E-05	6.24	0.000	0.000254	0.000486
Mean price (LA sales)	-4.56E-07	6.90E-08	-6.62	0.000	-5.91E-07	-3.21E-07
Count of rents (LA)	2.45E-05	1.62E-05	1.51	0.131	-7.26E-06	5.62E-05
Median monthly rents (LA)	-8E-05	0.000225	-0.36	0.722	-0.00052	0.000361
Count of rents (PRP)	-1.1E-05**	3.31E-06	-3.22	0.001	-1.7E-05	-4.17E-06
Median monthly rents (PRP)	0.00034*	0.000161	2.11	0.035	2.43E-05	0.000656
Explanatory variables						

Population density	0.002735***	0.000652	4.19	0.000	0.001456	0.004013
IMD	-0.00447	0.003355	-1.33	0.182	-0.01105	0.002102
Constant	-0.05402	0.139825	-0.39	0.699	-0.32807	0.220031

Note: *** p<0.001, ** p<0.01, * p<0.05.

LSOA level analysis: Geographically Weighted Regression (GWR) models

At the LSOA level, we employ GWR models to explore how the relationships between median housing price and RMI – as discussed in the previous section – vary across space and time. We began by fitting an Ordinal Least Squares model to LSOA-level RMI data (Appendices Table A-3). Most results are consistent with the results of the borough-level longitudinal model. Median housing price, number of usual residents, and all deprivation measures except those relating to employment and education are negatively associated with RMI. This means that an LSOA tends to be more stable (less mobile) if it has higher median housing prices.

We then employed cross-sectional GWR models to estimate London's residential mobility for each year between 2011 and 2019. The inclusion of spatially varying local parameters significantly improved the proportion of variance explained, as demonstrated by an increase in R-squared from 6.08 per cent to 46.85 per cent (year=2019).

Table 3 reports the summary statistics for each parameter estimate for the year 2019. The table reveals significant spatial variations for median housing prices and all socio-economic factors. Their parameters show a change in signs between the lower and the upper quartile (i.e. from negative to positive), suggesting that the relationship between mobility rates and housing price (as well as between mobility rates and indicators of education, or health) is positive in some London LSOAs but negative in other LSOAs.

Table 3 GWR parameter estimates summaries (year=2019, bandwidth = 6900.04)

Variable	Mean	Std. Dev.	Min	Lower quartile	Median	Upper quartile	Max
Local housing market statistics							
Count of sales	2.02E-05	1.21E-05	-5.9E-05	1.11E-05	1.86E-05	2.84E-05	0.000116
Median price (ln)	-7.3E-05	0.000668	-0.01346	-6.8E-05	9.43E-05	0.000174	0.004453
Demographic factors							

No. of usual residents	2.48E-06	4.92E-06	-1.6E-05	-4.15E-07	2.64E-06	5.63E-06	1.88E-05
No. of households	-4.11E-06	1.15E-05	-4E-05	-1.1E-05	-4.85E-06	3.45E-06	0.000033
Population density	1.25E-05	1.72E-05	-8.6E-05	1.68E-06	9.19E-06	2.47E-05	9.25E-05
Socio-economic factors							
Income	-0.00092	0.000545	-0.00377	-0.00132	-0.0009	-0.00056	0.001141
Employment	0.001458	0.000834	-0.00076	0.000815	0.001528	0.002172	0.004038
Education, skills training	0.000144	0.000458	-0.00201	-0.00014	0.000129	0.000354	0.001611
Health and disability	-0.00061	0.000894	-0.00281	-0.00109	-0.00051	1.16E-05	0.001443
Crime	-0.00033	0.000255	-0.00117	-0.00052	-0.00032	-0.00015	0.000764
Barriers to housing and services	-0.00055	0.0007	-0.0023	-0.00104	-0.00059	-8.3E-05	0.001081
Living environment	-0.00063	0.000623	-0.00199	-0.00114	-0.00061	-0.00015	0.000877
Diagnostic statistics							
R-squared		0.5218					
Adj. R-squared		0.4685					
AICc		-35700.1					

