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Creating a new dataset to analyse house prices in England

Bin Chi, Adam Dennett, Thomas Oléron-Evans, Robin Morphet

Abstract

House price data deficiencies hinder UK housing market research. House price research in the UK is limited by lack of an open and comprehensive house price database that contains transaction price alongside individual property characteristics. This research outlines one approach which addresses this deficiency in England. Land Registry Price Paid Data (PPD) is the official house price dataset in England covering residential transactions in the housing market. It has two main disadvantages: first it is not geo-referenced and second, it lacks accurate information on housing size. We create two data linkage methods to overcome these two shortcomings, first by linking the Land Registry PPD with Ordnance Survey (OS) MasterMap and OS AddressBase Plus, second by linking the resulting data with total floor area information from Domestic Energy Performance Certificates (EPCs). This new linked dataset offers greater flexibility for the exploration of house price variation in England over different scales. A strong positive relationship is observed between house price and total floor area. This relationship varies at different geographic scales and over different property types across England.

Keywords: Land Registry Price Paid Data, data linkage, England.

1. Introduction

Housing is a major source of inequality in the UK, particularly in England (Dorling, 2014). In some areas of England, buying a house is becoming prohibitively expensive (Inman, 2017). The current UK government has recognised that the UK housing market is broken and they want to fix it (DCLG, 2017). A more nuanced understanding of residential house prices in England will support better decision making to facilitate this goal. However, data deficiencies are an obstruction to a comprehensive analysis. House price data in England is imperfect (Gibb and Bailey, 2016; Wood, 2015) and this poses significant practical problems in exploring house price variation across England, especially over small geographical areas.

Current house price statistics are normally presented at a macro-geographic scale (i.e. region or local authority), while house prices actually show spatially heterogeneous patterns at smaller geographical scales (ONS, 2016, 2017). It is necessary to explore house price patterns at smaller geographic levels to gain a better understanding of the UK housing market. To support this, the choice of the dataset is regarded as critically important, but there has been little discussion of this in the literature (Gibb and Bailey, 2016; Whitehead et al., 2008; Wood, 2015). Meanwhile, the current official house price dataset (Land Registry PPD) covers all residential transactions in England and Wales since 1995, and includes information on a number of housing characteristics, but does not contain accurate housing size information, such

as total floor area. House price data linked with information on individual property characteristics are difficult to obtain within the UK (Gibbons and Machin, 2003; Orford, 2010), but dwelling size is regarded as one of the most important determinants of house price variation in house price modelling (Orford, 2010). Building a comprehensive housing price database will produce an advanced understanding of house price variation.

Presently, there is no comprehensive database which contains transaction price along with property characteristics in England (Wood, 2015). This research aims to overcome this limitation by developing a composite research dataset[1] comprising Land Registry PPD ,OS data and EPCs to better support house price analysis over small geographical areas in England. In this paper, we create two methodologies to enrich Land Registry PPD starting with an overview of Land Registry PPD along with a basic descriptive analysis in Section 2. Section 3 introduces the two data linkages which are created to overcome two deficiencies of the Land Registry PPD. This allows an exploration of the relationship between transaction price and total floor area in Section 4. Finally, the conclusions and implications for future study are discussed in Section 5.

2. Land Registry Price Paid Data

Land Registry PPD is the administrative dataset from the Her Majesty's Land Registry, which has been published as open data since 2013 (HM Land Registry, 2015). Land Registry PPD[2] provides the most accurate picture of full market sale in residential housing market among all the house prices resources in the UK since 1995 at address level (Marsden, 2015). The Office for National Statistics (ONS) uses this data to calculate certain house price statistics, such as House Price Statistics for Small Areas (South and Henretty, 2017) and the Official House Price Index (Office for National Statistics et al., 2016). Table 1 displays an explanation of data items in the Land Registry PPD; it not only contains the property sales price, transaction date and property address information, but also shows house type (detached, semi-detached, terraced houses or flats/maisonettes), tenure (freehold/leasehold), and whether a property is newly built or whether it was sold at full market value.

Table 1 Explanations of information fields in Land Registry PPD[3]

Data Item	Explanation
Transaction unique identifier	A reference unique number which is recording each published sale. e.g. {955B1020-9223-4981-AFF1-72C47E6CC60E}
Price	Sale price (transfer deed) .
Date of transfer	Date when the sale was completed. e.g. 2006-10-13
Property type	Indicates the type of house: D = Detached, S = Semi-Detached, T = Terraced, F = Flats/Maisonettes, O = Other

[1] The composite research dataset comprises data with a range of licenses conditions which make it available for academic research. This research includes one open data under the Open Government Licence v3.0 (Land Registry PPD: https://www.gov.uk/government/statistical-data-sets/price-paid-data-downloads), two OS datasets under individual academic licenses(OS MasterMap and OS AddressBase Plus) and one Domestic EPCs data (https://epc.opendatacommunities.org/) under a restrictive licence and copyright. These datasets are available for academic research upon application to the relevant authorities.

[2] It is based on a complete register of all residential property sale at for full market value in England and Wales excludes some residential property sales; details are available at: https://www.gov.uk/guidance/about-the-price-paid-data#data-excluded-from-price-paid-data

[3] Resource: https://www.gov.uk/guidance/about-the-price-paid-data .

Data Item	Explanation
Old/New	Indicates the age of the property and applies to all price paid transactions, residential and non-residential. There are two categories: a newly built property, an established residential building. If the property is firstly sold since 1995 it will identify as 'a newly built property'. Y = a newly built property, N = an established residential building
Duration	The tenure of property: freehold, leasehold
PPD category type	Indicates the type of Price Paid transaction. A = Standard Price Paid entry, includes single residential property sold for full market value. B = Additional Price Paid entry including transfers under a power of sale/repossessions, buy-to-lets (where they can be identified by a Mortgage) and transfers to non-private individuals. Category B is identified from October 2013.
Postcode	e.g. WC1H 9QH
PAON	Primary Addressable Object Name. such as the house number or name. e.g. 36
SAON	Secondary Addressable Object Name. Where a property has been divided into separate units (for example, flats), the PAON (above) will identify the building and a SAON will be specified that identifies the separate unit/flat. e.g. Flat 302
Street	e.g. Tottenham Street
locality	e.g. London
towncity	e.g. London
district	e.g. Camden
county	e.g. Greater London
Record status	Indicates additions, changes and deletions to the records A = Addition; C = Change; D = Delete.

The Land Registry PPD records 22,578,068 transactions in England and Wales between 1/1/1995 and 31/7/2017. Figure 1 shows the house price distribution from 1995 to 2016. Over this period, house price distributions in each year are seen to be positively skewed. It means prices are mainly clustered around a relatively low value together with a few extreme high values. Meanwhile, house prices have become more and more dispersed over time as the overall range of house price has dramatically widened during the last 22 years. The two local peaks (at £125,000 and £250,000) that may be observed in the graphs since 1998 reflect the Stamp Duty Land Tax (SDLT) thresholds. Moreover, house prices after 2006 exhibit a new peak at £500,000, which is also SDLT related.

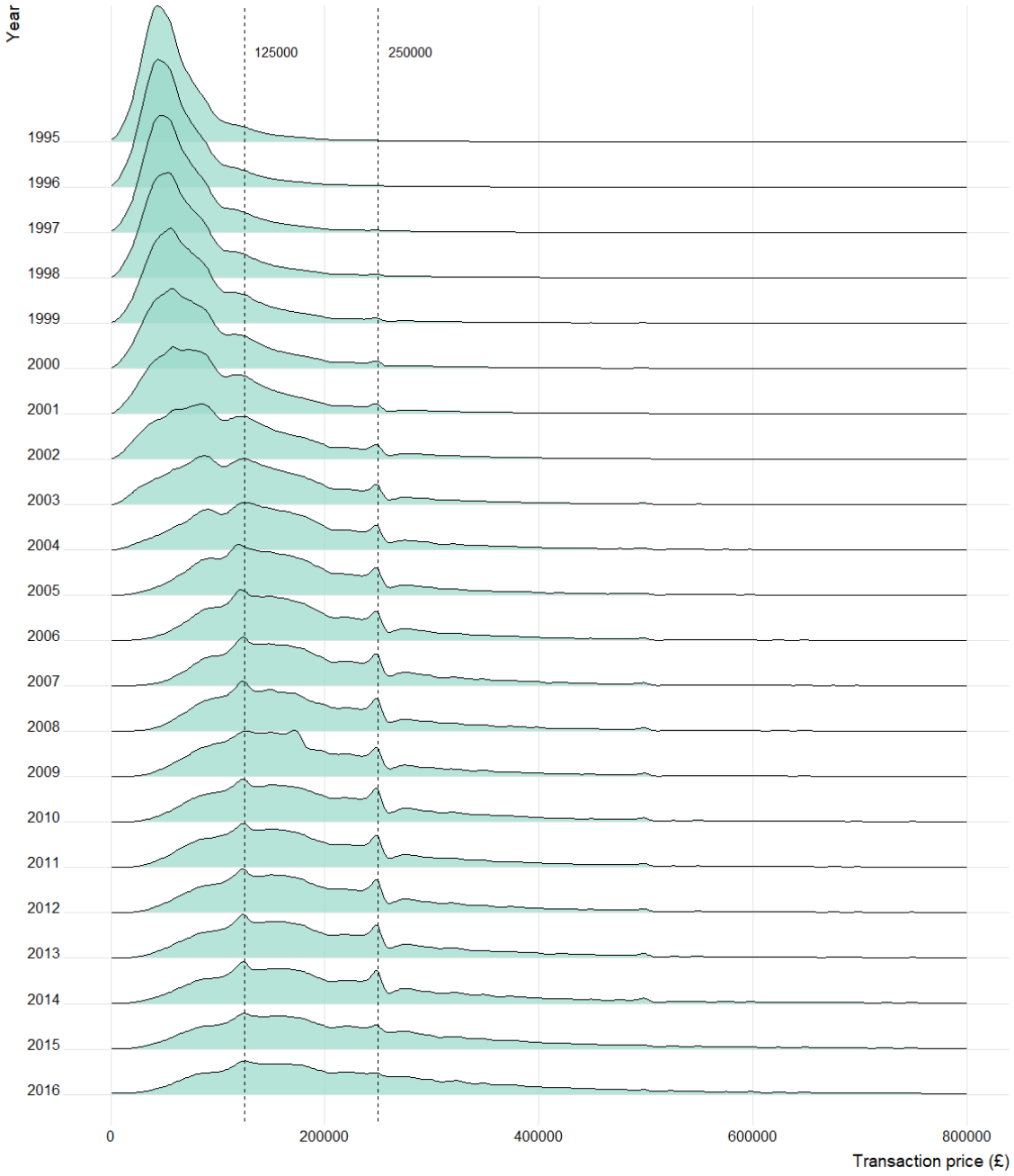


Figure 1 A Joyplot version of transaction price density plots in England and Wales,1995-2016[4]

The average number of annual transactions in England and Wales from 1995 to 2016 is around 1 million. Figure 2 shows the change of transaction volume from 1995 to 2016. There is a significant turning point when the global financial crisis erupted in 2007. Transaction numbers show a generally increasing trend from 1995 to 2007, but suddenly decrease by about a half in 2008. The number of residential property sales continues to recover after 2009, with an increase to over 1 million after 2015.

[4] The Land Registry Price Paid Data covers the period from 1/1/1995 to 31/7/2017. It does not cover the whole transactions occur in 2017. Thus all the description analysis within this section below not include the transactions in 2017. As the house price distribution shows a long tail and this graph only plot the distribution below £800,000.

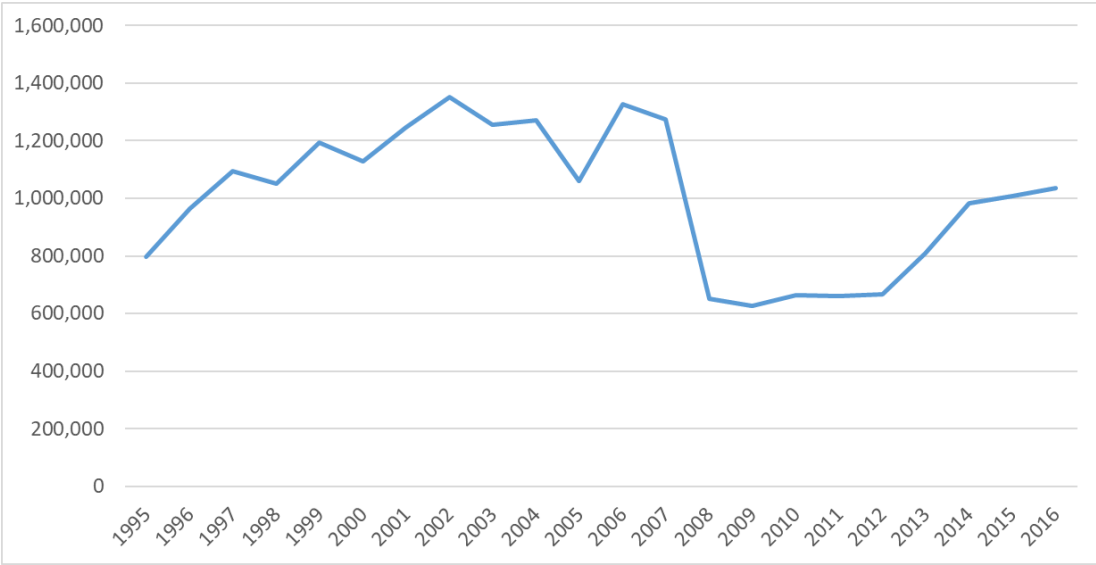


Figure 2 Transactions sales change in England and Wales, 1995-2016

3. Creating a new dataset by enriching the Land Registry Price Paid Data

Dwellings have heterogeneous characteristics and therefore the house prices will differ, even within the same neighborhood. Moreover, house prices show spatial sensitivity (Halket et al., 2015; Palm, 1978), meaning they vary across locations. That is why house price is normally presented at a certain location. Given this, the Land Registry PPD has two potential limitations for understanding house price variation. One is that it is not geocoded, the other is that it does not include property size information. Two methods are outlined below to overcome these limitations. One method aims to geo-reference transactions at the building level, whilst the other aims to add in property size (i.e. total floor area and number of habitable rooms) to the geo-referenced transactions by linking with Domestic EPCs. A brief flowchart of these two methods are shown in Figure 3.

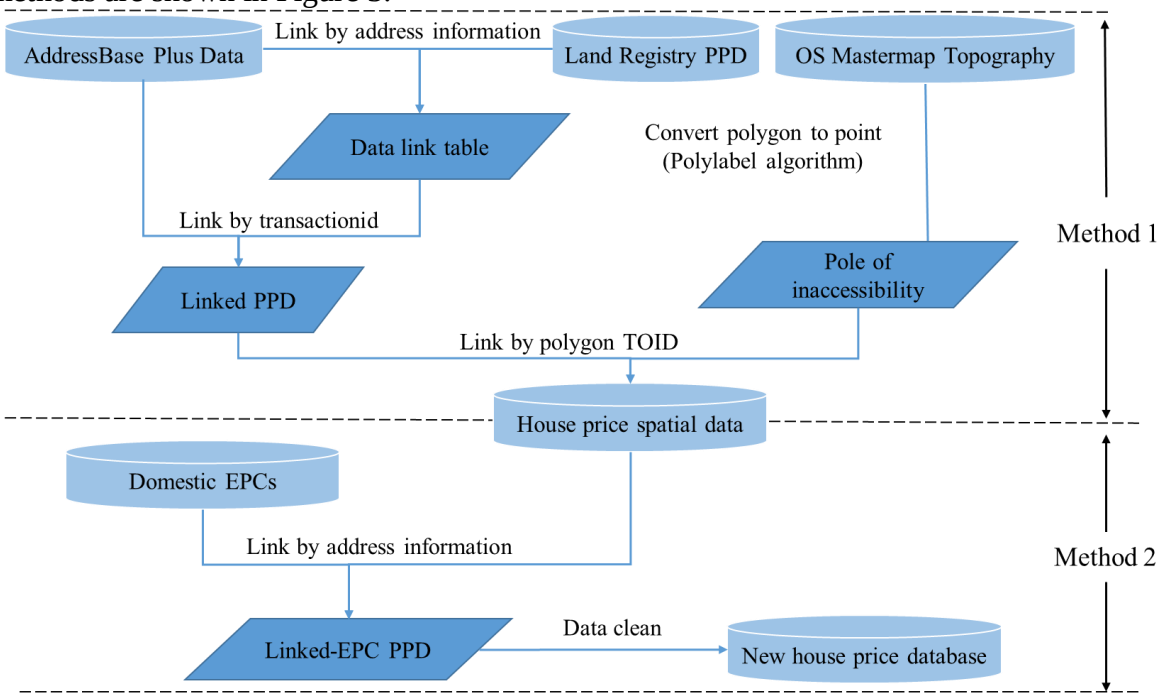


Figure 3 A brief flowchart for enhancing the Land Registry PPD

3.1 Geotagging the price paid data at building level

Geographic information exists in the form of the address string in the Land Registry PPD. The National Statistics Postcode Lookup (NSPL) is frequently used to link geographic information (i.e. latitude and longitude) to the Land Registry PPD through matching the postcode (South and Henretty, 2017). This method cannot accurately pinpoint the dwelling's real location, since it only locates the postcode's centroid point. OS MasterMap Topography Layer is a spatial dataset which represents individual buildings as geolocated polygons along with a unique geocode (TOID, Topographical Identifier). OS AddressBase Plus contains geocodes (TOID) and dwellings' postal delivery addresses from the Royal Mail across England and Wales. Linking these two datasets through geocodes (TOID, Topographical Identifier) creates a database that is interchangeable between the building's postal delivery address and its geographic information. Therefore, geocoding the Land Registry PPD can be achieved at the building location by integrating Land Registry PPD with AddressBase plus and OS MasterMap data.

Land Registry PPD, OS AddressBase Plus data and OS MasterMap Topography Layer build a foundation for the geo-referencing of transaction prices. As shown in Figure 3, Land Registry PPD and AddressBase Plus data can be linked by address information (postcode along with address strings), then link back to the OS MasterMap matching through the TOID. On the other side, an iterative grid algorithm called Polylabel (Garcia-Castellanos and Lombardo, 2007; Hügel, 2017) is used to calculate the pole of inaccessibility[5] of each polygon as proxy of geolocation of the building. The last step is to link these three datasets with TOID to build a house price spatial database.

