Space and Exclusion: The Relationship between physical segregation, economic marginalisation and poverty in the city.

Key words: Charles Booth, GIS, poverty data, urban morphology, street-scale, configuration.

Abstract

There has recently been a growing interest in the spatial causes of poverty, particularly in the processes involved in the formation of poverty areas within cities. Most research has concentrated on the social causes of poverty, crime and social malaise and there is a lack of fundamental research into the relationship between urban morphology and the spatialisation of poverty. This paper aims to address this deficiency.

This paper describes research conducted for an EPSRC project called "Space and Exclusion", which aims to investigate the relationship between physical segregation and economic marginalisation in the city, focusing on 19th century and contemporary London. By using a GIS system to layer historical spatial and poverty data along with contemporary deprivation indexes and space syntax measures of segregation, this paper presents findings on underlying spatial effects which influence the spatial distribution of poverty, investigates these effects on immigrants in particular, and maps the development of "poverty areas" over time.

The paper also describes the methods used to model the range of data sources, which included the data derived from the Charles Booth maps of London Poverty 1889 and 1899; using a variety of the latest advances in space syntax methods, such as segment analysis, which is a finer form analysis than the traditional axial map that analyses the line segment between junctions. This means that the axial analysis measures of Radius 3 integration, Radius n integration and so on can be supplemented with measures relating to the spatial integration of the street segment. Moreover, metric distance, least angle distance can be analysed, as well as – what was vital for the project discussed here – analysing the relationship between these spatial measures and social data that varies along a single axial line. The authors' findings relate to the socio-spatial structure of historical London, and pave the way for a comparative spatial model for examining the distribution of poverty in contemporary urban situations.

The paper demonstrates that individuals marginalized socially or economically follow distinctive patterns of settlement and that underlying these patterns were spatial conditions that may have influenced this distribution. For example, space syntax analysis suggests that Booth's London was not well integrated on a North-South axis, resulting in a split between East-West encounters, which was reflected in an East-West prosperity/poverty divide. It examines some of the more localised poverty areas and the effects that slum clearance had on the surrounding neighbourhoods of the London cityscape. Often, interruptions to the grid structure significantly influenced the spatial configuration of a poverty area, giving rise to conditions of spatial and social segregation. This paper concludes that the urban structure itself can influence the economic conditions for segregation. Poorer classes are often disadvantaged by being marginalized spatially, and the formation of poor areas is the outcome of a complex socio-spatial process, which can be further influenced by the impact of immigrants to an area.

1. Introduction

There has recently been a growing interest in the spatial causes of poverty, particularly in the processes involved in the formation of poverty areas within cities. Most research has concentrated on the social causes of poverty, crime and social malaise and there is a lack of fundamental research into the relationship between urban morphology and the spatialisation of poverty. This paper aims to address this deficiency and suggests that there is a distinctive and measurable pattern to the way in which poverty is distributed. The study of London's change over 10 years indicates that the creation of poverty areas is a spatial process. It shows that by looking at the distribution of poverty at the street, or even the street block level, it is possible to find a relationship between spatial segregation and poverty. Moreover, an understanding of localised patterns also assists in explaining why poverty areas emerge and continue over time.

This study stems from the work of Charles Booth's Descriptive Maps of London Poverty, which covered the extents of built-up London in 1889 and 1899 and presented the social conditions of the people of London according to seven classes. These were primarily economic, rather than social classes and it has been said that Booth's work was the first 'empirical sociology' (Pfautz, 1967, p. 127). For the purposes of space syntax research, Booth's most important contribution is the presentation of spatially accurate data at the level of the street block. Moreover, the existence of two maps set 10 years apart, showing data collected by the same methods, means that researchers have at their disposal an invaluable source of data showing spatial and social change over time.

