What are the determinants of brownfields regeneration? An analysis of brownfields in England

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Abstract:

Urban sprawl and the development of greenfield sites that most developed countries are currently facing, has recently pushed government in both the EU and the US to reuse previously developed land. Observers believe that, among other things, compact cities contribute to biodiversity conservation and decrease energy consumption. At the same time, the regeneration of brownfield sites addresses problems of contamination, improves the balances between urban, peri-urban and rural relationships, identifies sustainable future opportunities, may increase the supply of affordable housing close to local amenities and open space, reduce inequalities, and make our inner cities less congested and safer places to live. This paper uses econometric techniques, supported by GIS data, to address key questions that brownfield stakeholders and policymakers are facing in the UK and elsewhere: what site characteristics, what ownership type, what geographical characteristics, make brownfield sites more likely to be regenerated? What are the drivers of specific regeneration projects? Are there any regional variations? To address these questions we analyse a dataset of more than 2,000 observations of brownfield sites in England. The results show that more resources and specific policies are needed if the government wants to redevelop 'difficult sites', such as sites that have previously been used for commercial and industrial activities, large sites, and sites that are located in the poorer and bleakest areas of cities and regions of England.

1. Introduction

Urban sprawl and the development of greenfield sites that most developed countries are currently facing, has recently pushed government in both the EU and the US to reuse previously developed land. Observers believe that, among other things, compact cities contribute to biodiversity conservation and decrease energy consumption. At the same time, the regeneration of brownfield sites addresses

problems of contamination and other development patterns that generate environmental problems and sprawl, improves the balances between urban, peri-urban and rural relationships by decreasing the conversion of agricultural land and rural sites to urban uses, identifies sustainable future opportunities, may increase the supply of affordable housing close to local amenities and open space, reduce inequalities, promotes economic growth in inner cities and make cities themselves less congested and safer places to live. The reuse of brownfield sites is further attractive to communities and policymakers for at least three reasons. In England, the reuse of brownfields is further lead by four political drivers: the high population density of England, which is the most densely populated country in Europe; the low population density of English cities, compared to average European densities; the large quantity of under-utilized land within urban areas; the population growth that will require more than two million new dwellings by the end of year 2020 (English Partnerships, 2003). These, together with more recent goals of the Government to (i) reduce greenhouse gases emissions to tackle climate change, (ii) speed up the planning process, (iii) increase access to land and provide more affordable housing, (iv) attract private sector investment and unlock land for housing development, (v) build social cohesion and minimize anti-social behaviour have increased the emphasis towards a strategy to reuse brownfields (English Partnerhsips, 2007).

Already a decade ago, the Government announced that at least 60 per cent of new homes in England are to be built on previously developed land by 2008. Following the publication of this national target, the Urban Task Force (1999) set out that to provide desirable town and city dwellings for an expected four million additional households in England over 25 years, development should first occur in urban brownfield sites and limit greenfield land releases. Recent data have shown

that such goal is being achieved: Today, a national average of 70% of new development is on brownfield land, compared with 56% in 1997. The Urban Task Force is therefore now recommending a new target of 75% of new residential development across all England's regions to be on previously developed land by 2010 (Urban Task Force, 2005).

The recent Barker Review of land use planning (2006) emphasises that the Government should make better use of fiscal incentives to encourage a better use of land, especially for derelict or vacant land and for hard to remediate brownfield sites. Barker points out that some sites may be very complex to remediate, have 're-greened' or are located in areas where people prefer not to live, or company do not want to locate. Also the Urban Task Force (2005) recognizes that there may be difficult circumstances, such as poor public transport connections, proximity to disruptive facilities, or high levels of contamination that might require a substantial involvement of the public sector to regenerate those sites. The Urban Task Force (2005) further recognizes that the present legal and fiscal incentives have not yet generated the incentives to deliver the expected urban renaissance, as developers are still more attracted by greenfield over brownfields projects.

The need for a national strategy for brownfields in England has been pointed out by several observers (see BURA, 2006). Only recently, the Government has charged English Partnerships with developing a National Brownfield Strategy for England. The Government's 'Sustainable Communities Plan' outlined the role for English Partnerships to identify the land to be used for sustainable development, especially in the Growth Areas; additional key-worker and affordable housing; and land for community infrastructure, employment and transport (English Partnerships, 2003, 2006). The National Brownfield Strategy aims to set out how local and regional

governments and stakeholders should tackle existing problems of derelict sites; ensure a continuing supply of land by returning previously used land to beneficial use; and encourage and promote 'best practices' in the reuse of brownfield (English Partnerships, 2007, page 4).

In this paper we aim to investigate with econometric techniques supported by GIS based data the determinants and the barriers of regeneration for English brownfields. Our study addresses the outcome of the recent English brownfields regeneration agenda with three related questions: (i) what (local) characteristics make a site more likely to be regenerated? (ii) has brownfields regeneration mostly occurred in city centres, contributing therefore to limit urban sprawl? (iii) should size and location specific policies be suggested to better tackle brownfields reuse? Using data from the National Land Use Database for more than 21,000 brownfield sites we explore the site characteristics that make a brownfield more likely to be regenerated. Specifically, we look at how the following variables have had an impact on the reuse of a site: Previous use, dimension, ownership type, whether the site is located in a city, a metropolis, or in rural areas, geographical location, and other geographical based variables, such as the population density and the index of deprivation of the area where the site is located, and the distance to the city centre. Our analysis aims at providing policy makers with indications to what has limited brownfields regeneration and what has favoured the reuse of previously developed sites in England. Our approach, based on observed data, on revealed preferences of local authorities brownfields regeneration projects will help to shed lights on the successes and limitations of brownfields regeneration policies. Results from this analysis can provide guidance on where the government should act to remove barriers for brownfields regeneration.