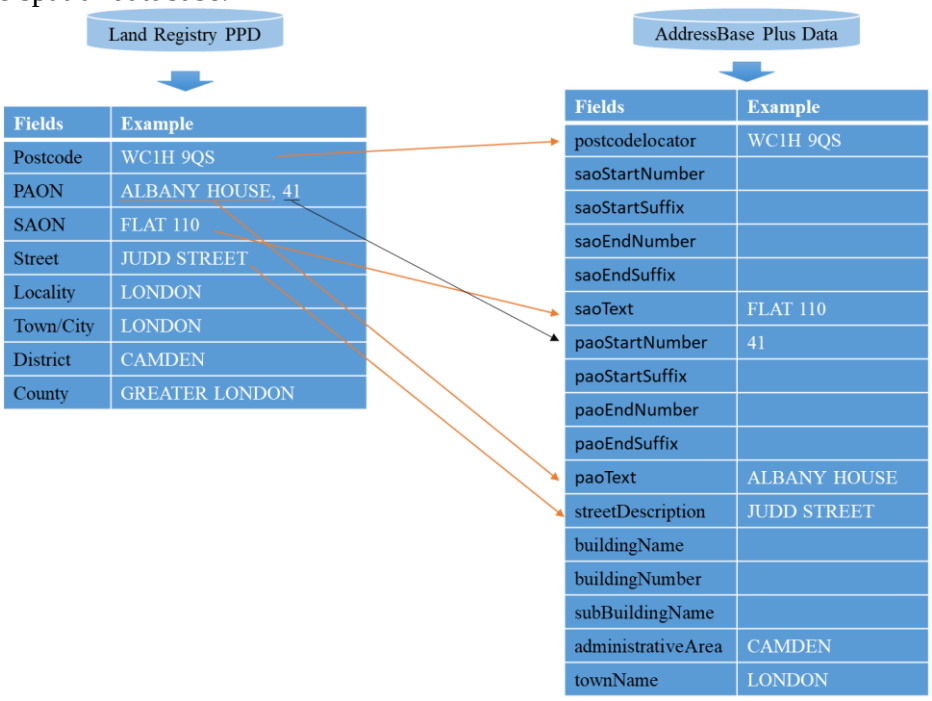


Figure 4 Address components difference in Land Registry PPD and AddressBase Plus data

Linking Land Registry PPD with AddressBase Plus by address information presents difficulties as the address records between these two datasets are structured differently (Figure 4). The full postal delivery addresses in the Land Registry PPD are categorized into four

[5] Pole of inaccessibility is a geographical point that represents the most remote place reach in a given area. The definition of pole of inaccessibility is the point within a polygon that is farthest form an edge. In cartographic visualization, it is use to label the text label on the centre of polygon.

address information items (i.e., postcode, paon, saon and street). The AddressBase Plus data not only contains the same postcode and street records, but also includes building name, building number and sub-building name. Moreover, it divides PAO (Primary Addressable Object) information as ‘paostartnumber’, ‘paostartsuffix’, ‘paoendnumber’, ‘paoendsuffix’ and ‘paotext’. Moreover, SAO (Secondary Addressable Object) information divides in the same way, named as ‘saostartnumber’, ‘saostartsuffix’, ‘saoendnumber’, ‘saoendsuffix’, ‘saotext’ respectively. These differences mean that matching is not straightforward and a multi-stage process is required to achieve successively more matches.

Some basic data cleaning and standardization are implemented to support the data linkage. As shown in Table 2, 32 new address variables are created to in Land Registry PPD and AddressBase Plus data, nine of them are created in the Land Registry PPD and the rest of 23 new variables are created in the AddressBase Plus data.

Table 2 New address variables created from existing address field[6]

Type	New variable	Create method
Combine	SAONPAON	Combine SAON and PAON with a blank space
	PAONSTREET	Combine PAON and street with a blank space
	SAONSTREET	Combine PAON and street with a blank space
	bb	Combine buildingname and buildingnumber, using a comma
	pp	Combine paostartnumber and paostartsunffix
	pp1	Combing paotext and paostartnumber fields using a comma
	pp2	Combing paotext and pp fields using a comma
	pp4	Combine paostartnumber and paostartsunffix using hyphens
	ppp	Combine paotext and pp4 with a blank space
	ss	Combine saostartnumber and saostartsuffix
	ss1	Combine saostartsuffix and saostartnumber
	subss	Combine subbuildingname and ss with a blank space
	saopp	Combine saotext and pp with a comma and a blank space
	sp	Combine ss and paotext fields using a blank space
	ssp	Combine saotext and sp1 with a comma and a blank space
	saobui	Combine fields saotext and buildingname using a blank space
	psao	Combine the paostartnumber and saotext1
Stripping	PAON1	Stripping surrounding whitespace from hyphens and the comma in PAON field.
	PAON2	Stripping surrounding whitespace from hyphens in PAON field
	SAON2	Stripping surrounding whitespace in SAON field
	saotext1	Deleting the ‘FLAT ’ leading string in saotext
Prepend string	FLATSAON	Prepend the SAON with ‘FLAT ’ string
	FLATPAON	Prepend the PAON with ‘FLAT ’ string
	UNITPAON	Prepend the PAON with ‘UNIT ’ string
	flatsao	Prepend the saostartnumber with ‘FLAT ’ string
	flatss	Prepend the ss with ‘FLAT ’ string
	flatsub	Prepend the subbuildingname with ‘FLAT ’ string
	unitss	Prepend the ss with ‘UNIT ’ string
	flatpao	Prepend the paostartsuffix with ‘FLAT ’ string
	paostartnumber1	Prepend the paostartnumber with ‘FLAT ’ string
Replace	subbuildingnamenew	Replace ‘UNIT’ and ‘APARTMENT’ string in subbuildingname to ‘FLAT ’ string
	saotext2	Replace the ‘APARTMENT’ ,‘SUITE’ sting in saotext to ‘FLAT ’ string and delete ’.’ string in saotext

The linkage between Land Registry PPD and AddressBase Plus data is designed to match within each unique postcode unit belonging to Land Registry PPD. However, some postcodes

[6] Variables written as capital stands for the new variable in Land Registry PPD.

included in the PPD are not covered by the AddressBase Plus data. The transactions which have these postcodes are deleted first. A data linkage is created using a 13 stage process that has 84 matching rules; it is based on the address string fields shown in Figure 4 and Table 2. Details of the 13 stage process and matching rules are shown in Appendix A. The matching rate for each stage is shown in Table 3.

Table 3 Match rate for different stages

Stage	Match rate	Cumulative match rate
Stage 1	0.002%	0.002%
Stage 2	91.51%	91.51%
Stage 3	2.19%	93.70%
Stage 4	0.23%	93.93%
Stage 5	0.74%	94.67%
Stage 6	0.11%	94.79%
Stage 7	0.30%	95.09%
Stage 8	1.83%	96.91%
Stage 9	0.32%	97.24%
Stage 10	0.47%	97.70%
Stage 11	0.01%	97.71%
Stage 12	0.19%	97.90%
Stage 13	0.04%	97.94%

Land Registry PPD used here covers all transactions before 31/7/2017 in England and Wales. Using the 13 stage/97 rules model, 97.94 % of transactions (22,113,003) are successfully matched. This data linkage result is designated as the data link table as shown in Figure A1 and also Figure 3. Stage 2 and stage 3 achieve a 93.70% match rate without additional stages being performed. These two stages therefore constitute the main matching process. Given the differences in address string format between the Land Registry PPD and AddressBase Plus datasets, a more complete data linkage was achieved by processing the newly created address variables through other 11 stages. These 11 stages are termed the match cleaning up process.

Following the work flow in Figure 3, the data link table obtained from the 13-stage matching linkage contains a unique transaction identifier (transactionid) from the Land Registry PPD and Topographical Identifier (ostopotoid) from OS AddressBase Plus data. Then using the Land Registry PPD with the data link table we can successfully add geocodes (Topographical Identifier, TOID) to the transaction price to give the linked PPD. After that, the linked PPD can be geo-referenced by linking the building's centre point (Pole of inaccessibility) by TOID. The method 1 process (Figure 3), successfully geo-referenced 22,029,412 records at building level and this new dataset is designated the house price spatial data set.

A sample of house price spatial data is shown in Figure 5. Following this linkage procedure, combining the linked PPD and Pole of inaccessibility derived from OS MasterMap Topography, confers two major advantages on the newly created data set. First, unlike the original PPD data, house price spatial data can now be aggregated at the level of any geographical unit (e.g. street level, OA level, regional level, etc.). Second, fully georeferenced house price data is more analytically flexible than data represented at postcode unit by linking NSPL. This flexibility allows for a much wider range of spatial analyses to be conducted, such as exploratory spatial data analysis and spatial interpolation.

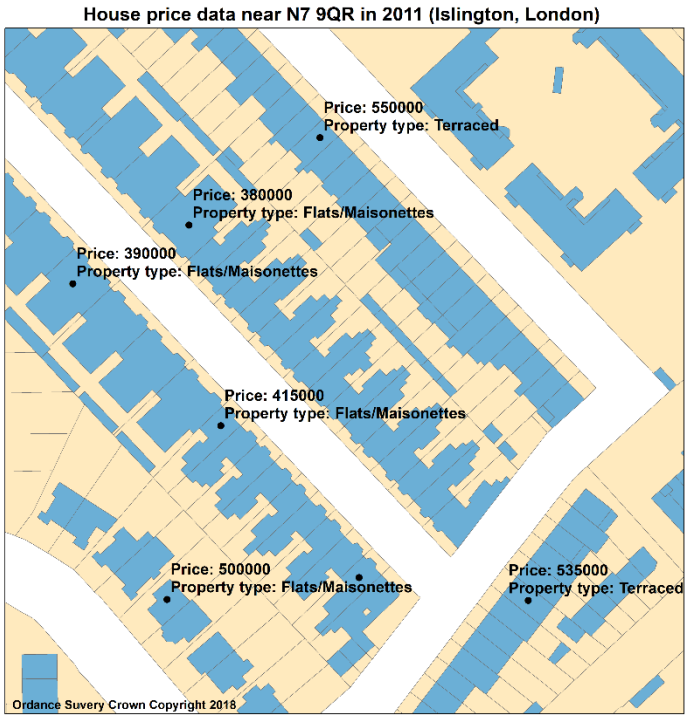


Figure 5 Sample of matched building polygons from Master Map with Land Registry data,1995

A 100% match rate is not to be expected mainly because in both datasets the addresses are structured differently. Additionally, there are three other reasons. First, 0.12% of the Land Registry records lack the postcode information in the price paid dataset. Second, some transactions do not possess matching address information in the AddressBase Plus Dataset; this may be because some properties no longer exist. Third, some transaction address records are insufficiently detailed to identify the unique building TOID in which they are situated. This issue caused one-to-many relationship problems with one (transaction) being related to many buildings during the matching process.

3.2 Enrichment house price data spatial data with property size information

Modelling suggests floor area is the most important determinant of house price (De Nadai and Lepri, 2018; Morancho, 2003; Orford, 2010; Sirmans et al., 2006; Thwaites and Wood, 2005). Thus enriching Land Registry PPD with floor area information will be highly valuable in supporting house price analysis, especially for house price variation analysis. Domestic Energy Performance Certificates (Domestic EPCs) released by the Department for Communities and Local Government (DCLG) describe a property's energy performance and its building stock information, such as its total floor area and its number of habitable rooms. EPCs are legally required when a building or building unit is offered for sale or rent in the UK and remain valid for 10 years. Some researchers have started to use the combination of Land Registry and EPC data to undertake house price research. The first house price per square metre map in England and Wales was based on data links between the Land Registry PPD and EPCs (Powell-Smith, 2017). This map offered a new insight into house price per square metre patterns at postcode district level. Moreover, Fuerst et al (2013) combined Land Registry data and EPC data to explore the relationship between energy performance and house prices across the UK in the period from 1995 to 2011. This section describes method 2 in Figure 3, which aims to enrich the house price spatial data with the total floor area information from Domestic EPCs.

(1) Data linkage

The current EPC dataset available to the public contains 85 items with 15,623,536 Domestic EPCs from 1/1/2008 to 1/10/2016. Table 4 shows the description of the key property characteristics recorded in Domestic EPCs.

Table 4 Explanations of address string and key property characteristics in EPC data[7]

Item	Explanation
Address1	First line of the address.
Address2	Second line of the address..
Address3	Third line of the address.
Postcode	The postcode of the property
Property type	Describes the type of property. e.g. Maisonette, Flat, House, Bungalow, Park home.
Built form	The building type of the Property e.g. Enclosed End-Terrace, Detached , End-Terrace, Semi-Detached, Mid-Terrace, Enclosed Mid-Terrace.
Inspection date	The date that the inspection was actually carried out by the energy assessor.
Lodgement date	Date lodged on the Energy Performance of Buildings Register.
Total floor area	The total useful floor area is the total of all enclosed spaces measured to the internal face of the external walls, the gross floor area as measured in accordance with the guidance issued from time to time by the Royal Institute of Chartered Surveyors or by a body replacing that institution.
Floor level	Flats and maisonettes only. Floor level relative to the lowest level of the property (0 for ground floor). If there is a basement, the basement is level 0 and the other floors are from 1 upwards.
Number of habitable rooms	Habitable rooms include any living room, sitting room, dining room, bedroom, study and similar; and also a non-separated conservatory. A kitchen/diner having a discrete seating area (with space for a table and four chairs) also counts as a habitable room. A non-separated conservatory adds to the habitable room count if it has an internal quality door between it and the dwelling. Excluded from the room count are any room used solely as a kitchen, utility room, bathroom, cloakroom, en-suite accommodation and similar; any hallway, stairs or landing; and also any room not having a window.
Floor height	Average height of the storey.
Address	Field containing the concatenation of address1, address2 and address3.

Figure 6 shows the process of data linkage between house price spatial data and Domestic EPCs. These two datasets offer the property information at address level but their address structures are different, thus basic data standardization is needed before linking house price spatial data and Domestic EPCs. First, all the address string in the Domestic EPCs were capitalised and then new address variables were created separately in the house price spatial data and Domestic EPC data sets. Finally, the newly created address variables were used to achieve the data linkage. Following this process, 180 new variables were created in the house price spatial data and 95 new variables were created in the EPC data to assist the data linkage. Details of the new variable creation methods are shown in Appendix B.

[7] Resources: https://epc.opendatacommunities.org/docs/guidance

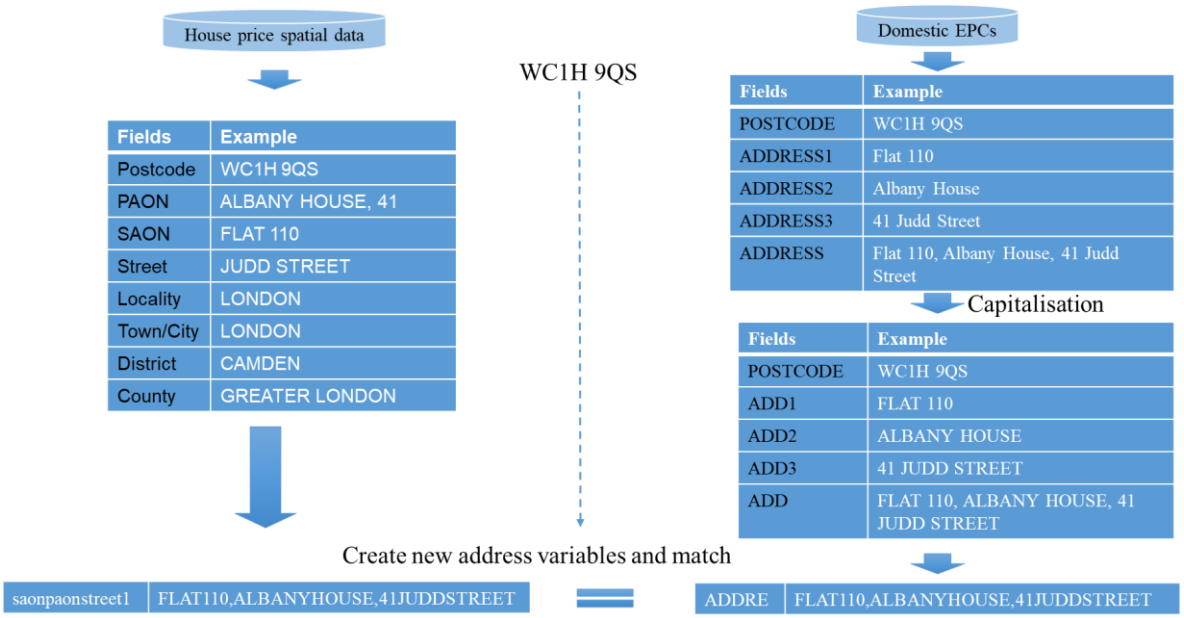


Figure 6 An example of data linkage process

Before the matching, transactions without postcodes in the Domestic EPCs dataset were excluded. A total of 0.64% of the data was deleted after applying this rule. Then with the newly created address variable in Table B1, a matching method containing a 4 stage (163 matching rules) matching process was designed to combine the house price spatial data and Domestic EPCs. Details of the matching process and matching rules are shown in Appendix C. Following the combination of house price spatial data and Domestic EPCs, 14,519,565 geo-referenced transaction records in England and Wales were successfully linked with EPC.

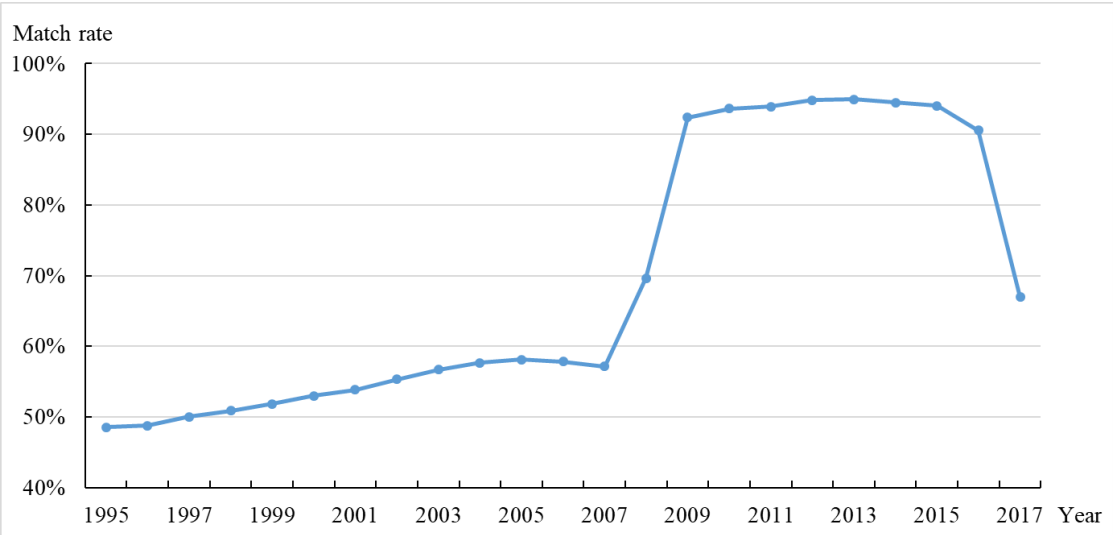


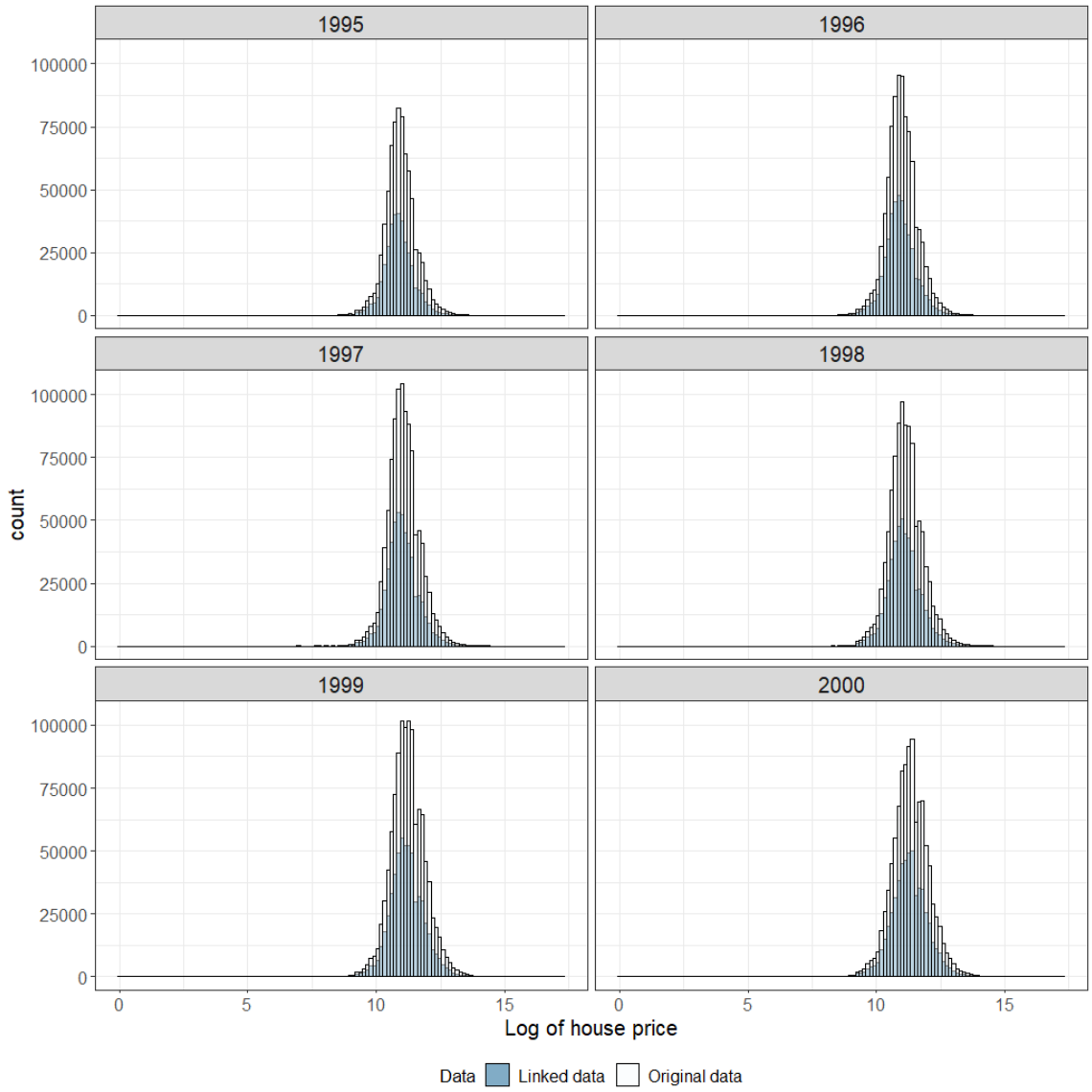
Figure 7 Match rate of house price spatial data in England,1995-2017

