Urban Dynamics Following the London Blitz – Multiple Equilibria or Slow Adjustment

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A number of recent studies have examined the impact of large exogenous shocks on urban dynamics (Davies and Weinstein 2002, 2008; Bosker *et al* 2007; Nitsch 2003; Meen and Nygaard *forthcoming*). The primary test in these papers is the extent to which city growth exhibits path dependence generated by locational or increasing returns to factors, or follows a random walk. These studies exhibit evidence of mean reversion, but at varying speeds of adjustment. For modern policy makers concerned with economic restructuring and housing provision in the 21st century this poses a challenge.

Policies such as 'mixed communities' in the UK and regeneration policies in general subsume that positive externalities exists that can be capitalized and (re)distributed in a manner consistent with social and political objectives. However, the new economic geography stresses that increasing returns and externalities may constitute drivers of economic differentiation and segregation (Krugman 1991a; Zeng 2008); and that expectations play an instrumental role in the adjustment dynamics (Krugman 1991b). The degree to which external economies constitute a force determining the spatial structure is related to the strength of external economies and the speed by which external economies may be capitalised (Krugman 1991b). Krugman (1991b) argues that where the speed of adjustment is sufficiently slow history (e.g. path dependency) is likely to dominate expectations.

This paper analyses adjustments in the built environment of London following widespread devastation during WW2. The adjustment process is found to be protracted and an absence of complete mean reversion may imply the existence of multiple equilibria – though none are found using the conventional approach in the literature. Compared to the current rate of housing stock removal/renewal the Blitz' stock intervention was tremendous. The slow speed of adjustment following this intervention suggests an important role for path dependency in explaining the challenge confronting policy makers in the 21st century.

The issue

Labour's neighbourhood renewal strategy aims that no one shall be seriously disadvantaged by where they live within the second decade of the 2000s. The neighbourhood renewal strategy is only one of several strategies by successive governments to tackle the spatial persistence of urban deprivation and inequality. Substantial amounts of public funds are invested in area regeneration and government has been concerned with identifying and understanding the anatomy of spatial deprivation. Overall, government policy has increasingly come to recognise that housing markets play an important role in meeting key public policy aims relating to health, social mobility and economic performance and competitiveness (DCLG 2007). In this sense housing is recognised as helping to 'create better communities that can attract investment and skilled workers' (DCLG 2007:6). Exactly how this process works, however, is less well understood and government housing and urban policy in the past has often been formulated on a thin theoretical base (Meen and Meen 2003). What is clear, is that over the past century patterns of inequality have persisted and that the economic trajectories of many (though not all) local areas exhibit strong persistence in relative inequality and deprivation (Orford *et al* 2002).

The *State of English Cities* report recognises that 'cities are complex, self-organising market driven systems of economic, social, technological and social relationships' and that the unique history of each cities may generate 'path dependence in the patterns of size, function, and specialization' (ODPM 2006:66). Modern work on social relationships pays particular attention to peer group influences since they can generate tipping and non-linearities. For instance, human capital investment, localised peer group effects and parents' choice of neighbourhood can lead to spatial stratification and persistent real wage differentials (Benabou 1993; Durlauf 1996). The new economic geography, on the other hand, focuses on increasing return as a driver of spatial differentiation and a source of segregation (Krugman 1991b; Fujita *et al* 1999; Zeng 2008), where increasing returns/external economies determined by initial conditions, agglomeration economies, or first-mover/clustering effects and credible commitments (Ottavino 2003), may produce spatial and structural lock-in. Importantly, expectations play an instrumental role in market based adjustment and the speed with which perceived benefits can be capitalised determines the importance of initial conditions (history and geography) and future potential (policy intervention) (Krugman 1991b).

Housing provision and household relocation in the UK is predominantly market driven. This means that in order to achieve important public policy aims, such as mixed communities and reduction in spatial inequality, it is necessary to understand not just the adjustment mechanism (public intervention, household or firm relocation) that generate neighbourhood change, but also the parameters of change – that is the speed by which externalities can be captured and capitalised. Understanding the latter is important for the inclusion of market driven (individual relocation) elements of urban regeneration. This article examines the speed of adjustment in the urban system of London following WW2 devastation. If housing markets adjust quickly then public policy options and costs are different from an environment where housing markets adjust slowly. Where housing markets adjust slowly the impact of peer group effects and/or area stigmas might be expected to remain more persistent than in housing markets and urban systems that adjust quickly. Similarly, where housing markets adjust quickly large scale public or private physical regeneration initiatives may be expected to have different outcomes from where housing markets adjust slowly.