We find that despite the apparent success achieved by the government with most new houses being built on brownfields, we argue that most brownfields redevelopment has happened in 'easy brownfields'. More resources, attention and specific policies are needed to redevelop 'difficult brownfields', such as large sites, sites that have previously been used for commercial and industrial activities, sites that are located in the poorer and bleakest areas of cities and regions of England.

The remaining of the paper is structured as follows. Section two reviews the literature on the barriers and drivers of brownfields redevelopment in England; section three describes the English dataset of previously developed land; section four presents the economic and econometric models; section five reports the results of the analysis and the final section concludes the paper.

2. Literature review

Several studies have looked at the barriers and drivers of brownfields regeneration. Most of these studies have focussed on the US experience (Wernstedt, 2004; Wernstedt et al, 2006a, 2006b; Meyer and Lyons, 2000; DeSousa, 2003, 2004; Schoenbaum, 2002; Greenberg et al, 2001; Bartsch and Collaton, 1997; Dennison, 1998; Eisen, 1999). More recently, researchers and governments have looked at the possible drivers and barriers of brownfields regeneration in England (Walker, 2000; Adams and Watkins, 2002; English Partnerships, 2003, 2006, 2007; BURA, 2006, Syms, 2004; Roberts and Sykes, 2000; Urban Task Force, 1999, 2005; Diamond and Little, 2005; Dair and Williams, 2006; Harrison and Davies, 2002; Dixon et al, 2006; Bardos et al, 2000; Dixon and Doak, 2005; Adams, 2004; Cozens et al, 1999; Adams et al, 2001; the European projects BERI, CLARINET, CABERNET, RESCUE). Most of these studies have however used qualitative data and in-depth case studies (Dair

and Williams, 2006; Bardos et al; 2006; Harrison and Davies, 2002), while studies using quantitative data to suggest policy recommendations for brownfields reuse in the English context are less common (Dixon et al, 2006; Adams et al, 2001).

Harrison and Davies (2002) use in-depth stakeholders interviews to examine how conservation professionals in the private, public and voluntary sectors are responding to biodiversity loss and opportunities for habitat creation posed by redeveloping brownfield sites. Dixon and Doak (2005) tackle the relationship between brownfield redevelopment and the EU Landfill Directive and conclude that the development industry could be hindered in regenerating contaminated sites by the Directive. Dair and Williams (2006), through a qualitative analysis of five brownfields projects, find that urban brownfield redevelopments are not always achieving sustainable outcomes: the protection of biodiversity and minimising pollution were regarded by stakeholders as important issues, but use of sustainable technology and buildings were almost wholly ignored. Adams (2004) explores the need for new competencies and strategies and the partnerships with planning authorities and local communities to boost the government's brownfield housing target in urban areas. Cozens et al (1999) discuss the relationship between crime and brownfields redevelopment for housing purposes. They find that most brownfield land available for development is found in existing highly urbanised areas, which already experience high crime rates, while brownfields in rural areas experience much lower crime rates; this pushing developers toward the less criminogenic and potentially more 'sustainable' neighbourhoods. Dixon et al (2006) conduct a survey of UK developers to elicit their opinions on brownfield development. The survey was a mail survey administered to 987 managing directors or other members of senior management of commercial developers (30%) and house builders (70%) companies.

The response rate was 25.53%. Interestingly, about 80% of the respondents developed entirely on brownfields and explained this preference with the availability of land and the financial and other incentives given by the government to develop on previously used land. Adams et al (2001) selected 20 brownfield sites within each of the four cities of Nottingham, Stoke, Dundee, and Aberdeen. Among the barriers to brownfields development, Adams et al identify the extent of ownership rights in potential development land (unclear ownership, multiple owners, land being held in a trust or subject to mortgage) and the interests and actions of those who hold the property rights (the owner may be unwilling to sell; or the owner may be willing to sell but may have unrealistic terms or valuation). English Partnerships (2007) is to our knowledge the only attempt being made so far to assess on a quantitative basis past information of brownfields reuse in England. The study, however, is limited to the physical description of previously developed land in England and does not provide much insight on the determinants of brownfields redevelopment.

3. Previously developed land in England

a) The definition of brownfield

In the US context, brownfields are "abandoned, idled or underused industrial and commercial properties where real or perceived contamination complicates expansion or redevelopment" (Simons, 1998). In the UK context, experts have only recently tried to agree on a definition of the term (see Alker et al, 2000). Researchers and policy makers have often used 'previously developed land' as a synonym of brownfield (Syms, 2004). According to the Planning Policy Guidance note 3 – Housing (PPG3), previously developed land "is that which is or was occupied by a permanent structure, including the curtilage of the developed land and any associated

fixed surface infrastructure. The definition includes defence buildings, but excludes: Land that is or has been occupied by agricultural or forestry buildings; Land that has been developed for minerals extraction or waste disposal by landfill purposes where provision for restoration has been made through development control procedures; Land in built-up areas such as parks, recreation grounds and allotments, which, although it may feature paths, pavilions and other buildings, has not been previously developed; Land that was previously-developed but where the remains of the permanent structure or fixed surface structure have blended into the landscape in the process of time (to the extent that it can reasonably be considered as part of the natural surroundings)" (DETR 2006, p. 26) More recently, English Partnerships, the national regeneration agency for England, has defined brownfields as "land and buildings where reuse may in some way be constrained by physical or regulatory issues that affect its potential for reuse. This includes land and buildings that are derelict and/or vacant and those that are occupied, in whole or part, but which have been identified as having redevelopment potential, though impacted by physical and/or regulatory constraints that hinder or prevent their reuse" (English Partnerships, 2006, p.9).