Within the linked EPC data, 13,881,493 of the entries are transactions in England. The match rate of transactions in England is shown in Figure 7. The match rate between 2009 and 2016 is higher than 90%, while the matching rate of the rest of the period is lower than 90%. As the publicly available EPC data only covers the period between 2008-1-1 and 2016-10-1, the match rate is relatively high over that period. The matching rate is 69.61% in 2008 and 66.94% in 2017 whilst between 2009 to 2016 it is over 90%. After checking the transactions (2008-2017) which failed to link, we found some sold dwellings during 2008 to 2016 were not recorded in the publicly available EPC data. This makes 100% matching unachievable. The

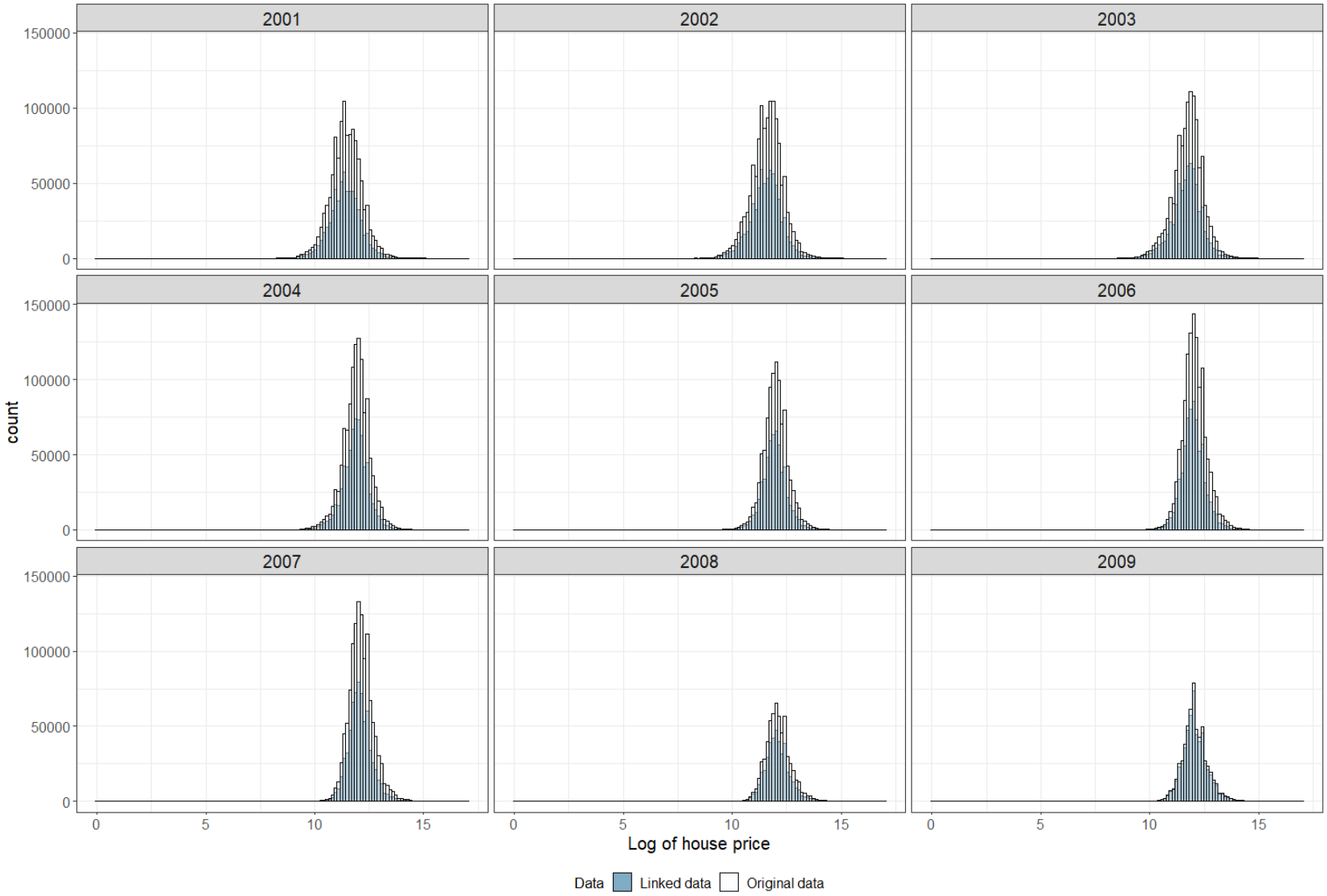
matching rate of the period before 2008 and after 2016 is in the range of 50% to 70%. This is mainly due to the dwellings sold before 2008 or after 2017 having also been sold again or rented during 2008 to 2016, permitting them to be matched in the Domestic EPCs.

(2) Evaluation of house price information lost after data linkage

Match rates offer a crude way to quantify the matching performance, but visualization of the house price difference before and after linkage displays a clear picture of the matching performance by considering all the available house price values in the dataset. As the house price distribution follows a positive skew distribution with a long tail (Figure 1), the logarithm of house price is used to rescale the house price range. Histograms of the logarithm of house price from the transaction data in house price spatial data (geo-referenced PPD) and linked-EPC PPD in a certain given year is chosen to visualise the house price distribution change (Figure 8). In each graph, the distribution of the linked-EPC PPD (linked data) is overlaid onto the distribution of the house price spatial data (original data). The histogram of linked data is colored in blue and the histogram of original data is colored in white. Therefore, the area between the white bar and blue bar represents the extent of the transactions which failed to match. After linking to the EPC data, more data was lost during the period of 2008 and 2017. However, no certain value of house price was significant lost after the data linkage.



(8A)


2001
2002
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2006
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Log of house price
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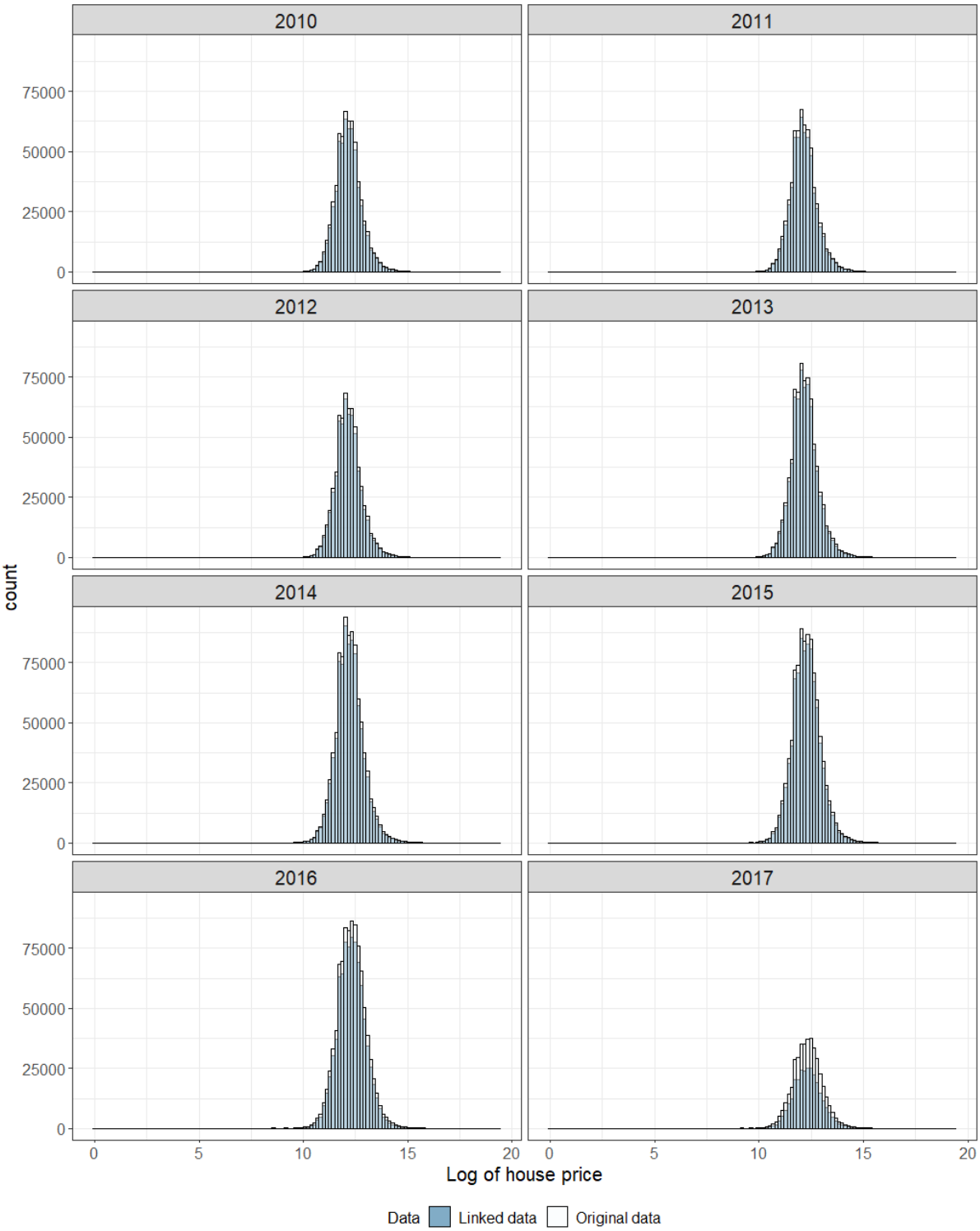
Original data

(8B)



(8C)

Figure 8 House price distribution of original data and linked-EPC PPD, 1995-2017[8]

The Kolmogorov–Smirnov test (K-S test) and the Jeffreys divergence (J-divergence) are used to quantify the extent of house price information lost. The Kolmogorov–Smirnov (K-S)

[8] Note: Original data in the graph above means house price spatial data in figure 3. Linked data means the Linked-EPC PPD data in figure 3.

test is a nonparametric test that examines the differences in the shape of a distribution. The K-S test, statistic D, is based on the maximum absolute difference between two cumulative distribution functions. Here, the test will be used to quantify the difference of two house price distributions (original data versus linked data). The Jeffreys divergences (J-divergence), derived from information theory, is a function used to establish the distance of one probability distribution to another (Jeffreys, 1946; Nielsen, 2010; Rohde, 2016). To calculate the J-divergence, the data from two different samples must first be assigned to k different categories. In the case of this research, these categories are a simple subdivision of the log house price into bins. The J-divergence is then defined as

$$J = \sum_{j=1}^{k} p^j \ln\left(\frac{p^j}{q^i}\right) + \sum_{j=1}^{k} q^j \ln\left(\frac{q^j}{p^i}\right) \quad (1)$$

where k is the number of categories, p^j is the proportion of data points in category j in the original house price data, and q^j is the proportion of data points in category j in the linked house price data. The final divergence measure, J, ranges from 0 to 1. If the distribution of both data samples across all the categories is the same, J will be 0. Larger values of J indicate greater differences between the two distributions.

To compute the J-divergence, the original data and linked data are divided into 150 bins, the 150 bins are created based on the 150 equal intervals of log house price in the original data in a given year. The results of J-divergence and K-S tests are shown in Figure 9. P-values of all the K-S tests are less than 0.05, which means there is a statistically significant difference between the original house price data and the linked house price data. The D statistic drops markedly after 2009, remaining at a low level thereafter. This demonstrates the distribution of house price before and after linkage are highly similar between 2009 to 2017. The J-divergence results also show that the final linked data exhibits relatively low information loss between 2009 and 2017. Considering the time period between 2009 to 2017, the information loss is slightly higher after 2016 than that shown by K-S. The information loss situation after 2015 is not as bad as for the period before 2008. Both K-S test and J-divergence test shows that the newly created house price data between 2009 to 2017 is representative of the pre-linked data and can offer a more reliable data set to represent the housing market than that for other years. As the house price data does not contain the whole of 2017 the following analyses will focus on the time period 2009 to 2016.

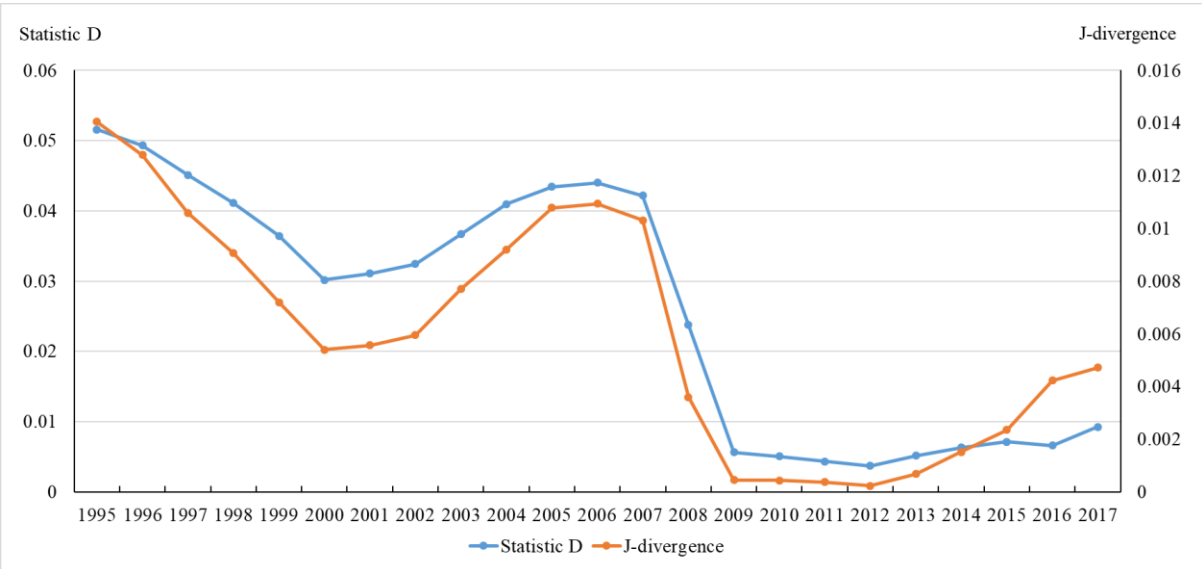


Figure 9 Results of K-S test and J-divergence method

3.3 Linked-EPC PPD between 2009 to 2016

There are 5,983,618 house price spatial data records in England for the period between 2009 and 2016. Some 5,597,702 of them have been successfully linked to EPC records. The overall matching rate for this period is 93.55%. The matching rates for detached, semi-detached or terraced houses are around 95%. Address elements for the Flats/Maisonettes category are more detailed than for detached, semi-detached or terraced houses. This makes linking the Flats/Maisonettes transactions with their domestic EPCs more difficult. Therefore, the matching rate for flats/maisonettes (89.98%) is smaller than the rates for houses (Table 5). The matching rate for the 'Other' property type is quite small (24.34%), but this will not influence using the Linked-EPC PPD to measure residential housing prices at full market value since the 'Other' category is for properties not sold at full market value[9].

Table 5 Summary of the matching for property type, 2009-2016

Property type	House price spatial data	Link-EPC PPD	Matching rate
Detached	1,385,966	1,309,328	94.47%
Flats/Maisonettes	1,175,397	1,057,660	89.98%
Other	47,689	11,609	24.34%
Semi-Detached	1,620,219	1,551,430	95.75%
Terraced	1,754,347	1,667,675	95.06%

[9] PPD Category Type for 'Other' property type in Land Registry PPD is B, it means Other property type is not sold in the full market value. It transfers under a power of sale/repossessions, buy-to-lets and transfers to non-private individuals(https://www.gov.uk/guidance/about-the-price-paid-data#data-excluded-from-price-paid-data).

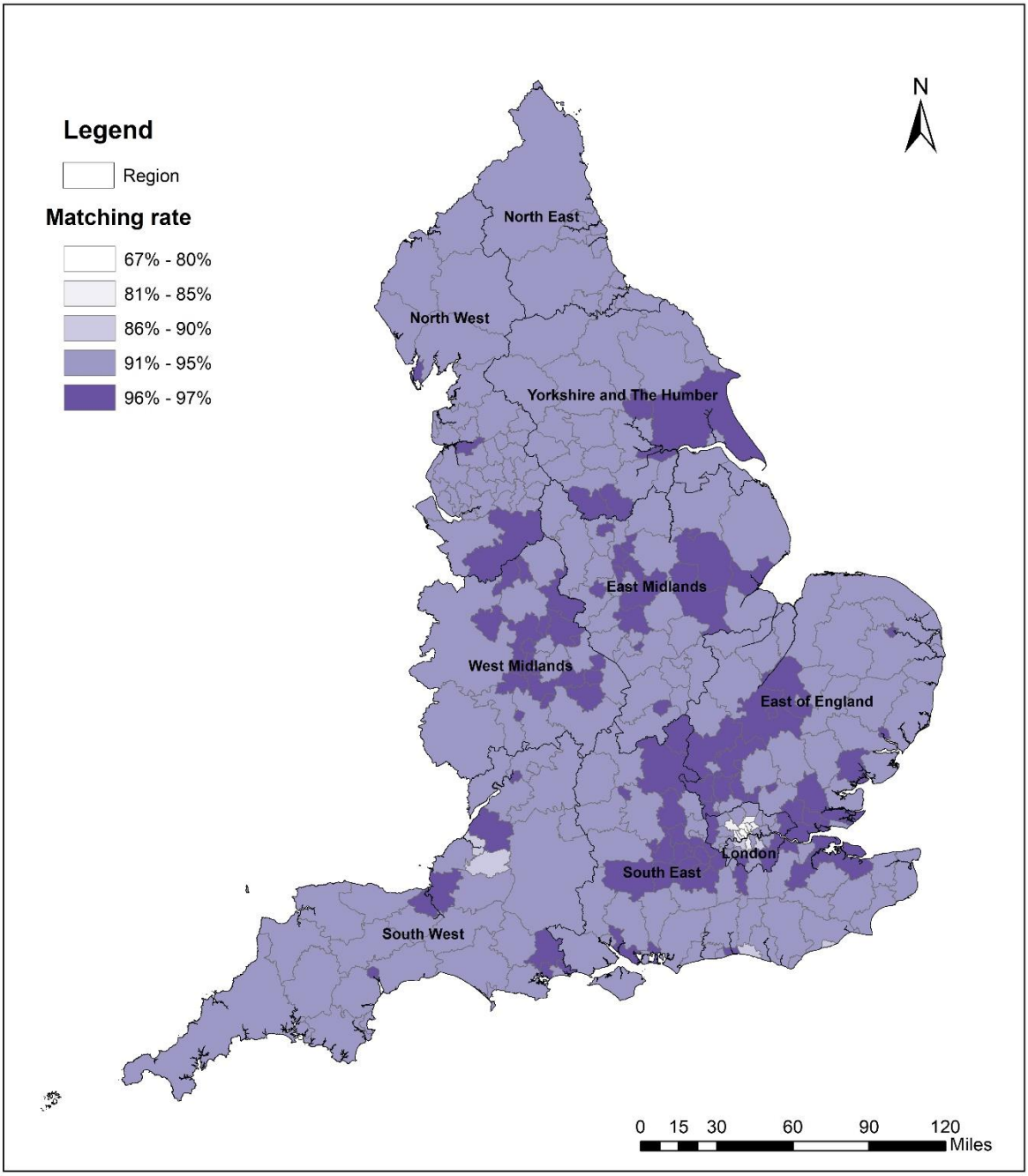


Figure 10 Overall matching rate at local authority between 2009 to 2016

The overall matching rates between 2009 to 2016 by local authority (Figure 10) are not equally distributed. The overall matching rate for 95% of local authorities is over 90%. The overall matching rate for the remaining 5% local authorities (17 local authorities – mainly in London) is between 90% and 65%. Within these 17 local authorities, the overall matching rate for three local authorities (City of London, Westminster and Camden) is lower than 80%. The matching rates of these local authorities are 66.64%, 79.51% and 79.49% respectively. The others (Isles of Scilly, Kensington and Chelsea, Hammersmith and Fulham, Brent, Hackney, Haringey, Lambeth, Islington, Brighton and Hove, Hastings, Bath and North East Somerset, City of Bristol, Wandsworth and Lewisham) have matching rates between 80% and 90%.

