Residential Property Value Patterns in London

Ref 015

Space Syntax spatial Analysis

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Abstract
The effect of spatial accessibility upon rent is a finding of classic spatial economics. Using space syntax spatial configuration analysis that index spatial accessibility to opportunity (Integration & Choice) the patterns of a large sample of residential property with single and multiple dwellings (+60,000) located in a north London Borough is analysed by using property council tax band as a proxy for property values. The findings show that; the council tax band proxy is a good indicator of residential property sale prices; spatial accessibility as indexed by space syntax spatial analysis give a good account of the variations in residential property values for single and multiples dwellings controlling for buildings age, property size and relative density. Multivariate analysis is used to establish variables weighting. The single most important spatial factor is property size, followed by relative density, small radius Integration, large radius integration, age, low radius Choice.

Introduction and background

The relevance of land, property price and rent to public investment decision has long been recognized. New roads and public transport investment, sewer and water lines, and urban renewal projects yield sizeable benefit to adjacent properties. In economics Marshall (1890) examines the question of land rent and land value at length. More preeminent is the spatial model which was presented by von Thünen (1826). Alonso (1964) adopted von Thünen's theory of agricultural land use and applied it to urban regions, describing cities as having a circular area of residential properties surrounding a central business district (CBD) of a certain radius. The monocentric city model of Alonso has subsequently been subject to a number of revisions and generalizations (Mills 1967, 1972; Muth 1969) and more recently Fujita 1969, and Fujita & Thisse 2008. The spatial settings of the base model is the monocentric city model where firms and households have an exogenous budget which they can spend on the consumption of land, transportation to focal points of centrally located places of work and services and "other" commodities. The main prediction of the monocentric city model is that households and firms are willing to pay more for land located closer to the CBD. Numerous papers have studied the relationship between distance to the CBD as an index of spatial accessibility and the value of a certain location. This is most commonly achieved by estimating a hedonic model with either the rent or the transaction price as the dependent variable and variables representing property characteristics, neighbourhood amenities, and location as explanatory variables. The distance to the CBD is taken as a key spatial accessibility variable in most studies in the field; it is understood as a rough proxy for location advantage differentials. While locations deemed almost equal, especially when approximated by the distance from the CBD, can have substantial disparities in accessibility and other micro-locational aspects, one of the strongest criticisms is that the emergence of a CBD location itself is exogenous to the model. Accessibility to goods and services is a complex notion which pervades spatial sorting issues (Hansen, 1959) and, for that reason, it can be considered as one of the main determinants of property values (Des Rosiers et al 2000) although its influence will differ depending on the configuration of the urban fabric (Kestens et al 2004). According to Levy and Lassault, spatial accessibility cannot be defined by itself because it depends on context specifics criteria: the transport spatial network and technology on the supply side, personal values, natural constraints and socio-economics acceptability on the demand side. The resulting housing sorting affects home location choices and, consequently, the housing market as a whole. The state of the current research in mass valuation methods raises the following problem; if spatial accessibility disparity could be assessed in real relative terms could the spatial configuration approach of accessibility account for residential property values? The challenge is to account for location with sufficient precision and making the CBD locations endogenous to the model would require a different approach to distance as locational differential. Recent studies examining commercial office rent levels in Stockholm, Sweden and Housing pricing in King County, Washington have shown that the space syntax spatial analysis measures: spatial integration and choice (Enstrom 2007, Matthews 2007), as emergent measures of spatial centrality, are linked to property values. Space Syntax spatial analysis is a set of techniques and theories for the notation, quantification and interpretation of configuration of spatial layout in general and urban layout.

This paper aims at examining residential property value variations of a large sample in an outer Borough of north London using space syntax spatial analysis and council tax band as a proxy of property price. The key objectives of this investigation is to better understand how strategic urban design impacts residential property values. This investigation is part of a large research development effort in the UK: the UrbanBuzz programme . The i-VALUL part of the UrbanBuzz programme explored the potential to monetize various impacts of strategic urban design. In this paper the key questions we explore in turns are: Do spatial layout variables influence residential property values? Are the layout variables independent of other variables in influence? How does council tax band correlate to residential property value? How does density influence residential property value? Are spatial effects similar in both single dwellings, i.e. houses, and buildings with multiple dwellings?

