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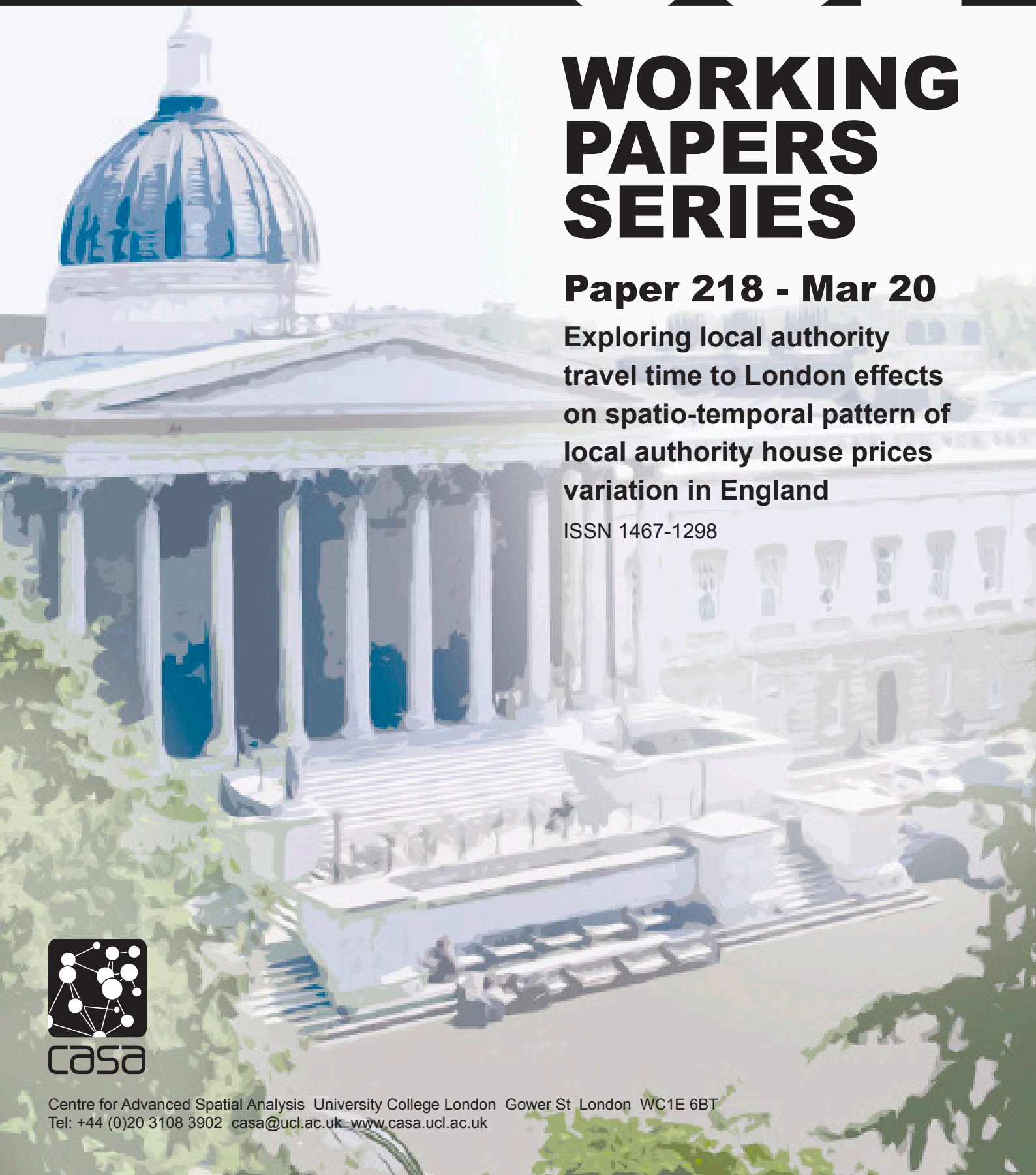

casa

Centre for Advanced Spatial Analysis University College London Gower St London WC1E 6BT
Tel: +44 (0)20 3108 3902 casa@ucl.ac.uk www.casa.ucl.ac.uk

Exploring local authority travel time to London effects on spatio-temporal pattern of local authority house prices variation in England

Bin Chi, Adam Dennett, Robin Morphet, Chris Hutchinson

Abstract: The spatial and temporal diffusion of house prices has been investigated at regional level in England, with London and the South East playing a leading role in terms of spillovers to other regions. High house prices in London not only increase neighbouring house prices but also force workers to live outside London and commuting in. To better understand this London effect, this research aims to explore the effect of travel time to London on house price variation across England. We conducted this research at local authority level rather than region level to offer a clearer insight into the relationship between house price variation and travel time to London, concentrating especially on the period post the 2008 financial crisis. Results show that local authorities with shorter travel tomes to London generally have greater house prices increases, but with some exceptions. The majority of local authorities within 75 minutes travel time to London had a high house price increase between 2009 and 2016. This underlies the London ripple effect and is reinforced by the high proportion of workers commuting to London.

1. Introduction

Housing is a major source of inequality in the UK, particularly in England (Dorling, 2014). In some areas of England such as London, the cost of renting or buying a house is becoming prohibitively expensive (Edwards, 2016). Escalating housing costs not only reduce people's ability to buy or rent a dwelling, but also push up nearby house prices. This spatial and temporal diffusion of house prices has been investigated at regional level in England since the 1980s, with London and the South East playing a leading role in terms of spill overs to other regions (Alexander and Barrow, 1994; Cook and Watson, 2016; Giussani and Hadjimatheou, 1991; MacDonald and Taylor, 1993). Meen (1999) suggested that migration, home equity effects, spatial arbitrage and spatial interactions of house prices are four possible explanations for the regional ripple pattern. Following the global financial crisis regional house price differentials have continued to widen with soaring house prices in London (Hamnett and Reades, 2019), which force more people into long distance London commuting (Commute for an hour to save £450,000 on house prices, 2015; Osborne, 2014; Thorn, 2018). In turn, the long distance London commuting tends to increase local house prices (Allen, 2014). According to an analysis of census 2011 commuter flow data, 90% of England's residents commute to destinations outside their home Middle Super Output Area (MSOA) and 48% of them commute to destinations outside their home local authority. In England,

London, with the largest inflow of workers, accounts for 29% of the commuting to destinations beyond the home local authority. Here, we offer a new insight of England's spatial-temporal local authority house price variation against the commuting time.

The structure of this research is as follows. Section 2 introduces the data use. Methods for estimated house price trends at local authority level and their travel time to London are presented in Section 3. Section 4 explores the relationship between local authority house prices variation and commuting time to London. Finally, we summarise and draw conclusions in Section 5, together with proposals for future research.

2. Data

2.1 House price data

We use the house price (£/m^2) from a newly created house price dataset in England. The house price (£/m^2) is the transaction price standardised by the total floor area. This new data set records 4,682,468 transactions sold at full market value in England between 2009 and 2016, representing 80% of the full market housing sales in the Land Registry Price Paid Data set (PPD) over the same period (Chi et al., 2019). 2009 is a convenient starting point as it marks the point when after the 2008 global financial crash when house prices in the UK began a steady increase once again.