b) The National Land Use Database

In 1998 the Government issued the policy document 'Planning for the Communities for the Future', (ODPM, 1998) that led to the construction of the National Land Use Database (NLUD). The NLUD initiative is a partnership project between Communities and Local Government, English Partnerships, the Improvement and Development Agency and Ordnance Survey. The database was created by the need to monitor the supply of brownfields to provide an adequate and strategic supply

of land and buildings for housing and other economic activities. Data are provided on a yearly basis by local planning authorities and collect information, such as geographical location, address, land use and planning attributes for vacant and derelict sites and other previously developed land and buildings that may be available for redevelopment in England. The format of the data has changed during the years to keep the database consistent with the new legislation – *Planning Policy Guidance Note 3 (PPG3)* (ODPM, 2006). This makes it difficult to compare database entries across years and we therefore limit our analysis at the year 2006 dataset. Five land types are collected within the NLUD: (i) Previously developed land which is now vacant; (ii Vacant buildings; (iii) Derelict land and buildings; (iv) Land or buildings currently in use and allocated in the local plan and/or having planning permission; (v) Land or buildings currently in use where it is known there is potential for redevelopment (but the sites do not have any plan allocation or planning permission) (NLUD, 2000, 2003; ODPM, 2006). Each site entry records the address and the British National Grid geographical reference, the previous and current activities (commercial, industrial, housing, or other), the area, the planning status, the proposed use, whether the site is suitable for housing, the most suitable use, an estimate of the housing density, and the ownership type, either public or private. Unfortunately the NLUD does not collect information on contamination at the sites. In fact, the NLUD and the new regime for contaminated land for England (DETR, 2000a) are separate and distinct exercises. The identification and classification of brownfields in the NLUD makes no representation on the likely presence of contamination. Some local authorities volunteer this information in the NLUD, but most authorities do not. Therefore, it would be inappropriate to consider the NLUD as a registry of contaminated sites. Where sites are to be redeveloped the planning and development

control process ensures that any potential risks associated with contamination are properly identified and cleaned up.

As the NLUD sites are geo-referenced, we were able to augment the database with Geographical Information Systems (GIS) data obtained by the Office for National Statistics, Communities and Local Government and elaborated through ArcGIS. The data collected used in the analysis are: the population density of the wards where the sites are located, whether the site is located in a city, a metropolis or a rural area, the Index of Multiple Deprivation for 2004[1] for the super output areas where sites are located, and the distances to the central business district.

4. The econometric model

The modelling approach adopted in this study postulates that the regeneration of brownfield sites is a function of the site's characteristics (e.g. geographical location, size, distance to the city centre, previous activity at the site, housing suitability and ownership) and neighbourhood characteristics (e.g. population density and deprivation score of the area where the sites is located). Our hypothesis is that a site will be in use (*in_use*) if the net benefit to the owner—defined here as utility—is greater than the utility derived from the site if it was unused (*unused*). The behavioral model is therefore, choose *in_use* over *unused* if and only if (iff):

$$U_{in\_use} > U_{unused}, \qquad (0.1)$$

where U represents utility. Now an owner's decision becomes a random utility model, and thus the utility function for *in_use* can be expressed as:

[1] The Index of Multiple Deprivation 2004 (ODPM, 2004) is calculated by the Social Disadvantage Research Centre at the University of Oxford for super output areas lower layer in England. The index is constructed by combining seven transformed Domain Indexes, using the following weights: Income (22.5%), Employment (22.5%), Health Deprivation and Disability (13.5%), Education, Skills and Training (13.5%), Barriers to Housing and Services (9.3%), Crime (9.3%), Living Environment (9.3%).

$$U_{in\_use} = \alpha_{in\_use} + \boldsymbol{\beta}'\mathbf{x}_{in\_use} + \varepsilon_{in\_use}, \qquad (0.2)$$

where U is the true—but unobservable (i.e. latent)—utility associated the site when it is in use; α is a constant term; $\boldsymbol{\beta}$ is an unknown vector of parameters for the site and neighbourhood characteristics, $\mathbf{x}$; and, ε is stochastic and is an unobservable factor of utility—and is treated as a random component. Due to the presence of this error component, the empirical model is driven by the probability that a site will be in use, i.e.:

$$P_{in\_use} = \text{Prob}\left(U_{in\_use} > U_{unused} \quad \forall in\_use \neq unused\right),$$

$$P_{in\_use} = \text{Prob}\left(\alpha_{in\_use} + \boldsymbol{\beta}'\mathbf{x}_{in\_use} + \varepsilon_{in\_use} > \boldsymbol{\beta}'\mathbf{x}_{unused} + \varepsilon_{unused} \quad \forall in\_use \neq unused\right)$$
$$P_{in\_use} = \text{Prob}\left(\varepsilon_{unused} - \varepsilon_{in\_use} < \alpha_{in\_use} + \boldsymbol{\beta}'\mathbf{x}_{in\_use} - \boldsymbol{\beta}'\mathbf{x}_{unused} \quad \forall in\_use \neq unused\right)$$
(0.3)

Assuming the cumulative probability in equation (0.3) has a multivariate normal density leads to the probit model.

Implicit in this straightforward probit specification is the assumptions of homogeneity among sites. However, it is possible that there may be differences among sites located in different Local Authorities—due to factors such as different political drivers or legislation and budget constraints. In this paper we propose three alternative probit specifications to relax the homogeneity assumption and thus capture some of the unobserved heterogeneity.

This is firstly achieved using a random effects probit model. Under this approach, we test the assumption that status of sites in a particular Local Authority is useful information in predicting the status for other sites in the same Local Authority area and also in other Local Authority areas.

