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The Economics of Conservation Areas

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Game of Zones: The Economics of Conservation Areas

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Abstract
Provided there are positive external benefits attached to the historic character of buildings, owners of properties in designated conservation areas benefit from a reduction in uncertainty regarding the future of their area. At the same time, the restrictions put in place to ensure the preservation of the historic character limit the degree to which properties can be altered and thus impose a cost to their owners. We test a simple theory of the designation process in which we postulate that the optimal level of designation is chosen so as to Pareto-maximize the welfare of local owners. The implication of the model is that a) an increase in preferences for historic character should increase the likelihood of a designation, and b) new designations at the margin should not be associated with significant house price capitalization effects. Our empirical results are in line with these expectations.

Keywords: Designation, Difference-in-Difference, RDD-DD, England, Gentrification, Heritage, Property Value
JEL classification: H23, H31, R40, R58

1 Introduction

One of the key motivations for a variety of spatial planning policies is how to solve coordination problems inherent to free markets. Wherever non-traded positive or negative non-pecuniary externalities exist, prices no longer provide efficient signals to market actors. In such a situation individually rational decisions may be collectively irrational which implies that it is theoretically possible to improve welfare by means of regulatory policies. Among such policies historic preservation that aims at the protection of historic buildings with a particular aesthetic, cultural or historic value, occupies a leading position in terms of the rigidity of the related regulations as well as the complexity of related social and private costs and benefits. The policy is controversial because the preservation of socially desirable buildings comes at the cost of restricting individual property rights. On the one hand, the policy would not be equitable if individual owners bore the cost of a presumed social welfare improvement. On the other hand, it can be argued that by imposing binding standards the policy helps to overcome a coordination problem among homeowners. Since owners can no longer "freeride" on the character of nearby buildings while making inappropriate changes to their own properties the policy helps to solve a so-called prisoner's dilemma and eventually benefits the owners (Holman & Ahlfeldt, 2012).

With this contribution we provide a framework to empirically analyze the practice of preservation policy and its impact on the utility of local homeowners. We develop a simple model world in which we distinguish between a *heritage effect*, which can be internal or external, i.e., the effect of the appearance of a historic building on the perceived value of the house itself (internal) or nearby houses (external), and a *policy effect*, which results from the legal treatment of the designation policy. We argue that with positive heritage effects, the policy benefits the owners by removing uncertainty regarding the future of the neighborhood, i.e., the presence of the heritage effect. These benefits are opposed by the costs of regulation (in the form of development restrictions and maintenance obligations) so that the net effect of the policy effect is ambiguous. Our theoretical framework predicts positive, but diminishing returns to designation. We consider the policy (locally) Pareto-efficient if the designation share is maximized under the condition that the benefits of designation do not exceed the costs for any owner in the neighborhood.

From the theoretical framework we derive two empirical specifications that allow us to test the nature and (local) welfare impact of the preservation policy. Firstly, provided that the planner behaves as an agent of the owners, new designation will result from increases in the local preferences for heritage. Secondly, a Pareto-optimal designation policy implies that at the margin, the costs and benefits of designation will offset each other, resulting in a zero impact of designation on the value of designated properties. At all other locations in a neighborhood the effect will be positive. We test these implications using two different empirical approaches. Firstly, we identify a causal effect of changes in neighborhood composition, what we define as gentrification, on the likelihood of designations using a tobit IV approach. Secondly, we use a hybrid difference-in-differences (DD) and regression discontinuity design (RDD) identification strategy to estimate the causal effect of new designations on the market value of properties. Our analysis is based on the whole of England, making use of 1 million property transactions from 1995 to 2010 and of about 8,000 designated conservation areas, of which 915 have been designated in the same observation period. We also make use of ward level education data from the UK census for 1991, 2001, and 2011 in order to analyze the effect of changing neighborhood characteristics on the designation status. Previewing our results we find that that an increase in the local share of residents holding a university or college degree leads to an expansion of the designated area. The property price effect inside newly designated conservation areas turns out not to be statistically distinguishable from zero. We find evidence that the effect just outside the conservation area boundary is positive and significant. These results are in line with a Pareto-optimal designation policy at the local neighborhood level, which can thus be argued to solve a coordination problem among homeowners (and landlords) within a neighborhood. We emphasize that it is not possible to conclude from these results that the policy is globally Pareto-optimal since excessive historic preservation on a wide scale may lead to adverse welfare impacts through supply restrictions as argued, for example, by Glaeser (2011).

Our analysis of the conservation area designation process adds to a growing body of literature on the political economy of housing markets, which implicitly or explicitly assumes that property owners are able to influence political outcomes in their own interest (e.g. Ahlfeldt, 2011; Ahlfeldt & Maennig, 2013; Brunner & Sonstelie, 2003; Brunner, Sonstelie, & Thayer, 2001; Cellini, Ferreira, & Rothstein, 2010; Dehring, Depken, & Ward, 2008; Fischel, 2001a, 2001b; Hilber & Mayer, 2009; Oates, 1969). We also contribute to a literature which investigates the costs and benefits of spatially targeted policies that aim at improving neighborhood quality (e.g. Cheshire & Hilber, 2008; Cheshire, Hilber, & Kaplanis, 2011; Hilber & Vermeulen, 2010; Rossi-Hansberg, Sarte, & Owens, 2010) as well as research that has looked into the value amenities add to neighborhoods and cities more generally (e.g. Ahlfeldt, Redding, Sturm, & Wolf, 2012;

Brueckner, Thisse, & Zenou, 1999; Cheshire & Sheppard, 1995; Edward L. Glaeser, Kolko, & Saiz, 2001). Notably, there is also a growing body of literature that is investigating the property price effects of designation policies, mostly focused on the U.S. (e.g. Asabere, Hachey, & Grubaugh, 1989; Asabere & Huffman, 1994; Asabere, Huffman, & Mehdian, 1994; Coulson & Lahr, 2005; Coulson & Leichenko, 2001; Edward L Glaeser, 2011; Leichenko, Coulson, & Listokin, 2001; Noonan & Krupka, 2011; Schaeffer & Millerick, 1991).