2.2 Railway stations and railway routes

Since no up to date spatial data set for English railway stations and routes exists, a data set was created by using Ordnance Survey (OS) VectorMap District (2018) as base map and then manually referring GB Rail GTFS (General Transit Feed Specification) data (2016)[1], estimates of station usage 2017-18 (11 December 2018 version)[2] and the national rail route diagram map (June 2019) [3], national rail train operators map (September 2019) [4], London Connections Map[5] and London Tube Map (December 2019) [6]. The railway stations data in OS VectorMap District (VMD) covers light rapid transit stations, railway stations, and London underground stations. Since the OS stations data does not reflect up to date railway station spatial data, stations were removed which were not present in the 2017-18 estimates of station usage. Any remaining stations not shown in the GB Rail GTFS, the national rail route diagram map,

[1] Resource from CASA QUANT (http://quant.casa.ucl.ac.uk/)
[2] Resource : https://dataportal.orr.gov.uk/statistics/usage/estimates-of-station-usage/
[3] National rail route diagram map resources: https://www.nationalrail.co.uk/stations_destinations/maps.aspx
[4] National rail train operators map resources: https://www.nationalrail.co.uk/stations_destinations/maps.aspx
[5] Resources: https://www.whatdotheyknow.com/request/224813/response/560395/attach/3/London%20Connections%20Map.pdf
[6] Resources: the December 2019(b) version of London Tube Map: http://content.tfl.gov.uk/large-print-tube-map.pdf

the national rail train operators map were removed manually. This left 2267 railway stations for use in the analysis[7] of which 594 (26%) are located in London.

The railway routes are created by merging railway tracks and tunnels from OS VMD and then manually deleting all the routes which are not mapped in the national rail route diagram and the national rail train operators and London tube map. The spatial tube routes in London are derived from the London Connections Map. The newly created railway station and railway route spatial data set is shown in figure 1.

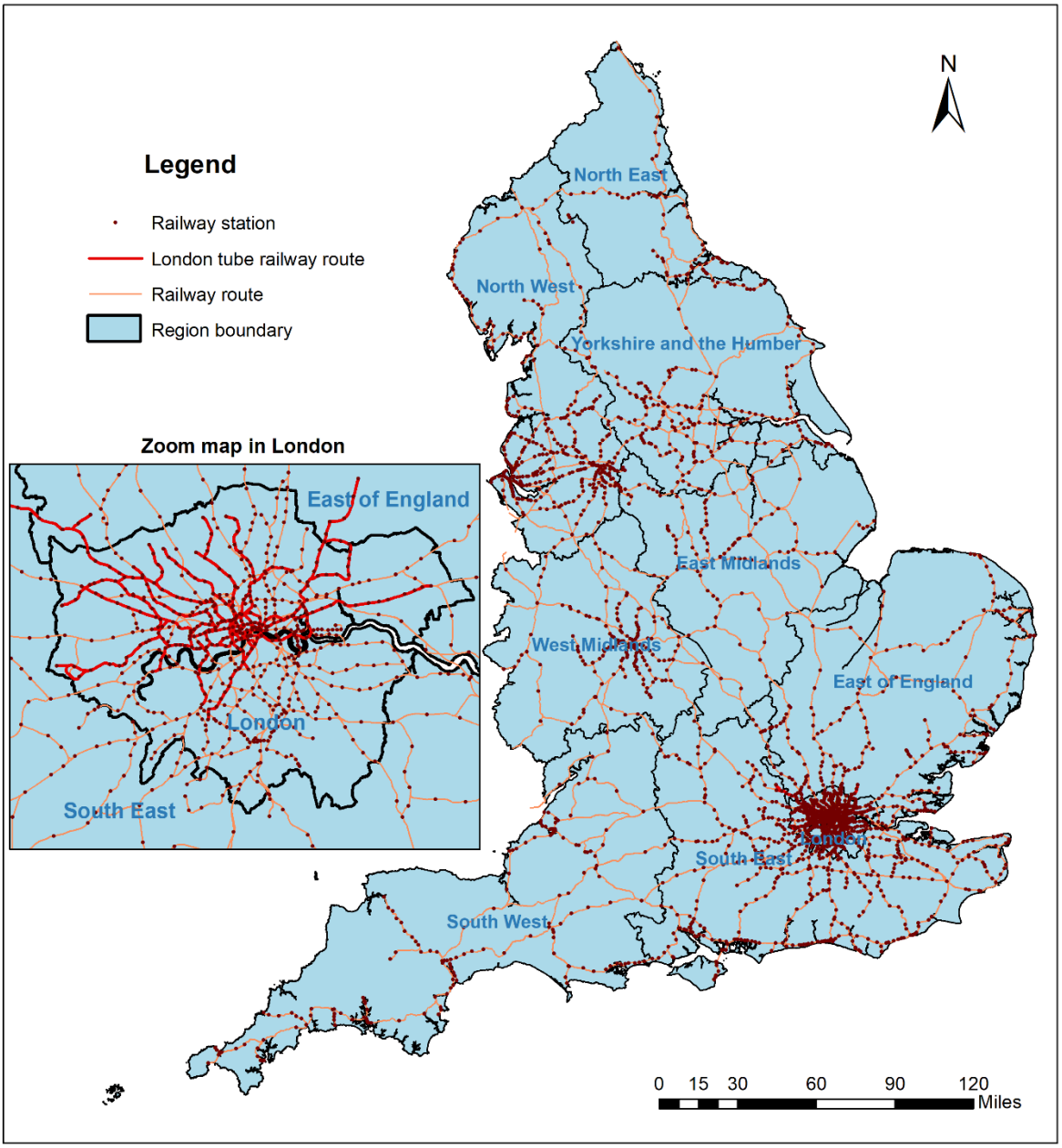

Figure 1. Railway stations and railway routes in England

[7] For the station which has multiple entrances we will only keep one record.

2.3 Public transport travel time data

The areas reachable from each railway station in England at 7a.m. within 15 minutes, 30 minutes, 60 minutes, 75 minutes, 90 minutes, 105 minutes, and 120 minutes, by public transport were extracted from the TravelTime Platform (https://www.traveltimeplatform.com/) on 23th September 2019. Since the majority of areas reachable with 15 minutes from the railway stations (outside London) do not sufficiently cover London (figure 2), the following analysis areas will only use reachable areas at and over 30 minutes.