Matching rates in England between 2009 and 2016 are over 90% as shown in Figure 7. Figure 11 displays the annual matching rate by local authority. 68% of local authorities have

an annual matching rate which is always over 90% between 2009 and 2016. The rates between 2009 and 2016 are, for the majority local authorities, quite stable over time with a slight fall after 2015. Local authorities with a high matching rate in 2009 continue with a high rate subsequently. Only two local authorities (City of London and Isles of Scilly), both of which are small in terms of their numbers of transactions, show an obvious fluctuation during this 9-year period.

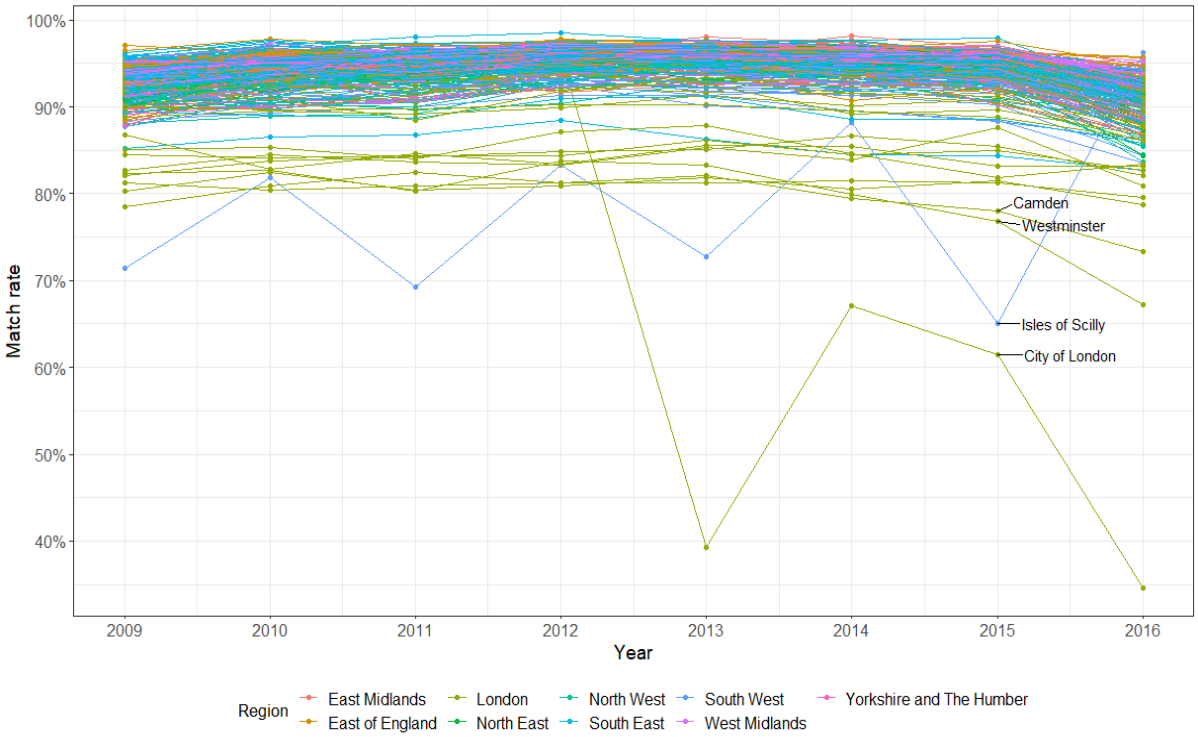


Figure 11 Match rate across local authority in England, 2009-2016

Properties that feature in the house price spatial data set (2009-2016) are not fully available in Domestic EPCs[10] (1/1/2008 -1/10/2016), this is the main reason for unequal matching rates across local authorities. For 34,768 transactions (2009-2016) relating to 16,602 postcode units Domestic EPCs cannot be found. For example, Domestic EPCs in City of London at postcode "EC2Y 9BA" are not available hence transactions in "EC2Y 9BA" cannot be successfully matched. In the City of London, 8.52% of house price transactions fail to link for this reason. Similarly, nearly 2.91% transactions in Westminster and in Salford cannot be successfully matched. Details of the proportion of transactions at local authority level with unmatched Domestic EPCs are shown for all postcodes in Appendix D. Some transactions in house price spatial data can relate a postcode unit which is also identified in the EPC data but contain no matching property identifiers. For example, one flat sold in 2009 at Camden (flat 65 Visage Apartments at Winchester Road) failed to match under method 2 because Domestic EPCs did not record this property.

3.4 Data cleaning

The Linked-EPC PPD comprises the transaction information in the Land Registry PPD together with property size (total floor area and number of habitable rooms) in EPCs. Some transactions

[10] Domestic EPCs are public by default, but can be withdrawn by the property owner, detail see : https://www.epcregister.com/optout. Thus properties in house price spatial data (geo-referenced Land Registry PPD) has an EPC but not publically accessible.

(category type B) in the Land Registry PPD relate to property not sold at full market value. This data is excluded prior to analysis. Moreover, some properties' total floor area and number of habitable rooms are recorded in EPCs with missing or untenable values (e.g. total floor area records as 0.01). Method 2 to 7 aims to clean up these outliers. All the excluded transactions along with cleaning methods are listed in Table 6, which accounts for 16.35% of the linked-EPC PPD. Missing and untenable property size values (total floor area and number of habitable rooms) in Domestic EPCs are responsible for 2/3rds (12.93% of all data) of the 16.35%.

Table 6 List of transactions exclude from the linked-EPC PPD

No.	Method	Transaction numbers	Proportion
1	Transaction's category type is B.	191,312	20.90%
2	Transaction's total floor area or number of habitable rooms are NA value or 0.	720,107	78.68%
3	Transaction's total floor area is small than 9 m^2 or bigger than 974 m^2.[11]	557	0.06%
4	Transaction's price per total floor area is bigger than 50000 £/m^2 or transaction price per total floor area is small than 200 £/m^2 .	766	0.08%
5	Transaction's floor size per habitable room is bigger than 100m^2.	703	0.08%
6	Transaction's number of habitable rooms are bigger than 20.	376	0.04%
7	Transaction's floor size per habitable room is smaller than 6.51m^2.[12]	1,413	0.15%
Overall		915,234	100%

After removing the transactions listed in table above, 4,682,468 transactions are left to support the house price analysis. This is the "new house price database" shown in Figure 3. Method 1 (Figure 3) geo-references 98% of full market sales in the Land Registry PPD in England between 2009 to 2016 and 6% of full market sales are lost after linking with Domestic EPCs. Subsequently, 12% of full market sales are excluded owing to missing and untenable property size values in Domestic EPCs. Thus, Domestic EPCs' data quality in terms of property size values and data coverage are the main reason that the newly created house price data only represents 80% of full market property sales in Land Registry PPD in England between 2009 to 2016.

Similarly, as the spatial coverage of the Land Registry PPD, the new house price database fully covers all the regional areas, local authorities and MSOAs in England. The Land Registry PPD covers 99.99% of LSOAs and this is the same for the new house price database. Although the newly created house price database is not as comprehensive as the Land Registry PPD, it is the largest house price data set for England (2009-2016) containing both the transaction price and total floor area. It is also currently, the best data for academic's exploration of residential house price variation along with total floor area in England between 2009 to 2016.

4. Relationship between transaction price and total floor area in England

Using the newly created house price database, a strong positive linear association between transaction price and total floor area (as measured by the Pearson correlation coefficient) can

[11] According to the total floor area from the English housing survey (2008-2016), the range of total floor area is from 9 square metres to 974 square metres (statistics by author). All total floor area data that is not inside the range of the English housing survey is classified as outliers

[12] According to the min room size for one person aged over 10 years in The Licensing of Houses in Multiple Occupation (Mandatory Conditions of Licences) (England) Regulations 2018.Resources: http://www.legislation.gov.uk/ukdsi/2018/9780111167359/regulation/2

be observed within individual local authorities. Figure 12 displays examples of this relationship for two sample local authorities in England.

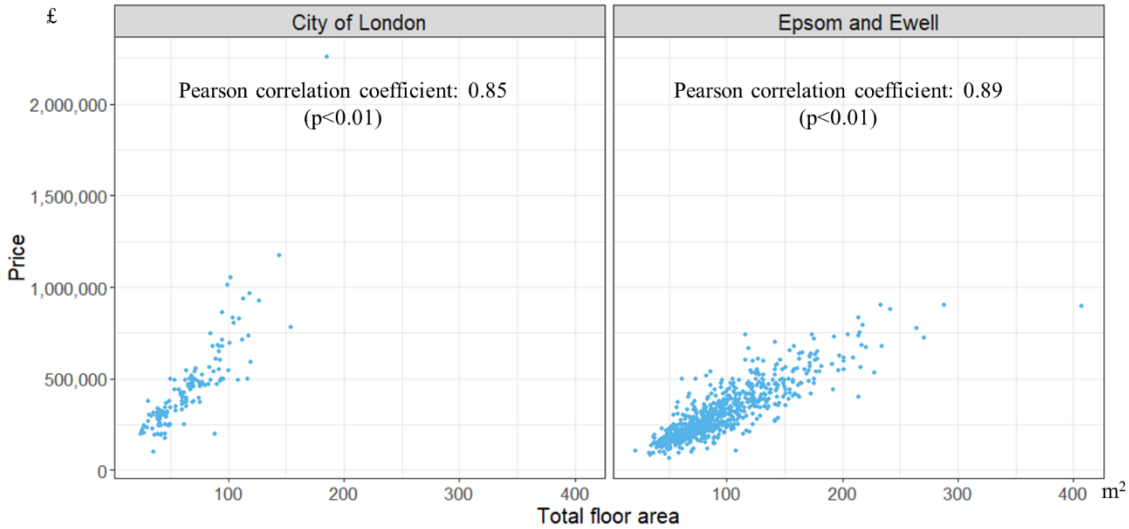


Figure 12 Transaction price against total floor area in local authorities, 2009

We are also able to observe the geography of this relationship. Figure 13 shows the extent of linear association between transaction price and total floor area in each local authority across England in 2009. For 99% of local authorities, the correlation coefficient between price and total floor area (ρ) is larger than 0.5. 79% of local authorities have ρ larger than 0.7; using the total floor area distribution in one of these local authorities, 70% of the residential house price variation can be estimated. Lower correlations reveal areas where other contextual factors are having an increased influence on house prices and these can be observed in parts of London, Manchester, Liverpool and South Yorkshire.

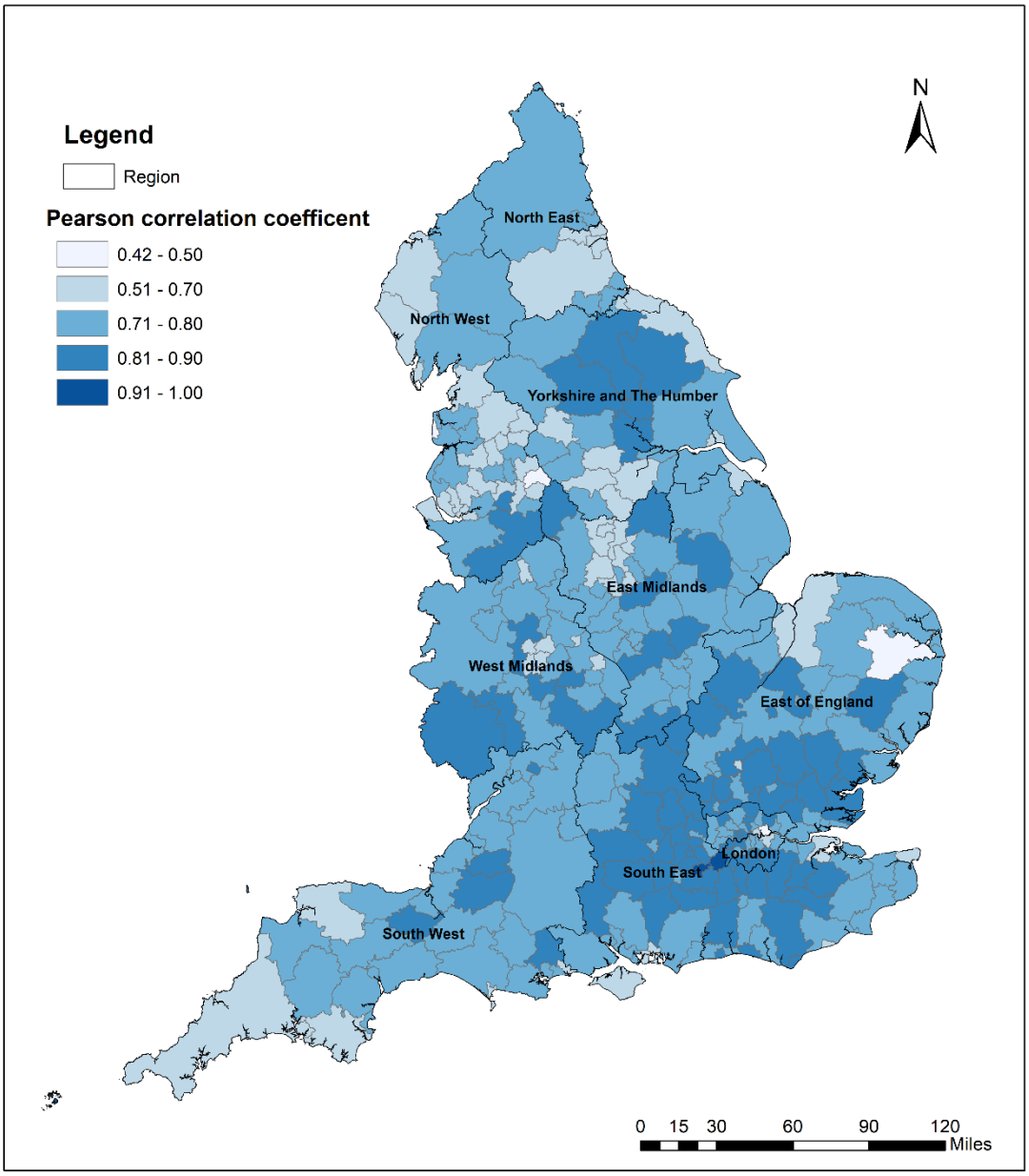


Figure 13 Pearson correlation coefficient at local authority level in England, 2009

We are able to unpick these relationships further by altering the scale of analysis. In some local authorities, house price and total floor area show a stronger linear relationship when moved to a smaller area of analysis, such as Middle Layer Super Output Area (MSOA) level and property type is controlled for. One sample is shown in Figure 14 where in Richmond upon Thames, local variations in floor area are particularly important for the price of semi-detached houses.

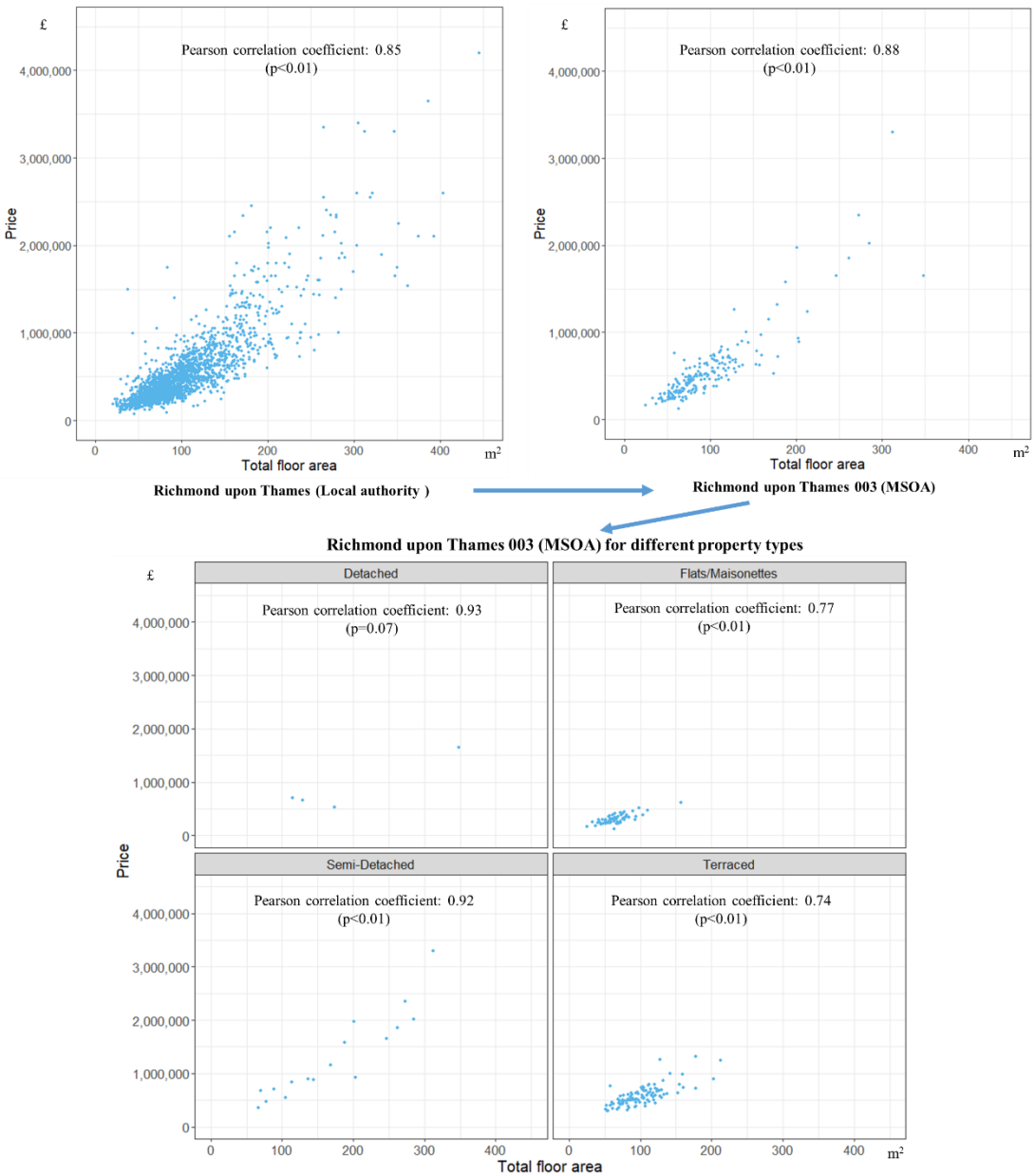


Figure 14 Transaction price against total floor area in Richmond upon Thames, 2009

5. Conclusion and Future study

This research has created a new house price data set to address the issue of incomplete house price data in England, for which there is no comprehensive database integrating both transaction price and property characteristics. We outlined one approach to address this data deficiency in England, based on the most comprehensive transaction data available (Land Registry PPD). Two data linkage methods were proposed to overcome two specific limitations of the Land Registry PPD: the lack of transaction's geo-location and of accurate property size. For the first data linkage method, a new spatial house price data can be achieved. This newly created spatial house price contains 98% of transactions in England and Wales (1995 -2016). For the second data linkage method, the newly created spatial house price has been added in the total floor area and number of habitable rooms information. According to the results of a K-S test and J-divergence measurement, the time period from year 2009 to 2016 demonstrates a relatively high matching performance. The overall matching rate within the 2009 to 2016

period in England is 94%, which is higher than those given in previous research (Powell-Smith, 2017; Simpson et al., 2018). This valuable new dataset advances explorations in house price variation, and offers new insights into the housing market across England.