UK existing research on property values and urban design

Urban layout design is the combined remit of transport planning and urban design policies, various professionals and end users involved in the value chain. In transportation design the monetized value of the street and road layout geometry is captured implicitly by the value of time ascribed to each link, the geometry of transport speed and congestion (Chiaradia 2007). These monetized values could fall under the broad term of accessibility values. In urban design, the attempt to give monetized value to layout design is relatively recent in the UK. There is a need to evaluate value creation in the urban environment beyond accessibility. The UK Commission for Architecture and the Built Environments response to the Calcutt Review states that it is important to concentrate on creating value instead of controlling costs (CABE, 2007a). Existing research focuses on the opportunity for increasing the economic value of properties through better urban design. Research suggests that economic viability can be added through good design and that both indirect and direct benefits will arise (Bartlett, 2001). Buildings and spaces create economic and social value and research from the UK and abroad show that investment in good design generates economic and social value (CABE, 2003). Contributing to this research on residential properties is the need for increasing densities and the affects that this has on value. There is currently a great need to accommodate further growth and increase densities, especially in residential areas. Housing density is an important element to this debate on residential property value. There is the need to unlock value through better use of space and good urban design (NWDA, 2007). CABE found that higher densities do not decrease value and while density is more important to developers, end users are concerned more with location (CABE, 2003). Higher densities, it was shown, required a higher amount of investment in design to achieve quality developments (Llewelyn-Davies, 2007).

These results can be understood as the wider economic benefits of urban design. For the same given level of capital investment; how urban design may provide a better return on investment? What are other positive externalities that are not captured in standard development cost benefit analysis? While the above studies are of seminal importance, because of their small sample size and because street layout design effect is not controlled for rigorously, they remain marginal to the financial decision making process and to the designer. One of the aims of UrbanBuzz's i-VALUL development project was to overcome these shortcomings. We investigate the link between property price for a large sample of single and multiple dwelling buildings using tax band information and an improved understanding of the relationship between detailed locational influences encoded in a spatial model derived from an axial line encoding and using space syntax Integration and Choice geometric distance at different metric radius as locational analytics.

Sample and variables definitions

Residential sample

London as a whole was home to over 7.5 million residents in 2006 with 60% of the population living in Outer London boroughs. Outer borough areas coverage is 80% of the Greater London Authority. The residential sample used is entirely located within an outer Borough in north London. A Borough is the geographical area definition of a local council authority (33) in Greater London. The Borough with an area of 4,325ha has a density of 60.9 persons/ha with an average household size of 2.6. The Borough has the highest population density with 6,300 Pop/km2 with the high turnover rate (2001-2006 - 17 to 20%). Outer London has an average population density of 3,624 and Inner London 9,311 Pop/km2.

The age structure (2002) of the Borough's is a relatively young age structure with 25% of the population being in the 0 to 19 range and 37% in the 20 to 39 range. Pensioners make up 14% of the population, which is lower than the Greater London and England and Wales figures of 15.5% and 18% respectively. The population has a high fertility rate compared to most other London boroughs. The Borough has one of the most culturally diverse boroughs. Black and minority ethnic groups make up the majority of the population at 54.7%. This is the second highest of all the London Boroughs. The largest religious group is Christian (48 per cent) followed by Hindu (17 per cent) and Muslim (12 per cent). The Borough has an economically active population of 65% of which 45% are in the three top occupation groups and 11% in the last occupation group. About 44% of the population in employment use public transport to travel to work (underground 26%, train 6%, bus 13%). In outer London, the borough has the fifth highest level of registered enterprises with 1 to 4 employees (ONS). The outer Borough has a ratio of 0.72 job to working age resident (ONS, 2006).

The residential sample consists of a database of 63,245 residential buildings with 101,849 dwellings. This sample was used to investigate the relationship between crime and urban layout (Shabbaz, Hillier, 2007). In a sense, this work can be seen as an extension of the crime work, since residential burglary rates were U-shaped in the borough, in that they were higher for low and high council tax values and lower in the middle. Looking more closely at the relation between council tax values and street layout should help qualify the features of the crime pattern. In the sample, buildings are distinguished between single and multiple dwellings buildings.