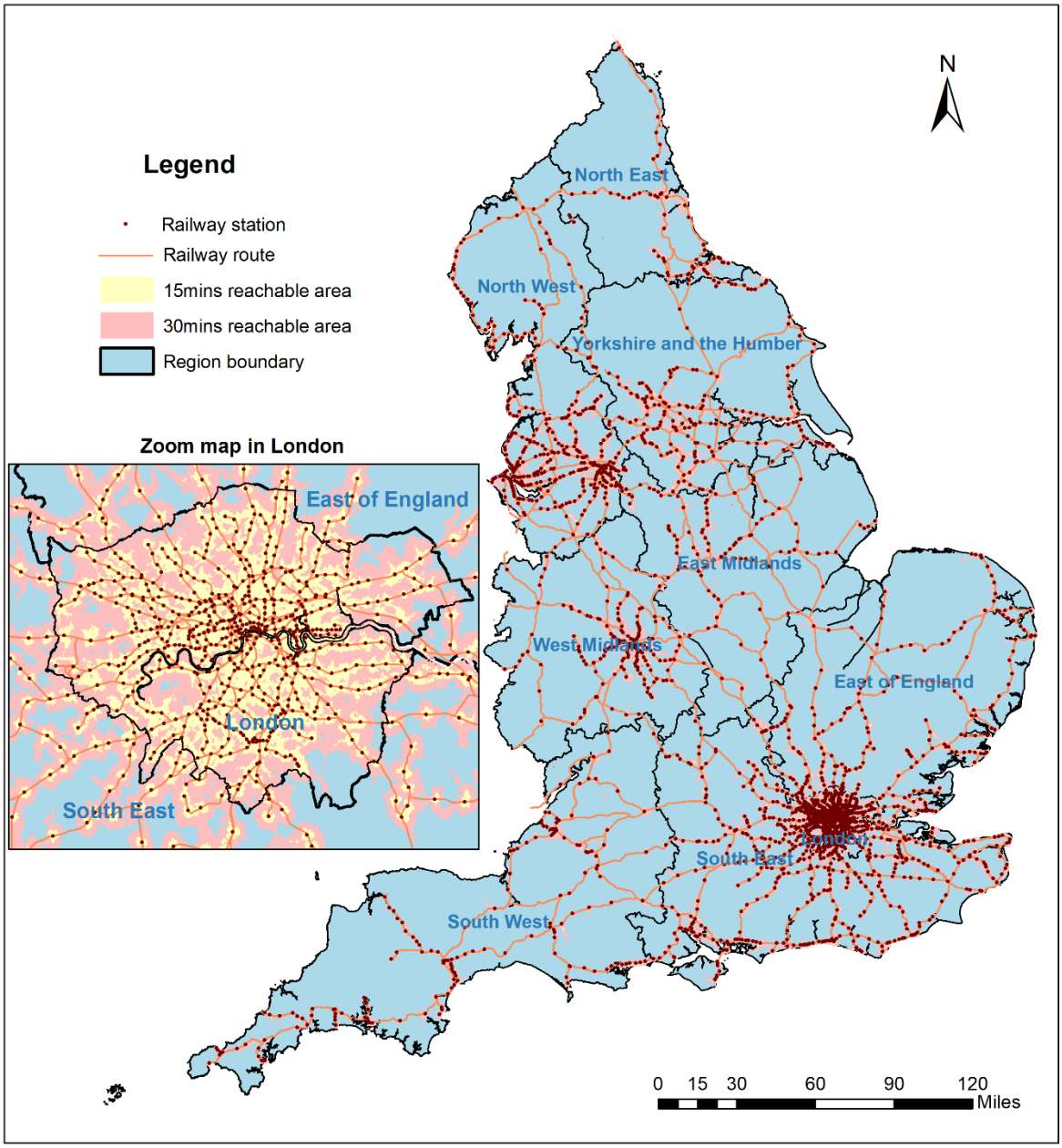

Figure 2. Reachable area within 15 minutes and 30 minutes by public transport for each railway station in England at 7 a.m.

3. Method

3.1 Growth curve model

Growth curve modelling generally uses a multilevel model with time as a predictor, to fit a trend in repeated-measures data over time and across different levels (Goldstein, 2010). In house price analysis, house price can be treated as a "repeated measurement" for the same area (Jones and Bullen, 1993). A three-level growth curve model is used to explore the local authority annual house price trend in England between 2009 and 2016 (Chi et al., 2020). Level 1 is individual, level 2 is MSOA level and level 3 is local authority level. Equation is listed below:

$$h_{ikj} = \beta_0 + \beta_1 t_{ikj} + l_{0j} + m_{kj} + l_{1j} t_{ikj} + e_{ikj} \quad (1)$$

$l_{0j} \sim N(0, \sigma_{l0}^2)$

$l_{1j} \sim N(0, \sigma_{l1}^2)$

$m_{kj} \sim N(0, \sigma_m^2)$

$e_{ikj} \sim N(0, \sigma_e^2)$

Here, h_{ikj} is the log house price (£/m^2) for transaction i in MSOA k belonging to local authority j. t_{ikj} is the year of the corresponding transaction. β_0 is overall mean house price across all local authorities between 2009 and 2016, β_1 is the slope, l_j or l_{0j} is the residual at level 3, m_{kj} is the residual at level 2, e_{ikj} is the residual at level 1. l_{1j} is the random slope at level 3. The natural logarithm of the response is used to deal with the technical problems of non-linearity and provides a meaningful interpretation of the estimated slope parameter β_1. β_1 is the overall average slope, which is approximately equal to the overall percentage increase in England over the whole period (2009-2016) when it smaller than 0.25 (Tufte, 1974) . l_{1j} is the random slope at local authority level , which measures the extent to which the slope of local authority j deviates from the overall slope β_1. l_{0j} is the random intercept of local authority level, which measures the extent to which the intercept of local authority j deviates from the overall intercept β_0.

The time variables (t_{ikj}) are centred at the beginning of year 2009 so that the estimated intercept is also the estimated house price (log scale) in 2009 (Raudenbush and Bryk, 2002). We refer to the estimated slope ($\beta_1 + l_{1j}$) for each local authority in equation 1 as "estimated house price percentage change". We transform the estimated intercept (($\beta_0 + l_{0j}$)) to its natural scale for each local authority and refer to it as the "starting-price".

3.2 Estimating the public travel time to London at local authority level in England

There are 326 local authorities in England, sorted into 9 groups according to the travel time at 7:00 a.m.. from the stations they contain. The local authorities in London are directly sorted in group 1 and named as London. The remaining local authorities are sorted into a "30 minutes to London" group if the 30 minutes reachable area stretches to London. Similarly, the rest of the local authorities are sorted into "45 minutes to London", "60 minutes to London", "75 minutes to London" , "90 minutes to London" , "105 minutes to London" , "120 minutes to London" and "over 2 hours to London". This spatial analysis is conducted in ArcGIS using the select by location and the spatial join functions.

4. Results and discussion

The growth curve model is run in MLwiN 3.03 (Charlton et al., 2019). All the results discussed below are based on the estimated values from the growth curve model. The data analysis is conducted in R and spatial maps are plotted in ArcGIS.

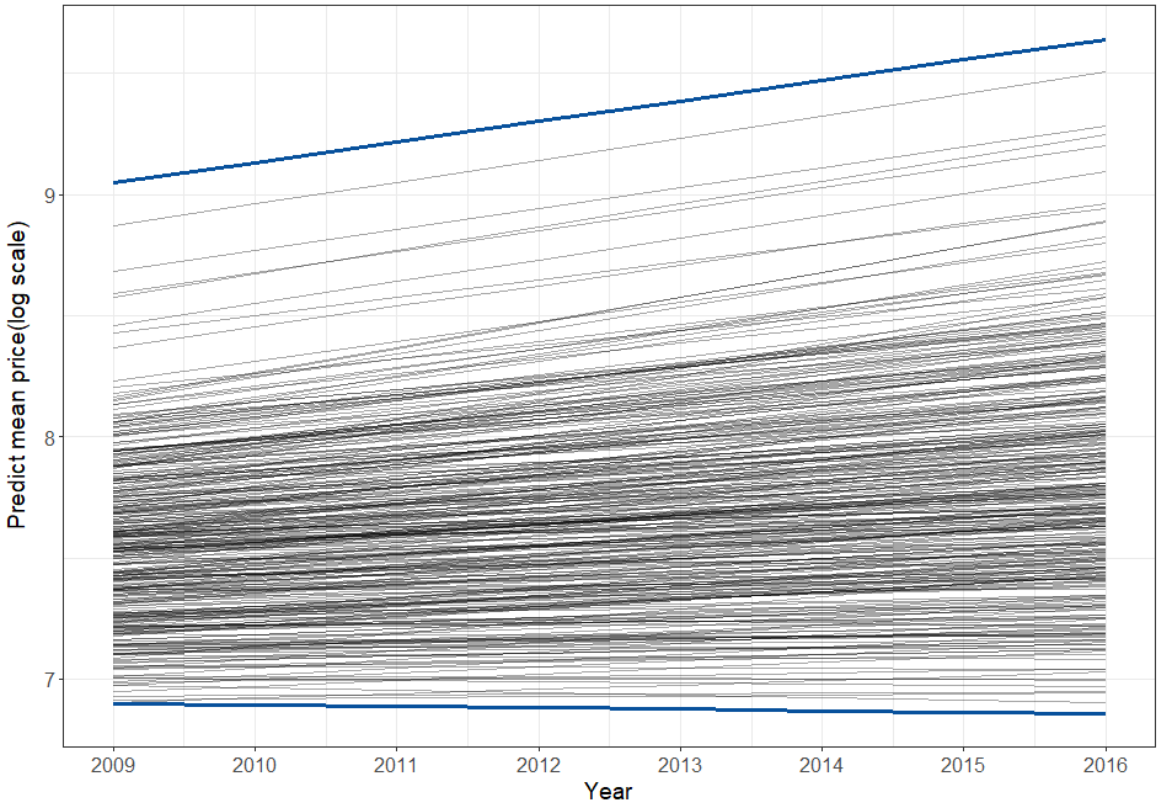

Figure 3. Estimated local house price growth trends across England (2009 -2016)