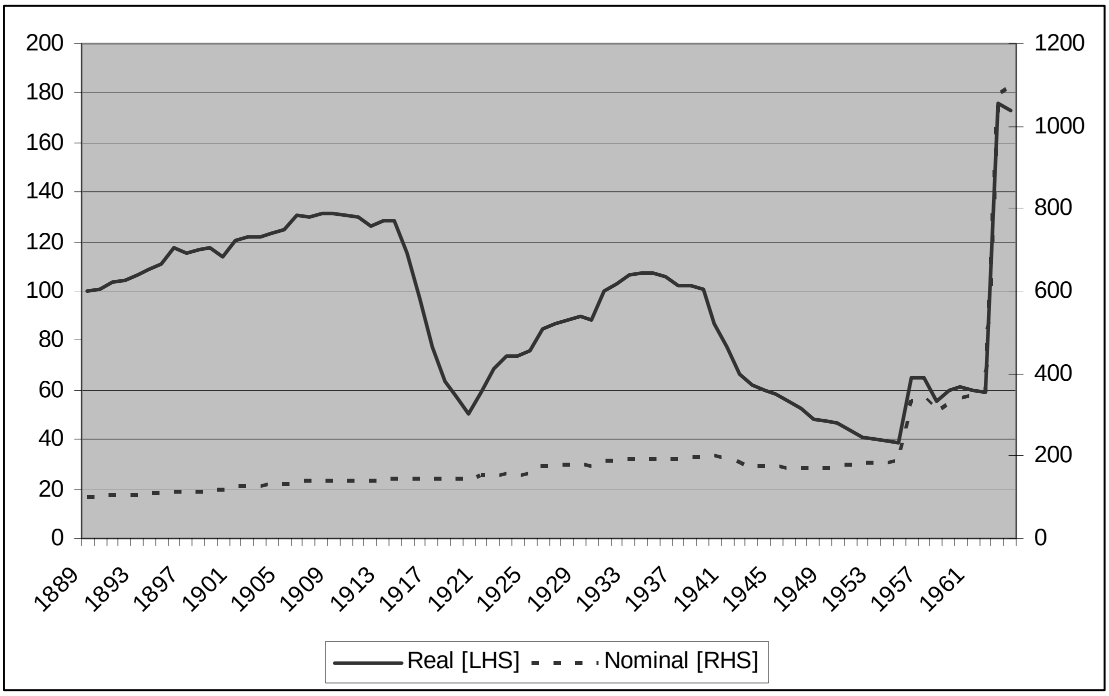
Data Description

The main data in this article is sourced from the London County Council's (LCC) annual statistical compilation – 'London Statistics'. The London Statistics summarises annual financial data of the LCC that form the basis of local authority taxation and spending capacities. Properties were assessed annually with revaluations conducted quinquennially prior to World War 2 (WW2). Following WW2 and prior to the local authority reorganisation in 1965 two partial re-valuations took place in 1956 and 1963. Each of the partial revaluations encompassed a distinct part of the stock, so that by the end of 1963 the entire stock was re-valued. Prior to 1901 data was collected on a parish basis. This data has been concorded to correspond with the London Borough boundaries in operation from 1889 to 1964.

Assessments were made on the basis of the rateability of a property; a measure divided into a gross component and a rateable value component. The gross value was defined as the annual rent a tenant might reasonably be expected to pay if the tenant was responsible for other tenant rates and taxes and the landlord undertook maintenance costs (LCC 1938). The rateable value was the gross value less probable annual maintenance costs, insurance and other expenses. Following de-rating of industrial and freight-transport hereditaments, the London Statistics collects the net rateable value (corresponding to the rateable value for residential property and de-rated rateable value for industry and freight-transport). Until 1931 the gross rateable value was 'conclusive evidence of the annual value for Income Tax (Schedule A) […] in most cases subject to a deduction for repairs to arrive at the net annual value' (LCC 1938:467), which formed the basis for income taxation.

Figure 1 below shows the total nominal and real rateable value for the London Administrative Area from 1889 to 1964 expressed as an index (1889=100). Real values have been constructed on the basis of O'Donoghue *et al* (2004). The nominal data series (stipulated line) exhibits a largely monotonic increase from 1889 to 1955, before a dramatic increase in the late 1950s and 1960s. The real data series (solid line) conforms to broad brush descriptions of Britain's economic fortunes from the end of the 19th century until the 1960s (Matthews *et al* 1982). The tail end of the Victorian 'long-swing' ending with the outbreak of war in 1914; rapid decline during the first war as capital accumulation slowed; an increase again with larger scale local authority building and falling interest rates (Matthews *et* al 1982:413) in the mid 1920s; a new war time shock before a period of rapid growth in the late 1950s and early 1960s. The relaxation of building controls in 1954 started a period of rapid redevelopment and a corresponding property boom, before controls in the Greater London Area were reintroduced in 1964 (Mort 2004). By the end of the period the real rateable value of the aggregate capital stock has increased by some 80 per cent.

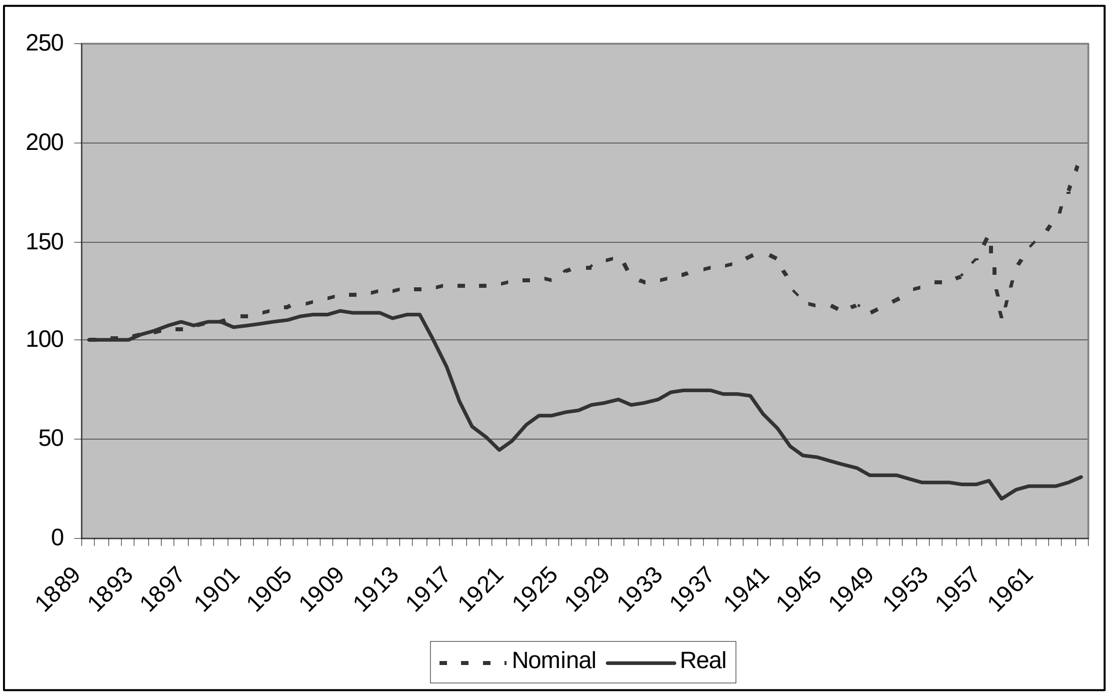
Figure 1 – Nominal and real rateable value index, London Administrative County 1889-1964



Source: London Statistics 1891-1964.
Note: Due to gaps in the publication of the London Statistics series figures for 1905, 1962 and 1963 are based on an extrapolation of trends. Values for 1916-1919, 1922 and 1924 are calculated from the debt and equalisation fund operations. Author's calculation.