The calculation of local parameters enables us to visualise these spatially varying relationships. Figure 34 below shows how the coefficients of 'median housing price' were distributed across London LSOAs and how such spatial pattern has changed during the past decade. Six time points were selected for the visualisation: 2011 and 2015 – to reveal general trends, and 2016, 2017, 2018 and 2019 – to reflect the most recent development. The coefficients were grouped into 10 intervals (decile groups), with the bottom ten per cent coloured in red (i.e. the smallest coefficient, often negative) and the top ten per cent in blue (i.e. the largest coefficient).

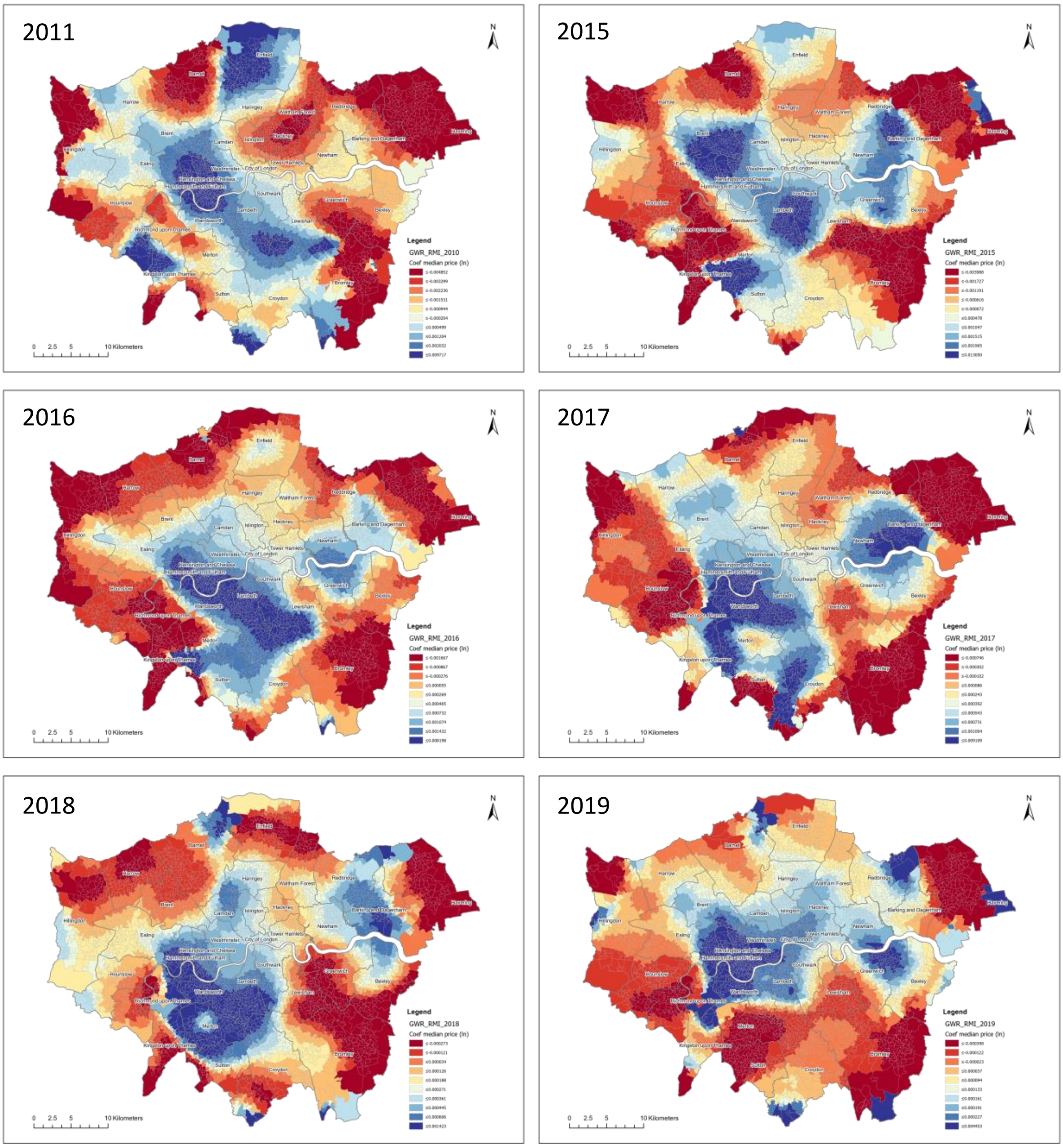


Figure 34 Spatial variations of the coefficients of 'median housing price'

Some major trends can be identified from Figure 34 regarding spatial variations of the coefficient of 'median housing price'. Compared to average levels in London, the coefficients were positive and generally higher in Inner London, as shown in bluish colours. This indicates that *higher residential mobility rates are associated with higher median housing prices* in these areas. These positive relationships differ from the negative relationship identified by the regression models discussed above, indicating that medium housing prices played a distinctive role in these neighbourhoods.

To be more specific, the 'deep blue' areas, where the positive associations between housing price and residential mobility are the strongest, have moved westwards during the past decades, from Camden and Southwark to Kensington and Chelsea, and Wandsworth. In addition, 'bluish' areas can also be found in parts of South West London and have moved from the suburbs (e.g. Kingston upon Thames) to areas that are closer to inner London (e.g. Richmond upon Thames). Other Outer London neighbourhoods also reported relatively strong positive relationships between mobility and housing price, such as Enfield and north-western Redbridge. A new 'blue' centre has emerged since 2010 in east London, covering neighbourhoods in south-eastern Newham, south Barking and Dagenham, and North Greenwich.