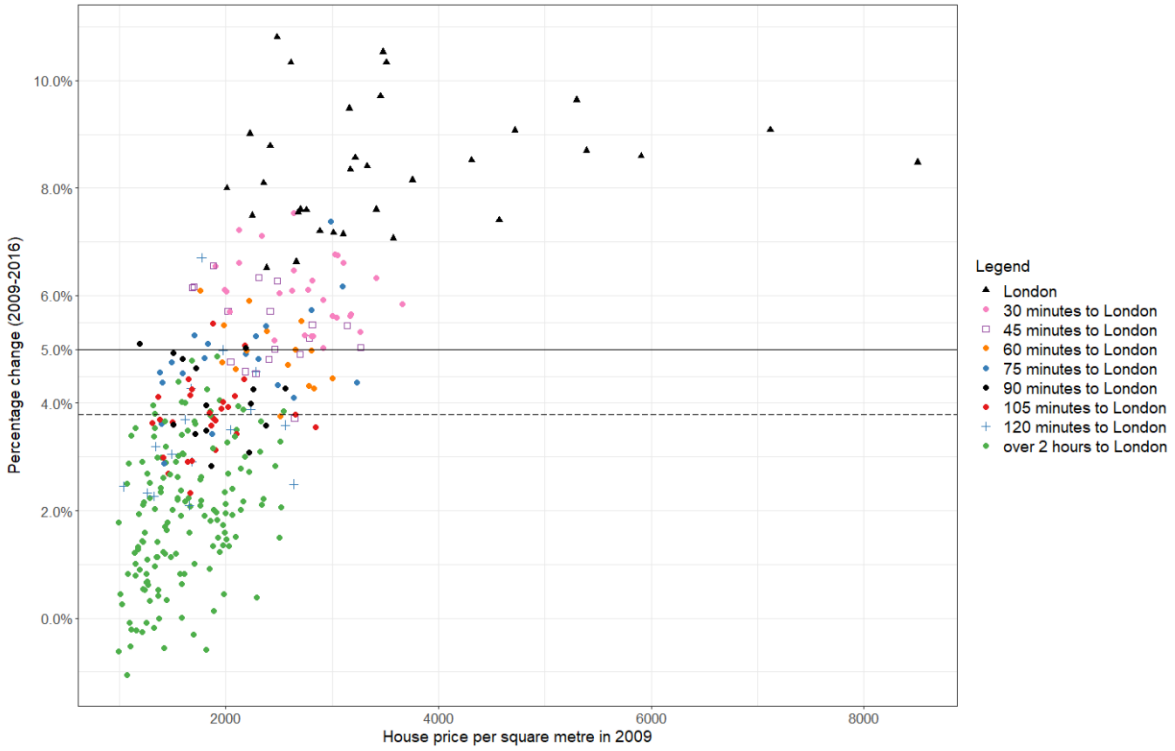

Figure 4. Local authority house prices against their commute time to London

Figure 3 shows the estimated growth curves for each local authority. Each line represents one local authority and reveals a fanning out pattern. Local authorities with higher house prices in 2009 are found to have faster growing prices over the eight-year period than local authorities with lower house prices. Figure 4 is created from Figure 3 by plotting the intercept and slope for each line along with the commuting time to London by public transport through the railway stations in their home local authority at 7:00 a.m.. Each point stands for one local authority and is coloured by the nine categories of travel time to London described in section 3.2. The dashed black line shows the mean local authority house price percentage change between 2009 and 2016 (3.79%). Of the 326 local authorities in England, 91 had a house price percentage increase at or over 5% and 59 had an increase between 3.79% and 5%. Most local authorities showing a house price increase greater than 5% are within 75 minutes travel time of London with only five such local authorities showing an over 75 minutes travel time to London. These five local authorities are City of Bristol, East Cambridgeshire, Corby, Warwick and Worthing (pink-red label in Figure 5).