Prior to 1914 virtually all house building was in the private sector. Policy reasons made local authority building important in the 1920s, while private incentives to build were severely restricted by the introduction of rent controls. Following WW2 the emphasis of building varied with different governments and policies (Matthews *et al* 1982). Figure 2 (below) shows rateable value of the building stock net of any capital gains between revaluations. The rateable values in the London Statistics series can be decomposed into quinquennial revaluation component (an approximation of capital gains) and a 'new build' component that comprises refurbishments and new construction. Until 1938 each volume of the London Statistics contains a time series summary of rateable values, new property increases and quinquennial revaluation gains. The decomposition technique is derived from these time series summaries and subsequently applied to our extended time series and for individual London boroughs.

Figure 2 – Nominal and real rateable value index (stock), London Administrative County 1889-1964

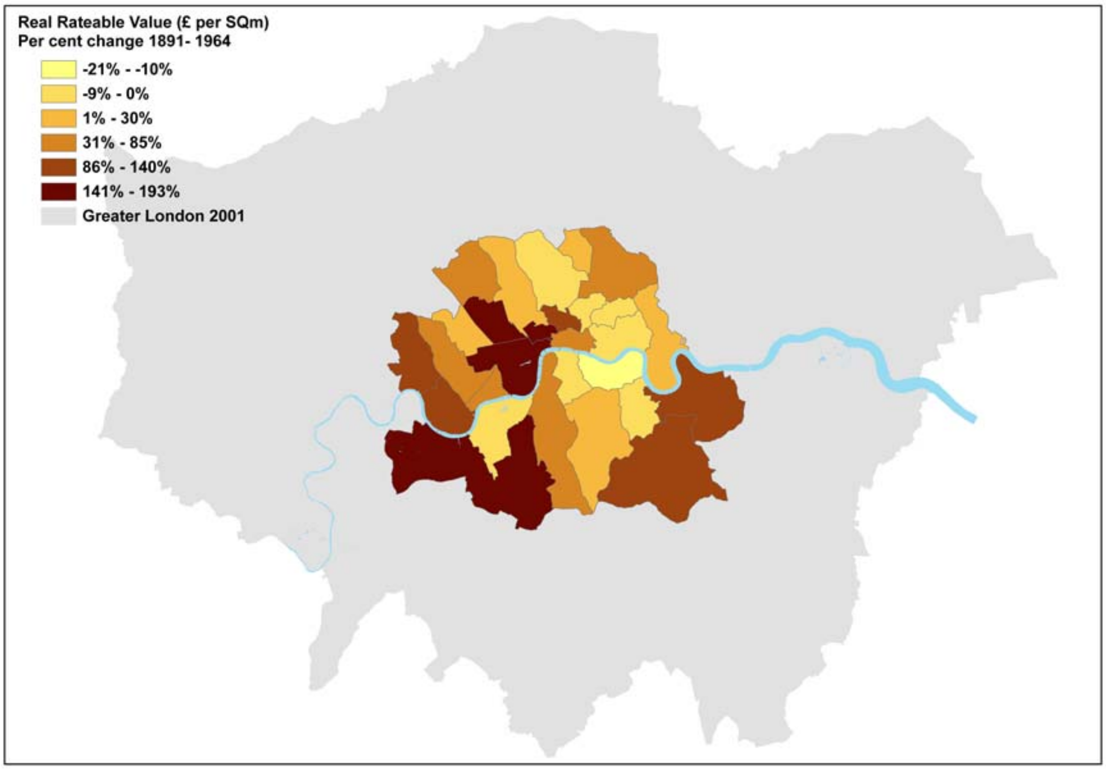


Source: London Statistics, various years 1891-1964.
Note: Due to gaps in the publication of the London Statistics series figures for 1905, 1962 and 1963 are based on an extrapolation of trends. Values for 1916-1919, 1922 and 1924 are calculated from the debt and equalisation fund operations. Author's calculation.

Adjusting the capital stock for capital gains gives a different picture of the London economy over the period. Unlike the total rateable value the capital gains adjusted capital stock series declined by two thirds over the period. Until the outbreak of WW2 the broad trends still follow the overall broad trends for the economy. However, gains in the inter war period are more muted. Importantly, the capital gains adjusted capital stock does not increase significantly in the 1950s and 1960s highlighting very significant capital appreciation during the 1954-64 property boom, but also the impact of inflation in the post war period. According to Matthews *et al* (1982:ft30:665) inflation rendered Schedule A taxation unrealistically low.

In the subsequent analysis we use the real rateable value and 'capital gains' real adjusted rateable value series on a London borough basis as indicators of local economic growth and local construction/reconstruction activity. In Figure 3 shows the overall change over the period 1891-1964 in real rateable value per square meter.

Figure 3 –London Administrative County change in real rateable value per square meter 1891-1964



Source: London Statistics, various years 1891-1964.
Note: Author's calculations

On the structure of change

A number of recent studies have examined the impact of large exogenous shocks to the distribution of economic activity and population intra-cities (Davis and Weinstein 2002, Davis and Weinstein 2008, Bosker *et al*. 2007). The object of these studies is to examine the extent to which city growth (relative size) follows a random-walk trajectory or experience mean-reversion. A random walk trajectory would imply that positive and negative shocks might permanently alter the trajectory of cities; alternatively mean reversion would imply significant path-dependency and highlight the role of geography (strategic location) and history (sunk investments/housing).

In a London context, *if* cities follow a random walk growth process then shocks like the London Blitz should have permanent effects on economic activity within London. Path dependence in Davis and Weinstein's and Bosker *et al's* works is measured by the degree to which growth patterns of concentration (population or industry) reverts to a pre-shock structure or not. We replicate this test for London using rateable values for London's fixed capital or property stock.