The key contribution of this study is to provide insights into the political economy of conservation area designation and to examine whether the outcome is Pareto-efficient for local homeowners. We also make a number of more specific, though still important contributions. Firstly, the theoretical framework we develop lends a structure to the designation process that helps to interpret the existing evidence that has typically been derived from ad-hoc empirical models. Secondly, our analysis of conservation area effects on property prices is one of the few rigorous analysis of this kind available for Europe (e.g. Ahlfeldt & Maennig, 2010; Koster, Van Ommeren, & Rietveld, 2012; Lazrak, Nijkamp, Rietveld, & Rouwendal, 2013) and the first to analyze England. It is unique in terms of the size and spatial detail of the data set and special in its focus on the spatial modeling of heritage externalities. Thirdly, our difference-in-differences analysis of the designation effects on property prices is the only study along with Koster at al. (2012) that uses a quasi-experimental research design to separate the policy effect of designation from correlated location effects. It is unique in using particularly carefully selected control groups. Fourthly, we make use of a novel combination of RDD and DD approaches to identify the policy effects on outcome trends and discontinuities from quasi-experimental variation, which could be applied more generally to program evaluations. Fifthly, we provide the first empirical analysis of the determinants of heritage designation. More generally, we establish a novel connection between the spatial outcome of a political bargaining process and one of the most striking contemporary urban phenomena: gentrification.

The structure of the paper is as follows. The next section introduces our theoretical model of heritage designations and the institutional setting. Section three presents our empirical strategy. A presentation and discussion of our empirical results is in section 4. The last section concludes.

2 Theory and context

2.1 Theoretical Framework

We assume that a linear neighborhood exists along a spatial dimension x on the interval [0,1]. Each parcel of land at point x is occupied by a housing structure which is endowed with $h(x)$ units of internal heritage. The aggregate of the distribution of internal heritage gives the heritage character (external heritage) H of the neighborhood at any point in time. Owners care about their *initial endowment* of internal heritage $h(x)$, which is under their full control, and the *long run* external heritage, which may be damaged by their neighbors' property (re)developments. Such redevelopments occur in the long run with a probability of $(1-\pi)$ where $0 \leq \pi < 1$ is the 'preservation probability' in the absence of conservation policies. The effect of conservation areas is to increase the preservation probability to 1 for parcels of land within their boundaries.[1] Therefore, long-run external heritage depends on both the internal heritage distribution and the level of designation.

Within the neighborhood, the initial internal heritage monotonically decreases in x. The theoretical argument does not depend on the functional form. For simplicity we assume $h(x)$ to be a linear function of the heritage endowment at the neighborhood's center (h_0):

$$h(x) = h_0(1-x) \tag{1}$$

One way to rationalize this distribution is to assume a neighborhood that grew outwards from its historical center (at $x = 0$) until the neighborhood limit (at $x = 1$) and an internal heritage that strictly increases in the age of the housing unit.[2]

To protect the neighborhood heritage, a planner can choose to designate a conservation area that covers all locations in the neighborhood from the historical center up to a point $x = D$ and hence, a share $0 \leq D \leq 1$ of the neighborhood. Since heritage is monotonically decreasing in x it is always rational to start designating at $x = 0$. By affecting the preservation probability, the designation share D determines the external heritage amount to be expected in the long run. The expected long-run external heritage derived from undesignated locations $(x > D)$ corre-

[1] Our argument does not depend on the assumption of full preservation probability, only that preservation is *more likely* inside conservation areas.

[2] Alternatively, x can simply be interpreted as the rank of a property in the heritage distribution.

sponds to the integral of the distribution of internal heritage multiplied by the preservation probability, $\int_D^1 \pi h(x)\, dx$. This is added to the amount derived from designated locations ($x \leq D$), which is simply the integral of the internal heritage as the preservation probability is equal to one, $\int_0^D h(x)\, dx$.

$$E[H|D] = \int_0^D h(x)\, dx + \int_D^1 \pi h(x)\, dx \quad (2)$$

$$E[H|D] = h_0\left(1 - \frac{D}{2}\right)D + \frac{\pi}{2} h_0 (1 - D)^2 \quad (3)$$

The expected external heritage integral $E[H|D]$ is indicated by the whole grey-shaded area in Fig. 1. below. The expected amount of external heritage saved by the preservation policy is illustrated as the black-dotted area $\breve{H}$ which denotes the difference in (expected) external heritage between a scenario with no designation and a scenario with a designation share D. This amount is:

$$\breve{H} = h_0(1 - \pi)\left(1 - \frac{D}{2}\right)D \quad (4)$$

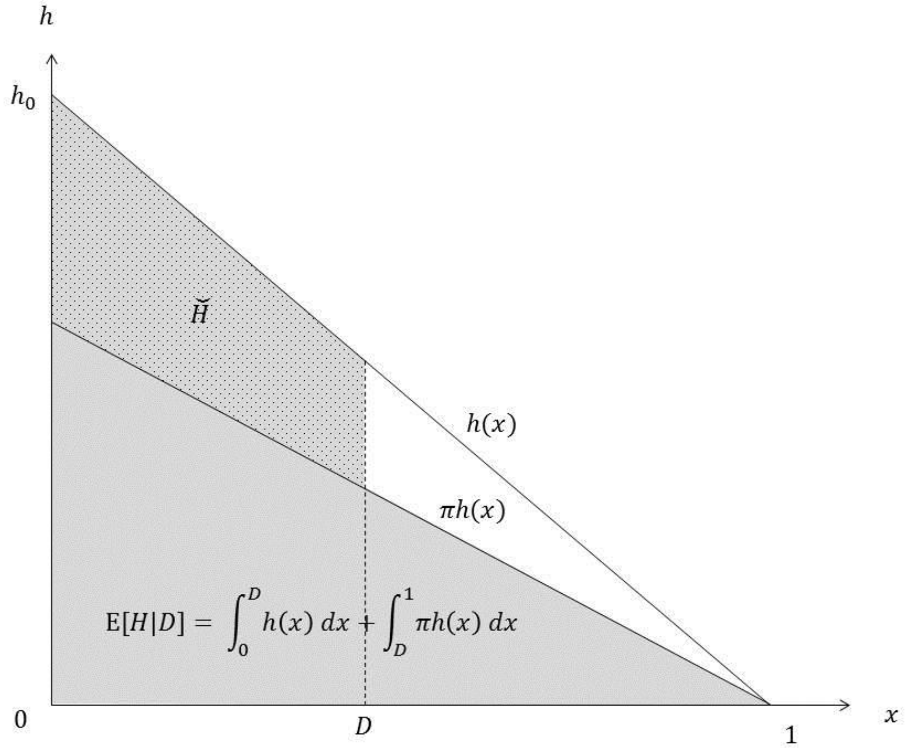
As evident from the partial derivatives, the amount of external heritage saved by the policy increases with the designation share but at a decreasing rate:

$$\frac{\partial \breve{H}}{\partial D} = \frac{\partial E[H|D]}{\partial D} = h_0(1 - D)(1 - \pi) > 0 \quad (5)$$

$$\frac{\partial^2 \breve{H}}{\partial D^2} = \frac{\partial E[H|D]}{\partial D} = -h_0(1 - \pi) < 1 \quad (6)$$

The partial derivatives of $\breve{H}$ (which are the same as of H) with respect to D establish a central stylized fact of our theory: There are diminishing returns to designation.

Fig. 1. Expected heritage distribution with partial designation



Notes: The function $h(x)$ gives the internal heritage at each location in the neighborhood. The expected external heritage is equal to the grey-shaded area and is the integral of $h(x)$ up to the designation share plus the integral of π times this $h(x)$ from the designation share until the neighborhood limit at $x = 1$. The stippled area marked $\breve{H}$ is the amount of expected external heritage preserved by the policy.

To link the distribution of heritage in the neighborhood to the utility U of an individual residing at x we define a utility function:

$$U(x) = A(x)X^{\delta}L^{1-\delta} \tag{7}$$

where X is a composite consumption good and L is housing space. The Cobb-Douglas form is motivated by the empirical observation that housing expenditure shares tend to be relatively constant across geographies and population groups (Davis & Ortalo-Magné, 2011). $A(x)$ is a composite amenities term:

$$A(x) = a(x)e^{\varphi h(x)}e^{\gamma E[H|D]}e^{-c\widetilde{D}(x)} \tag{8}$$

where a is a further composite indicator of m non-heritage amenities,[3] $h(x)$ is the internal heritage endowment (i.e., heritage character of the specific housing unit), φ is the internal heritage preference parameter, $E[H|D]$ is the external heritage (i.e., expected heritage of surrounding units, which depends on the designation policy) and is conditional on the designation share as defined above, γ is the external heritage preference parameter, and c represents the costs of designation policies, which arise from the development restrictions imposed inside conservation areas. The cost to an individual is $e^{-c\widetilde{D}(x)}$ and depends on the local designation status $\widetilde{D}(x)$, a binary function of x, which takes the value of one if $x \leq D$ and zero otherwise.

We assume a social planner seeking a Pareto-efficient designation share, which in the model implies maximizing the designation share (and the external heritage effects) on the condition that by designation the utility is not reduced at any location in the neighborhood.

The positive marginal utility effect of designation at any location in the neighborhood is given by:

$$\frac{dU(x)}{dD} = \frac{\partial U}{\partial E[H|D]} \frac{\partial E[H|D]}{\partial D} = \gamma U(x) h_0 (1-D)(1-\pi) \quad (9)$$

The negative utility effect to an owner of a property changing designation status from zero to one is:

$$\frac{dU(x)}{d\widetilde{D}(x)} = \frac{\partial U}{\partial \widetilde{D}(x)} = cU(x) \quad (10)$$

By setting the social marginal benefit equal to the private marginal cost of an affected owner the planner finds the Pareto-efficient designation share D^* by solving for D:

$$D^* = 1 - \frac{c}{(1-\pi)\gamma h_0} \quad (11)$$

Based on the resulting efficiency condition we can derive some useful comparative statics (see also Figure A1 in the Appendix). The (Pareto) optimal designation share is greater when people have a greater taste for external heritage γ or where there is altogether more heritage (determined by the heritage endowment at the neighborhood center h_0, and implicitly the age of the neighborhood):

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[3] Non-heritage amenities are given by: $a = b \prod_m \mathrm{a}_m{}^{\rho_m}$ where the different amenity levels are denoted a_m and are given a collective scaling factor b and individual parameters ρ_m.

$$\frac{\partial D^*}{\partial \gamma} > 0 \tag{12}$$

$$\frac{\partial D^*}{\partial h_0} > 0 \tag{13}$$

There is less optimal designation when the preservation probability π (if left undesignated) increases or if the cost of designation increases:

$$\frac{\partial D^*}{\partial \pi} < 0 \tag{14}$$

$$\frac{\partial D^*}{\partial c} < 0 \tag{15}$$

These theoretical implications are in line with intuition and can in principle be transformed into empirically testable hypotheses. However, the heritage at the neighborhood center h_0, the preservation probability π and the costs to owners of conservation policies c are all difficult to observe in reality. For that reason we will concentrate on testing the first comparative statics implication about taste for heritage (proxied by the education level of the local population) in the empirical section.