This paper describes research conducted for a UK government funded (EPSRC) project called "Space and Exclusion", which aims to investigate the relationship between physical segregation and economic marginalisation in the city, focusing on 19th century and later on contemporary London. The project has used a Geographical Information System to layer historical spatial and poverty data at the street "block" level. Space syntax theory and techniques of line segment maps, extracted from the Booth maps themselves, are applied in order to research this relationship. This paper presents findings on the underlying spatial effects which influence the spatial distribution of poverty; and maps the development of "poverty areas" over time. The focus is on the East End of London, which has been an area of persistent poverty and of immigrant settlement for the past 200 years.

The first part of the paper reviews recent research into the spatialisation of poverty. It suggests that previous research has indicated the importance of spatial segregation in contributing to the creation and stagnation of slum areas. After this is a review of the spatial analysis, taking account of spatial and economic change over the 10 year period, including an influx of immigrant refugees into the East End. The paper ends with the conclusion that individuals marginalized socially or economically follow distinct patterns of settlement and that spatial configuration that influenced this distribution. It further suggests that the process of the transformation of cities is due to local spatial forces.

2. Background

Previous research (Vaughan 1994, 1999) has used Space Syntax methods to understand the spatial clustering of ethnic minorities into ethnic or immigrant quarters. Vaughan's research has shown that there is a relationship between the pattern of distribution of immigrant groups according to their length of time in the country, economic status, occupational activities and family structure and has also found a pattern in the organisation of immigrant communal institutions (Vaughan 2002; Vaughan & Penn 2001). Vaughan's analysis of the relationship between economic activity and spatial segregation has concluded that immigrants tend to congregate in poverty areas, suggesting that it is the location of the area itself which contributes to the poverty of its inhabitants.

Other research has also suggested persistent, distinctive patterns in the geography of poverty. For example, research into the patterns of mortality in London over the past 100 years has found that the city contains areas of persistence in poverty which cannot be explained other than by an "underlying spatial effect" (Orford et al. 2002). Studies such as this are important in that they provide a clear picture of which geographical areas contain inequality and where this is persisting. However, Orford et al's study does not investigate the underlying relationships between deprivation and spatial effects as does Vaughan's previous work and the current research presented here.

3. Methods

Charles Booth's work in gathering and recording statistics of poverty in late nineteenth century London can be considered to be the foundation for social scientific cartography research today (see figure 1). He laid out for the first time precise definitions of class and poverty status. Although his written work has been extensively studied by researchers [cf. (Englander & O'Day 1998)], Booth's published maps of 'descriptive poverty', showing vast coverage of block-by-block variation in poverty classes across central London and its environs have rarely been used in a geographical, spatial study such as this one.

Figure 1. Charles Booth's 1889 map. Source: London Topographical Society

There were in fact three maps of poverty. The first, published in 1889, covered only the East End of London and was the result of a house to house survey. Later editions in that same year, and then in 1899 were maps of social condition, incorporating a combination of factors to do with regularity of income, work status and industrial occupation. Booth defined a range of poverty 'classes' from A upwards and coloured maps in a range from Yellow (upper middle and upper classes), Red (middle class), through to Black (lowest class) (see Table 1). Since the study area did not contain the highest class residents (Yellow), the analysis considers only the remaining six classifications.

Table 1: Booth's classification of the 'General Condition of the Inhabitants'. Source: Pfautz, 1967, p. 53.	
Black	The lowest grade (corresponding to Class A), inhabited principally by occasional labourers, loafers, and semi-criminals - the elements of disorder.
Dark Blue	Very poor (corresponding to Class B), inhabited principally by casual labourers and other living from hand to mouth.
Light Blue	Standard poverty (corresponding to Classes C and D) inhabited principally by those whose earnings are small... whether they are so because of irregularity of work (C) or because of a low rate of pay (D).
Purple	Mixed with poverty (usually C and D with E and F, but including Class B in many cases).
Pink	Working class comfort. Corresponding to Class E and F, but containing also a large proportion of the lower middle class of small tradesman and Class G.) These people keep no servants.
Red	Well-to-do; inhabited by middle-class families who keep one or two servants.
Yellow	Wealthy; hardly found in East London and little found in South London; inhabited by families who keep three or more servants, and whose houses are rated at £100 or more.