In this section we follow Davies and Weinstein (2002) and test for the existence of mean reversion, a single equilibrium, following the Blitz; subsequent sections examine the existence of multiple equilibria. The methodological premise for Davies and Weinstein (2002) is based in (1) where *s* is the log share of real rateable value of London borough *b* in 1945, *A* represents permanent locational factors that might determine real rateable value and ε_{45} is a borough specific disturbance term.

$$s_{b45} = \mathrm{A}_b + \varepsilon_{b45} \tag{1}$$

The disturbance term (2) in 1945 reflects both the impact of the exogenous war time shock υ_{b45} and the persistence of previous shocks adjustments ($\varepsilon_{b,t-1}$). Figure 1 shows a significant decline in real rateable values during the World War 1 as well; the parameter ρ is a measure of shock persistence. The disturbance term υ_{b45} is assumed to be independently and identically distributed (i.i.d)

$$\varepsilon_{b45} = \rho\varepsilon_{b,t-1} + \upsilon_{b45},\ 0 \le \rho \le 1 \tag{2}$$

If ρ is 0, then previous shocks have fully dissipated, if ρ is 1 then all shocks are permanent and the rateable value of borough *b* follows a random walk. The evolution of borough *b* from 1945 to 1964 is given by the first difference of (1) which yields (3)

$$s_{b64} - s_{b45} = \varepsilon_{b64} - \varepsilon_{b45} \tag{3}$$

The impact of the war time shock by 1964 is given by substituting (2) into (3)

$$s_{b64} - s_{b45} = (\rho - 1)\upsilon_{b45} + \left[\upsilon_{b64} + \rho(1-\rho)\varepsilon_{b,t-1}\right] \tag{4}$$

Equation (4) says that the rate of growth is a function of the war time shock plus the stochastic disturbance 1964 term and persistence of previous shocks. The term in square brackets is the error term and is uncorrelated with the wartime shock (Davis and Weinstein 2008). The change in real rateable value between 1939 and 1945 gives us a measure of the wartime shock, however, from (2) and (3) the error in 1945 contains elements of borough development until the outbreak of war as well, and thus Davies and Weinstein suggest that the wartime shock must be instrumented in order to eliminate possible measurement error. To see this consider the relative change in real rateable values during the war as given by (5) which says that change the relative share of borough *b* during the war is a function of the wartime shock plus lingering previous shocks. However, (5) also illustrates the case where city growth follows a random walk, if ρ is 1 then growth in any period is simply the full absorption of any shock. If ρ is not equal to 1 then the term in square brackets represent measurement error – e.g. the error terms are not independent of each other and the wartime shock must be instrumented. Moreover, under assumptions of a single equilibrium ρ is expected to be zero and thus the instrumented wartime shock should be minus unity (Davis and Weinstein 2008).

$$s_{b45} - s_{b39} = \upsilon_{b45} + \left[(\rho - 1))\upsilon_{b,t-1} + \rho(1-\rho)\varepsilon_{b,t-2}\right] \tag{5}$$

Davies and Weinberg (2002) suggest two methods for obtaining an estimate of ρ. Firstly, to test for a unit root, though dismiss this due to the low power of unit root tests in distinguishing $\rho < 1$ from $\rho = 1$ when the shock is unobservable. Secondly, estimates of ρ can be obtained from regressing the instrumented shock on relative real rateable share change between two periods (4). (6) is the OLS specification including I, the instrumented wartime shock. Under (6) $\alpha = \rho - 1$, hence if $\alpha = 0$ borough relative share follows a random walk ($\rho = 1$); alternatively for $-1 \leq \alpha < 0$ the random walk hypothesis can be rejected in favour of some form of mean reversion or path dependency. Equation (6) is the estimation basis in Davies and Weinberg (2002).

$$s_{b64} - s_{b46} = \alpha\left[I\left(s_{b45} - s_{b39}\right)\right] + \varepsilon_{b64} \quad (6)$$

Using the rateable value data we can identify the direct factor of variation – e.g. the London Blitz. Moreover, since the bombing impact is uncorrelated with the error terms in the square brackets in (4) we can get an unbiased estimate of ρ. By instrumenting the distribution change in rateable value in the war period as a function of the severity of the Blitz, we obtain an unbiased measure of change in rateable value distribution during the war time period. In terms of (4) this implies that v_{it} is uncorrelated with the error term in the square bracket. Moreover, under an assumption of a single equilibrium ρ is expected to be zero and thus the instrumented wartime shock should be minus unity (Davis and Weinstein 2008).

The result of the instrumenting exercise is show in Table 1. There are three potential instruments – bombing damage to housing during the Blitz, V-1 (*Vergeltungswaffe*) and V-2 attacks in 1944 and population change during the Blitz; expressed as per cent of 1939 housing stock in borough *i* damaged by the Blitz, the number of V1 and V2 rockets per 1000 inhabitants in 1944 and the per cent change in population between 1939 and 1941. There is a high degree of correlation between the bomb damage and population change/V1 and V2 rockets attacks - .64 and .46, respectively, but no correlation between V-1/V-2 rocket attacks and population change between 1939 and 1945 (.09). Given that population change cannot be determined independent of the change in rateable value concentration our preferred instrumentation equation contains bomb damage alone. The final column of Table 1 shows the instrumentation results for the change in the property addition series (e.g. excluding re-valuations) alone.

Table 1 Instrumental variable regression

	$\Delta(rv_{1939} - rv_{1945})$		$\Delta(rv_{1939}^{prop} - rv_{1945}^{prop})$
_cons	.0552*** (.0067)	.0191*** (.0030)	.0315*** (.0068)
Bomb damage		-.0015*** (.0002)	-.0032*** (.0005)
Population change	.0011*** (.0001)		
V1 and V2 attacks	-.0012*** (.0003)		
N	29	29	29
Adj. R^2	.7137	.6060	.5643
Root MSE	.00708	.0083	.0187

Note: Dependent variable is the change in rateable value distribution between 1938 and 1945; */**/*** signifies statistical significance at the .05/.01/.001 level; standard errors in brackets.
Source: London Statistics (various years).

Table 1 shows that a one percentage point change in bomb damage caused a decline in the annual rateable value share growth of .15 and .32 per cent, respectively, between 1939 and 1945.

In order to estimate ρ we regress the instrumented rateable value share growth between 1939 and 1945 on the rateable value share growth between 1945 and 1964, where the coefficient on war time growth corresponds to (ρ-1). A regression coefficient of the instrumented war time growth of minus unity corresponds to ρ=0 or complete mean reversion. The estimation results for the total rateable value and the revaluation adjusted rateable value series alone are set out in Table 2. In order to control for strategic bombing during the war we also include pre-war growth.