To develop a testable hypothesis on whether the efficiency condition is fulfilled, i.e., the planner sets $D = D^*$, we incorporate capitalization effects in the next step. We first assume that individuals maximize their utility defined above subject to a budget constraint: $W = X + \theta(x)L$, where $\theta(x)$ is a housing bid rent. Furthermore we assume spatial equilibrium such that all locations offer the same level of utility $\bar{U}$ which we set equal to one:

$$U(x) = A(x)[\delta W]^{\delta}[(1-\delta)\frac{W}{\theta}]^{1-\delta} = \bar{U} = 1 \tag{16}$$

This can be rearranged to give the spatial equilibrium bid rents for a representative individual:

$$\theta(x) = (1-\delta)\left[\delta^{\delta} W a(x) e^{\varphi h(x)} e^{\gamma E[H|D]} e^{-c\tilde{D}(x)}\right]^{\frac{1}{1-\delta}} \tag{17}$$

In keeping with intuition, the bid rent increases in the expected external heritage, which depends on the designation share D and the internal heritage endowment $h(x)$ and decreases in the designation cost, which is locally constrained to $x \leq D$ as defined above.

The spatial equilibrium condition can be used to derive the marginal effect of an increase in designation share on rents in the neighborhood. At all locations in the city a marginal increase in designation share D triggers a positive effect on rent through an increase in the expected external heritage. At the margin, in addition, the change in designation status $\widetilde{D}$ also creates a cost.

$$\frac{d\theta(x)}{dD} = \begin{cases} \frac{\partial\theta(x)}{\partial E[H|D]}\frac{\partial E[H|D]}{\partial D} + \frac{\partial\theta(x)}{\partial\widetilde{D}(x)}d\widetilde{D}(x)\ if\ x = D \\ \frac{\partial\theta(x)}{\partial E[H|D]}\frac{\partial E[H|D]}{\partial D}\ if\ x \neq D \end{cases} \quad (18)$$

Substituting in the Pareto optimal designation share $D = D^*$ derived above we get:

$$\frac{d\theta(x)}{dD} = \begin{cases} \frac{\theta(x)}{1-\delta}\left[\gamma h_0\left(1 - 1 + \frac{c}{(1-\pi)\gamma h_0}\right)(1-\pi) - c\right] = 0\ if\ x = D \\ \frac{\theta(x)}{1-\delta}\left[\gamma h_0\left(1 - 1 + \frac{c}{(1-\pi)\gamma h_0}\right)(1-\pi) - c\right] = \frac{\theta(x)}{1-\delta}\ if\ x \neq D \end{cases} \quad (19)$$

The two conditions directly translate into two testable hypotheses. If the designation process is in reality Pareto optimal, we expect the marginal effect of designation on housing rents to be zero at newly designated locations and to be positive at all other locations in the neighborhood. Likewise, an excessive or restrictive designation policy will be associated with negative or positive marginal designation effects.

Assuming that the preservation probability (if undesignated) and the preservation costs are held constant our theory predicts that, in equilibrium, (Pareto optimal) designations occur as a result of an increase in the benefits associated with (external) heritage. Such increases in benefits will occur mechanically over time if the internal (and thus the external) heritage depends on housing age. The effective benefits will also increase as a result of neighborhood turnover, if the in-migrating residents have larger heritage preferences than the incumbents. Designation then becomes a collateral effect of 'gentrification'. The older the conservation area, the greater the accrued benefits of designation may be.

Contrary to the assumption in our theory there is evidence suggesting that heritage externalities (Ahlfeldt & Maennig, 2010; Holman & Ahlfeldt, 2012) or housing externalities more generally (Rossi-Hansberg, et al., 2010) decline quite steeply in distance. The implication is that at the center of a conservation area, where the effective external heritage is largest, the marginal designation benefit will be larger than at the margin. We justify our simplified theory on the grounds that most conservation areas are small in reality even compared to the narrow scope of housing externalities. Moreover, we allow designation effects to vary in distance to the conservation area boundary and provide estimates of designation effects at the boundary, the critical point for Pareto-efficiency as the policy benefits are presumably at their lowest.

2.2 Institutional context

In England, the designation of conservation areas started in 1967 and continues today under the provisions 69 and 70 of the Planning Act 1990 (Listed Buildings and Conservation Areas).[4] Conservation areas are those that have been identified as having "special architectural or historic interest, the character or appearance of which is desirable to preserve or to enhance" (Section 69). The Planning Policy Guidance Note 15 (PPG15) states that a conservation area "may form groups of buildings, open spaces, trees, historic street patterns, village greens or features of historic or archaeological interest. It is the character of the areas rather than individual buildings that conservation areas seek to enhance." Conservation areas are designated on the grounds of local and regional criteria. After the designation, the Local Authority has more control over minor developments and the demolition of buildings (Botrill, 2005). However, the protection an area receives when it is designated a conservation area is determined at the national level to reflect the wider interests of society.

In 2011 there were around 9,800 conservation areas in England. Conservation areas vary in character and size. Many have strong historical links, for example an architectural style associated with a certain period. Besides these characteristics, designation is made based on softer benefits said to have emanated from conservation area designation including: the creation of a unique sense of place-based identity, encouraging community cohesion, and promoting regeneration (HM Government, 2010).[5] This 'instrumentalization' of conservation policy, which seeks to encompass heritage values, economic values, and public policy outcomes, has been identified as a key shift in the English policy context (Pendlebury, 2009; Strange, 2003). This is reflective of the notion of heritage not as a single definable entity, but as a political, social, cultural, and economic "bundle of processes" (Avrami, 2000cited in Pendlebury, 2009: 7).