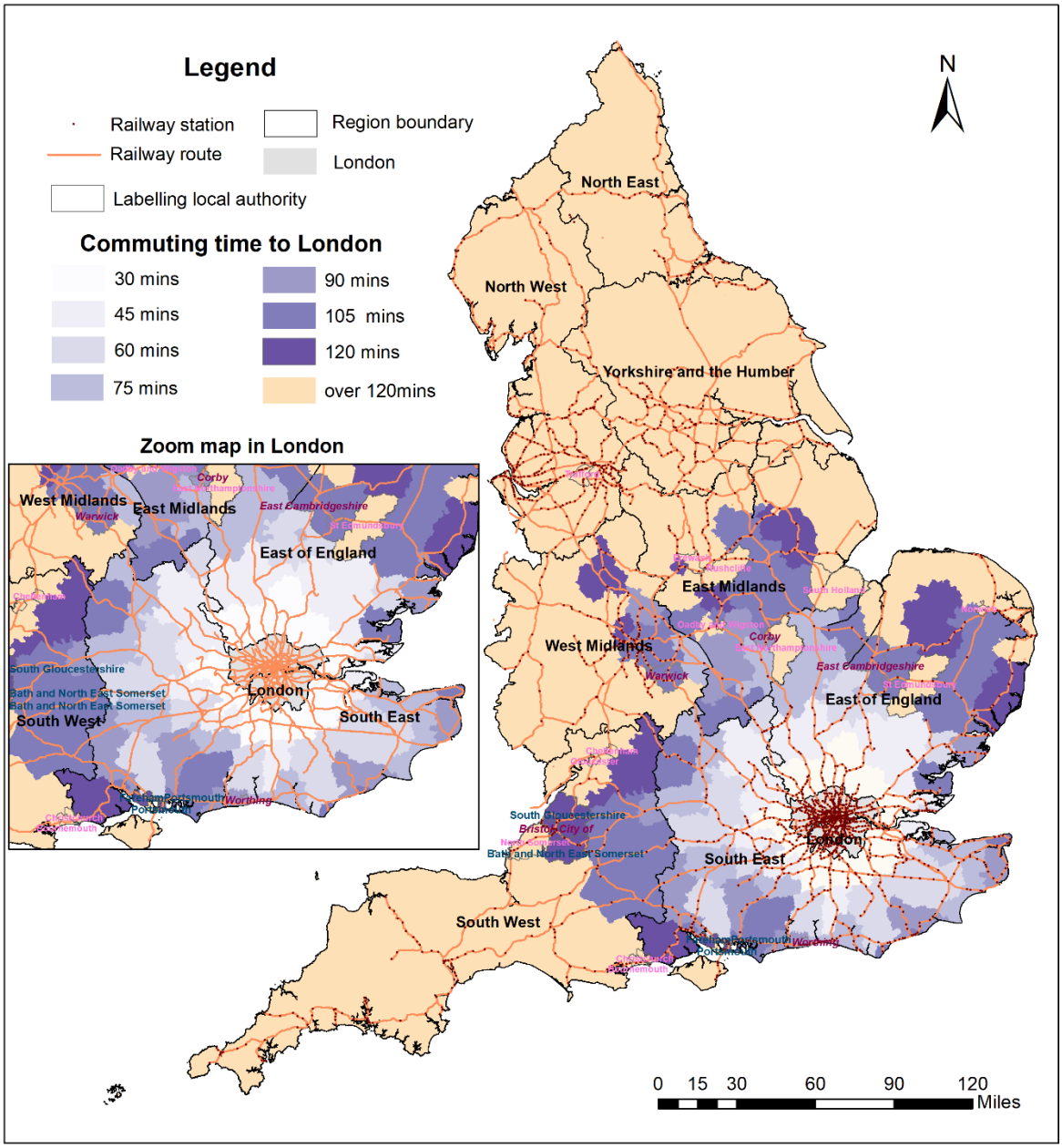

Figure 5. The geography of travel time to London at local authority level

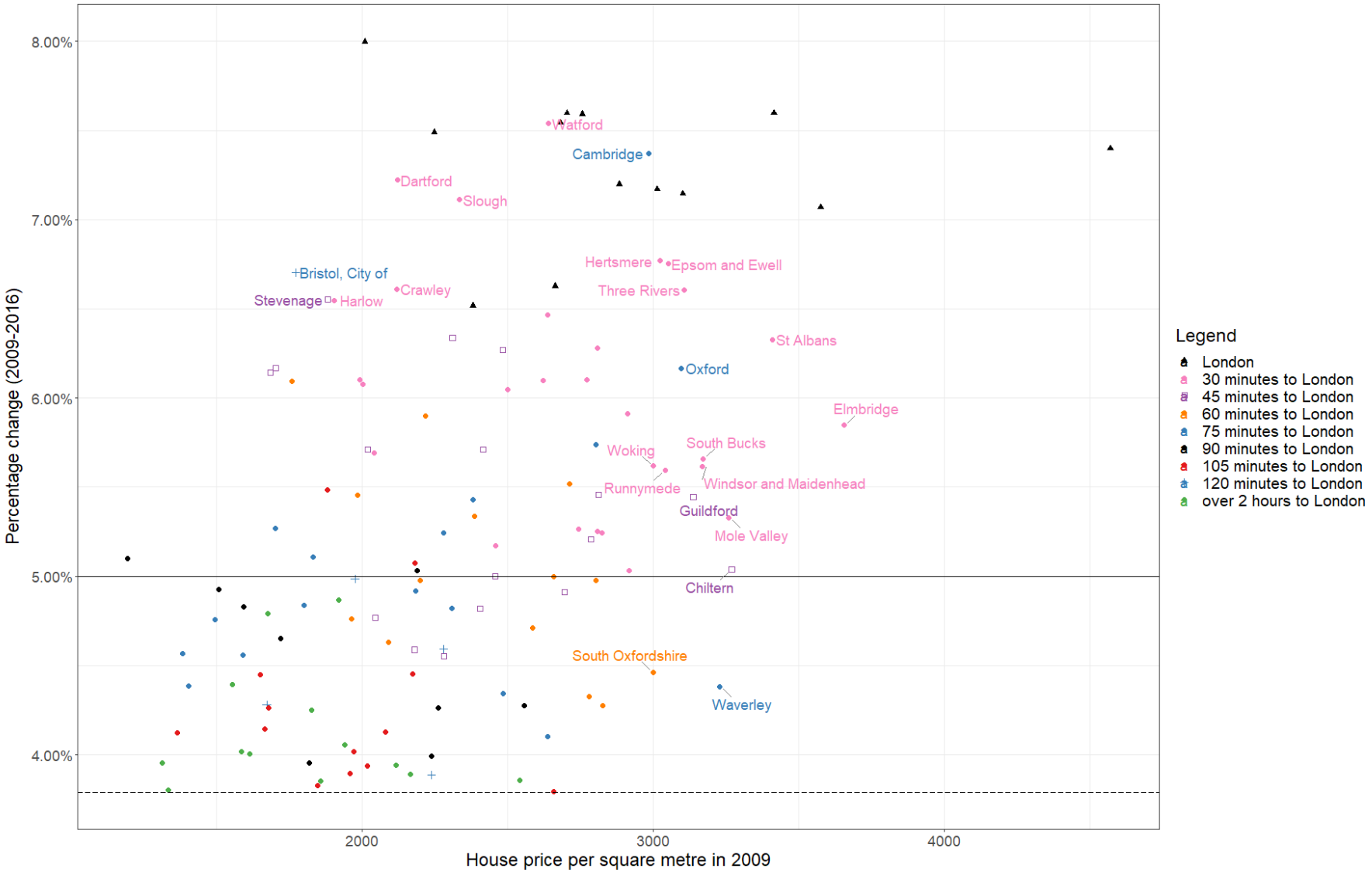

Figure 6. Local authority house prices against their commute time to London for the high house price increase area

Some of the local authorities with a travel time to London of between 75 and 105 minutes also show a relatively high house price increase. They are listed in Appendix A. Since no local authority outside London shows a house price increase over 8%, Figure 6 plots those authorities with a house price increase, of between 3.79% and 8%, against house price per square metre. We identify 23 local authorities with neither a higher starting-price or a higher house price increase compared to local authorities with similar travel times to London. With the exception of Bristol, the local authorities identified are all located near London (Figure 7). The City of Bristol, Cambridge and Oxford are within 75 minutes of London at 7 a.m.. They display similar house prices to those local authorities within 30 minutes of London. The London effect may not be the only reason causing these three local authorities to show a high starting-price or house price increase. In Oxford and Cambridge this effect between 2009 and 2016, could also reflect their advantageous economic position as major global University cities with a high density of related hi-tech companies. Bristol had a low house price in 2009 but a sharp house price increase during the following seven years and is also a hub for technology and creative industries and home to a world-leading university. With these exceptions, the remaining local authorities seem mainly influenced by the high house prices in London.

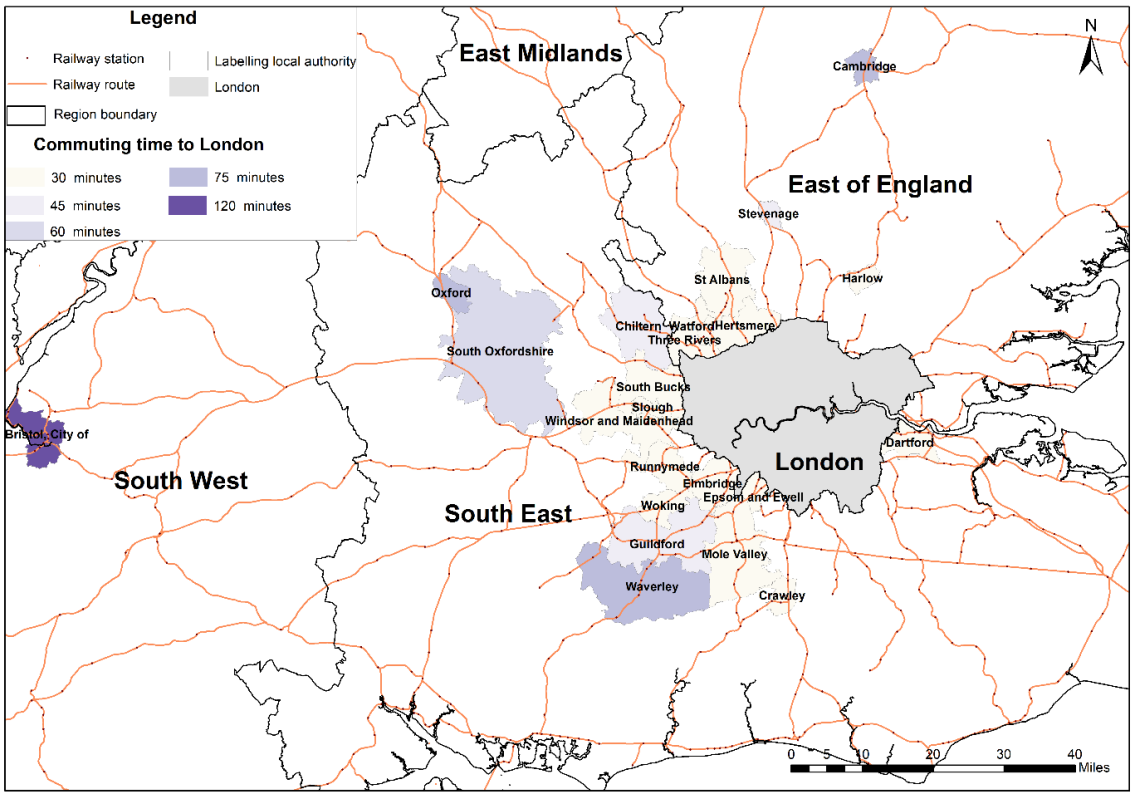

Figure 7. The geography of local authorities with higher starting-price or higher house price increase