The study utilised the two London-wide maps of 1889 and 1899. In order to use Booth's data across time periods, it was necessary to match the maps to modern British National Grid coordinates. The next stage was to translate the Booth map images into point data and tie the point data to the street segments to enable statistical analysis of social and spatial measures. Space syntax analysis started with drawing and processing an axial map of the extent of 19th century London. In order to focus on the East End of London, a smaller map was created by drawing a 2 km buffer around the study area, as standard practice dictates. The boundary for the study area is outlined in black in Figure 2. The late 19th century was a period of extensive slum clearances (see Yelling, 1986), so it was important to draw two separate axial maps of 1889 and 1899 for the East End area to take

account of spatial changes between the two periods studied. Eventually the historical Booth data will be compared with information from the most recent census (2001).

Figure 2: Radius-Radius (7) Axial map of London 1889 with the study area boundary outlined in black

Recent developments in space syntax research led to the creation of a segmented axial line model, or line segment map, which breaks the standard long axial lines into segments at each intersection. A GIS model of the East End was constructed to analyse the relationship between spatial measures and Booth's data along the given line segment. A detailed explanation of this process can be found on the project website at http://www.bartlett.ucl.ac.uk/research/space/space_and_exclusion-overview.htm.


Figure 3: Line segment map showing junctions, focusing on East End study area, with Booth 1889 in background.

4. Analysis

4.1. Distribution of class

The briefest glance at a Booth map (see Figure 1) makes it clear that there is a distinctive pattern to the way in which Booth's classes are distributed, and an experienced observer of urban form will note that the distribution seems to follow regularities according to the spatial structure of the area. Indeed, it is important to note, that although the East End was considered a poor area, Booth (1902), found that the poorest class only constituted 1.5% of all streets in the East End and Hackney, (op cit volume 1, p.34-36). The following set of histograms (Figure 4 below) shows the distribution of classes per street block (segment) within the study area. They show that the highest frequency of classification was streets coloured purple (defined by Booth as 'Mixed – Some comfortable, others poor'). There are slight variations in the distribution across the ten year span, which will be investigated further on in this paper, but in general it is evident that the distribution is a 'croissant', with the majority of street segments above the Light Blue (Poor) classification.
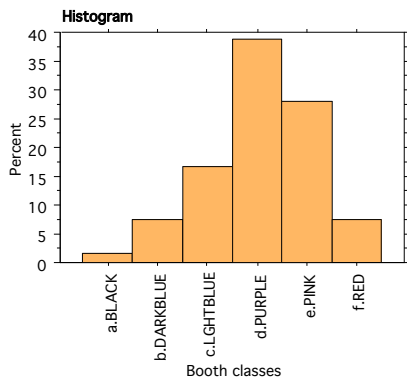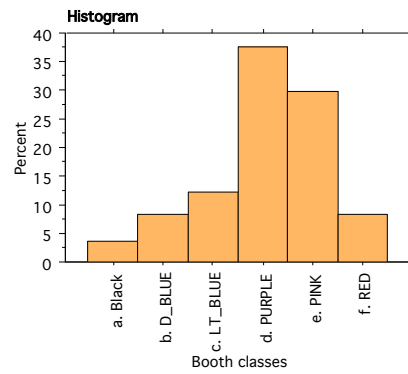
1889   1899

Figure 4: Frequency distribution of classes per street block for the 1889 and 1899 maps

It is evident that the East End was not a morass of poor streets but contained a variety of classes with a distinct pattern of distribution. Spatial analysis helps explain this. For example, in Figure 5, the integration values of the East End in 1889 are overlaid on the Booth map. It shows that the poorer classes were dispersed along spatially segregated streets. They tended toward isolation, although calculations of Entropy (as defined by Hillier et al 1987 and more recently Turner, 2001 as a measure of "how ordered the system is from a location") indicate an even dispersal throughout the sample area. That is, these classes were not confined to one quadrant of the sample area. Because of this dispersal pattern, some poor streets were surrounded by higher-class streets, while other poor streets were adjacent, set behind or perpendicular to them. This has been termed as 'marginal separation by linear integration' (Hillier & Penn, 1996).