We proceed to examine explicitly the unobserved heterogeneity across sites. This is achieved by portioning additively the stochastic component of utility into two parts:

$$U_{in\_use} = \alpha_{in\_use} + \boldsymbol{\beta}'\mathbf{x}_{in\_use} + \left[\boldsymbol{\eta}_{in\_use} + \varepsilon_{in\_use}\right], \quad (0.4)$$

where $\boldsymbol{\eta}$ is a vector of random terms. In the following section we present two models which use this form. The first of these models—labelled the random parameters probit model—allows $\boldsymbol{\eta}$ to take an infinite set of values; whereas the second of these models—labelled the latent class probit model— allows $\boldsymbol{\eta}$ to take finite set of distinct values. In both models the values of $\boldsymbol{\eta}$ can be either independent across sites or they can be the same for all sites within the same Local Authoirty. After evaluating the log-likelihood values from both specifications, we find that specifications where $\boldsymbol{\eta}$ is Local Authority addressing the intrinsic correlation among sites within the same Local Authority outperform specifications which assume independence across Local Authorities. In the case of the random parameters probit model we specify all parameters as having an unconstrained normal distribution. The model was estimated using 100 shuffled Halton simulated draws. In the case of the latent class probit model, an examination of the model diagnostics suggested three distinct values for $\boldsymbol{\eta}$.

5. Results

A) Descriptive statistics

Table 1 reports the descriptive statistics for the 21,808 brownfields recorded in the NLUD for 2006. The database is composed for about 40% of sites that are currently in use. Industrial, commercial and residential activities are the main previous uses at the sites, the remaining being recreational, agricultural, vacant buildings and land, unused and derelict. For about 20% of sites local authorities do not know the previous activity at the site. The average (median) site is about two (0.43) hectares, and is about 1.6km (0.87km) from the closest central business district. Most sites are located in cities, as

29.15% are urban sites and 25.66% are located in metropolis. More than 60% of the sites are privately owned and deemed suitable for housing, one of the most pressing objectives of government planning policies. The average population density in the Ward where sites are located is of about 24 persons per hectare. Finally, the Super Output Area where sites are located has an average score of 29.7 for the Index of Multiple Deprivation 2004, being the least deprived Super Output Area with a brownfield in Waverley BC, County Surrey in the South East, with an IMD score of 1.16, and the most deprived Super Output Areas with a brownfield in Liverpool, in the North East, with an IMD Score of 86.36.

Figure 1 shows the English brownfields divided into two groups of sites currently in use, in red, and unused, in yellow. Most brownfields are located in more densely populated areas, such as the capital, London, and other major (industrial) cities: Liverpool, Manchester, Hull, Newcastle Upon Tyne, Birmingham, Leeds, Plymouth, Portsmouth, Sheffield, Kirklees, St. Helens, Stoke-on-Trent, Swale, Tunbridge, Wells, Walsall, Wirral, and Wolverhampton. The map further shows a high number of sites in use in the wealthy and more densely populated areas of the south and southeast, compared to the poorer and less densely populated areas of the northern regions.

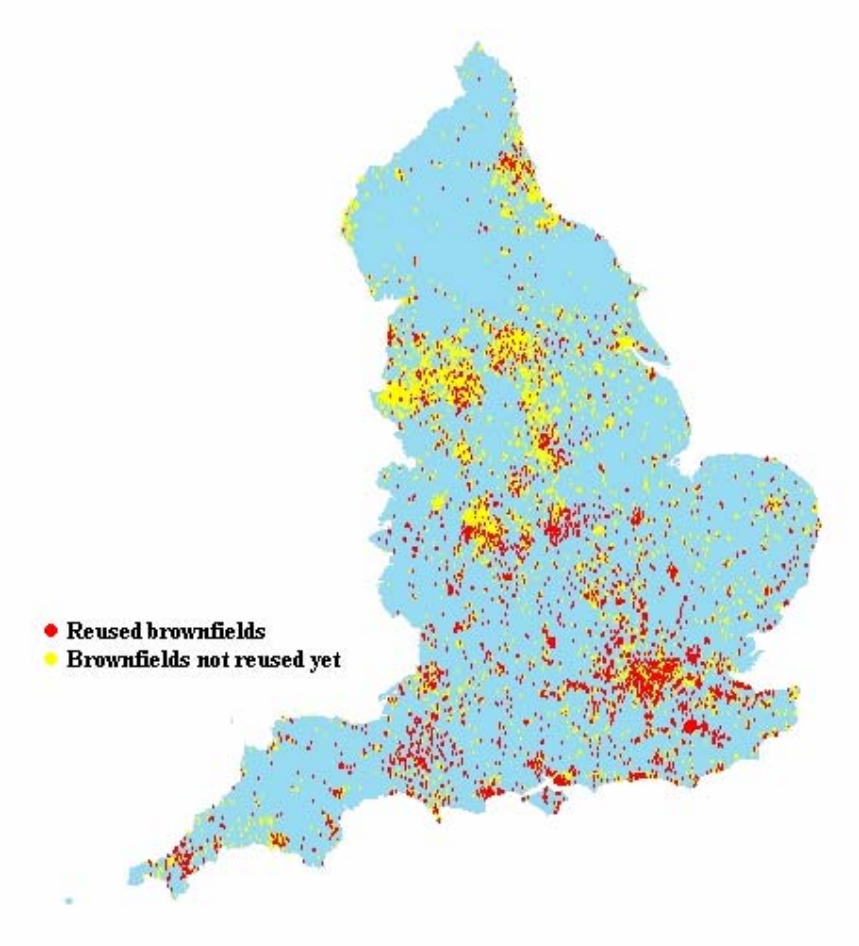
Table 1. Descriptive statistics. (Number of observations is 21808 for all variables; no missing values.)