4 However, the first legislation to protect the historic environment was enacted in 1882 when the Ancient Monuments Protection Act was passed to protect a small number of designated ancient monuments. More statutory measures came into force in the ensuing years, but it was the passage of the Ancient Monuments Consolidation and Amendment Act in 1913 that set out a more comprehensive legislative framework for the protection of ancient monuments.

5 See for details HM Government (2010): *The Government's Statement on the Historic Environment for England*. London: DCMS.

In combination with bottom-up schemes leading to designation (e.g., community-led designation), the complex heritage preservation agenda which pursues a multitude of objectives and the institutional setting with responsibilities shared across several institutional layers creates significant scope for organized interest groups like property owners to influence the outcome of a political bargaining process.

3 Empirical Strategy

3.1 Designation process

The first potentially testable implications of our theoretical model are the partial derivatives (12) to (15). As mentioned in the theory section it is difficult to find feasible proxies for the variables π, c and h_0. We therefore concentrate on testing the first of these conditions, i.e., the 'taste' for heritage γ has a positive effect on optimal designation share D^* in a neighborhood. We adopt the common assertion that the demand for urban consumption amenities increases in education and income (Brueckner, et al., 1999; Carlino & Saiz, 2008; Edward L. Glaeser & Gottlieb, 2006; Shapiro, 2006; van Duijn & Rouwendal, 2013). In particular, we assume that the preference for heritage γ_n in a neighborhood n is related to the share of people in the neighborhood who hold a higher education certificate (DEG_i)[6] with the following functional form:

$$\gamma_{nt} = {DEG_{nt}}^{\vartheta} e^{-\varepsilon_{nt}} \tag{20}$$

where $\vartheta > 0$ such that the relationship is positive. Since the purpose of our empirical exercise is to evaluate the causal impact of changes in heritage preferences on designation status – and not the causal impact of education on heritage preference – it is sufficient to assume that ϑ captures a correlation between education and heritage preferences. ε_{nt} is a random disturbance term capturing determinants of heritage preferences that are not correlated with education. Rearranging the Pareto-efficient designation share equation (11), substituting the education degree proxy relationship and taking logs we arrive at the following empirical specification:

$$\log(1 - D_{nt}) = \alpha - \vartheta \log(DEG_{nt}) - \omega_n + \varepsilon_{nt} \tag{21}$$

$$\text{where } \alpha = \log(1 - \pi) - \log(c) \text{ and } \omega_n = \log(h_{0n}) + l_n. \tag{22}$$

[6] We also use income as a proxy for a subsample of our data set – results are reported in the appendix.

The n subscripts correspond to the individual 'neighborhoods' of our theoretical model and we choose to represent these empirically as UK Census wards. Wards are the smallest geographical areas that are comparable between 1991 and 2011 Censuses. Subscript t stands for time periods for which we use the Census years of 1991 and 2011. All idiosyncratic time-invariant location components l_n (location-specific determinants of designation not modeled in our theory) and the unobserved heritage endowment h_{0n} of a neighborhood n as captured by ω_n as well as the preservation probability π and the costs to owners of conservation policies are removed by taking first-differences:

$$\Delta \log(1 - D_n) = \Delta\alpha - \vartheta\, \Delta \log(DEG_n) + \Delta\varepsilon_n \quad (23)$$

Our estimation equation now depicts that a neighborhood change reflected in a positive change in (log) educational degree share causes the (logged) share of undesignated land on the left-hand side to decrease. This is just another way of saying that a positive change in educational degree leads to a higher designation share, although the transformation is non-linear. Note that we implicitly assume that we are in equilibrium in the sense that all areas that should be designated at t are in fact designated. To support the case, we estimate our model using a long difference between 1991 and 2011, which is more than two decades after the start of the policy and the initial wave of designations. Results for the smaller differences between 1991–2001, and 2001–2011 respectively, are reported in the appendix.

Equation (23) evidently follows from a stylized model world. In the empirical implementation we add a number of covariates to control for alternative determinants of designation. The ongoing designation is then only determined by the local changes in preferences and the steady aging of buildings and the effects on heritage, which are differentiated out. To control for the contagion effects in designation we add the initial (1991) designation share. A number of variables are added to account for heterogeneity in the net benefits of designation and abilities to express (collective) opinions in a political bargaining that may influence the designation decision. These include the initial (1991) degree share, the homeownership rate, and the household size (both in initial shares and changes). We alter the baseline model in a number of robustness checks to account for institutional heterogeneity at the TTWA level, neighborhood appreciation trends and, to the extent possible, the historic and physical quality of the housing stock.

In practice, however, it is difficult to control for all determinants of designation that are external to our model. One particular concern is that areas can be designated if the heritage is threatened by poor maintenance in a declining neighborhood. Such derelict is likely to be negatively correlated with our explanatory variable and is unlikely to be fully captured by the control variables we have at hand. At the same time, the policy itself could make it more likely that educated people are attracted to designated areas due to a different valuation of uncertainty (reverse causality). Since an OLS estimation of equation (23) can result in a significant bias in either direction we make use of instrumental variables z_n, which predict changes in education, $\rho(z_n, \Delta\log DEG_n) \neq 0$, but must be conditionally uncorrelated with the differenced error term, $\rho(z_n, \Delta\varepsilon_{nt}) = 0$. We argue that rail station (in London additionally Tube station) density as well as effective employment accessibility (both time-invariant in levels) are good predictors of neighborhood gentrification (Florida, 2002; Edward L. Glaeser, et al., 2001).[7] We also argue that it is unlikely that these level variables directly impact on the likelihood of designation conditional on the unobserved heritage endowment in the fixed effects ω_n.