The data base includes details on building age, property size, relative density and tax band, building floor number and non-residential building which is mainly mixed use retail and services. Relative density is defined as the number of other dwellings wholly or in part within 30 metres of each dwelling. It is a density centred on each dwelling, it give an indication of ambient density. Property size was approximated by taking the area of the floorplate polygon and multiplying by the number of storeys. This is an imperfect measure since the polygon will sometimes, and sometimes not, include a garage, and this may sometimes be built over and sometimes not. It is also likely that older houses are much less likely to have a garage included in the polygon. With this in mind, however, we can probably use this as a reasonable approximation of property size. Single dwelling buildings and multiple dwelling buildings are analyzed separately.

Detached	6,617	6.5%
Semi- detached	28,303	27.7%
Terraced	19,285	18.9%
Purpose built block of flats or tenement	27,493	26.9%
Part of a converted or shared house	18,424	18%
In commercial building	1,980	1.9%

Table 1
type of dwellings

Households: Owner occupied:			Households: Rented from:			
Owner owns outright	Owns with a mortgage or loan	Shared ownership	Council (local authority)	Housing Association/Registered Social Landlord**	Private landlord or letting agency	Other
23,165	31,327	1,435	10,592	13,289	17,043	3,140
23.2%	31.3%	1.4%	10.6%	13.3%	17.0%	3.1%

Table 2
housing tenure

Tax Band	**values (£) (1991)**	**Single**		**Multiple**	
1 - A	Up to 44,000	17	0.3%	158	1.0%
2 - B	40,001 - 52,000	143	0.3%	2,070	13.2%
3 - C	52,001 - 68,000	1,518	3.2%	8,693	55.4%
4 - D	68,001 - 88,000	18,423	38.7%	3,649	23.2%
5 - E	88,001 - 120,000	18,599	39.1%	823	5.2%
6 - F	120,001 - 160,000	5,515	11.6%	184	1.2%
7 - G	160,001 – 320,000	3,115	6.6%	113	0.7%
8 - H	More than 320,001	215	0.5%	10	0.1%
		47,545		15,700	

Table 3
Single and multiple dwelling buildings sample.

Council Tax Band Valuation

Council Tax is a form of local taxation which is used to help pay for the services that the Local Council provides. It is payable in respect of each domestic property and the amount payable depends on the capital value of the property. The capital value is divided in bands which are in turn used to calculate the Council Tax. The valuation is undertaken by the Valuation Office Agency (VOA), an executive agency of the UK government.

The VOA's main functions are to compile and maintain the business rating and council tax valuation lists for England and Wales, value property in England, Wales, and Scotland for the purposes of taxes administered by the UK HM Revenue & Customs, provide statutory and non-statutory property valuation services in England, Wales, and Scotland and give policy advice to Ministers on property valuation matters

The VOA values a home on the basis of its value on 1 April 1991. Even new homes are valued on the basis of what they would have been worth in 1991. In undertaking valuations, the VOA take account of the characteristics of a home and everything that goes to make up its value - positive or negative. This is just what any other valuer would do. When valuing a property for council tax purposes VOA consider the physical state of the property and its locality at a specific date on or after 1 April 1993 and then consider what its value would have been on 1 April 1991. This is the common valuation date for all council tax valuations in England. The VOA assumes that any dwelling that they are valuing for council tax is in a 'state of reasonable repair'. This does not mean that VOA will assume that all properties are in 'good' state of repair. Instead, VOA decides what state it would be reasonable to expect for a dwelling having regard to its age, character and locality. For example, one house in a terrace of ten otherwise identical properties has not been maintained but allowed to deteriorate. However, its basic character is likely to remain the same as that of its neighbours. In such instances, VOA assume a 'state of reasonable repair' which is the same as actually exists for most of the nearby properties. Therefore, the property's disrepair is not reflected in its banding. Very occasionally a dwelling, whilst being of the same age and design as other properties in the neighbourhood, may be wholly different in character (for example: due to a specific structural defect). Here the state of repair that VOA assumes is not that of the majority of its neighbours but other dwellings which have similar defects. In such instances VOA will reflect the structural defect in the value of the property and we may band it differently to neighbouring properties which have no such defect.