The new house price database contains transaction price and total floor area. It advances the understanding of house price variation through exploring the relationship between transaction price and total floor area. House price and total floor area show a moderate or strong linear relationship in local authorities across England. This relationship varies between different geographic scales and by different property types across England. For some areas, a stronger linear relationship was observed at MSOAs and for individual property types within individual MSOAs. The strong relationship between transaction price and total floor area shows total floor area is an importation factor that impacts house price variation. Total floor area is one measure of property size, but others, such as building volume and plot size, are also worthy of investigation since they also impact house price variation. More descriptive and statistical analysis between house price and different property sizes will be conducted in the future.

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Appendix A

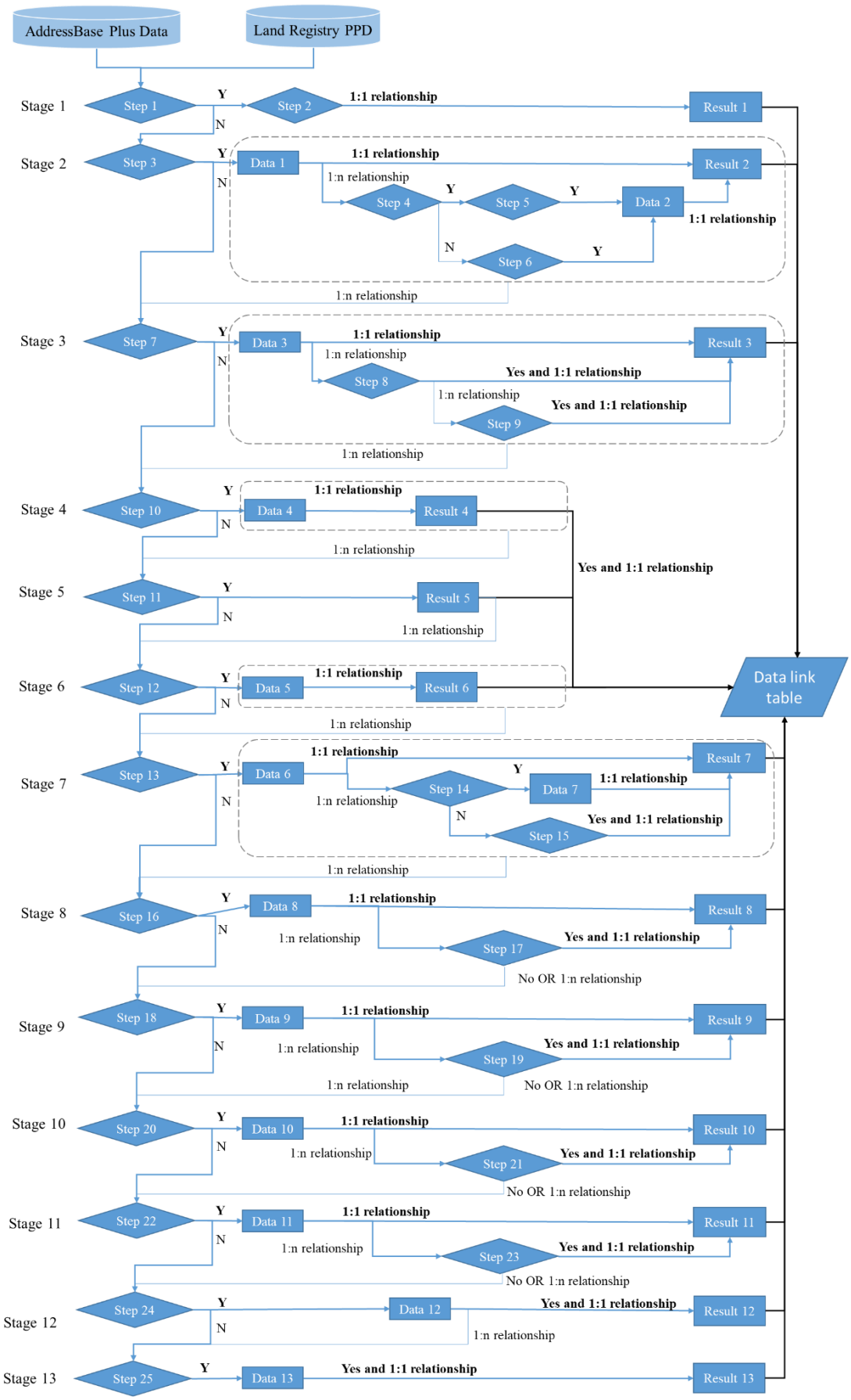

Figure A1 Master workflow of the 13 stages data linkage

Figure A1[13] presents the master workflow of 13 stages of data linkage between Land Registry PPD and AddressBase Plus data. Each stage contains more than one step and each step contains more than one match rules. Details of the match rules for each step are listed in Table A1. For each step, we assess whether all corresponding matching rules listed in the table are satisfied. If yes, the matching process will go the branch marked "Y" in Figure A1; otherwise, the matching process follow the branch marked "N". Take the first match part in Stage 2 as an example, in the OS MasterMap Topography Layer, TOID[14] is a unique reference to identify the building feature. TOID contained in the AddressBase Plus data is named as ostopotoid. Meanwhile in the Land Registry Price Paid Data, each transaction has a unique identifier named as transactionid. In each step we loop the matching rules within the same postcode. When putting in the Data 1 in the matching process of step 3. Firstly, a function starts with creating a dataset which contains all the unique postcodes from Land Registry PPD (temp data1), then the function continue subset all the records from Land Registry PPD and AddressBase Plus from a given postcode unit in temp data1, then the match executes the match rules in step 3 (i.e. "test whether PAON of each transaction in Land Registry Price Paid Data is equal to buildingname in AddressBase Plus" or "test whether PAON of each transaction in Land Registry Price Paid Data is equal to buildingnumber in AddressBase Plus" or "test whether PAON of each transaction in Land Registry Price Paid Data is equal to bb in AddressBase Plus"), if the result is YES then transactionid and ostopotoid will directly link based on the match rules in step 3 and restore in Data 1. After this, a new function will be used to identify if there is a one transactionid match one ostopotoid and if the result is YES and this tested link result will store in Result 2 dataset. Otherwise it will go to Stage 3 to conduct the match test in step 4. Following this all the successful 1:1 match link in Stage 2 will store in Result 2 dataset and final store in Data link table. All the matching process in Figure A1 works the same as described above and the final result is data link table. The data linkage job is conducted in RStudio.

Table A1 Details of 97 matching rules in 13 stages[15]

Stage No.	Step No.	Match rules
Stage 1	Step 1	PAON is NULL and SAON is not NULL
	Step 2	SAON is equal to pp
		SAON is equal to paostartnumber1
		SAON is equal to saostartnumber
		SAON is equal to buildingname
		SAON is equal to paotext
		SAON2 is equal pp
		SAONSTREET is equal to buildingname
Stage 2	Step 3	PAON is equal to buildingname
		PAON is equal to buildingnumber
		PAON is equal to bb
	Step 4	SAON is not NULL
	Step 5	PAON is equal to pp and SAON is equal to saotext
		PAON is equal to buildingname and SAON is equal to saotext

[13] Land Registry Price Paid Data used here covers the whole transactions before 31/7/2017, the version of OS MasterMap is 21/09/2017. The version of AddressBase Plus is 06/12/2017

[14] All the words coloured in grey shading are the fields name.

[15] In all the matching rule of this table, capital word coloured in grey stands for the address field in Land Registry, the capitalized word coloured in grey stands for the address field in AddressBase Plus data.

		PAON is equal to buildingnumber and SAON is equal to saotext
		PAON is equal to bb and SAON is equal to saotext
		PAON is equal to buildingname and SAON is equal to subbuildingname
		PAON is equal to buildingnumber and SAON is equal to subbuildingname
		PAON is equal to bb and SAON is equal to subbuildingname
		PAON is equal to pp1 and SAON is equal to saotext
		PAON is equal to paotext and SAON is equal to ss
		PAON is equal to bb and SAON is equal to ss
		PAON is equal to buildingname and FLATSAON is equal to subbuildingname
		PAON is equal to paotext and FLATSAON to saotex
		PAON is equal to buildingname and FLATSAON is equal to subbuildingnamenew
		PAON is equal to buildingname and SAON is equal to fss
		PAON is equal to paotext and SAON is equal to fss
		PAON is equal to bb and SAON is equal to fss
		SAONPAON is equal to buildingname
		PAON is equal to pp1 and SAON is equal to flatsao
		PAON is equal to pp1 and SAON is equal to saotext2
		PAON is equal to paotext and SAON is equal to saotext
		PAON is equal to buildingname and SAON is equal to ss
		PAON is equal to bb and FLATSAON is equal to saotext
		PAON is equal to pp1 and SAON is equal to ss
		PAON is equal to subbuildingname and SAONPAON is equal to buildingname
		PAON is equal to pp
		PAON is equal to paotext and SAON is equal to pp
	Step 6	SAON is NULL and PAON is equal to buildingnumber
		SAON is NULL and PAON is equal to paotext
Stage 3	Step 7	PAON is equal to paostartnumber
	Step 8	PAON is equal to paostartnumber and SAON is equal to flatpao
	Step 9	PAON is equal to pp and SAON is equal to saotext
		PAON is equal to pp and FLATSAON is equal to saotext
		PAON is equal to pp
		PAON is equal to pp and STREET is equal to streetdescription
Stage 4	Step 10	PAON is equal to pp
Stage 5	Step 11	Direct match when there is only one ostopotoid in its postcode unit
Stage 6	Step 12	PAON is equal to psao
Stage 7	Step 13	PAON is equal to pp2
		PAON is equal to pp1
	Step 14	PAON is equal to pp2 and SAON is equal to saotext
		PAON is equal to pp2 and SAON is equal to ss
		PAON is equal to pp2 and SAON is equal to flatss
		PAON is equal to pp2 and FLATSAON is equal to saotext
		PAON is equal to pp2 and SAON is equal to unitss
		PAON is equal to pp2 and SAON is equal to subbuildingname
		PAON1 is equal to buildingname and SAON is equal to subbuildingname
	Step 15	Detached, semi-detached and terrace transactions: PAON is equal to pp1 and SAON is equal to ss

		Flat transactions: PAON is equal to pp2 and SAON is equal to ss1
Stage 8	Step 16	PAON is equal to paotext
		PAON is equal to sp
	Step 17	PAON is equal to paotext and SAON is equal to ss
		PAON is equal to paotext and FLATSAON is equal to saotext
		PAON is equal to paotext and SAON is equal to flatss
		PAON is equal to paotext and SAON is equal to saotext
		PAON is equal to paotext and SAON is equal to pp
		PAON is equal to paotext and SAON is equal to subss
		PAON is equal to paotext and SAONPAON is equal to saobui
Stage 9	Step 18	PAON1 is equal to buildingname
		PAON1 is equal to pp4
	Step 19	PAON1 is equal to buildingname and SAON is equal to subbuildingname
		PAON1 is equal to buildingname and SAON is equal to saotext
		PAON2 is equal to pp4 and SAON is NULL
		PAON1 is equal to ppp and SAON is equal to ss
		PAON1 is equal to ppp and SAON is equal to flatss
		PAON1 is equal to ppp and SAON is equal to saotext
		PAON1 is equal to buildingname and FLATSAON is equal to subbuildingname
		PAON1 is equal to buildingname and SAON is equal to flatsub
		PAON1 is equal to buildingname and SAON is equal to ss
		PAON2 is equal to pp4 and SAON is equal to saotext
		PAON2 is equal to pp4 and FLATSAON is equal to saotext
		PAON2 is equal to pp4 and SAON is equal to subbuildingname
		PAON2 is equal to pp4 and SAON is equal to ssp
Stage 10	Step 20	STREET is equal to paotext
	Step 21	STREET is equal to paotext and PAON is equal to ss
		STREET is equal to paotext and PAON is equal to ss and SAON is equal to saotext and SAON is not NULL
		PAONSTREET is equal to buildingname
		PAONSTREET is equal to paotext
		PAONSTREET is equal to paotext and SAON is equal to ss
		STREET is equal to paotext and FLATPAON is equal to subbuildingname
		STREET is equal to paotext and UNITPAON is equal to saotext
Stage 11	Step 22	PAON is equal to saopp
	Step 23	PAON is equal to saopp and SAON is equal to flatss
Stage 12	Step 24	SAONPAON is equal to buildingname
Stage 13	Step 25	PAON is equal to ss and SAON is NULL
		PAONSTREET is equal to buildingname

Appendix B

Table B New address variables created from Land Registry PPD and EPC datasets

Variable	Create method	Dataset
ADD1	Capitalised the all the string in ADDRESS1, then remove leading and trailing whitespace	Domestic EPCs
ADD2	Capitalised the all the string in ADDRESS2, then remove leading and trailing whitespace	Domestic EPCs
ADD3	Capitalised the all the string in ADDRESS3, then remove leading and trailing whitespace	Domestic EPCs
ADD	Capitalised the all the string in ADDRESS, then remove leading and trailing whitespace	Domestic EPCs
ADD2NEW	Delete the '-' in the ADD2	Domestic EPCs
ADDC	Delete all the '/' , '.', ''' punctuation characters and blank space in ADD	Domestic EPCs
ADDU	Delete the 'UNIT ' string in the ADD, then delete all the comma and blank space	Domestic EPCs
ADDC3	Delete the comma in ADDC	Domestic EPCs
ADDCC	Delete all the '-' , '/' , '.', ''' punctuation characters and blank space in ADD	Domestic EPCs
ADDCCC	Delete the comma in ADDCC	Domestic EPCs
ADDC4	Delete all the '/' , '.', '-' punctuation characters and blank space in ADD	Domestic EPCs
ADDC6	Delete all the ''' , ',' punctuation characters and blank space in ADD	Domestic EPCs
ADDRE	Delete the blank space in ADD	Domestic EPCs
ADDREC	Delete the comma in ADDRE	Domestic EPCs
ADD1C	Delete all the '/' , '.', ''' punctuation characters and blank space in ADD1	Domestic EPCs
ADD1CC	Delete '-' punctuation characters in ADD1C	Domestic EPCs
ADD1C2	Delete the comma in ADD1C	Domestic EPCs
ADD1C3	Delete all the comma and blank space in ADD1	Domestic EPCs
ADD1C6	Delete the 'UNIT ' in ADD1, then delete all the comma and blank space	Domestic EPCs
ADD1C4	Delete ''' punctuation characters in ADD1C3	Domestic EPCs
ADD1C5	Delete the '.' and blank space in ADD1	Domestic EPCs
ADD1C7	Delete all the comma and blank space in ADD1	Domestic EPCs
ADD1C8	Delete all the comma in ADD1C5	Domestic EPCs
ADD1C9	Delete the all the blank space in ADD1	Domestic EPCs
ADD1C10	Delete the '/' punctuation characters in ADD1	Domestic EPCs
ADD12C2	Delete the comma in ADD12	Domestic EPCs
ADD12C	Delete '.', ''' ,'/' punctuation characters in ADD12	Domestic EPCs

ADD12C1	Delete ‘ .’, ’’’ ,‘/’ punctuation characters and comma in ADD12	Domestic EPCs
ADD12C3	Delete all ‘ .’, ’’’ ,‘/’ , ‘-’ punctuation characters and comma in the ADD12	Domestic EPCs
ADD12C4	Delete all the ‘ .’, ‘-’ ,‘/’ and blank space in ADD12	Domestic EPCs
ADD12C5	Delete all the ‘ .’, ‘,’ and blank space in ADD12	Domestic EPCs
ADD13C	Delete ‘ .’, ’’’ ,‘/’ punctuation characters and blank space in ADD13	Domestic EPCs
ADD13C1	Delete the comma in ADD13C	Domestic EPCs
ADD13C2	Delete the comma in ADD13	Domestic EPCs
ADD23C	Delete ‘ .’, ’’’ ,‘/’ punctuation characters in ADD23	Domestic EPCs
ADD23C1	Delete the comma in ADD23C	Domestic EPCs
ADD161	For the ADD1 contain a comma, then select the text before the first comma	Domestic EPCs
ADD162	For the ADD1 contain a comma and ‘-’ punctuation character, then select the string after the first comma, then delete the ‘-’ punctuation character	Domestic EPCs
ADD165	For the ADD1 contain a comma and ‘.’ punctuation character, then select the string after the first comma, then delete the ‘.‘ punctuation character	Domestic EPCs
add1sp	For the ADD2 is not start with number string and also does not contain a word with one character, select the string before the first blank space in ADD1	Domestic EPCs
add63	Delete ‘-’ and ‘.’ in add162	Domestic EPCs
add1nnn	Delete ‘NO ’ string in ADD1, then delete all the comma	Domestic EPCs
ADD1df1	Delete ‘FLAT ’ string in ADD1 , then select the string the first string before the first word boundary, then delete the comma	Domestic EPCs
ADD1du	Delete the ‘UNIT ’ string in ADD1 , then delete all the comma and blank space	Domestic EPCs
ADD163	Select the string before the first blank space in ADD1	Domestic EPCs
add261	For the add2 contain a comma, then select the string before the first comma	Domestic EPCs
add263	Select the string before the first blank space in ADD2, then delete comma	Domestic EPCs
add31	Delete ‘’’,’.’ and ‘/’ in ADD3	Domestic EPCs
fladd1c	Delete all the blank space in fladd1	Domestic EPCs
fladdc	Delete all the comma in the fladd	Domestic EPCs
ADD1dff	For the ADD1 has ‘FLAT ‘, delete ‘FLAT ’ string in ADD1	Domestic EPCs
add264	Select the string after the first blank space in ADD2	Domestic EPCs
add2641	Select the string after the first comma in ADD2	Domestic EPCs
apADD1	Delete ‘-’ , ‘/’ , ‘ .’, ’’’ ‘,’ punctuation characters and blank space in apadd1	Domestic EPCs
ADDr61	For the ADD contain a comma, then select the string before the first comma	Domestic EPCs