Another empirical concern is that, theoretically, a decrease in preferences for heritage must provoke a reduction of the designated area. The abolishment of conservation areas, however, is extremely rare in England (as in most institutional contexts) so our data is left-censored (we do not observe increases in the share of undesignated land). We therefore take the model to the data using a tobit approach:

$$Y_n^* = \Delta\alpha - \vartheta\,\Delta\log(DEG_n) + \Delta\varepsilon_n, \qquad \Delta\varepsilon_n \sim N(0, \sigma^2) \tag{24}$$

, where $Y_n^* = \Delta\log(1 - D_n)$ is a latent variable and the observed variable is defined as follows

$$Y_n = \begin{cases} Y_n^*, & if\ Y_n^* = \Delta\log(1 - D_n) \ < 0 \\ 0, & if\ Y_n^* \qquad\qquad\qquad \geq 0 \end{cases} \tag{25}$$

[7] Our measure of effective employment accessibility aggregates employment in surrounding regions weighted by distance. We use exponential distance weights that are popular in the theoretical (Fujita & Ogawa, 1982; Rossi-Hansberg, et al., 2010) and empirical literature (Ahlfeldt, et al., 2012; Ahlfeldt & Wendland, 2013) and the decay parameter estimate provided by Ahlfeldt (2013). Transport infrastructure is captured by a kernel density measure (Silverman, 1986) with a radius of 2 km which is considered to be the maximum distance people are willing to walk (Gibbons & Machin, 2005).

3.2 Pareto optimality

To test whether the designation share in practice is set at the (locally) Pareto-optimal level (D^*) we estimate the effect of the event of designation on property prices within and surrounding conservation areas. In its essence our quasi-experimental methods are a derivative of the established difference-in-differences (DD) methodology (e.g. Bertrand, Duflo, & Mullainathan, 2004). We draw elements of the increasingly popular regression discontinuity designs (RDD) (Imbens & Lemieux, 2008), however, to relax the DD assumptions of homogeneous trends and a singular treatment date to separate smooth variation (e.g., externalities) and discontinuities (e.g., policy zones) in treatment effects from correlated unobservables.

Difference-in-differences

We define a group of 912 'treated' conservation areas as those that were designated between the years 1996 and 2010 to ensure we observe property transactions both before and after the designation date. Our counterfactuals are established via various control groups of housing units that are similar to the treated units but are themselves not treated. These control groups are discussed in more detail in the results section and in the appendix (Section A2.2).

Our baseline DD model takes the following form:

$$p_{it} = \beta^I I_i + \beta^E E_i + \beta^{IPost}(I_i \times Post_{it}) + \beta^{EPost}(E_i \times Post_{it}) + X_i'\mu + f_n + Y_t + \epsilon_{it} \qquad (26)$$

where p_{it} is the natural logarithm of the transaction price for property i in time period t, I_i is a dummy variable equal to one if the observation is internal to a treated conservation area, E_i indicates observations external to the treated CA. While our standard models use a buffer area of 500m we also experiment with various alternative spatial specifications. $Post_{it}$ is a dummy variable indicating whether the transaction year t is equal to or greater than the designation year, X_i is a vector of controls for property, neighborhood and environmental characteristics, f_n is a set of n location fixed effects and Y_t are year effects. The β^{IPost} and β^{EPost} parameters give the difference-in-differences estimates of the designation effect on the properties within and just outside a conservation area. We show in Appendix 2.2 that β^{IPost} is equal to the net marginal policy (designation costs and benefits) effect while β^{EPost} reflects the pure (albeit spatially discounted) policy benefit.

Temporal regression discontinuity design of differences (RDD-DD)

The standard DD specification (26) identifies the policy treatment effect under some arguably restrictive assumptions. Firstly, the treatment and control groups follow the same trend before and after the treatment. Secondly, the treatment occurs at a singular and *a priori* known date and affects the level (and not the trend) of the outcome variable. These assumptions are evidently violated if the outcome variable does not respond immediately to the treatment, e.g., because of costly arbitrage, or in anticipation of the treatment, for example because of an investment motive by buyers (Ahlfeldt & Kavetsos, 2013). In our case, a positive pre-trend can also be associated with the gentrification that causes designation according to our theoretical model, a reverse causality problem.

To address these limitations of the standard DD we refine the model to accommodate differences in trends across the treatment and the control group. We borrow the functional form from the RDD literature where a (temporal) treatment effect is identified as an instant adjustment – a discontinuity – conditional on higher order polynomial (pre- and post-) trends, which are assumed to be unrelated to the treatment (Bento, Kaffine, & Roth, 2010). In our regression discontinuity design of differences (RDD-DD) we combine an RDD-type polynomial specification of trends with the control group-based counterfactual from the DD. It is therefore possible to attribute pre- and post-trends to the treatment as long as it is credible to assume that treatment and control groups would have followed the same trend in the absence of the treatment. It is notable that even if this assumption is violated the RDD-DD (unlike the standard RDD) will at least remove macro-economic shocks from the treatment effect by taking differences from the control group. This improves identification so long as the control group remains unaffected by the treatment. Our RDD-DD with linear trends takes the following form:

$$\begin{aligned} p_{it} = {} & \beta^{I} I_i + \beta^{IYD}(I_i \times YD_{it}) + \beta^{E} E_i + \beta^{EYD}(E_i \times YD_{it}) + \beta^{IPost}(I_i \times Post_{it}) \\ & + \beta^{IPostYD}(I_i \times Post_{it} \times YD_{it}) + \beta^{EPost}(E_i \times Post_{it}) \\ & + \beta^{EPostYD}(E_i \times Post_{it} \times YD_{it}) + X_i'\mu + f_n + Y_t + \epsilon_{it} \end{aligned} \quad (27)$$

where YD_{it} is the number of years since the designation date, with the pre-designation years having negative values. As in the RDD, the polynomial degree of the trend can be increased subject to sufficient degrees of freedom. We make use of a quadratic trend specification and evaluate the fit of the parametric polynomial function using a semi-parametric version of (27) that replaces the YD_{it} variables with full sets of years-since-designation effects (details in the appendix).