That is, if war-time bombing was targeted at, or around, industrial sites it is likely that bombing in fact was targeted at areas that had experienced rapid suburbanisation and industrial activity before the war (herein also lies an additional weakness in the V1 and V2 instrument in that these were range constrained), thus the estimates of ρ may be biased without the inclusion of pre-war growth rates. Moreover, we include this variable both in a linear and non-linear function. The latter controls for the fact that the decline in industrial activity in London set in prior to World War 2 and some areas my therefore have overshot their long-term rateable value trend or exhibited short-term above average growth rates (as would likely be in Greenfield or fringe developments).

Table 2 Instrumental variable regression

	$\Delta rv_{1945} - rv_{1964}$			$\Delta rv_{1945}^{prop} - rv_{1964}^{prop}$		
_cons	-.0024 (.0018)	-.0019 (.0019)	.0009 (.0025)	-.00339 (.0029)	-.0038 (.0030)	-.0025 (.0043)
Rateable value growth 1938-1945 (I)	-.4254* (.1745)	-.4993* (.1916)	-.4130* (.1751)	-.3200* (.1341)	-.2698 (.1593)	-.2350 (.1649)
Rateable value growth 1891-1938		.2713 (.2878)	1.436** (.5180)		-.2169 (.3605)	.3391 (.6121)
Rateable value growth 1891-1938^2			-60.96 (37.5968)			-30.44 (51.07)
Rateable value growth 1891-1938^3			14367.7* (5380.6)			-3494.9 (3302.8)
N	29	29	29	29	29	29
Adj. R^2	.1500	.1465	.3155	.1436	.1229	0982
Root MSE	.0096	.0096	.0086	.0153	.0155	.0157
Ramsey Reset	.7551	.8338	.9152	.5232	.5915	.7024
Breusch-Pagan hetero.	.8944	.9309	.7566	.7821	.6045	.4832

Note: Dependent variable is the change in rateable value distribution between 1945 and 1964; */**/*** signifies statistical significance at the .05/.01/.001 level; standard errors in brackets.
Source: London Statistics (various years).

The estimation results in Table 1 suggests that ρ is approximately 0.6, that is while there is a degree of mean reversion the London housing system had not returned to its pre-war structure by 1964. This may of course indicate that we have allowed for insufficient time to elapse following the war. However, it may also indicate that not all parts of the city did recover from war-time bombing. For instance, the City and Westminster were among the most severely hit during the Blitz, but did recover relatively quickly in the ensuing 20 years. Stepney and Poplar on the other hand (between the City and Westminster in terms of bomb damage during the Blitz) did not experience a similar recovery after the war – these were, however, areas of manufacturing and port activity concentration, as opposed to commercial/finance or service activity concentration in the other two areas. The degree of mean reversion in the property value series is even less, suggesting that ρ is approximately 0.7. The results differ from those estimated by Davies and Weinstein (2002) whose estimations suggests that ρ lies in the range 0 to .25 or close to complete reversion; but less so from Bosker *et al* (2007) where ρ lies in the range 0.4-0.45.

Overall the results suggests that even following severe exogenous shocks, such as the London Blitz, part of the London housing system exhibits a degree of path dependency. However, the results also suggest that the adjustment process is slow and confounded by longer-term adjustment processes (such as self-organising elements of the housing and labour market system) that might work independently of the immediate shock readjustment. This and the estimated ρ values raise the question of possible thresholds and interactions with the longer-term adjustment process. Alternatively ρ>0 might indicate the presence of multiple equilibriums

Multiple equilibriums

It is conceivable that areas in general revert to a previous pattern of evolution, but that in some instances, where for instance the shock has been particularly sever, the evolutionary path is permanently altered – this reasoning applies to both positive and negative shocks. In policy terms, such a scenario implicitly lies behind ideas of urban regeneration or the New Deals for Communities initiative. Thus Bosker *et al* (2007) Davies and Weinberg (2008) extend the above methodology to cases where one might consider more than a single equilibrium. In the case of three equilibriums the log share of borough b in 1964 is given by (7), where b_1 and b_2 represent a lower (more severe) and upper (less severe) wartime shock threshold and $\phi_{1,3}$ are constants representing a lower/higher equilibrium.

$$s_{b64} = \begin{cases} A_b + \phi_1 + \varepsilon_{b64}^1 & if \quad \upsilon_{b45} < b_1 \\ A_b + \varepsilon_{b64}^2 & if \quad b_1 < \upsilon_{b45} < b_2 \\ A_b + \phi_3 + \varepsilon_{b64}^3 & if \quad \upsilon_{b64} > b_2 \end{cases} \tag{7}$$

Since the errors change as borough b crosses threshold b_1 or b_2 the errors are stated relative to the new equilibrium.

$$\begin{aligned} \varepsilon_{b64}^1 &= \rho(\varepsilon_{b45} - \phi_1) + \upsilon_{b64} \\ \varepsilon_{b64}^2 &= \rho\varepsilon_{b45} - \upsilon_{b64} \\ \varepsilon_{b64}^3 &= \rho(\varepsilon_{b45} - \phi_3) + \upsilon_{b64} \end{aligned} \tag{8}$$

Differentiating (7) gives (9).

$$s_{b64} - s_{b45} = \begin{cases} \phi_1 + (\varepsilon_{b64}^1 - \varepsilon_{b45}) & if \quad \upsilon_{b45} < b_1 \\ (\varepsilon_{b64}^2 - \varepsilon_{b45}) & if \quad b_1 < \upsilon_{b45} < b_2 \\ \phi_3 + (\varepsilon_{b64}^3 - \varepsilon_{b45}) & if \quad \upsilon_{b45} > b_2 \end{cases} \tag{9}$$

Substituting (2) and (8) into (9) gives (10) and (10.1), which says that change in real rateable value share is a function of the severity of the wartime shock, with b_1 and b_2 determining the thresholds to a shift to a lower/higher equilibrium and D is a dummy variable signifying $b_1 < \upsilon_{b45}$ and $b_2 > \upsilon_{b45}$, and a stochastic disturbance term in 1964 and a residual effect. Note that only the constant term differs between the three outcomes in (10). Moreover, if there is little persistence of shocks then α, from (6), should be close to minus unity and the error terms in the square bracket is not correlated with the remainder of the right hand side variables. Equation (10.1) is the multiple equilibria version of (6).