Variable	Acronym	mean	median	st. deviation	max	min
AREA (hectares)		2.1	0.43	11.35	682.6	0.002
Population density. Persons per hectare in Ward in 2001	POP_DENS	24.47	24.47	21.99	236.05	0.04
Index of Multiple Deprivation score for super output areas for year 2004 where sites are located.[a]	IMD_SCOR	29.7	24.57	19.95	86.36	1.16
Distance to the Central Business District (CBD) in Km		1.644	0.871	2.158	27.535	0.007

Variable	Acronym	mean	st. deviation
Site is in use, has been regenerated (dummy)	IN_USE	0.4091	0.4916
Previous activity at the site was housing (dummy)	EX_HOU	0.1809	0.3849
Previous activity at the site was commercial (dummy)	EX_COM	0.2002	0.4001
Previous activity at the site was industrial (dummy)	EX_IND	0.2684	0.4431
Previous activity at the site was agricultural (dummy)	EX_AGRIC	0.0085	0.0917
Previous activity at the site was recreational area (dummy)	EX_REC	0.0093	0.0958
Previous activity at the site was derelict (dummy)	EX_DER	0.0260	0.1590
Previous activity at the site was unused (dummy)	EX_UNUSE	0.0070	0.0832
Previous activity at the site was vacant building (dummy)	EX_VAC_B	0.0226	0.1486
Previous activity at the site was vacant land (dummy)	EX_VAC_L	0.0718	0.2581
Previous activity at the site was unknown (dummy)	EX_DK	0.2054	0.4040
Site area is smaller than the median site area (0.43 hectares) (dummy)	SMALL	0.5018	0.500
Site area is between 0.43 and 1.21 hectares (dummy)	MEDIUM	0.2491	0.2491
Site area is larger than 1.21 hectares (dummy)	LARGE	0.2491	0.2491
Housing suitability (dummy)	HOUSE_SU	0.6545	0.4755
Privately owned (dummy)	PRIVATE	0.6099	0.4877
Site is located in a city (dummy)	CITY	0.2915	0.4544
Site is located in a metropolis (dummy)	METROPOL	0.2566	0.4367
Site is located in a rural area (dummy)	RURAL	0.4519	0.4976
Site is within 0.871km from CBD (dummy)	DIST_50	0.5000	0.500
Site is between 0.871km and 1.85656km from the CBD (dummy)	DIST_75	0.2500	0.4330
Site is beyond 1.85656km from CBD (dummy)	DIST_100	0.2500	0.4330
East Midlands (dummy)	EASTMIDL	0.0962	0.2949
East of England (dummy)	EASTENGL	0.0824	0.2749
London (dummy)	LONDON	0.0542	0.2265
North East (dummy)	NE	0.0675	0.2508
North West (dummy)	NW	0.2169	0.4121
South East (dummy)	SE	0.1323	0.3388
South West (dummy)	SW	0.1042	0.3055
West Midlands (dummy)	WESTMIDL	0.1329	0.3394
Yorkshire and Humberside (dummy)	YORK_HUM	0.1134	0.317

[a] Index was constructed by combining seven domain scores: Income, Employment, Health Deprivation and Disability, Education, Skills and Training, Barriers to Housing and Services, Crime, Living Environment. The higher the score the more deprived the super output area (ODPM, 2004).

Figure 1. Brownfield sites in England.



B) The determinants and constraints of brownfields regeneration

Tables 2 and 3 present the results of our econometric models. Models have been estimated for a sample of 20,345 observations, due to computable limitations of LIMDEP, that does not allow estimating panel data models with more than 337 observations within the same group. In future analysis we will explore other software, such as BIOGEME. The panel structure of the data reflects the fact that sites belong to the same local authority, for a total of 366 local authorities, or groups. The tables show that the panel analysis significantly improves the results obtained in the probit model. The log likelihood function and the Akaike Information Criterion

suggest that the panel models outperform the probit model. The model that seems to better explain the data is the random coefficients probit model. This latter model was estimated specifying a normal distribution for the scale parameters of all variables. The model was estimated using 100 shuffled Halton draws. The results for the random coefficient probit model show that a site is more likely do be regenerated when local authorities do not have a clear information of the previous activity at the site (EX_DK is the reference dummy for previous activities at the site). In fact, all the dummy variables for the previous uses at the sites are negative and significant. Among these variables, EX_HOU, EX_AGRIC and EX_UNUSE have smaller coefficients, compared to the other previous uses, suggesting that when a site was used for residential, agricultural activities or was not previously used is more likely to be regenerated. This is a first important result that acknowledges the difficulties in developing sites that have been previously used for commercial and or industrial activities. These sites may in fact be considered mode difficult to develop due to the presence of obsolete structures, and problems or fear of contamination. When we consider the size, we notice that smaller sites are more likely to be developed, being the coefficient of SMALL positive and significant, compared to medium and large size sites. Our analysis wanted to explore to what extent the goal of the government of redeveloping sites located within urban cores to limit urban sprawl has been achieved. To address this question we look at the coefficient of the two dummy variables CITY and METROPOL that consider whether a site is located in a city or in a metropolis, and the two dummies for the distance to the city centre DIST_50 and DIST_75. All coefficients, except the one for DIST_75, are not significant, indicating that there hasn’t been a significant difference in the redevelopment of sites in rural versus urban areas. This is confirmed by the coefficient of DIST_75 which is negative, suggesting

that sites that are within the median distance and 1.8km from the city centre are less likely to be developed compared to sites at the city centre, in periphery or in rural areas. Being a site owned by the private sector or being suitable for housing make it more likely to be reused. For example, a private ownership increases by about 10% the probability of redeveloping the site. Census characteristics affecting the probability of redeveloping a site are well captured by the Index of Multiple Deprivation, that indicates that the more deprived a site is, the less likely to be redeveloped. The population density, ceteris paribus, does not seem to influence particular pressure on the redevelopment of brownfields, being the coefficient of POP_DENS barely significant in the random coefficients probit model. Finally, the dummy variables for the geographical regions confirm the results presented in Figure 1 that sites located in London, the South West, and the South East are more likely to be regenerated compared to sites located in other regions.