A significant 'dis-in-diff' parameter (β^{IPost} or β^{EPost}) can be entirely attributed to the treatment even under the existence of complex relative trends that are unrelated to the treatment or may even have caused the treatment as the comparison is made just before and just after the treatment date. Under the assumption of homogeneous counterfactual trends the significant pre-trend parameters (β^{IYD} or β^{EYD}) describe the anticipation effects. Significant post-trend parameters ($\beta^{IPostYD}$ or $\beta^{EPostYD}$) then indicate changes in relative trends after the treatment. In conjunction, the 'dis-in-diff' and the pre- and post-trend parameters describe the full temporal structure of the treatment effect. As a program evaluation tool that is applicable to a variety of event studies, the RDD-DD thus naturally comes with a stronger test (dis-in-diff) and a weaker test (trends) of whether there exists an effect of the treatment.

Spatial regression discontinuity design of difference-in-differences (RDD-DD)

In contrast to our theory, in reality there most likely exists a spatial decay to the heritage externalities. This decay implies that the external heritage effect should be stronger at the center of the conservation area than at the boundaries. The policy benefit, which is a transformation of the external heritage effect, should also be greater at the center of the newly designated conservation area. Likewise, the predicted positive policy effects just outside the boundary should be decaying in distance to the conservation area (CA) boundary. At the CA boundary there may be a discontinuity as the cost of the policy ends abruptly at the boundary, whereas potential externalities decay smoothly across it. The combination of trends and discontinuities potentially caused by the treatment resembles the temporal identification problem just described and will be addressed by a similar combination of RDD and DD tools. Essentially, we use the RDD tools to capture how the difference (before and after) in the differences (treatment vs. control) of property prices varies along the (internal and external) distances from the CA boundary. Unlike in the standard (spatial) RDD, unobserved time-invariant spatial effects can be held constant due to the availability of spatiotemporal variation. In our spatial RDD-DD model it is therefore possible to attribute spatial trends (with respect to distance to the CA boundary) as well as a discontinuity (at the CA boundary) to the treatment provided that the spatial trends are uncorrelated with unobserved temporal trends. The spatial RDD-DD we estimate takes the following form:[8]

$$p_{it} = \beta^{I}T_i + \beta^{ID}(T_i \times D_i) + \beta^{IPost}(T_i \times Post_{it}) + \beta^{IDPost}(T_i \times D_i \times Post_{it}) + \beta^{E}O_i + \beta^{OD}(O_i \times D_i) + \beta^{OPost}(O_i \times Post_{it}) + \beta^{ODPost}(O_i \times D_i \times Post_{it}) + X_i'\mu + f_n + Y_t + \epsilon_{it} \quad (28)$$

where D_i is the distance from the property to the conservation area boundary (internal distances are negative values), O_i indicates properties outside a treated conservation area and T_i indicates the conservation area that is nearest to a property that is treated at any point of the study period. In order to fully explore the extent of spatial externalities O_i indicates a larger area outside CAs[9] rather than just within 500m as indicated by E_i in previous models. As with the temporal RDD-DD specification we also estimate an expanded model specification in which we allow for quadratic distance trends and semi-nonparametric specifications replacing the distance variable with some distance bin effects.

The coefficient β^{IPost} gives the intercept of the internal effect (i.e., the internal effect at the boundary) and β^{IDPost} estimates how this changes with respect to internal distance. Jointly, these terms capture the net policy costs and benefits of designation for internal treated areas. A zero β^{IPost} coefficient would be reflective of a zero effect at the boundary and would be in line with the optimality condition derived in the theory section. A negative β^{IDPost} would be in line with the existence of policy benefits (due to increased preservation probability) that spillover with decay. The parameters β^{EPost} and β^{EDPost} allow for a spatial discontinuity treatment effect at the boundary and heterogeneity in spatial trends inside and outside the treated areas. As with β^{IDPost}, a jointly negative $\beta^{IDPost} + \beta^{EDPost}$ would be in line with the decaying policy benefits external to the conservation area. The discontinuity at the border is measured by the external intercept term β^{EPost}. A statistically positive estimate would indicate a cost to the policy. A jointly positive effect of $\beta^{IPost} + \beta^{EPost}$ would in turn indicate the existence of policy benefits.

[8] In models with historical CAs as control groups the following terms are also included $\beta^{CD}(C_i \times D_i) + \beta^{EC}EC_i + \beta^{ECD}(EC_i \times D_i)$, where C_i indicates internal to control CA and EC_i external to control CA. This ensures that spatial effects are estimated conditional on the spatial trends in control CA.

[9] Specifically, the empirical analysis uses properties within 1,400m of the treated conservation area.

4 Data

We have compiled two distinct data sets for the two stages of the empirical analysis. Both data sets make use of data provided by English Heritage. These include a precise GIS map of 8,167 conservation areas in England, the Conservation Areas Survey containing information on community support and risk status (average condition, vulnerability and trajectory of a conservation) and a complete register of listed buildings.

For the analysis of the determinants of designation we use UK census wards as a unit of analysis. Shares of designated land within each Census ward are computed in a Geographical Information Systems (GIS) environment. Various ward level data on educational level, average household size and homeownership status and vacancy rate were obtained from the UK Census. Any changes in ward boundaries between the years were corrected for using the online conversion tool GeoConvert.[10] For robustness tests we also collected a measure of the ward's average income (Experian). The instrumental variables station density and employment potential are regenerated data that stem from nomis (workplace employment) and the Ordinance Survey (rail stations).