ADDr62	For the ADD contain a comma and -punctuation character, then select the string after the first comma, then delete the ‘-’ , ‘’’, ‘.’ and '/'punctuation character	Domestic EPCs
add361	For the ADD3 contain a comma, then select the text before the first comma	Domestic EPCs
ADDC5	Delete all the ‘/’ , ‘ .’ punctuation characters and blank space in ADD	Domestic EPCs
ADDC7	Delete all the ‘-’ punctuation characters and blank space in ADD	Domestic EPCs
ADDC8	Delete all the ‘.’,’’’ punctuation characters and blank space in ADD	Domestic EPCs
ADDC9	Delete all the ‘.’,’’’ and ’/’ punctuation characters in ADD	Domestic EPCs
ADDC10	Delete all the ‘-’ , ‘/’ , ‘ .’, ’’’ ,‘,’ punctuation characters and blank space in ADD	Domestic EPCs
ADD262	For the ADD2 contain a comma character, then select the string after the first comma	Domestic EPCs
add1f61	For the ADD1 in EPC data has ‘FLAT ’ string, then delete the FLAT ’ string, then subset the string before the first comma , then delete the all the comma	Domestic EPCs
add1f61f2	Combine ‘FLAT ’ and add1f61 , then combine ADD2 with a comma and a blank space, then delete all the blank space and comma.	Domestic EPCs
adddap	Delete ‘APARTMENT ’ string in ADD , then delete all the blank space	Domestic EPCs
saonn	Delete all the ‘/’ punctuation characters in SAON	House price spatial data
paonn	Delete all the ‘’’, ‘.’ punctuation characters in PAON	House price spatial data
paonn61	Select the string before the first comma in paonn	House price spatial data
paonn2	Delete comma and blank space in PAON	House price spatial data
paonn3	Delete ‘-’ and blank space in PAON	House price spatial data
streetn	Delete all the ‘’’ punctuation characters in street	House price spatial data
streetn1	Delete ‘-’ , ‘ .’, ’’’ punctuation characters and blank space in street	House price spatial data
streetn2	Delete ‘-’ , ’’’ punctuation characters and blank space in street	House price spatial data
streetn5	Delete ‘/’ , ‘ .’, ’’’ punctuation characters and blank space in street	House price spatial data
localityn	Delete all the ‘’’, ‘.’ punctuation characters in locality	House price spatial data
saonpaonstreet31	Delete the comma in saonpaonstreet3	House price spatial data
saonpaonstreetn31	Delete the comma in saonpaonstreetn3	House price spatial data
paon61	For the PAON contain comma, subset the text before the first comma	House price spatial data

paon61c	Delete all the blank space in paon61	House price spatial data
paon62	For the PAON contain comma, subset the string after the first comma	House price spatial data
paon64	Subset the string before the first blank space in PAON	House price spatial data
paon641	Subset the string after the first blank space in PAON	House price spatial data
paon65	For the PAON contain comma, Extract the last word from PAON	House price spatial data
paon65n	For the paonn contain comma, subset the string after last blank space in paonn	House price spatial data
saon2	Delete ‘APARTMENT ’ string in SAON	House price spatial data
fldsaon	For SAON contain 'FLAT' string and PAON not start with number string. Delete ‘FLAT ’ string in SAON	House price spatial data
fldsaon1	For SAON contain 'FLAT' string and PAON start with number string. Delete ‘FLAT ’ string in SAON	House price spatial data
saon7	Replace ‘FLAT ’ string to ‘APARTMENT ’ string in SAON	House price spatial data
saon71	Replace ‘FLAT ’ string to ‘APARTMENT ’ string in saonn	House price spatial data
saonn4	Delete ‘FLAT ’ string in saonn	House price spatial data
saon1	Replace ‘APARTMENT ’ string to ‘FLAT ’ string in saonn	House price spatial data
saonn2	Delete ‘APARTMENT ’ string in saonn	House price spatial data
saonn3	Delete ‘.’ And ‘ / ’ in SAON	House price spatial data
ADD1num	Extract the number string in ADD1	House price spatial data
saonn5	For SAON contain ‘APARTMENT ’ , replace ‘APARTMENT ’ string to ‘UNIT ’ string in SAON and then delete ‘/’ punctuation characters	House price spatial data
sao1	Replace ‘APARTMENT ’ string to ‘FLAT ’ string in SAON	House price spatial data
saon8	Replace ‘LOFT ’ to ‘FLAT ’ in SAON	House price spatial data
saon4	Delete ‘FLAT ’ string in SAON	House price spatial data
paon6164	Select the number string from paon61	House price spatial data
paon6163	Select all the non-digitals from paon61	House price spatial data

paon11	Delete all the comma in the PAON	House price spatial data
ADD12	Combine ADD1 and ADD2 with a comma and a blank space, then delete all the blank space	Domestic EPCs
ADD12new	Combine ADD1 and add2new with a blank space, then delete the ‘/’ , ‘ .’, ’’’ punctuation characters, blank space and comma	Domestic EPCs
ADD13	Combine ADD1 and ADD3 with a comma and a blank space , then delete all the blank space	Domestic EPCs
ADD23	Combine ADD2 and ADD3 with a blank space , then delete all the blank space	Domestic EPCs
ADD66	Combine ADD161 and ADD162 with a comma and a blank space , then delete all the comma and blank space	Domestic EPCs
ADD662	Combine ADD66 and ADD2 with a comma and a blank space ,then delete the comma and blank space	Domestic EPCs
ADD67	Combine ADD161 and ADD165 with a comma and a blank space , then delete all the comma and blank space	Domestic EPCs
ADDSP12	Combine add1sp and add2 with a comma and a blank space, then delete the comma and blank space	Domestic EPCs
ADD68	Combine add161 and add63 with a comma and a blank space , then delete ‘’’ and blank space	Domestic EPCs
ADD69	Combine add1nn and ADD2 with a comma and a blank space, then delete all the blank space	Domestic EPCs
ADD1632	Combine ADD163 and ADD2 with a blank space , then delete all the comma and blank space	Domestic EPCs
flADD	Combine ‘FLAT ’ string and ADD with a comma and a blank space , then delete all the comma and blank space	Domestic EPCs
ADD2611	Combine add261 and add1 with a comma and a blank pace , then delete all the comma and blank space	Domestic EPCs
fladd1	Combine ‘FLAT ’ and ADD1 with a blank space	Domestic EPCs
fladd	Combine ‘FLAT ’ and ADD with a blank space , then delete all the blank space	Domestic EPCs
flADD13	Combine fladd1 and add31 with a blank space , then delete all the comma and blank space.	Domestic EPCs
ADD5	Combine add263 and ADD1dff , then combine add264, then delete all the blank space	Domestic EPCs
apadd1	Combine ‘APARTMENT ’ and ADD1 with a blank space	Domestic EPCs
ADDr66	Combine ADDr61 and ADDr62 with a comma and a blank space , then delete all the comma and blank space	Domestic EPCs
ADD6	Combine ADD1 and ADD2 with a comma and a blank space , then combine add361 with a comma and a blank space ,then delete all the, ‘/’ , ‘ .’, ’’’ punctuation characters and blank space	Domestic EPCs
add12643	Combine ADD1 and add2641 with a comma and a blank space, then combine add3 with a comma and a blank space, then delete all the blank spaces	Domestic EPCs
ADD1264	Combine ADD1 and add264 with a comma and a blank space , then delete all the blank space and comma	Domestic EPCs
ADD8	Combine ADD1C10 and ADD2 with a comma and a blank space ,then delete all the blank space	Domestic EPCs
ADD7	Combine ADD161 and ADD2 with a blank space , then delete all the blank space	Domestic EPCs
ADD1num2	Combine ADD1num and ADD2 with a comma and a blank space , then delete, ‘/’ , ‘ .’, ’’’ punctuation characters and all blank space	Domestic EPCs
ADD1262	Combine ADD1 and ADD262 with a comma and a blank space , then delete all the blank space	Domestic EPCs
ADD1262C	Combine ADD1 and ADD262 with a comma and a blank space , then delete all the blank space and comma	Domestic EPCs

ADD1262cc	Combine ADD1 and ADD262 with a comma and a blank space , then delete all the blank space and ’’’	Domestic EPCs
apadd1632	Combine ‘APARTMENT’ and add163 with a blank space , then combine with ADD2 with a comma and a blank space , then delete all the blank space and comma	Domestic EPCs
saonpaonstreet	Combine SAON and PAON with a comma and a blank space , then combine street with a blank space, then delete all the blank space	House price spatial data
saonpaonstreet5	Combine SAON and PAON with a comma and a blank space , then combine street with a blank space, then delete all the blank space and cooma	House price spatial data
saonpaonstreet1	Combine SAON and PAON with a comma and a blank space , then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonstreet2	Combine SAON and PAON with a blank space and then remove leading and trailing whitespace, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonstreetn	Combine saonn and paonn with a comma and a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
saonpaonstreetn1	Combine saonn and paonn with a comma and a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonstreetn2	Combine saonn and paonn with a blank space , then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonlo	Combine SAON and PAON with a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonlon	Combine saonn and paonn with a blank space, then combine localityn with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonstreet3	Combine SAON and PAON with a blank space, then delete combine street with a blank space, then delete all the blank space	House price spatial data
saonpaonstreetn3	Combine saonn and paonn with a blank space, then delete combine streetn with a blank space, then delete all the blank space	House price spatial data
saonpaonstreetlo	Combine SAON and PAON with a comma and a blank space , then combine street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaonstreetnlo	Combine saonn and paonn with a comma and a blank space, then combine streetn with a comma and a blank space, then combine localityn with a comma and a blank space,, then delete all the blank space	House price spatial data
saonpaon1	Combine SAON and PAON with a blank space, then delete all the blank space	House price spatial data
saonpaon2	Combine SAON and PAON with a comma and a blank space, then delete all the blank space and all the blank space	House price spatial data
saonpaon3	Combine SAON and PAON with a comma and a blank space	House price spatial data
paonstreetlo	Combine PAON and street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
paonstreetnlo	Combine paonn and streetn with a comma and a blank space, then combine localityn with a comma and a blank space, then delete all the blank space	House price spatial data

paonstreetlo1	Combine PAON and street with a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
paonstreetnlo1	Combine paonn and streetn with a blank space, then combine localityn with a comma and a blank space, then delete all the blank space	House price spatial data
paonstreetlo2	Combine PAON and street with a blank space, then combine locality with a blank space, then delete all the blank space and comma	House price spatial data
paonstreetn	Combine PAON and streetn with a comma and a blank space, then delete all the blank space	House price spatial data
paon66	Combine paon61 and paon62 with a comma and a blank space, then delete the blank space	House price spatial data
paon65streetlo	Combine paon65 and street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
paon65streetnlo	Combine paon65n and streetn with a comma and a blank space, then combine localityn with a comma and a blank space, then delete all the blank space	House price spatial data
paon65streetlo1	Combine paon65 and street with a blank space, then combine locality with a blank space, then delete all the blank space and comma	House price spatial data
paon61streetlo	Combine paon61 and street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
paon61streetlo1	Combine paon61 and street with a blank space, then combine locality with a blank space, then delete all the blank space and comma	House price spatial data
paon61lo	Combine paon61 and locality with a comma and a blank space, then delete all the blank space	House price spatial data
paon61street	Combine paon61 and street with a blank space, then delete all the blank space and comma	House price spatial data
paon65street	Combine paon65 and street with a blank space, then delete all the blank space and comma	House price spatial data
paon66streetlo	Combine paon62 and paon61 with a blank space, then combine street with a blank space, then combine locality with a blank space, then delete all the comma and blank space	House price spatial data
paon65streetlo	Combine paon65 and street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the comma and blank space	House price spatial data
paon61new	Combine ‘THE’ and paon61 with a blank space	House price spatial data
paonstreetlo3	Combine PAON and street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the blank space and comma	House price spatial data
paonstreet	Combine PAON and street with a comma and a blank space, then delete all the comma and blank space	House price spatial data
paonstreetn1	Combine PAON and streetn1 with a comma and a blank space, then delete all the comma and all the blank space	House price spatial data
paonstreet1	Combine PAON and street with a comma and a blank space, then delete all blank space	House price spatial data
paonstreet2	Combine PAON and street with a blank space, then delete all blank space	House price spatial data

paon62streetlo	Combine paon62 and street with a comma and a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
paon62streetlo1	Combine paon62 and street with a blank space, then combine locality with a blank space, then delete all the blank space and comma	House price spatial data
paonflat	Combine ‘FLAT’ string and PAON with a blank space	House price spatial data
paonfstreet	Combine paonflat with street with a comma and a blank space, then delete all the blank space	House price spatial data
paonap	Combine ‘APARTMENT’ string and PAON with a blank space	House price spatial data
paonapstreet	Combine paonap with street with a comma and a blank space, then delete all the blank space	House price spatial data
paonfstreet1	Combine paonflat with street with a blank space, then delete all the blank space	House price spatial data
paonfstreetn5	Combine paonflat with streetn5 with a blank space, then delete all the blank space	House price spatial data
paonstreet3	Combine PAON and street with a blank space, then delete all blank space and comma	House price spatial data
paonapstreet1	Combine paonap with street with a blank space, then delete all the blank space	House price spatial data
paonapstreet2	Combine paonap with street with a blank space, then delete all the blank space and comma	House price spatial data
paonapstreetn5	Combine paonap with streetn5 with a blank space, then delete all the blank space	House price spatial data
paonstreet4	Replace 'FLAT' to ' APARTMENT' in paonstreet3	House price spatial data
paonfl1	Combine ‘FLAT,’ string and PAON with a blank space	House price spatial data
paonf1streetn5	Combine paonfl1 with streetn5 with a comma and a blank space, then delete all the blank space	House price spatial data
paonfstreetn6	Combine paonflat with streetn5 with a comma and a blank space, then delete all the blank space	House price spatial data
flpaon3streetn5	Combine ‘FLAT ’ string and paon with a blank space, then combine with streetn5 with a blank space then delete all the blank space and ‘-‘	House price spatial data
saonpaon65street	Combine SAON and paon65 with a comma and a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaon62streetn2	Combine SAON and paon62 with a comma and a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
saonpaon61street	Combine SAON and paon61 with a blank space, then combine street with a comma and a blank space, then delete all the blank space and comma	House price spatial data
saonpaon62streetn	Combine SAON and paon62 with a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data

saonpaonn	Combine saonn and paonn with a comma and a blank space, then delete all the blank space	House price spatial data
saon2street	Combine saon2 and street with a comma and a blank space, then delete all the blank space	House price spatial data
saon2paon61street	Combine saon2 and paon61 with a blank space, then combine street with a comma and blank space, then delete all the blank space.	House price spatial data
flsaonpaonstreet0	Combine flsaon and PAON with a comma and a blank space and then combine street with a comma and a blank space	House price spatial data
flsaonpaon1	Combine flsaon and PAON with a blank space, then delete all the blank space	House price spatial data
flsaonpaon2	Combine flsaon and PAON with a comma and a blank space, then delete all the blank space	House price spatial data
flsaon	For the SAON start with number string , combine 'FLAT' string with SAON with a blank space	House price spatial data
flsaon1	For the SAON start with number string , combine 'FLAT' string with saonn with a blank space	House price spatial data
flsaon3	combine 'FLAT' string with SAON with a blank space	House price spatial data
flsaon1paonstreetn2	Combine flsaon1 with paonn with a comma and a blank space, then combine the streetn2 with a comma and a blank space, then delete all the blank space	House price spatial data
flsaonpaonstreet1	Combine flsaon with PAON with a blank space, then combine the street with a blank space, then delete all the blank space and comma	House price spatial data
flsaonpaon62street1	Combine flsaon and paon62 with a blank space, then combine street with a blank space, then delete all the blank space and comma	House price spatial data
fldsaonpaonstreet1	Combine fldsaon and PAON with a blank space, then combine street with a blank space, then delete all the blank space and comma	House price spatial data
saon7paonstreet1	Combine saon7 and PAON with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saon7paonstreet2	Combine saon7 and PAON with a blank space, then combine street with a blank space, then delete all the blank space and comma	House price spatial data
apsaon	For SAON starts with number string, combine 'APARTMENT' string with SAON with a blank space	House price spatial data
apsaonpaonstreet1	Combine apsaon and PAON with a blank space, then combine street with a blank space, then delete all the blank space and comma	House price spatial data
saon7paonstreetn	Combine saon71 and paonn with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saon7paonn	Combine saon7 and paonn with a comma and a blank space, then delete all the blank space	House price spatial data
saon7paon	Combine saon7 and PAON with a comma and a blank space, then delete all the blank space	House price spatial data
saon4paonstreetn	Combine saonn4 and paonn with a comma and a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
saon4paonstreetn1	Combine saonn4 and paonn with a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data

apsaonpaon6streetn	Combine apsaon and paon62 with a comma and a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
flsaonpaonstreetn	Combine flsaon and PAON with a comma and a blank space, then combine with streetn with a blank space, then delete all the blank space	House price spatial data
saon4paonstreetn3	Combine saonn4 and paonn with a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
saon4paonstreetn4	Combine saonn4 and paonn with a comma and a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paonstreetn	combine saon1 and paonn with a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paonstreetn1	Combine saon1 and paonn with a comma and a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paonstreetn2	Combine saon1 and paonn with a blank space, then combine streetn with a blank space, then delete all the blank space and comma	House price spatial data
saon2paonstreetn3	Combine saonn2 and paonn with a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
saon2paonstreetn2	Combine saonn2 and paonn with a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saonn2paonn1	Combine saonn2 and paonn with a blank space, then delete all the blank space	House price spatial data
saonpaon62street	Combine SAON and paon62 with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saon2paonstreetn	Combine saonn2 and paonn with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saonn3paonnstreet	Combine saonn3 and paonn with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saonn2paonn1streetn	Combine saonn2 and paonn with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saonpaon62streetn1	Combine SAON and paon62 with a comma and a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paonstreet6n	Combine saon1 and paon62 with a comma and a blank space, then combine streetn with a comma and a blank space,then delete all the blank space	House price spatial data
saon1paonstreet6n1	Combine saon1 and paon62 with a comma and a blank space, then combine street with a blank space,then delete all the blank space	House price spatial data
saon2paonstreetn4	Combine saonn2 and paonn with a comma and a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
saon5paonstreetn1	Combine saonn5 and paonn with a blank space, then combine streetn with a comma and a blank space, then delete all the blank space	House price spatial data
paonsaon2streetn	Combine paonn and saonn2 with a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
paon62saonpstreet	Combine paon62 and saon with a blank space, then combine paon61 with a blank space and then combine street with a comma and a blank space, then delete all the blank space and comma	House price spatial data

saonpaon66street	Combine saonn and paon62 with a comma and a blank space, then combine paon61 with a blank space, then combine street with a blank space,then delete all the blank space and comma	House price spatial data
saon1paonstreetn3	Combine saon1 and PAON with a comma and a blank space, then combine streetn with a blank space, then delete all the blank space	House price spatial data
saon1paonstreet	Combine sao1 and PAON with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saon2paonlo	Combine saon2 and PAON with a blank space, then combine locality with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paon	Combine sao1 and PAON with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paon61street	Combine sao1 and paon61 with a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
saon1paon1	Combine sao1 and PAON with a blank space, then delete all the blank space	House price spatial data
psaonpaonstreet	Combine paon64 and SAON, then combine paon641 with a blank space, then combine street with a comma and a blank space, then delete all the blank space and comma	House price spatial data
saon2paon62street	Combine saon2 and paon62 with a comma and a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
saon2paonstreet	Combine saon2 and PAON with a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
flsaonpaonstreet	Combine flsaon with PAON with a comma and a blank space, then combine the street with a comma and a blank space, then delete all the blank space and comma	House price spatial data
psaon8street	Combine PAON and fldsaon1 , then combine street with a blank space then delete al the blank space and comma	House price spatial data
saonstreet	Combine SAON and street with a comma and a blank space, then delete all the blank space	House price spatial data
saonstreet1	Combine SAON and street with a blank space, then delete all the blank space and comma	House price spatial data
saonstreet2	Combine SAON and street with a comma and a blank space, then delete all the blank space and comma	House price spatial data
saonstreet3	Combine SAON and street with a blank space, then delete all the blank space	House price spatial data
saonstreetlo	Combine SAON and street with a comma and a blank space, then combine with locality with a comma and a blank space, then delete all the blank space	House price spatial data
unsaonpaonstreet2	Combine ‘UNIT’ string with SAON with a blank space, then combing PAON with a blank space, then combine with street with a comma and a blank space and the delete all the blank space.	House price spatial data
flsaonpaonstreet2	Combine flsaon2 with PAON with a blank space, then combine the street with a comma and a blank space, then delete all the blank space	House price spatial data
saon7paon6street	Combine saon7 and paon62 with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saon8paonstreet2	Combine saon8 and PAON with a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data