Table 2. Results

	Probit model		Random Effects Probit Model		Random Coefficients Probit Model			
					Means		Scale	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Constant	3.2286	29.6340	3.5701	19.0740	4.0110	32.2730	0.7084	31.2680
EX_HOU	-2.8981	-35.1630	-3.5898	-69.0630	-3.8656	-55.5440	0.6057	14.8510
EX_COM	-3.5138	-43.0090	-4.1478	-80.0850	-4.4296	-71.7030	0.1918	5.6670
EX_IND	-3.6877	-45.7980	-4.3756	-82.6240	-4.5949	-76.3040	0.1125	4.0070
EX_AGRIC	-2.9731	-23.9290	-3.6714	-55.2640	-3.5522	-29.1100	1.2078	6.1440
EX_REC	-3.0839	-24.4910	-3.9175	-26.6750	-4.2885	-24.9660	0.6521	3.4590
EX_DER	-4.9150	-32.5960	-5.4949	-38.0470	-6.2913	-22.2230	1.1574	4.7410
EX_VAC_B	-4.4027	-33.9130	-4.8808	-45.1240	-5.3451	-40.8390	0.9450	7.0030
EX_VAC_L	-4.6801	-46.6620	-5.2523	-84.6570	-5.7031	-51.4480	1.1565	13.5590
EX_UNUSE	-2.1514	-14.7050	-2.9444	-20.9360	-3.0457	-19.7490	0.3933	2.7420
SMALL	0.1723	4.9740	0.1902	5.3390	0.1725	4.0460	0.3213	11.5010
MEDIUM	0.0026	0.0690	-0.0106	-0.2510	-0.0011	-0.0240	0.1627	4.6340
HOUSE_SU	0.3919	13.2560	0.3522	14.1680	0.3540	9.8460	0.6213	25.5620
PRIVATE	0.3336	12.4810	0.3555	16.4340	0.2601	8.8100	0.4146	18.4260
CITY	0.0422	1.1690	0.1119	2.4820	0.0657	1.3530	0.1684	5.4430
METROPOL	0.3421	6.8380	0.0714	0.8580	0.0228	0.2850	0.1908	4.0500
POP_DENS	0.0010	1.2730	0.0010	0.8340	0.0020	1.5590	0.0030	5.0280
IMD_SCOR	-0.0166	-18.3990	-0.0080	-7.5940	-0.0067	-5.6130	0.0080	11.9660
DIST_50	0.0456	1.2370	-0.0163	-0.4060	0.0041	0.0840	0.1308	4.6390
DIST_75	-0.0980	-2.4220	-0.1252	-2.6880	-0.1200	-2.2750	0.1327	3.0580
EASTMIDL	-0.5519	-6.8840	-1.0391	-5.2160	-1.0687	-8.7940	0.5196	8.7610
EASTENGL	-0.4630	-5.7830	-0.6489	-3.1410	-1.3478	-10.9100	0.7570	12.4140
NW	-1.4077	-19.3890	-1.4044	-6.5600	-1.9103	-16.9060	0.3452	7.9740
NE	-0.9361	-11.1380	-1.2465	-4.9790	-1.4645	-10.7270	0.0462	0.5010
SE	-0.0663	-0.8970	0.0065	0.0360	-0.2645	-2.3080	0.6740	16.7220
SW	-0.0945	-1.2200	-0.4252	-2.2510	-0.8684	-7.1780	0.3707	6.0280
WESTMIDL	-0.4379	-5.9410	-0.3042	-1.6190	-0.5904	-4.8000	0.9922	16.8000
YORK_HUM	-1.2437	-15.8430	-1.3999	-7.3250	-1.2106	-9.3360	0.0418	0.5130
Rho			0.4189	23.0950				
Log likelihood function		-6534.26		-5219.16		-4874.74		
McFadden Pseudo R-squared		0.53		0.20		0.25		
Akaike Information Criterion		0.64		0.51		0.48		
N		20345		20345		20345		

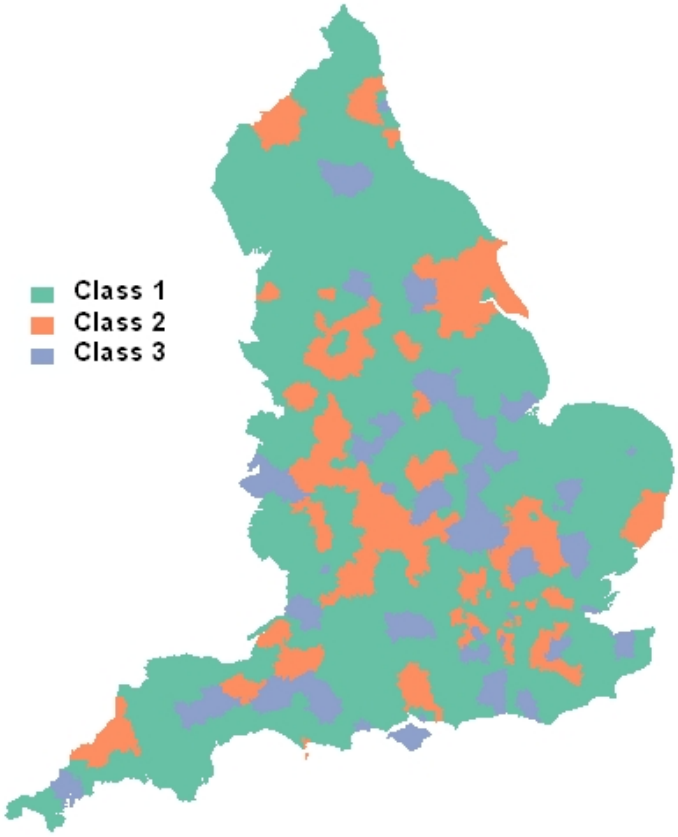
C) Geographical differences in brownfields regeneration