$$s_{b64} - s_{b45} = \begin{cases} \phi_1(1-\rho) + (\rho - 1)\upsilon_{b45} + [\upsilon_{b64} + \rho(1-\rho)\varepsilon_{b18}] & if \quad \upsilon_{b45} < b_1 \\ (\rho - 1)\upsilon_{b45} + [\upsilon_{b64} + \rho(1-\rho)\varepsilon_{b18}] & if \quad b_1 < \upsilon_{b45} \\ \phi_3(1-\rho) + (\rho - 1)\upsilon_{b45} + [\upsilon_{b64} + \rho(1-\rho)\varepsilon_{b18}] & if \quad \upsilon_{b45} > b_2 \end{cases} \quad (10)$$

$$\begin{aligned} s_{b64} - s_{b45} = {} & (1-\rho)\phi_1 D_1(b_1, \upsilon_{b45}) + (1-\rho)\phi_3 D_3(b_2, \upsilon_{b45}) \\ & + (\rho - 1)(\upsilon_{b45}) + [\upsilon_{b64} + \rho(1-\rho)\varepsilon_{b18}] \end{aligned} \quad (10.1)$$

Thus far the methodology assumes that we know the relevant thresholds (values of b_1 and b_2) that determine structural shifts. According to Davis and Weinstein (2008) a standard threshold regression cannot be applied since the wartime shock must be instrumented, due to measurement error in (5), and the threshold values would be a function of the instruments. In order to analytically circumvent this Davies and Weinstein impose ρ=0, which implies that any shock will have completely dissipated by the following measurement period – that is sufficient time has elapsed for borough b to undo the effect of the wartime shock and settle to a new (lower/constant/higher) equilibrium.[1] With ρ=0, (10.1) the change in real rateable value share over the *entire period* (1939-64) can now be written as (11) by substituting (5) into (10.1) and instrumenting υ_{b45} by damage to the housing stock following bombing during World War 2.

$$s_{b64} - s_{b39} = \omega + \phi_1 D_1(b_1, \upsilon_{b45}) + \phi_3 D_3(b_2, \upsilon_{b45}) + \varepsilon_{b64} \quad (11)$$

Equation (11) now has a well defined likelihood function and can be estimated by standard threshold regression to determine ω, ϕ_1 and ϕ_3 (the equilibrium levels) contingent on the threshold values b_1 and b_2.

In principle there can be n thresholds separating n+1 stable equilibria. The extent to which borough b shifts from one equilibrium to another should thus be a function of the size of the wartime shock. By regressing the real rateable value change on the number of houses substantially damaged or destroyed due to bombing as a percentage of the housing stock in 1937 (the last year for which we have observations of housing stock) and then multiplying the estimated coefficient by the number of per cent of houses destroyed we can rank boroughs according to severity of shock. We then proceed by performing a grid search with each borough as a potential threshold for b_1 and b_2. The values for b_1 and b_2 that maximise the likelihood function become our preferred estimates of the thresholds. We only consider a case with a maximum number of three thresholds.

In addition to the wartime shock it is important to recognise that borough specific changes occur against the backdrop of macro-effects such as economic structural change, government policies etc. To control for these factors Davis and Weinstein (2008) include linear indicators of pre-war growth and post-war reconstruction expenses. In the case of London change in the economic geography was occurring prior to the outbreak of WW2. London's suburbanisation had expanded rapidly in the late Victorian era and early parts of

[1] This, as seen in the above section, may not be a valid restriction on the London data where estimates of ρ>0.

the 20 century and London was the largest manufacturing centre in the UK (in absolute terms). Following the war significant changes were proposed to the layout of the city in terms of the Abercrombie Plan. Though the plan was largely not implemented land use in the form of the Town and Country Planning Act in 1947, amended with the addition of Green Belts in 1955, became considerably more controlled following the war. In addition the relative strategic location of different parts of the city altered during the 1960s and 1970s as transport and technological change shifted important parts of economic activity related to London's port activities further down the Thames. The decimated port area was largely rebuilt in light of its previous function following the war (Tindall 2006). Thus, though experiencing considerable rebuilding in the short and medium term, over the longer post-war term the eastern and southern riverside areas experienced considerable change. We therefore amend (11) to include the change in manufacturing population (β_{b31}) between 1921-1931 (the last census taken before the war) hypothesising that the post-war development trajectory of areas that exhibit stronger agglomeration of manufacturing activity (measured by the standardised proportion of residents employed in manufacturing industries in 1921 and 1931) were more likely to loose real rateable share value.

An important element of the Davis and Weinstein (2008) and Bosker *et al* (2007) *theoretical* foundation is that an equilibrium cannot at the same time be stable and lie along the transition path to another equilibrium. Thus thresholds must lie between equilibrium. In other words, an area will converge on a new equilibrium upon reaching a threshold; for a negative shock the convergence must then be to an even more negative state and vice versa. This gives rise to a ranking condition in which ω represents the second equilibrium from the left, but not necessarily the pre-shock equilibrium – specifically, $D_1 + \omega < b_1 < \omega < b_2 < D_3 + \omega$.

Before examining the estimation results it may be worth considering a few reasons for why the ranking order may empirically be less valid than theoretically:

Firstly, the fragmentation of property rights; landownership and land use in London is largely privately held and though property rights in landownership tends to be less fragmented than the property rights with respect to what it built on top of the land, changing the use of land is a lengthy and difficult process involving numerous stakeholders. Moreover, the value of fixed capital (that which is built on top of the land) is governed by considerations of economic obsolescence, which will differ for each fixed asset. Thus, whilst a particular asset (z) may have lost its value, surrounding assets (*x*) may not. A shock negates the current value of the fixed asset (though not necessarily other property rights) enabling the realization of potentially higher value (re)construction. Similarly, the negation of the industrial stock circumvents issues of economic obsolescence and enables the construction of higher value land use. This means that areas that experience relatively large shocks may indeed grow faster or have a higher real rateable value growth share following a large shock.

Secondly, geography; if strategic location adds to the productivity of land then shocks coupled with economic restructuring may also result in a high-impact, but poor subsequent growth outcome. The riverside parts of London with docks and commercial wharfs relied on river-going shipping communication and were substantially targeted during the war. Closeness to the river, the ocean and the main market (London) had been a strategic advantage in the days when most shipping took place along the coast and up rivers. However, with the development of the canal system and subsequent expansion of railway based traffic, the area lost some of its strategic locational advantage while ocean going traffic added to its locational advantage. Agglomeration economies may be due to locational factors that can persist after the shock. On the other hand, agglomeration economies may also exist due to economies of scale following locational advantages that were technology specific. Once the agglomeration has been destroyed (wholly or partially) and technology has changed there may no longer exist the relevant locational advantage. Bosker *et al* (2007) find that the inclusion of geography was crucial to establishing evidence for the existence of multiple equilibriums amongst German cities.