paonlo	For PAON start with number string, combine PAON and locality with a comma and a blank space, then delete all the blank space.	House price spatial data
flsaonpaonstreet3	Combine flsaon with PAON with a blank space, then combine the street with a comma and a blank space, then delete all the blank space and comma	House price spatial data
saonpaon62steet	Combine SAON and paon62 with a comma and a blank space, then combine street with a comma and blank space, then delete all the blank space	House price spatial data
flsaonpaon61street	Combine flsaon with paon61 with a blank space, then combine the street with a comma and a blank space, then delete all the blank space and comma	House price spatial data
flsaonpaon61street1	Combine flsaon with paon61 with a blank space, then combine the street with a comma and a blank space, then delete all the blank space	House price spatial data
saon4paonstreet	Combine saon4 with PAON with a blank space, then combine the street with a blank space, then delete all the blank space	House price spatial data
saonpaon61street1	Combine SAON and paon61 with a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
flsaonpaonstreet5	Combine flsaon with PAON with a comma and a blank space, then combine the street with a comma and a blank space, then delete all the blank space	House price spatial data
paonsaonstreet	Combine PAON and SAON, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
saonpaon61	Combine SAON and paon61with a comma and a blank space, then delete all the blank space	House price spatial data
paonsaonstreet1	Combine PAON and SAON with a comma and a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
apsaonpaon	Combine apsaon and PAON with a blank space, then delete all the blank space	House price spatial data
saon1paon62street	Combine sao1 and paon62 with a comma and a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
apsaonpaon62street1	Combine apsaon and paon62 with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saon2paonstreet1	Combine saon2 and PAON with a blank space, then combine street with a comma and a blank space	House price spatial data
apsaonpaonstreet2	Combine apsaon and PAON with a blank space, then combine street with a comma and a blank space, then delete all the blank space	House price spatial data
psaonpstreet	Combine paon6164 and SAON, then combine paon6163 with a blank space, then combine paon62 with a comma and hen combine street with a comma and a blank space and delete all the blank space	House price spatial data
saonpaonstreet11	Combine SAON and paon11 with a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data
saonpaon61streetn	Combine saonn and paonn61 with a comma and a blank space and and then combine streetn with a comma and a blank space, and then delete all the blank space	House price spatial data
saonpaon65street1	Combine SAON and paon65 with a comma and a blank space, then combine street with a blank space, then delete all the blank space	House price spatial data

Appendix C

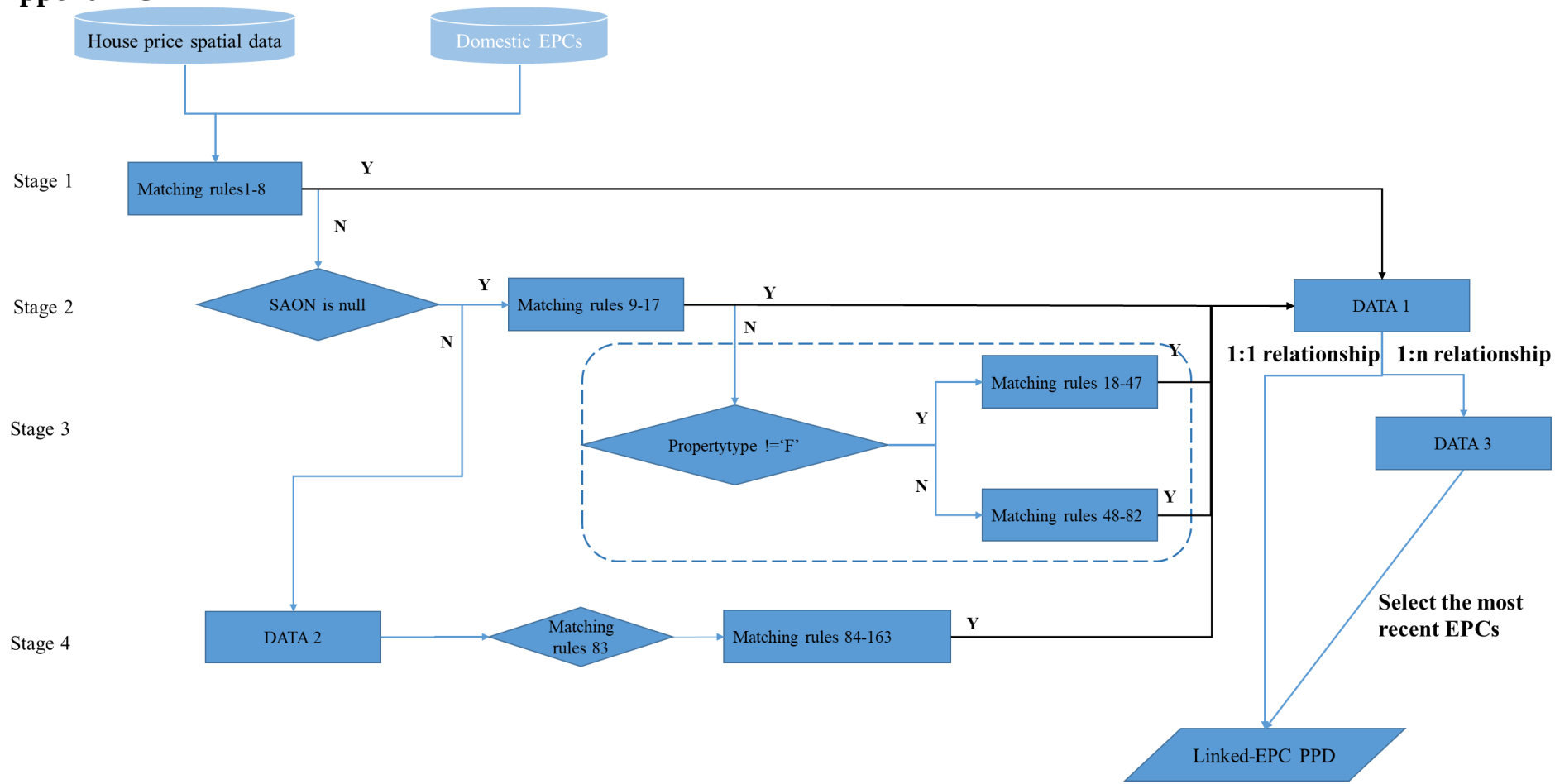

Figure C1 Master workflow of the 4 stages data linkage between house price spatial data and Domestic EPCs

Figure C1 demonstrates the data linkage workflow between Domestic EPCs and house price spatial data. Each stage contains more than one match rule. Details of the match rules for each Stage are listed in Table C1. In the Domestic EPCs, each record is created using a unique identifier with names of epcid. Each transaction in house price spatial data has a unique identifier named transactionid. The whole matching process between these two datasets is divided into four Stages. Take Stage one as an example of the matching process. All the matches are based on a "temple address strings" (i.e. postcode+saonpaonstreet) which is the combination of postcode and address variables. When Domestic EPCs and house price spatial data are put into the matching process, the process starts to link house price spatial data (transactionid) with epcid basing on the "temple address strings". For example, it tests whether postcode+saonpaonstreet in house price spatial data is equal to any postcode +ADDRE in Domestic EPCs. If the result shows yes and the epcid will direct link with transactionid and restore in Data 1, otherwise the transaction records will move to the other matching rules within the same Stage to conduct further matching tests, For the transactions that cannot be matching in Stage 1, they will move to Stage 2 to do the further matching tests. All the successfully linked transactions in Stage 1 are stored in DATA 1. However, in the real world, one property could have more than one Domestic EPCs in this matching process. The transaction property with only one successfully linked EPC will direct stored in linked-EPC PPD, transaction property with successful links to more than one EPC will be stored in DATA 3. A new function will be conducted to select all the Domestic EPCs for which total floor area is not null or 0 and will then keep the EPC's inspection date or lodgement date which is closest to the transaction date in the house price data. This result will then be stored in linked-EPC PPD. Stages 2 to 4 follow a similar process to Stage 1. Finally, linked-EPC PPD is the data linkage result. These data linkage results will firstly join back to Domestic EPCs according to the same epcid, then join with house price spatial data according to the transactionid. The data linkage process is conducted in R Studio.

Table C1 Details of matching rules in 4 stages[16]

Stage No.	Match rules No.	Match rules
Stage 1	1	(saonpaonstreet OR saonpaonstreet1 OR saonpaonstreet2 OR saonpaonlo OR saonpaonstreetlo OR saonpaonstreet3 OR saonpaon1) = ADDRE;
	2	(saopaonstreetn OR saonpaonstreetn1 OR saopaonstreetn2 OR saonpaonlon OR saonpaonstreetnlo or saonpaonstreetn3) = ADDC
	3	(saonpaonstreet OR saonpaonstreet1 OR saonpaonstreet2 OR saonpaonstreet3 OR saonpaonstreetlo or saonpaonlo) = ADD12;
	4	(saopaonstreetn OR saonpaonstreetn1 OR saopaonstreetn2 OR saonpaonlon) = ADD12C;
	5	saonpaonlon = ADDCC;
	6	saonpaonstreetn3 = ADD12C1;
	7	saonpaonstreet31 = ADDREC
	8	saonpaonstreetn31 = ADDC3
Stage 2	9	(paonstreetlo OR paonstreetlo1) = ADDRE;
	10	(paonstreetnlo OR paonstreetnlo1) = ADDC;

[16] In this table, all the address fields in house price spatial data is written in small letters and the address variable in the Domestic EPCs is written capital letters.

	11	(paonstreetlo OR paonstreetlo1) = ADD12
	12	(paonstreetnlo OR paonstreetnlo1) = ADD12C
	13	paonstreetlo2= ADD12C2
	14	paonstreetlo2= ADDREC
	15	paonstreetn=ADD12C3
	16	street is null and paonn3 =ADD1CC
	17	For the PAON contain comma, then paon66=ADD1CC
Stage 3	18	paon65streetlo=ADDRE
	19	paon65streetlo=ADD12
	20	paon65streetnlo =ADDCC
	21	(paon65streetlo1 OR paon61streetlo1)=ADDREC
	22	paon61streetlo=ADDC
	23	(paon61streetlo1 OR paon65street) = ADDC3
	24	paon61streetlo1= ADD12C1
	25	paon61lo= ADD12C
	26	paon61street= ADD12C1
	27	paon61street= ADD13C1
	28	paon65street= ADD1C2
	29	paon66streetlo=ADDCCC
	30	paon66streetlo =ADD12C3
	31	For the propertytype in EPCs is not Flat or Maisonette, paon65streetlo1 =ADD23C1
	32	For the propertytype in EPCs is not Flat or Maisonette, paon61new=ADD1
	33	paonstreetlo3= ADD12new
	34	paonstreetlo3= ADD13C1
	35	paonstreetlo3 = ADD13C2
	36	paonstreet= ADD1C3
	37	PAON=ADD1
	38	paonstreetlo3 =ADD662
	39	paonstreet= ADD67
	40	For the street is not null and the propertytype in EPCs is not Flat or Maisonette , paonstreet= ADDSP12;
	41	paonstreetn1=ADD1C4
	42	For the propertytype in EPCs is not Flat or Maisonette, paonstreet=ADDU
	43	paonstreet1=ADD68
	44	paonstreet1=ADD69
	45	For the address are written differently(e.g "WOODLANDS PARK" vs "WOODLAND PARK"), (paonstreet1 OR paonstreet2) =ADD1C5
	46	For the address are written differently and the propertytype in EPCs is not Flat or Maisonette, paonn2=ADD1C6
	47	For the ADD did not have 'number - number' (i.e 3-5), paonstreet3=ADDCCC
	48	For the paon61 did not contain ‘FLAT’ string and ‘FLOOR’ string, then paon62streetlo= ADDRE;
	49	For the paon61 does not contain FLAT’ string and ‘FLOOR’ string and also not start with number, then paon62streetlo=ADD12
	50	paon65streetnlo=ADDCC;

	51	For property type in EPC is Flat/Maisonette, paon62streetlo1=ADDREC;
	52	For property type in EPC is Flat/Maisonette, (paon61streetlo OR paon61streetlo1)=ADDC;
	53	paon61streetlo1=ADDC3
	54	paon61streetlo1=ADD12C1
	55	For property type in EPC is Flat/Maisonette, paon61street= ADD13C1
	56	paon66streetlo= ADDCCC
	57	paon66streetlo =ADD12C3
	58	paonfstreet= ADD12
	59	(paonfstreet OR paonapstreet OR paonfstreet1)= ADDRE
	60	(paonstreet OR paonstreetn1)= ADD1C7
	61	paonstreetn1= ADD1C8
	62	For the address words written different, (paonstreet1 OR paonstreet2)=ADD1C5; PAON=ADD1df1; **paonn2=ADD1du**; paon61c=ADD1C9; paonfstreetn5=ADD1C3;
	63	For PAON starts with number string, (paonfstreetn5=ADD1C9
	64	For PAON starts with number string, (paonfstreetn5 OR paonstreet1)=ADD1C;
	65	For property type in EPC is Flat/Maisonette, paonstreet3=ADD1632;
	66	For PAON starts with number string and add2 in EPCs not starts with number string, paonapstreet1=ADD12C2
	67	For PAON starts with number string, paonapstreetn5=ADD12C1
	68	(paonn2 OR paonstreet4)=ADDC3
	69	paonstreet3=flADD
	70	paonn2=ADD2611
	71	paonstreet3=flADD13
	72	paonstreet3=ADD13C2
	73	For PAON starts with number string, paonfstreetn5=ADD1C2
	74	(paonn2 OR paonstreet2)=ADD1C2
	75	paonfstreetn6= ADD12C
	76	paonapstreet2=ADD12C2
	77	paonf1streetn5=ADD12C;
	78	For the add in EPC is not start with ‘number string, number stirng’ pattern, for the PAON start with number but do not contain '-' in number string. flpaon3streetn5=ADDC10
	79	paonstreet2=ADD5
	80	paonstreet2=apADD1
	81	paonapstreet2=ADD13C2
	82	paonstreet3=ADDr66
Stage 4	83	Correct the address components in EPC basing on address components in PPD (e.g "GREENFELL COURT" to "GRENFELL COURT")
	84	saonpaonstreet2=ADDRE
	85	saonpaonstreet2=ADD12
	86	saonpaonstreetn=ADDC
	87	saonpaon65street=ADD12C;
	88	saonpaon62streetn2=ADD13C
	89	saonpaonstreetn=ADD6

	90	saonpaonstreetn=ADDCC
	91	saonpaon61street=ADD12C2
	92	saonpaon61street=ADDREC
	93	saonpaon62streetn=ADD7
	94	saonpaonstreet1=ADD13C2
	95	saonpaon1=ADD1C9
	96	saonpaonn=ADDC4
	97	paonstreetn=ADDC4 and saon='FLAT';
	98	For the property type is not Flats/Maisonettes;paonstreetn=ADDC4 , then delete keep the successful linkage whose properety type in EPC is not Flat or Maisonette
	99	For property type in EPC is Flat/Maisonette and for propertytype in house price data is 'F' :saon2paon61street= ADDCC; fldsaonpaonstreet1=ADDREC
	100	saonpaonn=ADD12C;
	101	paonstreetn=ADDC4 and saon did not contain 'FLOOR','UPPER','BASEMENT', 'LOWER' ,'FLAT ' or any number string
	102	For propertytype in house price data is 'F', (flsaonpaonstreet0=ADD; flsaon1paonstreetn2=ADDCC; flsaonpaonstreet1= ADDREC; flsaonpaon62street1 = ADDREC; saon7paonstreet1=ADDRE; saon7paonstreet2=ADDREC;saon7paonstreet2=ADD12C2 ; apsaonpaonstreet1=ADD12C2)
	103	For propertytype in house price data is 'F' and SAON start with number string, apsaonpaonstreet1=ADDREC
	104	saon7paonstreetn=ADDC4
	105	saon7paonn=ADD12C4
	106	saon4paonstreetn=ADDC4
	107	apsaonpaon6streetn=ADDC4
	108	For propertytype in house price data is 'F', flsaonpaonstreetn=ADDC4
	109	For the PAON start with number string , saon4paonstreetn3=ADDC5
	110	saon4paonstreetn4=ADD12C
	111	For property type in EPC is Flat/Maisonette and for propertytype in house price data is 'F', saon4paonstreetn1=ADD12C
	112	For propertytype in house price data is 'F': saon1paonstreetn=ADDC; saon1paonstreetn=ADD12C; saon1paonstreetn1=ADDC ;saon1paonstreetn1=ADD12C; saon1paonstreetn2=ADDC3; saon1paonstreetn2=ADD12C1;
	113	For property type in EPC is Flat/Maisonette and for propertytype in house price data is 'F', saon2paon61street=ADD12C
	114	For propertytype in house price data is 'F': saon2paonstreetn3=ADDC; saon2paonstreetn3=ADD12C
	115	For propertytype in house price data is 'F' and PAON start with number string: saon2paonstreetn2=ADDC; saon2paonstreetn2=ADD12C
	116	saonn2paonn1=ADDC
	117	saonpaon62street=ADD12C
	118	saon1paonstreet6n1=ADD12C
	119	For property type in EPC is Flat/Maisonette and for propertytype in house price data is 'F', saon2paonstreetn=ADD12C
	120	saonn3paonnstreet=ADD13C
	121	saonn2paonn1streetn=ADDC

	122	saonpaon62streetn1=ADDC
	123	saon1paonstreet6n=ADD12C
	124	For propertytype in house price data is ‘F’: paon62saonpstreet= ADDREC; saon2paonstreetn4=ADDC; saon2paonstreetn4=ADD12C
	125	For propertytype in house price data is ‘F’: saon2paonstreetn4=ADD1num2 and ADD1 in EPC does not contain a character pattern that consist of number strings with a character
	126	For propertytype in house price data is ‘F’ and SAON contain ‘APARTMENT ’ string: saon5paonstreetn1=ADDC; paonsaon2streetn=ADD1C; saon2paonstreetn2=ADD13C; saonpaon61streetn=ADDC
	127	saonpaon66street=ADDC6
	128	For propertytype in house price data is ‘F’: saon1paonstreetn3=ADD12C
	129	For property type in EPC is Flat/Maisonette and for propertytype in house price data is ‘F’: saon2street=ADDC; saon2paonlo=ADDRE; saon2paonstreet=ADD12
	130	saon1paonstreet=ADDRE
	131	saon1paon=ADD12
	132	For propertytype in house price data is ‘F’: saon1paon61street=ADD12; saon1paon1=ADD1; saon1paonstreetn2=ADD12C2; psaonpaonstreet=ADDRE
	133	For property type in EPC is Flat/Maisonette and for propertytype in house price data is ‘F’: saon2paon62street=ADD12
	134	For add2 contain 'number - number' character pattern , saon2paonstreet=ADD1262
	135	saonpaonstreetn2=ADD7
	136	For property type in EPC is Flat/Maisonette and for propertytype in house price data is ‘F’: flsaonpaonstreet=add1f61f2; psaon8street=ADDREC; saonpaonstreet1=add12643
	137	For propertytype is not F,saonstreet=ADDRE
	138	saonstreetlo= ADDRE
	139	For SOAN starts with number string, unsaonpaonstreet2=ADDRE
	140	For propertytype in house price data is ‘F’: flsaonpaonstreet2=ADD8; saon7paon6street=ADDRE; saon7paon6street=ADD12
	141	For property type in EPC is Flat/Maisonette and for propertytype in house price data is ‘F’: flsaonpaon1=ADD1C9; saonpaon1=fladd; saonpaon1=fladd1c; saonpaonstreet3=fladd
	142	saon8paonstreet2=ADDRE
	143	For property type in EPC is Flat/Maisonette and for propertytype in house price data is ‘F’: saonpaonstreet2=fladd
	144	PAON start with number string, paonlo=ADD12;
	145	For propertytype in house price data is ‘F’: saonpaonstreet1=adddap; saonpaon2=fladdc; saonpaonstreet11=ADD12; saonpaon61street=ADD1262C and paon62 contain ‘-’ string; saonpaon61street=ADD1262C and add261 contain ‘-’ string; flsaonpaonstreet3=ADD12C5; flsaonpaonstreet3=ADD12C1; saonpaon62steet=ADDC7
	146	For property type in EPC is Flat/Maisonette and for propertytype in house price data is ‘F’: saonpaon61street=fladdc; saonpaonstreet5 =apadd1632; saonstreet1=ADD1C7; saonpaonstreet1=add1f61f2; saonstreet2=ADD1264;flsaonpaon61street=ADDREC;saon4paonstreet=ADD12
	147	For propertytype in house price data is ‘F’: saonpaon61street1=ADD1262; flsaonpaon2=ADDRE
	148	saonpaon3=ADD1