Table 3 reports the results of a latent class panel probit model estimated with three latent classes. The three classes, representing three groups of local authorities, were chosen according to the model minimising the Akaike Information Criterion. At the bottom of the table, the estimated prior probabilities for each class show that our sites are about 62% likely to belong to class 1, 22% to class 2 and 16% to class 3. Figure 2 reports a graphical representation of the three classes of the local authorities. This model allows us to better investigate the relationship between brownfield reuse and location of the sites. Class 2 shows that sites located in these local authorities have been following the recommendations of redeveloping brownfields to limit urban sprawl: sites in these local authorities are in fact more likely to be redeveloped when they are closer to the city centre and in metropolis. Also the sites from the local authorities of class 1 are more likely to be developed if they are located in metropolis, but they do not show do be affected by the distance to the city centre. Finally, urban, or rural location and distance to the city centre do not significantly determine the redevelopment of the sites in the local authorities of class 3.

Table 3. Latent class model with 3 latent classes

	Latent Class / Panel Probit Model					
	Class 1		Class 2		Class 3	
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Constant	3.2270	19.6710	3.4384	15.9070	4.2255	6.8890
EX_HOU	-3.7868	-30.2870	-2.4343	-16.8370	-1.8343	-6.8290
EX_COM	-4.4607	-35.2570	-2.6959	-18.8030	-2.8588	-11.1100
EX_IND	-4.5829	-36.7470	-3.0893	-21.9680	-2.9456	-11.7440
EX_AGRIC	-3.8865	-20.5050	-1.3541	-4.0150	-2.2422	-6.1660
EX_REC	-4.4170	-17.7140	-2.3077	-9.4620	-2.4359	-7.0790
EX_DER	-5.2905	-22.5450	-4.0012	-14.1330	-5.4450	-8.8270
EX_VAC_B	-4.7547	-24.9420	-3.3448	-12.4960	-12.3156	0.0000
EX_VAC_L	-4.5724	-32.1010	-4.8560	-21.2580	-4.7011	-15.4900
EX_UNUSE	-2.9516	-11.6230	-1.7996	-5.9800	-1.9054	-4.5840
SMALL	-0.0780	-1.1890	0.3435	4.9630	0.4369	4.4130
MEDIUM	-0.0957	-1.3590	0.0427	0.5770	0.1203	1.1630
HOUSE_SU	0.4619	8.2860	0.2765	4.9560	0.2696	2.8340
PRIVATE	0.4068	7.8840	0.3234	6.0340	0.1175	1.1560
CITY	0.0649	0.9940	0.0074	0.1010	0.0616	0.6040
METROPOL	0.2273	2.2810	0.2506	2.9000	0.0142	0.0450
POP_DENS	0.0004	0.2950	-0.0006	-0.3780	0.0071	2.4630
IMD_SCOR	-0.0041	-2.5180	-0.0130	-8.1930	-0.0076	-2.2290
DIST_50	-0.0243	-0.3750	-0.1670	-2.1650	0.0791	0.7390
DIST_75	-0.0091	-0.1260	-0.3408	-4.0500	-0.0479	-0.3990
EASTMIDL	-0.8506	-5.8720	-0.1856	-1.0980	-2.3428	-4.1810
EASTENGL	-0.6710	-4.6800	-0.2119	-1.2000	-2.3219	-4.1430
NW	-1.4833	-12.5370	-1.4333	-9.8060	-1.2723	-2.1410
NE	-1.2551	-8.0740	-1.2611	-8.1900	-1.2791	-2.1340
SE	0.1281	1.0590	0.4626	2.8270	-1.8411	-3.2840
SW	0.0571	0.4530	-0.7606	-4.5130	-1.1274	-2.0260
WESTMIDL	-1.2079	-8.0310	-0.9830	-6.9290	-0.5758	-1.0130
YORK_HUM	-1.5079	-10.9540	-1.6763	-10.3240	-1.8667	-3.4880
Estimated prior probabilities for class membership	Probability	t-statistic	Probability	t-statistic	Probability	t-statistic
	0.62	21.464	0.22	8.528	0.16	6.996
Log likelihood function		-5164.38				
McFadden Pseudo R-squared		0.21				
Akaike Information Criterion		0.51				
N		20345				

Figure 3. Three classes of local authorities estimated by the latent class model



6. Conclusions

This paper has looked at the determinants and barriers of brownfields redevelopment in England. An analysis of past decisions on the redevelopment of previously developed land shows that a panel data investigation that considers sites in the same local authorities as one group is an appropriate approach. The results highlight that the brownfield community has done some progress in redeveloping previously developed sites, but that some constraints still need to be overcome. The current goals of the government of building most new houses on brownfields is being achieved, but more resources, attention and specific policies are needed to redevelop difficult sites, such as large sites, sites that have previously been used for commercial

and industrial activities, sites that are located in the poorer and bleakest areas of cities and regions of England. It is finally interesting to highlight how the government does not seem to fully understand the opportunity cost of not developing publicly owned sites, as public ownership seems to be a constraint in regeneration. We therefore support the recommendations of the Barker Review (2006) to use policy instruments, such as introducing a charge on vacant and derelict brownfield land and a subsidy to help developers bring forward hard-to-remediate brownfield sites, but we also recommend that a specific set of policy instruments should be used to address publicly owned brownfields.

References

Adams D, and Watkins C, (2002) *Greenfields, Brownfields and Housing Development*, Blackwell Science, Oxford.

Alberini, A., A. Longo, S. Tonin, F. Trombetta, M. Turvani (2005) "The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers," *Regional Science and Urban Economics*, 35(4), 327-351.