Figure 5: Descriptive Map of London Poverty 1889, showing East End, overlaid with axial local integration

The higher class streets of the East End seem to form the skeletal structure of the system. Analysis of the local integration map for 1889 (figure 6) shows that these main streets of the area are well connected streets, which surround pockets of lower integration and lower class streets. However, it is also notable that these main streets are not well connected globally to main streets elsewhere in London, providing an explanation of how the East End had become known as a 'Poor Area'. It is also evident that there are pockets of spatially segregated poverty areas, formed by the interruption of the grid due to railway lines, large industrial buildings and the like. Booth himself highlighted the importance of physical boundaries in isolating 'poverty areas' and their inhabitants from the mainstream of urban life – as pointed out by Pfautz (1967), p. 113, quoting Booth: "Another dark spot of long-standing poverty and extremely low life... is wedged in between the Regent's Canal and the gas works".

Figure 6: Line segment map showing Radius 3 integration for East End study area.

A further analysis of a wide range of spatial values broken down by class led to the following cell charts (Figure 7), which shows the mean integration values for each of the maps, with each Booth class shown as a separate point. The repetition of the pattern across all the values shows robustness in the data and a consistency in the manner in which poverty conditions are distributed spatially, even as the size of the context being measured changes with each change of radius. In all cases there is a similar distribution for the top three classes of the study area (Red, Pink, Purple), which follow a consistent pattern with a rise in integration values following the rise in the Booth classification values.
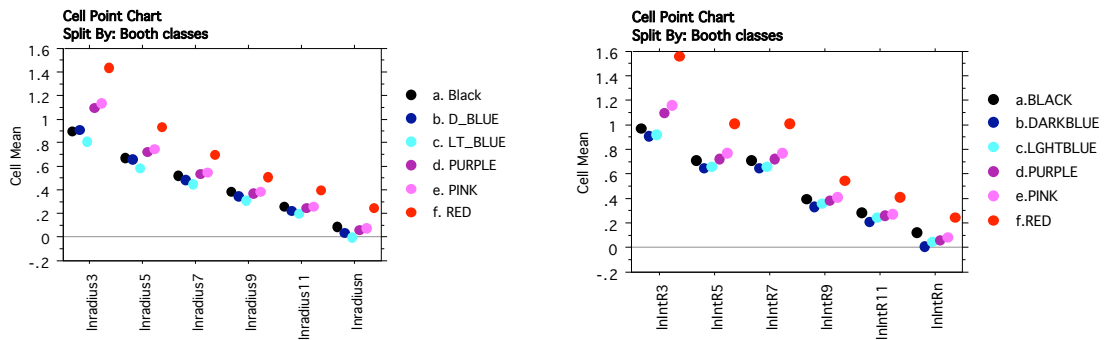
Figure 7: Mean line segment Radius 3/5/7/9/11/n, split by Booth Classes, East End 1889 and 1899

The bottom two classes (Black and Dark Blue) follow a different pattern, clustering at averages slightly higher than those of the class sitting just above them (Light Blue). The Booth map shown in Figure 1 above highlights this point also, indicating that in many cases the Black and Dark Blue classes of streets are only two steps removed from the main streets – so it is a step change rather than a spatial segregation change which is reflected here. This result is at first surprising, when the expectation would be that the lowest classes would be those most removed from the integrated structure of the district. However, bearing in mind they comprise the 'Lowest class' and the 'Very poor, casual, chronic want' population of the area, it is less surprising that this population, which is least likely to be functioning participants in the economic and social life of the city, would follow the

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regularities of the spatial structure. Indeed, there are places in Booth's writings where these two classes are lumped together, (e.g. Yelling, 1986, p. 51).