On the contrary, the coefficients were generally lower in outer London, as shown in reddish colours. This suggests that the positive relationship between mobility and housing price has become weaker in most Outer London boroughs. These relationships may even become negative in areas coloured in dark red and amber, such as most of Bromly and Havering. The negative relationships imply that *higher housing price is an important factor that discourages residential movement* – an observation that is in line with the prediction of the borough-level regression models discussed above.

Conclusion and discussion

An understanding of the scale of population churn can enable greater insight into the size of a population, service provision, capitation, and budget estimates as well as democratic participation and community engagement. To measure population churn, existing studies often use data from the decennial Census, population estimates or administrative sources, which are often out-of-date or imprecise at local levels. In this report, we used CDRC data to develop a new Residential Mobility Index (RMI). By linking consumer registers, electoral registers, and land registry data, the RMI provides a 'highly disaggregate' and 'frequently updateable' (Lansley et al. 2019:1587) inventory of local populations and their movements, which allows us to monitor changes in internal migration at a high spatial and temporal granularity.

The RMI-based analysis sheds some light on new trends and geographies of population churn in London, which supplements conventional population statistics. The Censuses point to greater patterns of flux experienced across London boroughs during the 2000s, the RMI further extends this argument and suggests that demographic changes were being felt differently by different boroughs at different moments. While Inner London boroughs consistently experienced disproportionately higher levels of population churn, their relative positions have undergone significant changes in the past two decades. 2008-2010 appeared to be one key moment of change, when most Inner London boroughs experienced a sharp decline in their residential mobility rankings after the financial crisis, except Greenwich, Lambeth and Southwark. 2015-2018 was another key moment of change when more than half of London boroughs became less attractive to immigrants after the EU referendum. The only exceptions are two Inner London boroughs (i.e. Greenwich and Hammersmith and Fulham) and a few Outer London boroughs (e.g. Croydon, Ealing, Enfield, Hillingdon, Hounslow, Redbridge, and Waltham Forest).