Of the 59 local authorities with a house price percentage increase over 3.79% but below 5% (Figure 6), the majority are located in local authorities with a travel time to London of less than 105 minutes. Of the remainder, only 4 (Fareham, Portsmouth, Bath and North East Somerset - dark blue label in Figure 5) are within 120 minutes and another thirteen (Trafford in the North West; East Northamptonshire, Erewash, Oadby and Wigston, Rushcliffe and South Holland in the East Midlands; Norwich and St Edmundsbury in the East of England; Bournemouth, Cheltenham, Christchurch, Gloucester, North Somerset and South Gloucestershire in South West - light pink label in Figure 5) are over 2 hours travel time to London. The potential reason for East Northamptonshire, St Edmundsbury and South Gloucestershire, Bath and North East Somerset and North Somerset showing a relatively higher house price percentage increase is their location near to local authorities showing house price increases greater than 5% (i.e. City of Bristol, Corby and East Cambridgeshire). The majority of local authorities with over 2 hours travel time to London exhibit house price increases of less than 3.79%.

The geography of travel time to London at local authority level in England (Figure 5) shows, with some exceptions, a clear gradient radial pattern with the shortest travel-time to London in the areas around London and increasing travel-time time as distance from the centre increases. Two significant pockets of poor access to London in Figure 5 are East Northamptonshire and St Edmundsbury. Further comparison of the spatial pattern of house price percentage change with travel time (Figure 8) shows some interesting counter examples to the overall trend. This reveals that some local authorities with relatively fast travel to London show a relatively lower house price increase. Examples are Uttlesford (within 45 minutes), Wealden (within 60 minutes), Shepway (within 75 minutes), Daventry and Rother (within 90 minutes).

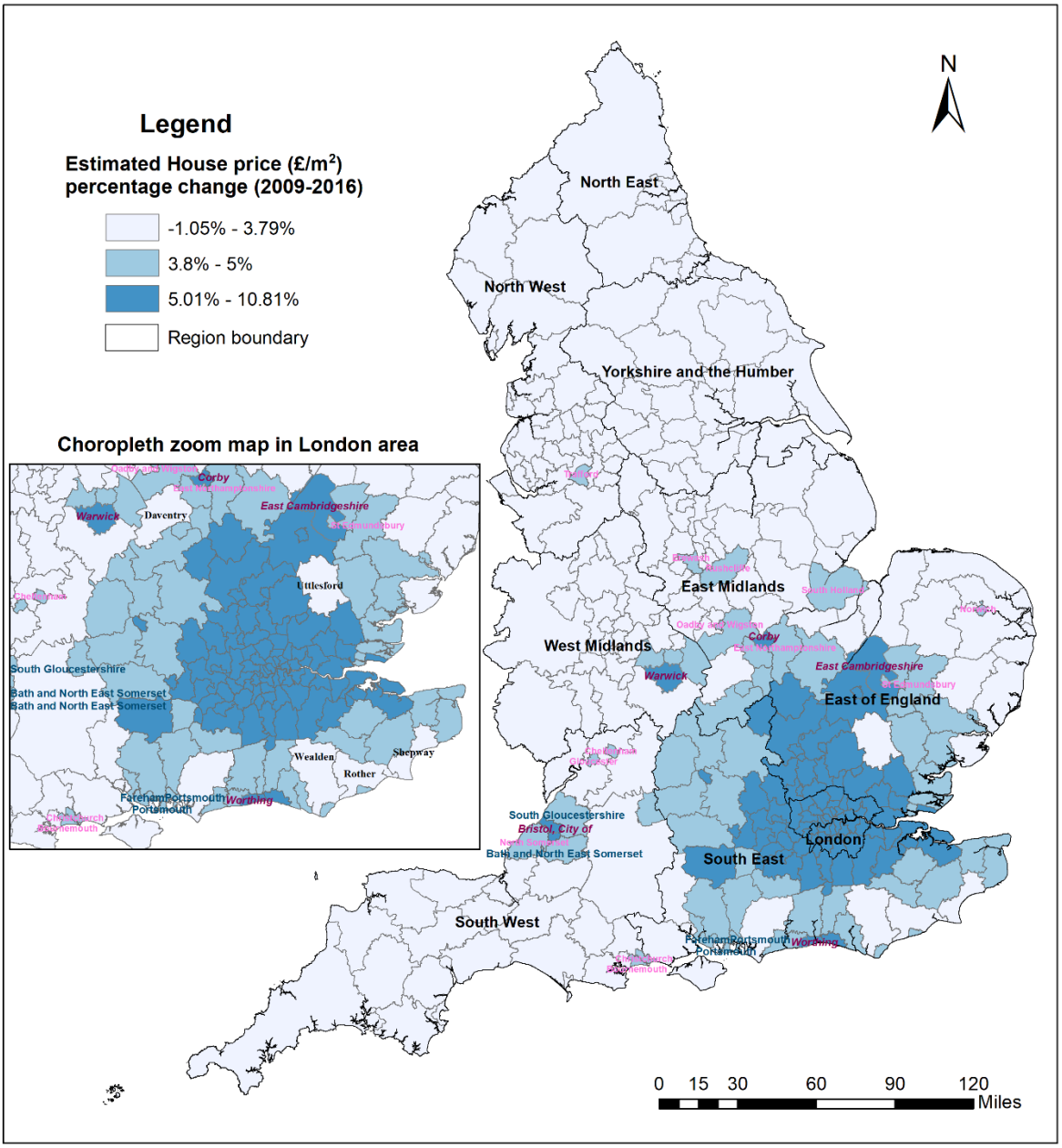

Figure 8. The spatial pattern of overall average house prices percentage changes at local authority level

We are also able to compare the local authority travel times to London (Figure 5) and their 2009 starting-prices (Figure 9). This reveals local authorities with shorter travel time to London generally have greater house prices increases, but with some exceptions. On the other hand, starting-prices of the local authorities with the same travel time to London do vary. Furthermore, comparing the spatial pattern of local authority travel times to London (Figure 5) and their 2009 starting-prices (Figure 10), few local authorities in the same travel time bracket show relatively cheaper starting-prices. For the local authorities whose travel time to London is within 30 minutes, Harlow and Gravesham showed relatively low house prices in 2009 of over 1,900 £/m^2 but below 2,000 £/m^2. In contrast, their neighbouring local authorities show house prices over 2,000 £/m^2. Similarly, for those local authorities whose travel time to London is within 45 minutes, Luton, Medway and Stevenage showed house prices between 1,600 £/m^2

and 1,900 £/m^2. In contrast, their neighbouring local authorities show house prices over 2,000 £/m^2. Swindon is within 90 minutes travel of London, but its starting-price is below 1600 £/m^2 with nearby local authorities having prices over 2,000 £/m^2.