Adams, D. (2004) "The changing regulatory environment for speculative housebuilding and the construction of core competencies for brownfield development" Environment and Planning A 36: 601-624

Adams, D., Disberry, A., Hutchison, N. and Munjoma, T. (2001) "Ownership constraints to brownfield redevelopment" Environment and Planning A 33: 453-477.

Alker S, Joy V, Roberts P, Smith N. (2000). "The definition of brownfield," *Journal of Environmental Planning and Management* 43(1): 49-69.

Bardos, R.P., Kearney, T.E., Nathanail, C.P., Weenk, A. and Martin, I.D. (2000) Assessing the Wider Environmental Value of Remediating Land Contamination paper for 7th International FZK/TNO Conference on Contaminated Soil "ConSoil."

Barker, K. (2006) "Barker Review of Land Use Planning. Final Report – Recommendations" HM Treasury, London, December.

Bartsch, C. and Collaton, E. (1997) Brownfields: Cleaning and Reusing Contaminated Properties. Westport, CT: Praeger

BURA (2006) Towards a National Strategy for Regeneration – A BURA Steering and Development Forum Report, British Urban Regeneration Association, May.

Cozens, P., Hillier, D. and Prescott, G. (1999) "The sustainable and the criminogenic: the case of new-build housing projects in Britain" Property Management 17 (3): 252-261

Dennison, M. (1998) Brownfields Redevelopment. Rockville, MD: Government Institutes

De Sousa, C.A. (2003) "Turning brownfields into green space in the City of Toronto" Landscape and Urban Planning 62 (4): 181-198

De Sousa, C.A. (2004) "The greening of brownfields in American cities" Journal of Environmental Planning and Management 47 (4): 579-600

DETR (2000) *Our Town and Cities: The Future - Delivering the Urban Renaissance*, Department of Environment, Transport and Regions, London.

DETR (2000a) Circular 02/2000, Contaminated Land: Implementation of Part IIA of the Environmental Protection Act 1990, Department of Environment, Transport and Regions, London.

DETR (2006) *Planning Policy Guidance Note 3: Housing*, Department of Environment, Transport and Regions, London.

Diamond, J. and J Liddle (2005) *Management of Regeneration*, Routledge, Oxon.

Dair, C.M. and K. Williams (2006) "Sustainable land reuse: the influence of different stakeholders in achieving sustainable brownfield developments in England," *Environment and Planning A*, 38: 1345-1366.

Dixon, T. and Doak, J. (2005) Actors and Drivers: Who and What Makes the Brownfield Regeneration Process Go Round? Paper presented to the SUBR:IM Conference, March 1st 2005

Dixon, T., Pocock, Y. and Waters, M. (2006) "An analysis of the UK development industry's role in brownfield regeneration" *Journal of Property Investment and Finance*, 24 (6): 521-541

Eisen, J.B. (1999) "Brownfields policies for sustainable cities" Duke Environmental Law and Policy Forum 9 (2): 187-229

English Partnerships (2003) "Towards a National Brownfield strategy" London: English Partnerships – The National Regeneration Agency.

English Partnerships (2006) "The Brownfield Guide: A practitioners' guide to land reuse in England" English Partnerships, London, October.

English Partnerships (2007) "National Brownfield strategy: Recommendations to Government" English Partnerships, London, June.

Greenberg, M., Lowrie, K., Mayer, H., Tyler Miller, K. and Solitare, L. (2001) "Brownfield redevelopment as a smart growth option in the United States" The Environmentalist 21: 129-143

Harrison, C. and Davies, G. (2002) "Conserving biodiversity that matter: practicioner' perspectives on brownfield development and urban nature conservation in London," *Journal of Environmental Management* 65: 95-108.

Meyer, P.B. and Lyons, T.S. (2000) "Lessons from private sector brownfield redevelopers" Journal of American Planning Association 66 (1): 46-57NLUD (2000) *Previously Developed Land (PDL) – Data specification, v2.2*, National Land Use Database, October, London.

NLUD (2003) *Land Use and Land Cover Classification, Version 4.4*, National Land Use Database, March, London.

ODPM (2004) *Index of Multiple Deprivation 2004*, Office of the Deputy Prime Minister, London, available at http://www.communities.gov.uk/index.asp?id=1128439

ODPM (2006) *National Land Use Database: Land Use and Land Cover Classification*, Office of the Deputy Prime Minister, February, London.

Roberts, P. and H. Sykes (eds.) (2000) *Urban Regeneration: A Handbook*, Sage Publications, London.

Schoenbaum, M. (2002) "Environmental contamination, brownfields policy, and economic redevelopment in an industrial area of Baltimore, Maryland", Land Economics, 78(1), pp. 60 – 71.

Syms, P. (2004) Previously Developed Land: Industrial Activities and Contamination. Second Edition. Blackwell Publishing, Oxford.

Urban Task Force (1999) "Towards an Urban Renaissance" London: Department of Environment, Transport and the Regions, Thomas Telford Publishing.

Urban Task Force (2005) "Towards a Strong Urban Renaissance" An independent report by members of the Urban Task Force chaired by Lord Rogers of Riverside (The Rogers' Report), available at www.urbantaskforce.org, November 2005.

Walker, G. (2000) "Urban planning, hazardous installations, and blight: an evaluation of responses to hazard - development conflict," *Environment and Planning C: Government and Policy*, 18: 127-143.

Wernstedt, K. (2004) Overview of Existing Studies on Community Impacts of Land Reuse. NCEE Working Paper 04-06,

Wernstedt, K., P.B. Meyer, and A. Alberini. (2006a). Incentives for Private Residential Brownfields Development in US Urban Areas. Journal of Environmental Planning and Management 49(1): 101-19.

Wernstedt, K., P.B. Meyer, and A. Alberini. (2006b). Attracting private investment to contaminated properties: The value of public interventions. Journal of Policy Analysis and Management 25(2): 347-69.