Council Tax band and property sale price distribution

Since council tax bands were originally set on the basis of value assessments, we may expect there to be some continuing relation between the distribution (as opposed to the level) of tax band and the real value of property. Although real values will have changed considerably and perhaps differently within different bands, it is reasonable to expect that changes will tend to be within bands rather than across bands. Council Tax Band should offer a good approximation of the distribution of real values. How reliable is tax band in relationship to residential property sale prices? Working with Savills, a leading real estate service provider in London, the tax council band was checked against the distribution of residential property sales from the second quarter of 2006 to the first quarter of 2007. The comparison was made with an inflated tax band valuation. The figure shows how the two trends are correlated. Overall Council Tax Band and residential property sale prices are positively correlated.

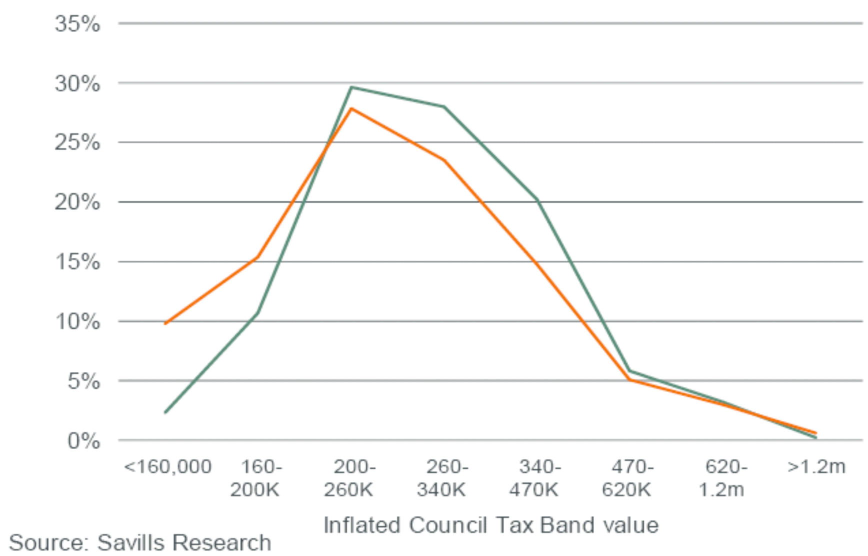

Figure 1

Grey line: % residential property sold in the Borough between Q206 and Q107 in relationship to their inflated council tax band. Orange line: % of residential property sale between Q206 and Q107 in relationship to their sale price.

Spatial variables

A set of spatial variables are analyzed such as segment length, axial line length, total street length within 300m radius and proximity to non-residential land use in relationship to each council tax band. Each dwelling is sorted according to tax band and assigned segment length, axial line length, and total axial length, proximity to non-residential land use. The values are summed and averaged for each tax band. Similarly this principle is used for the space syntax variables. Space syntax variables used are as follow:

Space syntax angular segment spatial analysis is used (Hillier & Iida 2007, Turner 2005). The spatial model is made of more than 7000 segments.

Average of mean integration of each council tax band at different radius: using the spatial model as a look up table, each dwelling within a given council tax band is assigned the corresponding value of mean integration. These Mean Integration values are summed up and averaged for each tax band.

Average of mean choice of each council tax band at different radius: using the spatial model as a look up table, each dwelling within a given council tax band is assigned the corresponding value of Choice. These Choice values a summed up and averaged for each tax band.

The following metric radii are investigated: angular mean integration reciprocal at metric radius of n, 2,000, 1,000, 500, 300m.

Results

Integration variable – radius in m	r^2	β	α intercept
N	0.99	+0.114	4.50
2,000	0.16	+0.005	1.39
1,000	0.22	-0.043	11.42
500	0.58	-0.121	13.17
300	0.58	-3.035	49.30
Choice variable – radius in m	**r^2**	**β**	**α intercept**
Choice N	0.75	+0.154	4.12
Simple spatial variable	**r^2**	**β**	**α intercept**
Segment length	0.77	+14.072	52.72
Line length	0.85	+34.248	235.18
Total street length within 300m	0.66	-181.631	3,738.21
Dwelling centred density	0.88	-1.755	18.30
Non-residential use proximity	0.43	-0.122	1.09

Table 4

Single dwelling buildings – spatial analysis

Single dwelling buildings Higher Tax Band single dwelling buildings (HTBSDB) are:

- positively associated with higher mean integration radius N and negatively associated with local radius.
- farther away from non-residential uses
- located on longer street segments (between junctions and angular change). This means that HTBSDB tend to form part of larger urban blocks than Low Tax Band Dwelling Buildings. Note that as we are in an outer London Borough, population density is lower than inner London Boroughs (Burdett 2005) and overall the Borough has a sparser spatial

network. Consequently block sizes are larger, which imply longer segment lengths and line lengths than inner London Boroughs. This may mean that in relation to the fast/large scale movement spatial network it may not have a high level of large scale movement and probably plot sizes are also larger. This is because the sample has no residence on the two first levels of arterial, the foreground streets, which have high level of traffic, noise and pollution.