Thirdly, an exogenous shock like World War 2 may occur against a backdrop of low-frequency endogenous drivers of growth (as implicitly in the second point above). Thus there is a question of what is being measured. If ρ=0, e.g. mean reversion, borough b reverts to its previous growth pattern, which may already reflect a structural break conditioned by the low frequency driver. Thus, a finding of mean reversion would rightly conclude that *ex ante* growth trajectories re-establish themselves, but does not fundamentally answer the question why different cities or different parts of a city exhibit different growth patterns. For instance, it might be argued that sub-urbanisation in the late Victorian era itself constitutes a shock conditioned by the expansion of manufacturing and supported by a comparative manufacturing advantage that was premised in a first starter advantage and captured markets in the form of empire. In effect resulting in London over-shooting its long-term equilibrium as other countries caught up and superseded England's first starter advantage and subsequently empire dissolved – leaving behind factors (housing, distribution of the population, infrastructure) that continue to exert path-dependency today.

A similar argument might be made to non-manufacturing parts of the London economy, but the picture is somewhat different here. Whereas England was losing its manufacturing position vis-à-vis other European nations and especially the United States of America in the latter half of the 19th century and more rapidly so following the World War 1, its position as a financial centre was not equivalently weakened. Here it is important to distinguish between different forms of agglomeration. If London exhibited agglomeration economies in manufacturing in Victorian times, this was premised on the agglomeration of fixed capital. However, agglomeration economies in financial and professional services are more reliant on the agglomeration in intangible assets (networks, human capital etc) that should be less affected by physical destruction. This is not to say that London's financial dominance following two world wars was unaffected (the rise of New York is testimony to this), but compared to London's and England's loss of manufacturing dominance, London's loss of financial dominance was less. If the rateable value of some London boroughs' housing stock exhibits the effects of over-shooting in the late Victorian era, we would expect the pre-war growth indicator to be non-linear rather than linear, allowing some areas that expanded quickly during late Victorian times and the early parts of the 20th century also to contract more sharply following the war. We therefore include λ_{b38} a vector of pre-war growth indicators – that is, the growth rate between 1891 and 1938 and its squared and cubed equivalents as per (12).

$$s_{b64} - s_{b39} = \omega + \phi_1 D_1(b_1, \upsilon_{b45}) + \phi_3 D_3(b_2, \upsilon_{b45}) + \beta_{b31} + \lambda_{b38} + \varepsilon_{b64} \qquad (12)$$

The premise of the methodology as employed by Davies and Weinstein is for the data to determine where potential thresholds are located based on a maximum likelihood criteria; the Bayesian Information Criteria (BIC) is then used to distinguish between models with different number of thresholds.

Table 3 shows the maximum likelihood (ML) estimation results from equation (13).[2] The grid search approach suggests the presence of two potential thresholds at -.0182 and -.0174 for the lower and upper shock values, respectively. Each of the thresholds is entered sequentially so that column 2 reports the estimates using only on threshold (two possible equilibriums) and column 3 reports the estimates using both thresholds (three possible equilibriums). The BIC (BIC) reported in Table 3 favours a model with 2 equilibriums; moreover, the upper threshold reported in column 3 is not significant. However, in both cases the intercept ordering suggested by Davis and Weinstein (2008) and Bosker *et al* (2007) is not met.

The results in column 2 suggest that a borough that receives a large war-time shock has a *greater* post-war growth rate than a borough experiencing a smaller war-time shock. The finding is robust to the exclusion of the City of Westminster, which experienced the fastest post-war growth level and also increased its relative rateable value share substantially over the period 1945 to 1963. Table 3 also shows that an increase in the proportion of residents employed in manufacturing industries in the pre-war period is negatively related with post-war growth, that is boroughs that experienced a relative increase in the number of residents employed in manufacturing prior to the war, were subsequently more exposed to the structural economic change following World War 2. However, the variable is only marginally significant at the 6 per cent level.

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[2] Note that the methodology does not require any of the equilibriums to equal the, assumed, pre-war equilibrium – simply whether there is systematic difference between the growth rates following the exogenous shock.

Table 3 Multiple equilibria estimation

	Threshold regression 1939-64			
	2 Equilibria	**3 Equilibria**	**2 Equilibria**	**3 Equilibria**
Growth 1891 to 1939	**0.342**	0.292	0.856	0.748
	-0.168	-0.168	-0.334	-0.328
	[0.042]	[0.083]	[0.010]	[0.022]
Growth 1891 to 1939 (^2)			-43.972	-49.460
			-23.512	-22.890
			[0.061]	[0.031]
Growth 1891 to 1939 (^3)			-6312.4	-5723.3
			-3477.2	-3368.5
			[0.069]	[0.089]
Manufacturing change 1921 to 1931	-0.007	**-0.007**	-0.005	-0.005
	-0.004	-0.004	-0.004	-0.004
	[0.061]	[0.054]	[0.206]	[0.184]
D1 (du2rx11)	**0.007**	**0.012**	**0.006**	**0.012**
	-0.002	-0.004	-0.002	-0.004
	[0.004]	[0.005]	[0.016]	[0.006]
D3 (du2_16)		0.006		0.007
		-0.004		-0.004
		[0.150]		[0.095]
_cons (ω)	**-0.004**	**-0.001**	-0.002	**-0.007**
	-0.001	-0.004	-0.002	-0.004
	[0.002]	[0.015]	[0.350]	[0.054]
b_1	-0.018	-0.018	-0.018	-0.018
b_2		-0.017		-0.017
N	29	29	29	29
Log-likelihood	111.04	112.24	113.21	115.91
BIC	-84.2	-80.8	-80.8	-74.1
Intercept ordering	Fail	Fail	Fail	Fail

Note: Dependent variable annual real rateable value change 1939-1945; standard error in brackets; p-value in square brackets. **Bold** indicates significant at .05 level.