The RMI-based analysis also highlights the importance of scale. Drawing on the aggregation of address-level consumer data, the RMI is able to capture short distance moves within local authority boundaries, which are usually under-documented in publicly available population statistics (except the Census). The RMI provides a reliable estimation of the spatial consequences of residential mobility at fine geographic scales (e.g. the LSOA level and above). This enables us to explore the granularities of churn at different scales and examine the geographically varying relationships between place characteristics and mobility propensities across different scales. The exploration of housing price-mobility relationship demonstrates the scalar effect. While the borough-level analysis suggests that London's housing price generally hinders residential movement, LSOA-level analysis points out several areas where housing price is positively associated with mobility.

The research that is described here is a starting point, rather than an endpoint. It presents multiple ways through which the novel source of data – the RMI – could be used to glean new geodemographic insight into London's churning population. Future work aims to establish a holistic understanding of London's population churn and its socio-demographic consequences, involving origin-destination analysis, population flow mapping, and neighbourhood ethnic composition estimate.

In this context we believe the following policy dimensions and recommendations can be made for the ongoing monitoring of the London 2021 Plan.

Policy Implications and Recommendations: Population Churn and monitoring the 2021 London Plan

5. **Democracy and community engagement: Knowing local populations**

The legitimacy of the London Plan in the eyes of the people of London depends significantly on the credibility of the claims made by City Hall and London Boroughs about the scale and pace of local change. This report has demonstrated the significant and growing role population churn plays over very short periods of time in reconfiguring the population geographies of London. As part of the monitoring of the London Plan ***we recommend that regular monitoring updates should report on these geographies of population churn to inform the implementation of the 2021 London Plan.***

6. Development Control in London: Monitoring the London Plan, the reliability of data and challenges to development impact assessments

Many of the technical details of the roll out of development control policies depend on estimates of the impact of development on surrounding locations. Localised development plans and masterplans across all the boroughs of the city depend in part on the local empirical evidence on which they are based to test the impact of developments on public goods such as access to open space, health and education services, forms of congestion in transport and mobility modes. All of these are rooted in estimates of both present and future populations. In short, the calculation of appropriate assessments of Section 106 contributions and impact agreements depend on meaningful population data. But we know that some parts of London are growing faster than others. We know that the age profile of different parts of London is being reconfigured, particularly in the wake of the COVID pandemic. The numbers of children per household varies rapidly through population churn, secular trends of suburbanisation and gentrification have reshaped the population profiles of different boroughs in London since the 2011 census, the relationship between multi centric commercial hubs and residential neighbourhoods across London is evolving rapidly as more people choose to work from home for at least parts of the week.

It is already the case that consultancies across the city offer services aimed specifically to minimise the contributions of major developments through challenges to the knowledge base on which impact assessments are made. Notwithstanding the first-rate attempts to estimate inter census change this is likely to increase through time if the London Plan is claimed to represent the needs of the demographic geographies of the London of 2011 rather than 2021 or later. Consequently, understanding the impacts of population churn on London's rapidly changing residential patterns on a more real time basis is imperative for accurate, appropriate and defensible development control practice in the next decade and avoiding challenges to the London Plan as it works its way down through the city's geographical hierarchy of development control practices. In this context ***we recommend the GLA consider how population churn estimates might be used to inform the GLA monitoring of the 2021 London Plan.***

7. Capitation and budget estimates based on headcounts

The proportions of support vary greatly and have changed through time significant proportions of local government and other London Borough revenue support for the provision of local public services accrue from central government subsidies. These tend most commonly to reflect population demographics, the demand for places in schools, primary care, public health and environmental services. Globally, we are seeing an increased pressure on governments to use alternative sources for such estimations than a decennial census. We have explored tentatively the use of some sources of new data closer to 'real time' and the implications for the geographical distribution of populations across London and their rates of change in forms of population churn. Given the scale and accelerated rate of population churn over the last three decades while any conclusions should be treated carefully ***we recommend that but one element of monitoring of the London Plan should explore the possibility of using alternative data methodologies of measurement of residential populations when considering the development of London through the London Plan.***