Comparing single and multiple dwellings

Using the same analysis a more complex pattern is found for multiple dwelling buildings. The lower tax bands are dominated by social housing and the higher by private apartments and converted large period housing.

Higher Tax Band multiple dwelling (HTBMD) are:

- positively associated with higher Integration N and Choice N than singles for low tax band and comparable for high
- located on longer segments following a pattern similar to single dwellings and they are part of larger urban blocks.
- associated with lower densities and not very different from singles, and are particularly close for higher tax bands.
- closer to the shops and other non-residential activity than singles and this gets stronger with higher tax band.

Lower Tax Band multiple dwelling are:

- higher ambient density
- higher
- positively associated with Integration and Choice at low radius, small segment, smaller block size, and probably smaller plot
- closer to non-residential use

Overall it seems that Lower Tax Band Multiple Dwellings are in close proximity to centres which combine both high values for low and high radius Integration and Choice while the higher the Tax Band of the dwelling, the more it is oriented towards the global rather than the local system. This result was consistent throughout both types of buildings.

Because buildings are so different, it is difficult to estimate the price for buildings generically. Instead, it is assumed that a house can be decomposed into characteristics such as number of bedrooms, size of plot, or distance to the city centre, etc. A hedonic model of prices is one that decomposes the prices of an item into separate components that determine the price to obtain estimates of the contributory value of each characteristic. A hedonic model does not necessarily separate all the factors that could be separated, only those that affect the usefulness to a buyer of what is being sold. Hedonic models are most commonly estimated using regression analysis, although more generalized models. A hedonic model is similar to a multi-variables analysis. In the following section, the value of residential property is analysed according to location as captured by space syntax analysis, building centred density, size, and age.

Correlation matrices and stepwise regression of spaces syntax spatial analysis

Integration is much stronger than Choice. Integration N (recipMD and 1/MD) is strongly and positively related to higher tax bands.

When property size, age, and building ambient density are added, space syntax spatial locational variables are slightly weakened but remain strong. So their effects on Council Tax Bands are to a considerable degree independent of residential property size, density and age factors.

	recipMD	TOmov2000m	TOmov500m	THRUmovCITYscale	THRUmov2000m	THRUmov500m
recipMD	1.000	.649	.341	.531	.486	.344
TOmov2000m	.649	1.000	.624	.473	.501	.466
TOmov500m	.341	.624	1.000	.433	.466	.668
THRUmovCITYscale	.531	.473	.433	1.000	.946	.818
THRUmov2000m	.486	.501	.466	.946	1.000	.888
THRUmov500m	.344	.466	.668	.818	.888	1.000

Table 5

Spatial variables correlation matrix

ANOVA Table
TaxNum vs. 4 Independents
Step: 4
Split By: LUandRU=1then1else0
Cell: 1.000

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	4	6816.283	1704.071	1502.444	<.0001
Residual	48345	54832.863	1.134		
Total	48349	61649.146			

Variables In Model
TaxNum vs. 4 Independents
Step: 4
Split By: LUandRU=1then1else0
Cell: 1.000

	Coefficient	Std. Error	Std. Coeff.	F-to-Remove
Intercept	3.287	.045	3.287	5435.459
TOmovCITYscale(1/MD)	13.795	.349	.208	1558.955
TOmov500m	-.010	2.083E-4	-.303	2340.856
THRUmovCITYscale	.064	.006	.103	134.403
THRUmov500m	-.060	.014	-.043	18.533

Variables In Model
TaxNum vs. 7 Independents
Step: 6
Split By: LUandRU=1then1else0
Cell: 1.000