It is at the local scale (radius 3) that the greatest class differentiation takes place and this is particularly the case for the Red (Middle Class) streets. T-tests of mean spatial values for each class – in both maps - suggest a reason for this difference – the three lowest classes are significantly more segregated than average both for Radius 3 integration and for Radius n integration (p<.0001) .On the other hand, of the three higher classes, only 'Red' ('Middle Class') streets are both globally and locally more integrated than average (p<.0001).

Analysis of the frequency distribution of radius 3 for each Booth class, taking both maps indicated that the reason for 'Red' streets having higher than average local integration values relates to there being a significant proportion of 'Red' street segments amongst the most integrated streets locally (taking each map in turn, 36%/52% of Red street segments are in the top 3 bands of integration as opposed to only 10%/13% of 'Pink' streets in each of the 1889/1898 cases, respectively).

This difference can be explained by the spatial structure of poverty – and prosperity – in the East End area. 'Middle Class' streets are located in such a way as to benefit the type of economic activity they represent. Previous space syntax research has shown that streets with high integration values tend to contain the socially and economically lively activities of the city (Hillier, 1996); that is not to say that the middle classes preferred to live on busy, noisy streets, but that their occupations – which in this area were predominately in trade and skilled crafts meant they were inclined to live on the main streets of the area[1]. Bearing in mind existing knowledge on how cities work (Hillier, 1998), these findings also imply that there was a mix of local people and people moving through the area on these main streets, making them a beneficial location for the shops to catch passing trade.

Another indicative result from this analysis is that measures of standard deviation for the mean values (Figure 8) show that within the bottom 3 classes (Black, Dark Blue and Light Blue), the range of spatial values is very similar. This is particularly the case for radius 3 (local) integration, which seems to have the highest amount of differentiation between classes. In fact, it seems as if there is a 'Poverty Line' dividing the poor from the prosperous (Gillie, 1996), lying between Light Blue and Purple streets. Considering that Purple streets are defined as a mixture of poor and more prosperous people, it seems evident that these streets are operating as a point of class transition. In other words, people living in Purple streets that are moving up the economic ladder, are in a better position to take advantage of their improved spatial location.
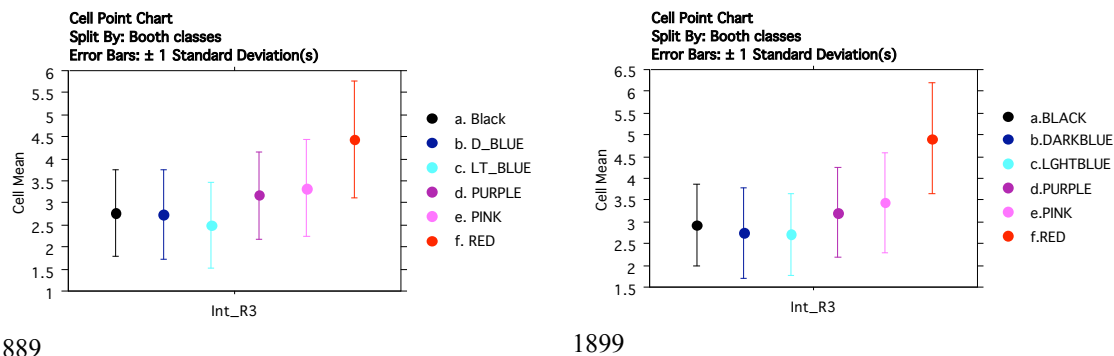

1889   1899

Figure 8: Mean line segment Radius 3 integration values, split by Booth Classes, East End 1889 and 1899

4.2.   Angular analysis

In order to study the relationship between the spatial distribution of street blocks and their Booth classification, the authors created a table which compared the spatial configuration of each block in turn to its neighbour, as well as the angle of incidence[2] between street blocks. Analysis of the frequency distribution of adjacent segments showed a tendency for segments to connect to other segments of the same colour; which is not surprising bearing in mind that most segments comprise axial lines containing several segments of the same Booth classification. Purple segments connected at a rate of 75% to other Purple segments, which is unsurprising, since Purple segments constitute the largest classification group (40%). However whilst Black,

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[1] See Watson, 1914.
[2] This is a measure of the angles between two street blocks, ranging from alignments in a straight line, to angles of 45 , 90 , 135 , up to a fraction below 180 .