8. Public service quality and changing landscapes of diversity

One of London's strengths is the cosmopolitan nature of the city. International migration has for centuries been central to the history of the city but this has rarely been without social, cultural and economic challenges. Longstanding academic research demonstrates that international migration generally provides greater benefits than costs to the economy. Migrants tend to come to the city schooled and skilled and tend also to be younger with high employment participation rates, meaning that they generally contribute more in taxes than they receive in support from the state. But these costs and benefits have an uneven geography, the benefits are realised at the scale of the labour market and the travel to work area, the costs accrue at the scale of residential impact. Migration benefits significantly the whole economy of London, pressures on some welfare services such as school places, GP surgeries and access to public space reflect much more localised pressures. Former policies in the United Kingdom (such as the long-abolished Section 11 programme) tended to recognise this by financial support for local authority obligations to mediate the arrival and impact of international migration related changes. But as London's population geography changes the geographies of costs and benefits of international migration change accordingly. Consequently the impact of developments in London in areas of high migration need to be assessed in the context of these dynamics in order to reflect both the costs of public goods (such as health, education and green space) as well as the economic benefits of migration for the city as a whole. A significant number of developments in London demand appropriate equality impact assessments and in this context ***we recommend that City Hall should explore how the boroughs and the 'GLA Family' could use new data sources on population churn to inform monitoring of the 2021 London Plan to understand the impact of migration on different parts of the city***.

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Appendices

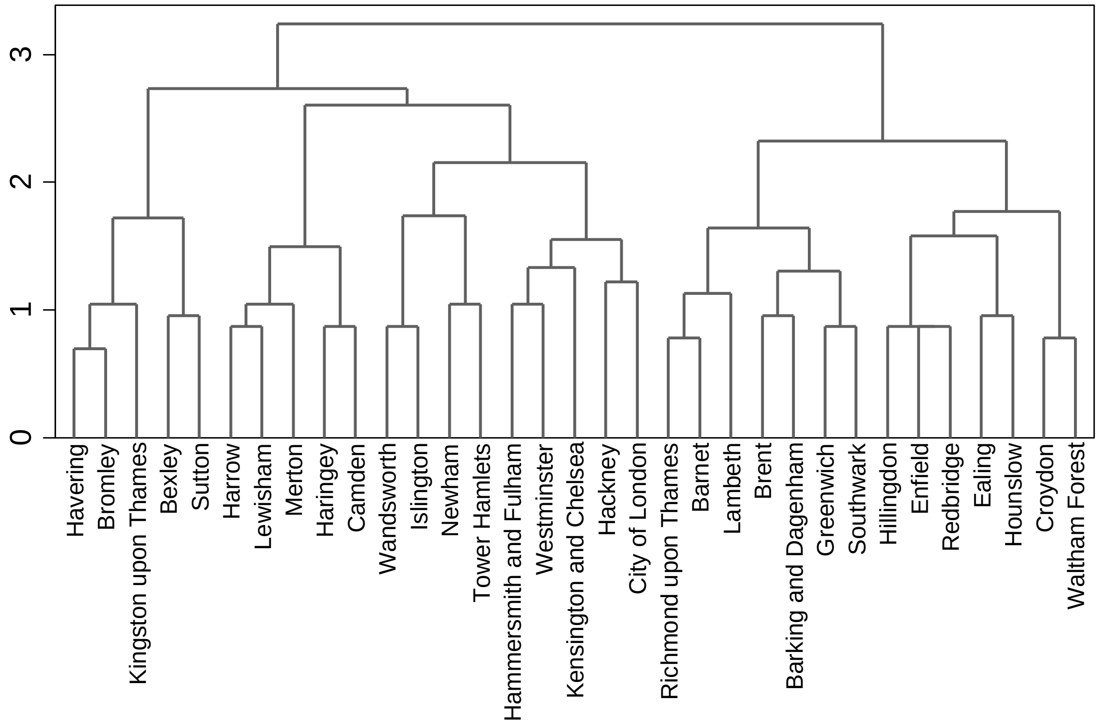

Figure A-1 Dendrogram for RMI cluster analysis

Table A-1 Summary statistics (London boroughs, year=2019)