	Coefficient	Std. Error	Std. Coeff.	F-to-Remove
Intercept	-.309	.092	-.309	11.404
TOmovCITYscale(1/MD)	6.322	.288	.093	482.297
TOmov500m	-.006	1.797E-4	-.185	1197.336
THRUmov500m	.036	.008	.025	22.546
log(area*storeys/REScount)	2.781	.031	.391	7837.393
sqrtBUF1grndres	-.540	.009	-.247	3532.312
Age	-.045	.004	-.040	100.197

Variables Not In Model
TaxNum vs. 7 Independents
Step: 6
Split By: LUandRU=1then1else0
Cell: 1.000

	Partial Cor.	F-to-Enter
THRUmovCITYscale	.007	2.345

Table 6

Single dwelling buildings MRA

The multi-regression analysis shows the influence of the following factors in order of their importance:

- Property size is by far the most important single factor in tax band
- Density is next – lower is higher tax
- low radius Integration is next – less means higher tax
- high radius Integration is next – more means higher tax
- Age is a positive, but relatively weak – older mean marginally higher tax
- low radius Choice level is weakly beneficial – more means higher tax
- low radius Choice level is immaterial

Variables In Model
TaxNum vs. 7 Independents
Step: 4
Split By: LUandRU=1then1else0
Cell: 0.000

	Coefficient	Std. Error	Std. Coeff.	F-to-Remove
Intercept	.631	.123	.631	26.335
TOmovCITYscale(1/MD)	6.082	.544	.096	124.931
TOmov500m	-.007	2.272E-4	-.256	889.731
log(area*storeys/REScount)	.759	.045	.146	282.585
sqrtBUF1grndres	.198	.011	.163	345.345

Variables Not In Model
TaxNum vs. 7 Independents
Step: 4
Split By: LUandRU=1then1else0
Cell: 0.000

	Partial Cor.	F-to-Enter
THRUmovCITYscale	-.015	3.364
THRUmov500m	-.014	2.919
Age	.034	16.837

Table 7
Multiple dwelling MRA

Conclusions

This paper examines the relationship between locational indexing of street layout with space syntax spatial analysis measures, non-residential land uses (mainly retail), property size, building centred density, and age and property value using Council Tax Band as a proxy for residential property value. It showed that Council Tax Bands are a good proxy of residential property sale prices. It uses two endogenous locational measures (angular segment Choice and Integration) which can be specified at different spatial scales (small to large metric radii) that index residential area and centre development spatial structure in an outer Borough of North London. These spatial indexes have been shown to account for the distribution of movement intensity patterns for various transportation modes (pedestrian, cycle, motorised - public and private, and overground and underground rail). As such, they are good at capturing the empirics of spatial accessibility. What then seems to emerge is a qualification of the classic urban land use theory (Alonso 1964 and Muth 1968) which has the ability to explain the urban centralisation of the poor and at the heart of the model is a compensating differential whereby housing and land prices decline with the distance from the central business district with an exogenous definition of centre. The classic model (AMM) argues that richer consumer want is to buy more land (larger property) and therefore the consumer chooses to live where land is cheap. There is a substitution effect between distance to centre and property size and an arbitrage with spatial accessibility via transportation mode and commute time. This is up to a threshold where the contribution of either the liveable area or plot size to house value is known to be decreasing.

In the sample used the lower value tax bands are associated with smaller properties, higher density, proximity to non-residential land use and a comparatively higher value by square meter. These attributes seem to be the spatial signatures of centres that combine high values for low and high radius integration/choice, and the co-location of most non-residential land use. High tax band can also be found in proximity to non-residential land use i.e. the centre. There are always high income people living close to the centre and walking. If some high income people away from the centre drive and some low income people take public transportation then, generally, there must be people living between the high income people that are driving and the high income people that are walking. From a land point of view, it suggests that in comparison to plot size away from the centre, the dwelling number to plot sizes ratio is higher near the centre and land is used more intensively and has consequently higher value; in relative terms both land value by square meter and dwelling value per square meter near centre are higher than away from the centre. Here we see a combined effect of built density substitution for land plot size and increased demand pressure for the amenity values of a centre. In London most of the centres are on the large scale movement network where the bus route and underground and train stations are predominantly located.

A last point to consider is location where residential property is absent.