	149	For propertytype in house price data is ‘F’: saonstreet3=ADDC; flsaonpaon2=ADD12; flsaonpaonstreet5=ADD1262; PAON did not contain number string and comma, saonstreet=ADD1264
	150	paonsaonstreet=ADDRE
	151	For propertytype in house price data is ‘F’: saonpaon61=ADD12; saon7paon=ADD12; paonsaonstreet1=ADD12; flsaonpaon61street1=ADD12
	152	For propertytype in house price data is ‘F’ : apsaonpaon=ADD12C2; apsaonpaon62street1=ADDC8
	153	saon1paon62street=ADD12
	154	For propertytype in house price data is ‘F’ and PAON does not start with number string, For property type in EPC is Flat/Maisonette, saonstreet=ADDC5
	155	saonpaonstreet2=ADDRE
	156	For propertytype in house price data is ‘F’: saon2paonstreet1=ADDC9; apsaonpaonstreet2=ADD1262cc; psaonpstreet=ADDRE
	157	saonpaon65street1=ADD12C
	158	For propertytype in house price data is ‘F’: saon2paonstreetn3=ADDC
	159	saonpaonn=ADD12C
	160	saon1paonstreetn1=ADDC
	161	For property type in EPC is Flat/Maisonette and ADD in EPC does not contian 'number -number' pattern and propertytype in house price data is ‘F’, saon4paonstreetn1=ADDC4
	162	For propertytype in house price data is ‘F’: saon1paonstreetn=ADDC4
	163	saonpaonlon=ADDC4

Appendix D

Table D Unable matched in method 2 due to the missing postcode in EPCs by local authority

Local authority	House price spatial data	Unable matched	Proportion	Region
City of London	2218	189	8.52%	London
Westminster	27254	794	2.91%	London
Salford	26909	772	2.87%	North West
Isles of Scilly	125	3	2.40%	South West
Tower Hamlets	33165	647	1.95%	London
Newcastle upon Tyne	26176	483	1.85%	North East
Liverpool	39210	630	1.61%	North West
Manchester	47723	753	1.58%	North West
Rochdale	17689	251	1.42%	North West
St. Helens	14962	212	1.42%	North West
West Devon	7008	94	1.34%	South West
Brent	20639	271	1.31%	London
Newham	18715	229	1.22%	London
Hackney	20172	243	1.20%	London

Crawley	11311	132	1.17%	South East
Blaby	12020	139	1.16%	East Midlands
Ashford	15818	177	1.12%	South East
North Warwickshire	6307	66	1.05%	West Midlands
Watford	12014	125	1.04%	East of England
Halton	10320	104	1.01%	North West
Redditch	9015	88	0.98%	West Midlands
Vale of White Horse	15374	150	0.98%	South East
Horsham	19208	184	0.96%	South East
Hartlepool	8573	82	0.96%	North East
Selby	10778	102	0.95%	Yorkshire and The Humber
West Oxfordshire	13163	124	0.94%	South East
Cheltenham	17099	156	0.91%	South West
South Tyneside	12482	111	0.89%	North East
Cambridge	13664	121	0.89%	East of England
West Berkshire	18949	167	0.88%	South East
Melton	6150	54	0.88%	East Midlands
Camden	20737	181	0.87%	London
Trafford	26363	228	0.86%	North West
Hertsmere	11922	101	0.85%	East of England
Test Valley	14951	126	0.84%	South East
Peterborough	21360	180	0.84%	East of England
East Dorset	12473	105	0.84%	South West
Erewash	13667	115	0.84%	East Midlands
Barnsley	23505	196	0.83%	Yorkshire and The Humber
Daventry	10367	86	0.83%	East Midlands
Wandsworth	42603	350	0.82%	London
Blackburn with Darwen	11938	97	0.81%	North West
Purbeck	5588	45	0.81%	South West
West Dorset	14339	115	0.80%	South West
Bromsgrove	11174	89	0.80%	West Midlands
West Lancashire	9433	75	0.80%	North West
Warwick	18482	146	0.79%	West Midlands
Middlesbrough	12441	98	0.79%	North East
Ealing	26603	209	0.79%	London
Hounslow	21980	172	0.78%	London
Nottingham	26340	204	0.77%	East Midlands
Rugby	12921	100	0.77%	West Midlands
Wokingham	20556	159	0.77%	South East
Maldon	7503	58	0.77%	East of England
Hyndburn	8286	63	0.76%	North West
Harlow	8699	66	0.76%	East of England

South Northamptonshire	11547	87	0.75%	East Midlands
Maidstone	19936	150	0.75%	South East
Wellingborough	8409	63	0.75%	East Midlands
Cotswold	11487	85	0.74%	South West
Hambleton	9773	72	0.74%	Yorkshire and The Humber
Stevenage	9095	67	0.74%	East of England
Colchester	26020	191	0.73%	East of England
Bedford	20766	151	0.73%	East of England
Tonbridge and Malling	16250	118	0.73%	South East
Cornwall	68595	498	0.73%	South West
Huntingdonshire	23966	173	0.72%	East of England
Barnet	34504	248	0.72%	London
Stockton-on-Tees	20581	147	0.71%	North East
Basildon	20405	145	0.71%	East of England
South Ribble	12693	90	0.71%	North West
Darlington	11282	79	0.70%	North East
Southwark	28234	195	0.69%	London
Leicester	24474	169	0.69%	East Midlands
Bolton	25249	174	0.69%	North West
Bradford	46397	319	0.69%	Yorkshire and The Humber
Bolsover	8513	58	0.68%	East Midlands
Wealden	21302	145	0.68%	South East
East Hertfordshire	19688	134	0.68%	East of England
Calderdale	22405	151	0.67%	Yorkshire and The Humber
Malvern Hills	8462	57	0.67%	West Midlands
Stratford-on-Avon	15938	107	0.67%	West Midlands
Norwich	16912	113	0.67%	East of England
North Hertfordshire	16798	111	0.66%	East of England
Slough	12295	81	0.66%	South East
Lichfield	11304	74	0.65%	West Midlands
Sandwell	22880	149	0.65%	West Midlands
Bassetlaw	11839	77	0.65%	East Midlands
South Hams	11762	76	0.65%	South West
Eden	5456	35	0.64%	North West
Uttlesford	11718	75	0.64%	East of England
Winchester	14869	94	0.63%	South East
Dartford	13631	86	0.63%	South East
Gosport	10472	66	0.63%	South East
Broxtowe	12756	79	0.62%	East Midlands
Chichester	15834	98	0.62%	South East
Wakefield	31928	197	0.62%	Yorkshire and The Humber
Derby	26310	162	0.62%	East Midlands
Harrogate	20403	125	0.61%	Yorkshire and The Humber

Shropshire	32673	199	0.61%	West Midlands
Sefton	25542	155	0.61%	North West
Stafford	14506	88	0.61%	West Midlands
Amber Valley	14721	89	0.60%	East Midlands
Cheshire West and Chester	37100	223	0.60%	North West
Northumberland	33116	199	0.60%	North East
Wychavon	14427	86	0.60%	West Midlands
Bury	19149	114	0.60%	North West
Stockport	32647	193	0.59%	North West
North Devon	12039	71	0.59%	South West
Torbay	19180	113	0.59%	South West
Waverley	16241	95	0.58%	South East
North Tyneside	23460	137	0.58%	North East
Burnley	9442	55	0.58%	North West
Derbyshire Dales	7897	46	0.58%	East Midlands
Kirklees	39670	230	0.58%	Yorkshire and The Humber
Mendip	14538	84	0.58%	South West
Swindon	28678	165	0.58%	South West
Adur	8198	47	0.57%	South East
Northampton	27255	155	0.57%	East Midlands
Wiltshire	59442	338	0.57%	South West
Milton Keynes	33118	188	0.57%	South East
Sunderland	22382	127	0.57%	North East
Bristol, City of	55132	312	0.57%	South West
Leeds	82385	466	0.57%	Yorkshire and The Humber
Preston	13104	74	0.56%	North West
Warrington	22188	125	0.56%	North West
Great Yarmouth	11380	64	0.56%	East of England
Lincoln	11982	67	0.56%	East Midlands
Richmondshire	4709	26	0.55%	Yorkshire and The Humber
Lambeth	31941	176	0.55%	London
Birmingham	86831	478	0.55%	West Midlands
Oldham	17733	97	0.55%	North West
Tamworth	6957	38	0.55%	West Midlands
South Lakeland	13011	71	0.55%	North West
Forest Heath	8995	49	0.54%	East of England
Welwyn Hatfield	11945	65	0.54%	East of England
Runnymede	10485	57	0.54%	South East
Braintree	18580	101	0.54%	East of England
Cannock Chase	9400	51	0.54%	West Midlands
Allerdale	10150	55	0.54%	North West
South Oxfordshire	17385	94	0.54%	South East
Redcar and Cleveland	12990	70	0.54%	North East

Tewkesbury	11337	61	0.54%	South West
Wyre Forest	10244	55	0.54%	West Midlands
Reading	20499	110	0.54%	South East
Babergh	10687	57	0.53%	East of England
Doncaster	27755	147	0.53%	Yorkshire and The Humber
Bath and North East Somerset	22575	119	0.53%	South West
Corby	8161	43	0.53%	East Midlands
Sutton	23180	122	0.53%	London
East Hampshire	15243	80	0.52%	South East
Harrow	20033	105	0.52%	London
Aylesbury Vale	25411	133	0.52%	South East
Canterbury	20267	106	0.52%	South East
Oxford	13613	71	0.52%	South East
Eastbourne	15864	82	0.52%	South East
Mid Sussex	20139	104	0.52%	South East
Boston	7166	37	0.52%	East Midlands
Stroud	14545	75	0.52%	South West
Forest of Dean	8729	45	0.52%	South West
South Derbyshire	12522	64	0.51%	East Midlands
Wigan	29441	149	0.51%	North West
North Dorset	9094	46	0.51%	South West
Telford and Wrekin	17793	90	0.51%	West Midlands
Ribble Valley	6529	33	0.51%	North West
County Durham	50896	257	0.50%	North East
Gateshead	18482	93	0.50%	North East
Taunton Deane	15734	79	0.50%	South West
Exeter	15753	79	0.50%	South West
Oadby and Wigston	5786	29	0.50%	East Midlands
North West Leicestershire	12041	60	0.50%	East Midlands
Mid Suffolk	12066	60	0.50%	East of England
Hillingdon	27406	136	0.50%	London
Mid Devon	9690	48	0.50%	South West
Guildford	17033	84	0.49%	South East
Fareham	15062	74	0.49%	South East
Pendle	9432	46	0.49%	North West
Three Rivers	10472	51	0.49%	East of England
Chiltern	11112	54	0.49%	South East
Sheffield	50829	247	0.49%	Yorkshire and The Humber
South Norfolk	18529	90	0.49%	East of England
Tameside	19403	94	0.48%	North West
Ipswich	16164	78	0.48%	East of England
Nuneaton and Bedworth	13197	63	0.48%	West Midlands

Bournemouth	27352	130	0.48%	South West
Herefordshire, County of	19243	91	0.47%	West Midlands
South Staffordshire	9608	45	0.47%	West Midlands
Craven	7046	33	0.47%	Yorkshire and The Humber
Barrow-in-Furness	8565	40	0.47%	North West
York	25823	120	0.46%	Yorkshire and The Humber
Stoke-on-Trent	23394	108	0.46%	West Midlands
Tendring	20640	95	0.46%	East of England
Southend-on-Sea	23596	108	0.46%	East of England
St Edmundsbury	13878	63	0.45%	East of England
Sevenoaks	13242	60	0.45%	South East
South Somerset	20045	90	0.45%	South West
West Somerset	4456	20	0.45%	South West
North Somerset	29243	131	0.45%	South West
Islington	21435	95	0.44%	London
Rutland	4968	22	0.44%	East Midlands
Solihull	23756	105	0.44%	West Midlands
West Lindsey	11369	50	0.44%	East Midlands
Carlisle	12529	55	0.44%	North West
South Gloucestershire	33060	145	0.44%	South West
Wirral	31067	136	0.44%	North West
Hinckley and Bosworth	14426	63	0.44%	East Midlands
Gloucester	16767	73	0.44%	South West
Wolverhampton	18916	82	0.43%	West Midlands
Hart	11373	49	0.43%	South East
Teignbridge	18195	78	0.43%	South West
Spelthorne	12167	52	0.43%	South East
Harborough	11992	51	0.43%	East Midlands
Luton	17788	75	0.42%	East of England
North East Derbyshire	9507	40	0.42%	East Midlands
Epping Forest	15227	64	0.42%	East of England
Wyre	12406	52	0.42%	North West
Woking	14137	59	0.42%	South East
Barking and Dagenham	14707	61	0.41%	London
Breckland	17190	71	0.41%	East of England
Mole Valley	10484	43	0.41%	South East
Basingstoke and Deane	22086	90	0.41%	South East
North East Lincolnshire	16490	67	0.41%	Yorkshire and The Humber
Southampton	25664	104	0.41%	South East
Rushmoor	11938	48	0.40%	South East
Chesterfield	10503	42	0.40%	East Midlands

Wycombe	20299	81	0.40%	South East
Cherwell	18598	74	0.40%	South East
Newark and Sherwood	14082	56	0.40%	East Midlands
Kingston upon Hull, City of	22708	90	0.40%	Yorkshire and The Humber
Central Bedfordshire	37229	147	0.39%	East of England
Rossendale	7100	28	0.39%	North West
Sedgemoor	14992	59	0.39%	South West
Copeland	7127	28	0.39%	North West
Dudley	28517	112	0.39%	West Midlands
Epsom and Ewell	10223	40	0.39%	South East
Tunbridge Wells	14570	57	0.39%	South East
Chorley	13569	53	0.39%	North West
Fenland	12332	48	0.39%	East of England
Lancaster	16735	65	0.39%	North West
King's Lynn and West Norfolk	19076	74	0.39%	East of England
Staffordshire Moorlands	10056	39	0.39%	West Midlands
Blackpool	14191	55	0.39%	North West
Gravesham	10051	38	0.38%	South East
Thanet	19202	72	0.37%	South East
Plymouth	29891	112	0.37%	South West
Poole	21101	79	0.37%	South West
Ryedale	6162	23	0.37%	Yorkshire and The Humber
South Kesteven	19089	71	0.37%	East Midlands
East Devon	22059	82	0.37%	South West
Shepway	14560	54	0.37%	South East
Havering	26565	98	0.37%	London
Knowsley	9828	36	0.37%	North West
Cheshire East	46512	170	0.37%	North West
Enfield	26101	95	0.36%	London
Weymouth and Portland	8801	32	0.36%	South West
Greenwich	25652	93	0.36%	London
Arun	24552	89	0.36%	South East
North Kesteven	15175	55	0.36%	East Midlands
Bracknell Forest	15209	55	0.36%	South East
Lewisham	28850	104	0.36%	London
Eastleigh	15819	57	0.36%	South East
Walsall	21465	77	0.36%	West Midlands
Dacorum	18873	67	0.36%	East of England
Swale	17039	60	0.35%	South East
Thurrock	17711	62	0.35%	East of England
Bexley	25417	88	0.35%	London

Ashfield	14272	49	0.34%	East Midlands
Windsor and Maidenhead	17516	60	0.34%	South East
Suffolk Coastal	17005	57	0.34%	East of England
North Norfolk	15284	51	0.33%	East of England
Charnwood	20774	69	0.33%	East Midlands
Kettering	13286	44	0.33%	East Midlands
Mansfield	11524	38	0.33%	East Midlands
Castle Point	10363	34	0.33%	East of England
Hammersmith and Fulham	19945	65	0.33%	London
Newcastle-under-Lyme	12465	40	0.32%	West Midlands
Broadland	15719	50	0.32%	East of England
Dover	14570	46	0.32%	South East
North Lincolnshire	16214	51	0.31%	Yorkshire and The Humber
South Cambridgeshire	19141	60	0.31%	East of England
New Forest	23416	73	0.31%	South East
Kensington and Chelsea	19024	59	0.31%	London
Coventry	31416	97	0.31%	West Midlands
Reigate and Banstead	20222	62	0.31%	South East
Fylde	9810	30	0.31%	North West
Brentwood	10164	31	0.30%	East of England
Havant	14116	43	0.30%	South East
Worcester	12528	38	0.30%	West Midlands
Lewes	13586	41	0.30%	South East
St Albans	19929	60	0.30%	East of England
East Lindsey	16287	49	0.30%	East Midlands
Chelmsford	21628	65	0.30%	East of England
Isle of Wight	20395	61	0.30%	South East
Torridge	9750	29	0.30%	South West
Elmbridge	19702	58	0.29%	South East
High Peak	10226	30	0.29%	East Midlands
East Staffordshire	12294	36	0.29%	West Midlands
East Cambridgeshire	11118	32	0.29%	East of England
Rochford	10107	29	0.29%	East of England
Bromley	41033	117	0.29%	London
Rotherham	23266	66	0.28%	Yorkshire and The Humber
Surrey Heath	10589	30	0.28%	South East
East Riding of Yorkshire	41880	118	0.28%	Yorkshire and The Humber
Redbridge	24242	66	0.27%	London
South Holland	11521	31	0.27%	East Midlands
Croydon	36530	98	0.27%	London

Medway	30620	80	0.26%	South East
Gedling	14232	37	0.26%	East Midlands
Worthing	16935	44	0.26%	South East
Rushcliffe	15102	39	0.26%	East Midlands
Christchurch	7844	20	0.25%	South West
Scarborough	14566	36	0.25%	Yorkshire and The Humber
Waveney	14671	36	0.25%	East of England
Richmond upon Thames	25758	60	0.23%	London
Haringey	19046	43	0.23%	London
Merton	22642	48	0.21%	London
Portsmouth	23684	50	0.21%	South East
South Bucks	7874	16	0.20%	South East
Hastings	12156	24	0.20%	South East
Kingston upon Thames	19247	37	0.19%	London
Broxbourne	11355	21	0.18%	East of England
Brighton and Hove	37863	68	0.18%	South East
Waltham Forest	21839	37	0.17%	London
East Northamptonshire	12275	20	0.16%	East Midlands
Rother	14470	20	0.14%	South East
Tandridge	11019	11	0.10%	South East