Dark Blue and Light Blue segments had a 50% rate, Pink and Red segments had much higher rates (75%), suggesting they tended to be on longer streets.

In order to disregard blocks forming part of a single street, only segments with junctions at angles between 45 and 135 were included in a repeat of the above experiment. Analysis of the maps showed that whilst around 51% of 'Middle-class' streets were connected to others of the same classification, an additional 33% were connected to segments one or two classes below. In a similar fashion, Black street segments were analysed to see their neighbours at junctions of 45 -135 . The results showed that Black streets bonded extensively both with other Black streets (36%), as well as Dark Blue streets (15%).

4.3.   Analysis of change over time

The 10 years between Charles Booth's two 'Descriptive Maps', were a period of great upheaval, particularly in the study area. This was due to a significant influx of (mainly Jewish) refugees from Eastern Europe, who arrived at the East End docks and rapidly found their way to the eastern edge of the East End, where an existing Jewish community and a burgeoning tailoring industry provided the necessary social and economic support required by this refugee group. Historical evidence suggests that the outcome of this influx was rental inflation, due to the willingness of the immigrants to live in extremely overcrowded conditions (Booth, 1902, Vol. IV, p. 59.)[3] The increase in rents also led to the displacement of some of the existing impoverished inhabitants of the area, who moved down river (eastwards) to seek cheaper accommodation, as Newman (1980) shows. Not only was there significant social change at this time, but a large amount of slum clearance was taking place during this period, as described by Yelling (1986) and Gaskell (1990).

For the purpose of this analysis, three areas were chosen within the East End that had undergone significant spatial change, such as buildings/streets demolished and replaced with new street alignments, (see Figure 9).
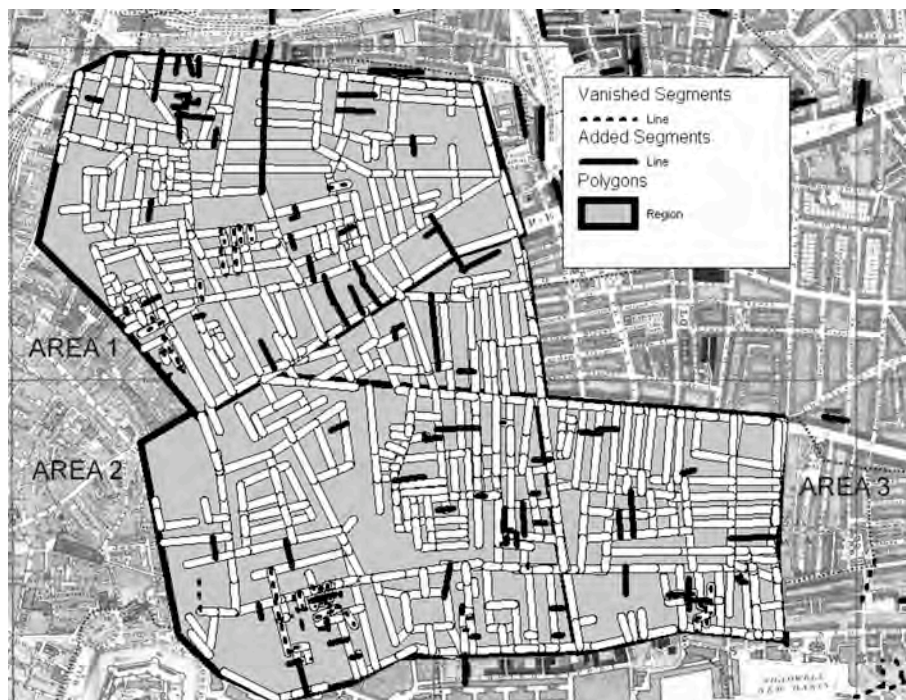