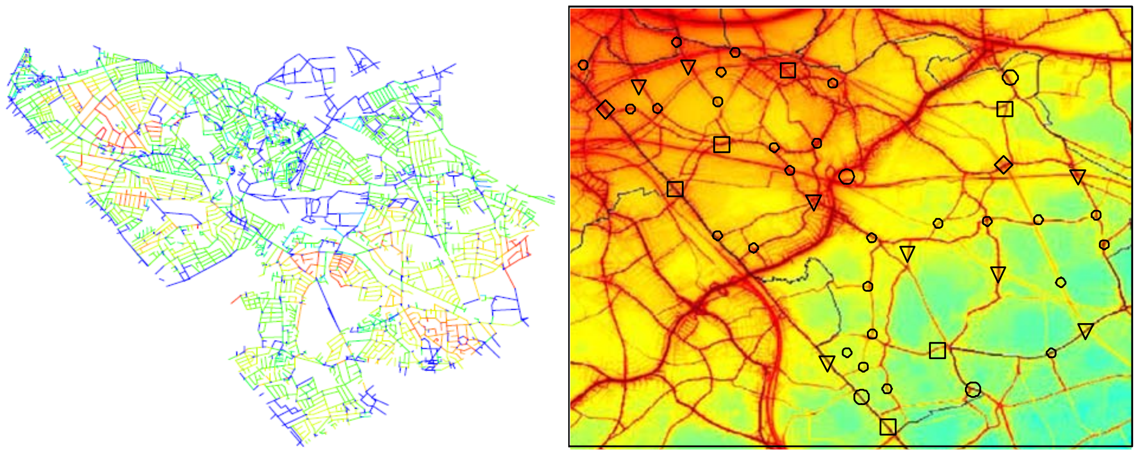

Figure 2
Spatial distributions of Council Tax Band, road and rail air pollution (annual mean NO2) and centres
Centre*: diamond – major centre; square – main district centre; triangle – other centre such as supermarket; circle – local centre).*
Council Tax Bands *- red for high, light blue for low council tax bands. Dark blue mean no residence. The linear dark blue corresponds to main and secondary arterials where centres are located; the spatial foreground. Dark blue areas also correspond to light industrial activity, and supermarket areas. The foreground network is where noise and pollution levels (right) are high (red) and related to traffic level.*

It is clear from the maps that residential property are absent from the foreground spatial network where air pollution is the highest. Since the first study that linked air pollution to property values (Ridker & Henning, 1967), further research has verified, modified, and redefined the economic interpretation of this relationship. In summarising 25 years of property value/air pollution literature (Smith & Huang 1993, 1995) reported that about 74% of the studies found at least one significant air pollution variable. Allowing for publication bias toward significant findings, there seems to be a preponderance of evidence that air pollution is negatively related to residential property prices. This is important because it reveals information about:

1/ willingness to pay for air quality – a non-market commodity. To the extent that spatial policy maker could use the results of air pollution / property values studies in formulating their air quality management plans, the findings are socially relevant.

2/ capital depreciation/appreciation over time due to air pollution – transport technology changes positive or adverse economic impacts. For this purpose we examine the Booth's Maps of London at the end of the XIX century (http://booth.lse.ac.uk) which are spatial description of social preferences and affordances, colouring each building to indicate the income and social class of its inhabitants. Comparing east and west London which were overall socially contrasted we find a common characteristic: arterials are coloured in red which indicate "middle class and well to do" inhabitants. These social preferences are a significant difference with the current situation. Further to air quality management plan and willingness to pay for air quality, transport policy maker could undertake a cost benefit analysis of replacing/decreasing air polluting motorised vehicle with clean air or no-impact on air quality motorised vehicle and mitigate these cost by an estimation of the resulting capital appreciation of the vast amount of affected building stock along arterials. This is both economically and socially relevant. Most of this building stock has high spatial accessibility.

Considering the findings of this paper, the existing space syntax literature on air pollution and motorised traffic, (Croxford 1996, 1998; Penn 1998), motorised traffic levels spatial distribution (Penn 1998a, Hillier 2005, Chiaradia 2007, 2007a) these results seem to be indicative of the potential use of the space syntax spatial analysis as framework tools in spatial econometrics as defined by Anselin (1988); i.e. tools for handling multi-scale spatial design dependence and heterogeneity. We can test for multi-scale spatial design dependence and heterogeneity and where appropriate use the information to improve the efficiency of spatial externalities estimators.

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