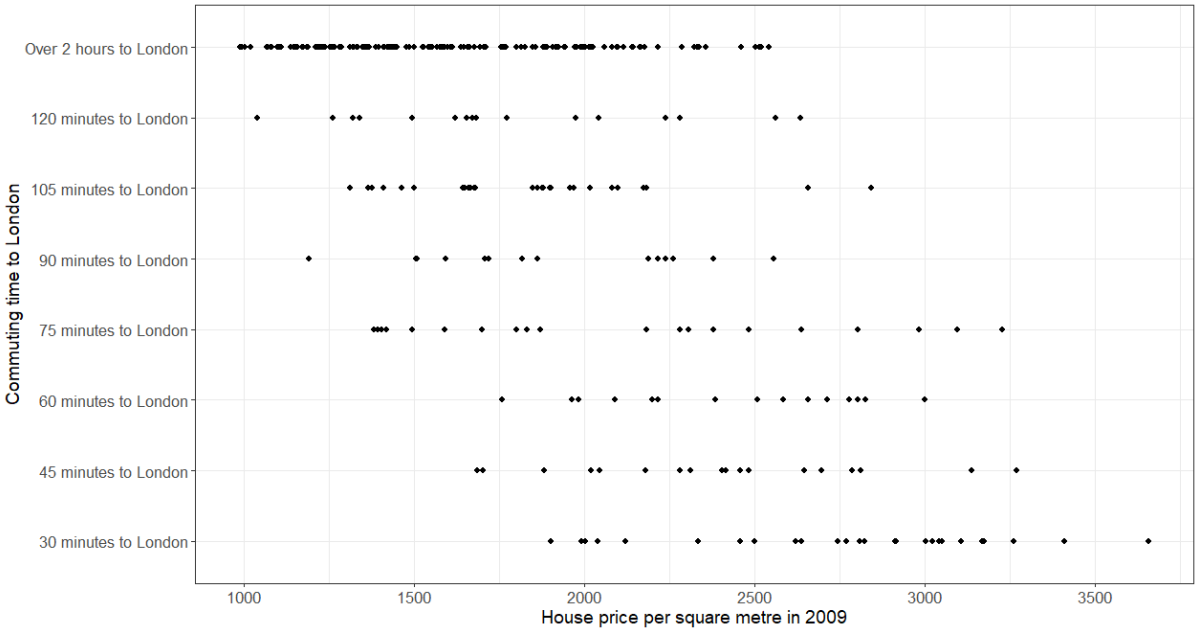

Figure 9. The relationship between local authority starting-price and travel time to London

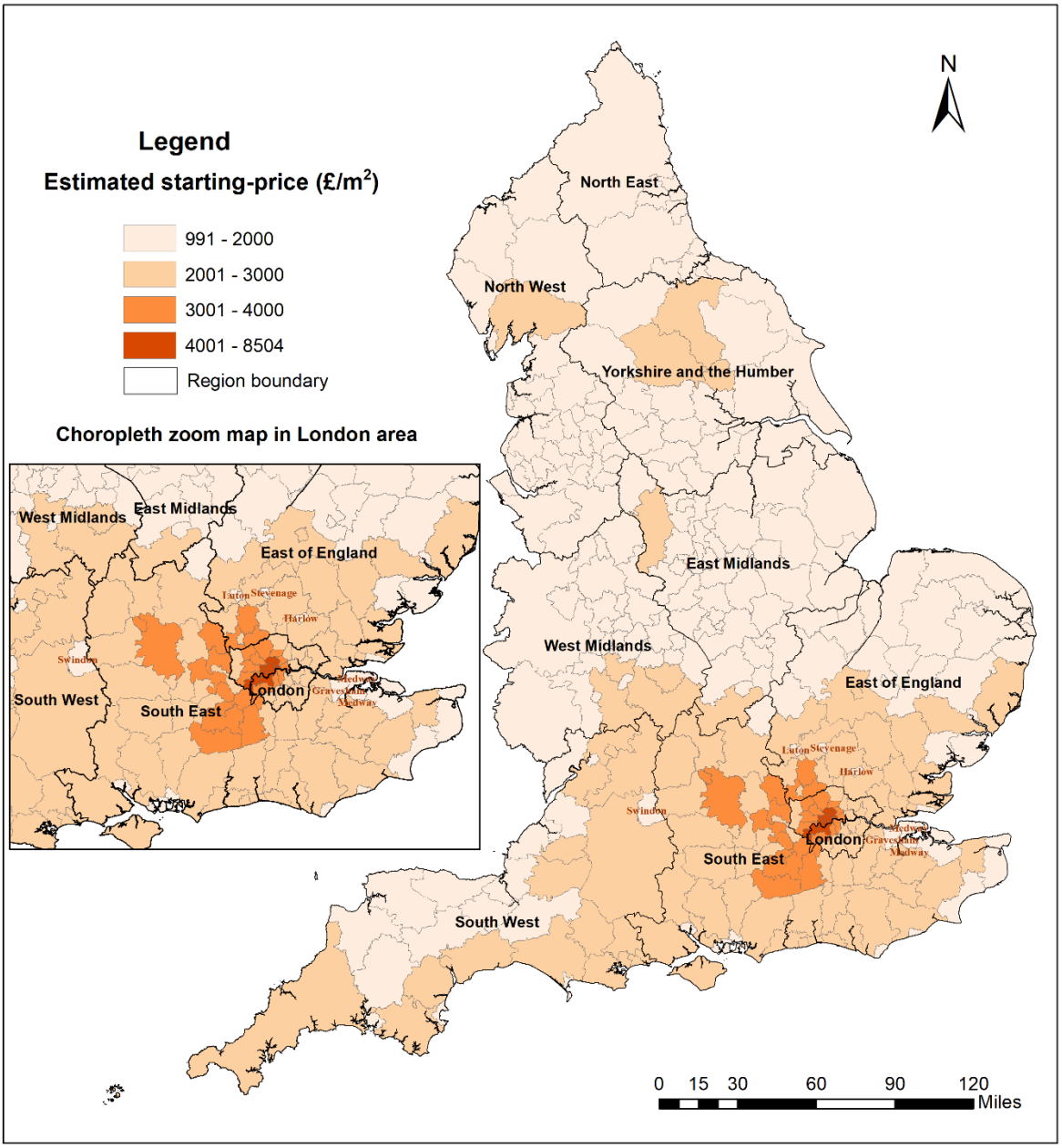

Figure 10. The spatial patterns of local authority starting-price (2009) at local authority level

5. Conclusion and further study

This research takes a first step in exploring the effect of travel time to London on house price variation across England. Local authority travel time to London and its spatio-temporal pattern of local authority house prices variation after economies crisis in England is centred in this research. The growth curve model is used to provide a model-based local authority house price growth estimates between 2009 and 2016. The intercept at 2009 (starting-price) and slope between 2009 and 2016 (percentage increase) for each local authority are extracted to quantify the local authority house price variation. Local authority house price percentage increases and starting prices are further compared to the spatial pattern of travel to London times from the rest of England. The post-2008 financial crisis house price rebound started in London and our results reveal that the 'ripple' out of London broadly corresponds to rail travel times back into the Capital. Local authorities with faster travel to London generally have greater house prices increases and higher starting prices, with some exceptions. Fifty-three local authorities within 75

minutes travel time to London show a greater than 5% house price percentage increase. Of these areas, almost 80% have more than 17.72 % of workers commuting beyond the local authority area, go to London (Appendix B). Prices in these areas (local authority within 75 minutes travel-time to London) are not no doubt inflated by the additional incomes (alongside potential sale equity) earned by those with jobs in London who are able to commute on a daily basis.