Figure 9: Spatial changes to streets within Areas 1-3 over 10 year period of Booth's 1889 and 1899 maps

In the case of Area 1, at the western edge of the East End, there evidently were some significant changes in the ten year period. For example, Table 2 below indicates that despite the total number of blocks remaining similar, there was a sharp increase in the number of Light Blue blocks alongside a sharp decrease in Purple and Red street blocks. Since the change in the number of Red blocks is primarily the result of a reclassification of Commercial Street from Red to Pink, the change in Purple blocks is the most striking.

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[3] See Russell and Lewis (1900), Newman (1980) and Vaughan (1994) for more on the history of Jewish settlement in the East End. The spatial form of the map was analysed in detail in Vaughan, 1994.

The table also shows calculations of Local Mean Depth[4] - showing that there was an increase in angular depth for Black streets alongside a decrease for all other classes during the 10 year period.

Table 2: Area 1 analysis of change over time

Area 1 blocks (segments) by class	1889 segment numbers	1898 segment numbers	segment number difference	Local Mean Depth 1889	Local Mean Depth 1899	Local Mean Depth difference
Black	35	39	4	.893	1.006	.113
Dark Blue	18	24	6	1.158	1.052	-.106
Light Blue	41	102	61	1.016	1.002	-.014
Purple	300	261	-39	.940	.934	-.006
Pink	134	172	38	.968	.948	-.020
Red	176	111	-65	.887	.843	-.044
Total	704	709	5	.940	.941	.001

Area 1 is the area which Russell and Lewis (1900) show as being the most intensively settled by immigrants, with many streets containing up to 100% Jews. Previous research (Vaughan 1994) has indicated that it is the streets with the poorest Booth classification which contained the largest number of immigrants and it may be concluded that the additional 10 Black and Dark Blue streets, despite the significant amount of slum clearance which took place in the area, is reflecting the fact that improvements to the spatial organisation of the area did not have an impact on the lowest classes – and new immigrants.

The reduction in the number of street blocks classified as Purple seems to tally with the increase in the number of blocks classified as Light Blue and this reflects a more general process of intensification of poverty in this particular district.

A similar area in size and immigrant status was chosen, Area 2 (see Figure 10). The economic transformation in this case was much more dramatic. Around 100 Black and Dark Blue street blocks disappeared during the 10 year period. Statistical analysis of the spatial change (and a variety of measures, including axial radius 3) did not show significant improvements in the spatial connectivity of the area. However, the results for Local Mean Depth show that as the number of Black and Dark Blue blocks decreased, their depth decreased too. At the top end of the scale, the change in economic situation was negligible. Yet, the spatial shift is much more apparent if the segments of streets coloured by Booth classification is studied, (see Figure 10). It is apparent that the disappearance of a large number of the poorest classes happened in parallel to an increase in these classifications further down river. See Area 3 analysis below for example.

Figure 10: Booth classification for Area 2, comparing 1889 with 1899 maps

Table 3: Area 2 analysis of change over time

Area 2 blocks (segments) by class	1889 segment numbers	1898 segment numbers	segment number difference	Local Mean Depth 1889	Local Mean Depth 1899	Local Mean Depth difference
Black	31	4	-27	5.355	5.182	-.173
Dark Blue	90	15	-75	5.335	4.979	-.356
Light Blue	22	125	103	5.193	5.277	.084
Purple	328	337	9	4.905	5.004	.099

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[4] Mean Depth is derived from the measure of Total Depth, which measures the total amount of angular depth from the root segment to all other segments (e.g. two right turns at 90 degrees each would be a total depth of 2 (a 90 degree turn is = to 1, therefore 2 x1 = 2)] divided by the number of spaces visited.