Variable	Observation	Mean	Std. Dev.	Min	Max
Dependent variable					
Residential mobility index	33.00	0.02	0.01	0.01	0.03
London housing market statistics					
Count of sales (private)	33.00	10208.67	3666.22	864.00	18268.00
Median price (private sales)	33.00	537136.40	195154.40	315000.00	1250000.00
Count of rents (private)	33.00	1872.42	894.13	100.00	4160.00
Median monthly rents (private)	33.00	1482.70	339.96	1100.00	2427.00
Count of sales (LA)	33.00	55.55	49.62	0.00	202.00
Mean price (LA sales)	29.00	230889.90	74382.38	131952.40	475200.00
Count of rents (LA)	33.00	492.15	373.66	0.00	1395.00
Median monthly rents (LA)	27.00	461.74	40.28	389.27	550.30
Count of rents (PRP)	33.00	12523.27	6858.68	230.00	32023.00
Median monthly rents (PRP)	33.00	531.14	30.05	472.49	607.63
Control variables					
Population density	33.00	74.43	39.98	22.14	163.20
IMD	33.00	21.30	6.07	9.43	32.77

Table A-2 Summary statistics (London LSOAs, year=2019)

Variable	Observation	Mean	Std. Dev.	Min	Max
Dependent variable					
Residential mobility index	5045	0.38	0.25	0	1
Local housing market statistics					
Count of sales	5045	69.78	77.46	0	1570
Median price (ln)	4835	12.38	0.73	9.98	15.44
Demographic factors					
No. of usual residents	5045	1690.64	261.92	985	4933
No. of households	5045	675.86	133.16	404	1236
Population density	5045	95.82	61.03	1.20	684.70
Socio-economic factors					
Income	4842	4.91	2.58	1	10
Employment	4842	5.74	2.57	1	10
Education, skills training	4842	6.74	2.36	1	10
Health and disability	4842	6.76	2.39	1	10
Crime	4842	4.49	2.23	1	10
Barriers to housing and services	4842	2.96	1.93	1	10
Living environment	4842	3.71	1.76	1	9

Table A-3 OLS model predicting London residential mobility index (LSOA level)

Variables	Coefficient	P>|t|	95 per cent Conf. Interval	
Local housing market statistics				
Count of sales	0.000***	(0.000)	0.0001121	0.0001553
Median price (ln)	-0.003**	(0.001)	-0.0047449	-0.0007018
Demographic factors				
No. of usual residents	-0.000***	(0.000)	-0.0000289	-0.0000132
No. of households	0.000***	(0.000)	0.0002072	0.0002386
Population density	0.000***	(0.000)	0.0002114	0.000269
Socio-economic factors				
Income	-0.014***	(0.001)	-0.0152834	-0.0118838
Employment	0.013***	(0.001)	0.0113628	0.0146405
Education, skills training	0.004***	(0.000)	0.0026841	0.004486
Health and disability	-0.007***	(0.001)	-0.0080437	-0.0060185
Crime	-0.003***	(0.000)	-0.0037711	-0.0022098
Barriers to housing and services	-0.006***	(0.000)	-0.0071513	-0.0053558
Living environment	-0.009***	(0.000)	-0.0101157	-0.0081699
Constant	0.344***	(0.014)	0.3168214	0.370516
Observations	115,860			
R-squared	0.068			

The Moran's I measure was adopted to examine whether the residuals of the OLS model are spatially autocorrelated. The result confirms the existence of autocorrelation in the residuals (z>0, p<0.001), which demonstrates that the residuals are spatially clustered – or in other words, nearby observations tend to be similar. It also demonstrates that, compared to the OLS model, a geographically weighted model considering spatially varying relationships is preferable.