Column 4 and 5 in Table 3 show the estimation results of Eq. (13) with non-linear pre-war growth. As above the BIC and variable significance statistics favours a model with 2 equilibriums. Moreover, the results again suggest that boroughs that experienced especially hard war-time shocks exhibited faster post-war growth, which violates the intercept ordering criteria. Allowing the growth rate after 1939 to be non-linearly related to pre 1939 growth renders the role of industrial occupation non-significant. However, the non-linear term is only significant at the 7 per cent level. Overall, there is little evidence for the existence of multiple equlibria on the basis of the methodology for which the test is designed, e.g. the conventional approach in the literature.

Discussion and conclusion

Many English cities have experienced a "renaissance" in recent decades. However, there is also some evidence that patterns of deprivation/prosperity have remained largely unchanged over the past 30 years and even exhibit strong persistence over the last century. Successive UK governments have initiated policies that were aimed at structurally altering the landscape of deprivation by large scale public and public-private investment in physical and economic regeneration. The government defines regeneration as 'a set of activities that reverse economic, social and physical decline in areas where market forces will not do this without support from government' (DCLG 2008:6). However, it also recognises that regeneration initiatives are more likely to be sustainable and effective if there is private sector (including owner occupier) commitment (DCLG 2008). Following WW2 regeneration concentrated on housing renewal. In the 1960 this focus expanded to areas where economic restructuring was causing economic decline. Following significant changes to the funding structure, with greater emphasis on private sector investment in the 1980s and 1990s, the regeneration remit at the start of the 21st century widened to additionally emphasises quality of life and prosperity measures.

From an emphasis on physical regeneration government policies has evolved to focus on the causes and drivers of urban and spatial decline. As such current government policy identifies three phases of decline (DCLG 2008:80). Firstly, a change in the underlying economic circumstance: although economic drivers are not necessarily seen as the exclusive causes of area decline, collapse of major employers and/or erosion of the comparative advantage of local industries has significantly affected the pattern of deprivation in the UK.[3] A second phase is identified as the market response to the economic shock. This, to some extent, will presumably reflect both the sources and nature of the initial comparative advantage, but in line with the government's mixed community policy, the government's regeneration policy argues that economic diversity, a skilled labour force and good social and physical infrastructure will assist areas in adjusting quickly to economic shocks. Finally, the legacy of change: a phase where the failure of economic, social and property markets may interact to generate a self reinforcing cycle of decline.

This paper argues that patterns of deprivation/prosperity arise from the location decisions of individual households and economic theory suggests that for such a market based adjustment process to generate the "desired" outcome, history and expectations play significant roles. History in this respect encapsulates existing sunk investments as well as social and culturally determined perceptions of an area. For a market based adjustment process to structurally alter the existing landscape of deprivation it is therefore pertinent that individuals can be persuaded to believe that gains from relocation are greater than the cost of relocation. Herein the role of expectations. As set out in the methodological section the speed with which externalities (will) can be capitalised will likely influence the extent to which individuals can be persuaded to believe that gains from relocation are greater than

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[3] However, it should be noted that tackling deprivation is a policy issue confronting the majority of Local Authorities (LA) in England. Only3 per cent of LAs *do not* contain a Lower Super Output Area where the Index of Multiple Deprivation is above the national average (DCLG 2008:83).

costs. Over the last decade the government has committed substantial funding to tackle deprivation in the most deprived Local Authorities through the Neighbourhood Renewal Fund. Moreover, public-private partnerships have attracted significant private sector investment into regeneration. However, it is worth pausing to reflect on the achievements of this investment. While the lives of many UK citizens have been improved there is also a recognition that in many places change has been slow to emerge with few tangible improvements in terms of employment opportunities or reducing the barriers to economic growth (DCLG 2008).

The theme for this conference is integration and segmentation and it is highlighted that forces of economic and institutional convergence may contribute to an element of housing market integration across Europe, but also that local social and cultural conditions may contribute to persistence in differences and segmentation. In particular, the theme of the conference hypothesises that housing market integration may be facilitated by the globalisation of financial flows and the rising popularity of residential investments. Similar forces must be assumed to operate within national economies and it might therefore be relevant to consider the strength of both integration and segmentation in the absence of, or more constrained access to financial flows, in coming years. The literature on non-linearities in housing markets would suggest that large-scale financial intervention in the most deprived areas may in the long-term not succeed in moving these areas beyond the threshold levels where endogenous growth will operate *unless* this investment remains persistent and sustained. But what is persistent and sustained? Five years, 10 years, 50 years? Are we likely to experience a similar amount of public and private sector investment into regeneration in the next decade?

This paper has examined the adjustment process in housing markets in London following WW2 and asked the question whether the two decades following the war were characterised by slow adjustment and/or the emergence of multiple equilibria? The results show that the London housing system had not returned to its pre-war structure some two decades later. On the one hand this may indicate the emergence of multiple equilibria. That is, the effect of the bombing was so severe that property rights and sunk investment barriers to change were removed allowing for the emergence sufficient investment to generate economies of scale or agglomeration economies that would allow for a higher mean growth rate in these areas. Alternatively, and in line with the methodological premises found in the literature, that the bombing was severe enough to permanently damage the existing economic structure, possibly interacting with the emergence of social or cultural stigmas, to such an extent that a lower mean growth rate emerged. Following the standard approach and methodological premise found in the literature there is little evidence for the latter interpretation and the methodology may not be suited to evidence the former interpretation.

On the other hand the absence of a return to the pre-war growth structure by 1964 may simply reflect that the process of adjustment was not completed by this stage. A slow adjustment process has significant implications for the role of individual households in regeneration processes. If adjustment processes are slow (our results show that 20 years after the WW2 the effect of the bombing was still affecting the relative distribution of rateable values), history and path dependence are likely to dominate expectations. If housing markets exhibit non-linearities then the areas where history dominates expectations are likely to be the two tail ends of the deprivation distribution. This means that regeneration policies aimed at permanently altering the trajectory of local areas may require continued large scale public investment to push an area beyond the threshold where expectations being to dominate history. Only at this point is it likely that the role of individual households can significantly influence the process of regeneration. Moreover, in the absence of sustained financial intervention the results would indicate that mean reversion may re-assert the pre-intervention status of the area.

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