Pink	96	81	-15	4.943	4.759	-.184
Red	34	32	-2	3.748	3.463	-.285
Total	601	594	-7	4.944	4.945	.001

In order to take account of the impact of immigration on the change over time, a comparative area was chosen which did not include a large influx of immigrants at this time. This was the area at the eastern edge of the study area.

Table 4: Area 3 analysis of change over time

Area 3 blocks (segments) by class	1889 segment numbers	1898 segment numbers	segment number difference	Local Mean Depth 1889	Local Mean Depth 1899	Local Mean Depth difference
Black	29	4	-25	1.157	1.324	.167
Dark Blue	23	29	6	1.077	1.012	-.065
Light Blue	47	89	42	1.051	.993	-.058
Purple	239	207	-32	.912	.894	-.018
Pink	58	117	59	.935	.896	-.039
Red	30	43	13	.837	.812	-.025
Total	426	489	63	.951	.916	-.035

Analysis of the three areas together indicates that the slum clearances on the western edge of the East End had the effect of improving the economic situation of that area – but that this was an improvement which the incomers were in a better position to take advantage of. The effect in an area like this one was that displacement of populations upriver took place like a ripple effect, so as to shift the worse off either to streets of lesser spatial integration or to new back streets, which were also not as well connected to the spatial and economic structure of the neighbourhood.

5. Conclusions

The analysis so far has revealed the following:
The East End of London, which has for a long time been highlighted as an area of persistent poverty, contained a wide range of economic situations, with a significant number of streets containing the poorest classes, but also a significant number of streets with a much better situation. The analysis has also shown that the distribution of this wide variation of classifications is strongly related to the spatial form of the area, as well as to the manner in which the East End is connected to London overall. The East End was shown to suffer from a London-wide division between East and West (as well as the segmentation of the city by the river Thames.

Internally, the analysis showed that the Middle Class streets could utilise their location to support their economic activity. They were acting as the skeletal structure of the area, forming avenues of connection to the interstices of the East End. In parallel to this, there were localised clusters of very poor streets cut off from the life of the city, whilst Purple streets – shown by the analysis to be points of class transition, were in a position to take advantage of spatial changes in the street network.

Analysis of the poorest three classes had some of the most interesting results, with the highest of the three (Light Blue) being the most segregated, whilst the Black and Dark Blue streets were split into two types: deeply segregated, or adjacent to more integrated (Red) streets. Analysis of entropy indicated that the poorest streets formed localised clusters throughout the study area.

Analysis of change over the ten year period indicated that there was a circular influence between social and spatial change. It showed that the slum clearance had an effect of improving the social situation of the immediate surroundings, but this masked the fact that the poorest people contained within these areas had to find cheaper accommodation deeper within or outside of the district. Another more subtle impact was shown to take place, with the areas surrounding the slum clearances having a marked drop in economic situation – the beginning of a ripple effect as an outcome of spatial change and an indication that the improvement of spatial organisation may not have had a profound impact on the lower classes. Indeed, White (2003) describes how many of the poorest indigenous inhabitants of the area moved out, or were displaced to the adjacent streets of the area at this time, only to be replaced by the incoming immigrants. At the start of this project it was hypothesised that due to their classification as a mixture of populations, Purple streets were going to be more prone to volatile changes over time. Bearing in mind the influx of poor immigrants to the area at the time, it is likely that a more complex process took place, with an improvement in accessibility counterbalanced by a reduction in economic condition.

This paper has outlined how advances in space syntax methodology have benefited this project by enabling it to analyse street-level data at a spatial scale which relates to people's every day experience of urban life. In addition, this paper has reported on the first findings of analysis of change over time, something which will be developed during the remaining duration of this project and hopefully will be reported on in future papers.

Acknowledgements

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