The reachable areas are based on travel time data for 2019 through TravelTime Platform, giving an up to date geography of travel time. Since, however, the date of travel time dataset is not within the house price variation period (2009-2016) some errors may be introduced. Further research will use the historic railway travel timetables to further explore this public travel time effect on house price variation through a multilevel hedonic model. It is also the case that there are not perfect correlations between travel time and travel price or indeed travel comfort (in terms of overcrowding, reliability etc.) and research here would certainly shed more light. The hedonic model, in introducing environmental and social variables, may assist in explaining those counter examples to the radial trend from London. Understanding the underlying mechanisms of how the London effect in terms of the travel time to London operates on house price variation in England will underpin a nationwide house price model and also offer a solid support for housing, planning and transport policy.

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Appendix A

Table A. A summary of the local authorities with travel time between 75 minutes to 105 minutes but have high house price percentage increase

Local authority	Region	House price (£/m^2) percentage increase	Price in 2009 (£/m^2)	Travel time to London
Cambridge	East of England	7.37%	2984	75 minutes
Oxford	South East	6.17%	3097	75 minutes
Brighton and Hove	South East	5.74%	2803	75 minutes
East Cambridgeshire	East of England	5.49%	1881	105 minutes
Adur	South East	5.43%	2380	75 minutes
Swale	South East	5.27%	1701	75 minutes
Basingstoke and Deane	South East	5.24%	2281	75 minutes
Bedford	East of England	5.11%	1831	75 minutes
Corby	East Midlands	5.10%	1193	90 minutes
Warwick	West Midlands	5.07%	2182	105 minutes
Worthing	South East	5.03%	2190	90 minutes
Ipswich	East of England	4.93%	1507	90 minutes
Canterbury	South East	4.92%	2184	75 minutes
Huntingdonshire	East of England	4.84%	1801	75 minutes
Swindon	South West	4.83%	1593	90 minutes
Cherwell	South East	4.82%	2308	75 minutes
Northampton	East Midlands	4.76%	1494	75 minutes
Dover	South East	4.65%	1721	90 minutes
Wellingborough	East Midlands	4.57%	1383	75 minutes
Rugby	West Midlands	4.56%	1590	75 minutes
Maldon	East of England	4.45%	2173	105 minutes
Thanet	South East	4.45%	1651	105 minutes
Kettering	East Midlands	4.38%	1404	75 minutes
Waverley	South East	4.38%	3229	75 minutes
Lewes	South East	4.34%	2485	75 minutes
East Hampshire	South East	4.28%	2556	90 minutes

Eastleigh	South East	4.26%	2262	90 minutes
Forest Heath	East of England	4.26%	1680	105 minutes
Hastings	South East	4.14%	1666	105 minutes
South Northamptonshire	East Midlands	4.13%	2081	105 minutes
Coventry	West Midlands	4.12%	1365	105 minutes
Vale of White Horse	South East	4.10%	2637	75 minutes
Eastbourne	South East	4.02%	1971	105 minutes
Arun	South East	3.99%	2239	90 minutes
Harborough	East Midlands	3.96%	1819	90 minutes
Babergh	East of England	3.94%	2019	105 minutes
Havant	South East	3.90%	1959	105 minutes
Solihull	West Midlands	3.83%	1848	105 minutes
West Oxfordshire	South East	3.79%	2657	105 minutes

Appendix B

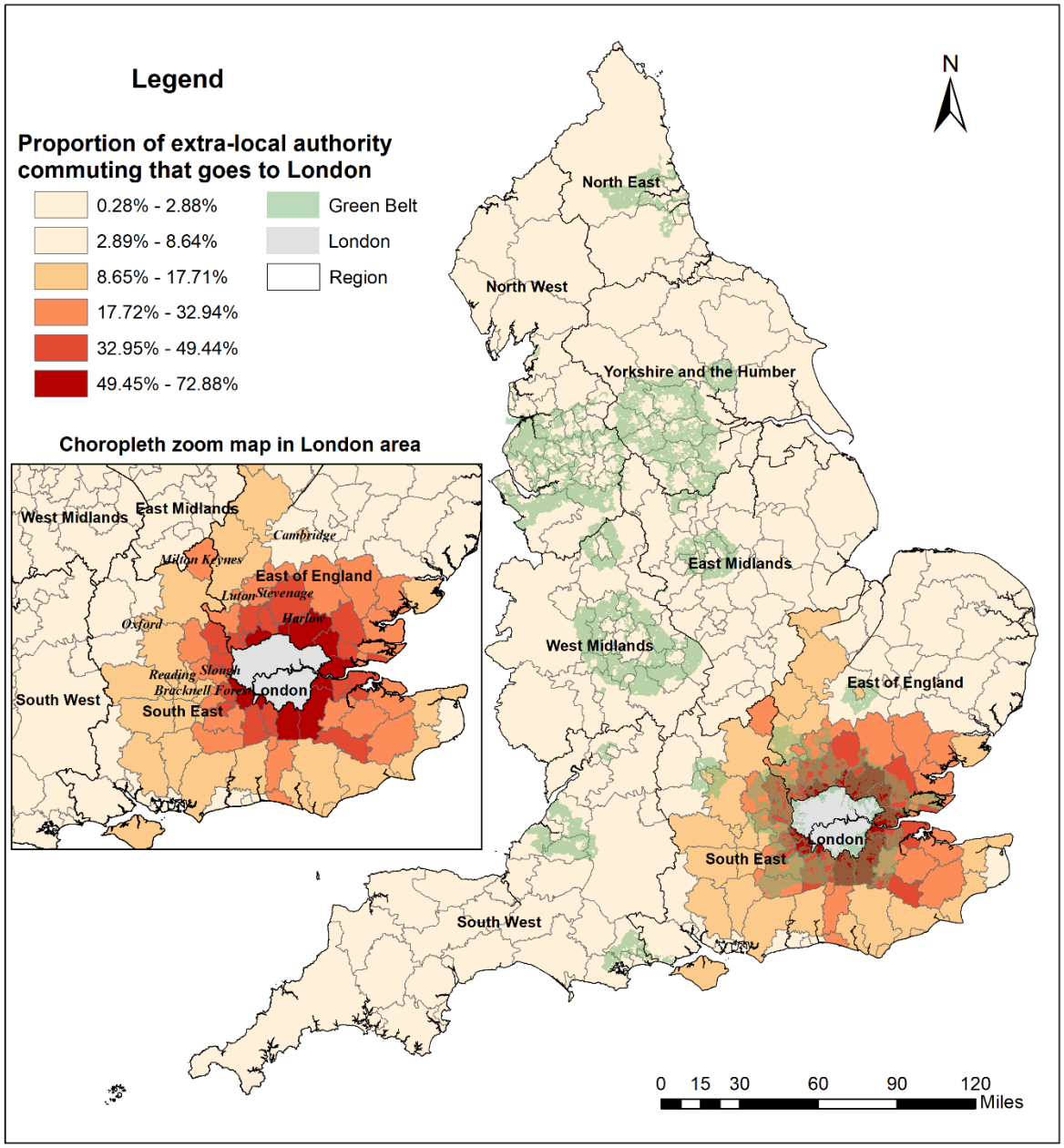

Figure B. Percentage of outside travel to work in London against the total outside travel to work[8]

[8] Data for this map is aggregated travel to work data (Table WU03EW_MSOA) in the Census 2011 at local authority unit and then treated all the local authorities in London as one unit. The proportion of extra-local authority commuting that goes to London refers to the number of people commuting outside of home local authority to work in London divided by the number of people commuting outside of home local authority to work.