For the analysis of the capitalization effects of designation we use transactions data related to mortgages granted by the Nationwide Building Society (NBS) between 1995 and 2010. The data for England comprise 1,088,446 observations and include the price paid for individual housing units along with detailed property characteristics. These characteristics include floor space (m^2), the type of property (detached, semi-detached, flat, bungalow or terraced), the date of construction, the number of bedrooms and bathrooms, garage or parking facilities and the type of heating. There is also some buyer information including the type of mortgage (freehold or leasehold) and whether they are a first-time buyer. Importantly, the transaction data includes the full UK postcode of the property sold allowing it to be assigned to grid-reference coordinates.

With this information it is possible within GIS to calculate distances to conservation area borders and to determine whether the property lies inside or outside of these borders. Furthermore, it is possible to calculate distances and other spatial measures (e.g., densities) for the

[10] http://geoconvert.mimas.ac.uk/

amenities and environmental characteristics such as National Parks, as well as natural features like lakes, rivers and coastline. The postcode reference also allows a merger of transactions and various household characteristics (median income and ethnic composition) from the UK census, natural land cover and land use, various amenities such as access to employment opportunities, cultural and entertainment establishments and school quality. A more detailed description of all the data used is in the appendix.

5 Empirical Results

5.1 Designation process

Table 1 reports the results of our tobit model of the designation process defined in equation (24). The non-instrumented baseline model is in column (1). As predicted by our theory, increases in educational levels that are presumably correlated with heritage preferences are associated with reductions in the share of undesignated land. More precisely, an increase in the degree share by 1% is associated with a 0.12% reduction in the share of undesignated land. This decrease corresponds to an $0.12\% \times (1-\overline{D}_{t-1})/\overline{D}_{t-1} = 2.61\%$ increase in the share of designated land for a ward with the mean of the positive initial designation shares $\overline{D}_{t-1} = 4.4\%$. The effect substantially increases once we instrument the change in degree share using rail station density and employment potential (column 2). This increase is in line with unobserved (positive) deterioration trends that a) increase the likelihood of designation and b) are negatively correlated with changes in degree share. Introducing the instruments, the effect of a 1% increase in degree share on the share of undesignated land increases to 0.52%, which for a ward with the mean initial designation share $\overline{D}_{t-1}$ corresponds to an increase in the designated land share of about 11%. While we have argued that our estimates are supposed to reflect a causal estimate of gentrification (proxied by degree shares) on designation probabilities and not necessarily a causal effect of degree share on designation share, a parameter estimate of $\hat{\vartheta} = 0.52$ is at least indicative of heritage preferences increasing relatively steeply in education.

In a series of robustness checks columns (3) to (5) in Tab. 1 provide variations of the benchmark model (2). We add TTWA effects to control for unobserved institutional heterogeneity in column (3). Column (4) adds a measure of property price appreciation, which we obtain from ward-level regressions of log property prices on a time trend (and property controls, see the appendix for details). In this specification we control for a potentially positive correlation between owners' risk aversion and the value of their properties – typically their largest assets. This is a potentially important control since a larger risk aversion increases the benefit from a policy that increases certainty regarding the future of the neighborhood and, thus, potentially increases the optimal designation share. It is a demanding control since positive price trends are potentially endogenous to changes in neighborhood composition and may thus absorb some of the gentrification effect on designation. The price trends are indeed positively, though not statistically significantly, associated with increases in the share of designate land. Adding controls capturing vacancy trends and levels, the density of listed buildings and some risk and vulnerability assessments from the Conservation Areas Survey tend to increase the education effect (column 5).

Across all specifications we find that, besides positive changes in designation share, high initial levels of degree shares are positively correlated with increases in the share of designated land. While high initial and positive changes in homeownership rate, ceteris paribus, are associated with less designation, it is notable that the (positive) impact of neighborhood change on designations shares (interaction term) is particularly large in high homeownership areas (see column 6). This is in line with a political economy literature that suggests that homeowners tend to form well-organized interest groups (e.g. Ahlfeldt & Maennig, 2013; Brunner & Sonstelie, 2003; Dehring, et al., 2008; Fischel, 2001a). Aside from the uninstrumented model (1), the results in Table 1 suggest contagion effects in designation, i.e., designated land shares tend to increase where shares were initially high.

Tab. 1. Designation process

	(1) Tobit	(2) IV Tobit	(3) IV Tobit	(4) IV Tobit	(5) IV Tobit	(6) IV Tobit
	Δ log share undesignated land (t)					
Δ log degree share (t) (ϑ)	-0.116*** (0.019)	-0.519*** (0.061)	-0.587*** (0.105)	-0.528*** (0.062)	-0.560*** (0.061)	-0.513*** (0.060)
log degree share (t-1)	-0.127*** (0.010)	-0.276*** (0.024)	-0.337*** (0.046)	-0.280*** (0.024)	-0.289*** (0.025)	-0.269*** (0.023)
log designation share (t-1)	-0.004 (0.012)	-0.022* (0.013)	-0.027** (0.013)	-0.035*** (0.013)	-0.026* (0.033)	-0.025** (0.013)
Δ log homeownership (t)	0.189*** (0.025)	0.263*** (0.029)	0.319*** (0.042)	0.262*** (0.029)	0.259*** (0.033)	0.255*** (0.028)
log homeownership (t-1)	0.127*** (0.015)	0.057*** (0.018)	0.091*** (0.018)	0.053*** (0.018)	0.042*** (0.018)	0.153*** (0.040)
Δ log average household size (t)	0.042 (0.037)	0.031 (0.040)	0.006 (0.046)	0.028 (0.039)	-0.009 (0.040)	0.047 (0.040)
log average household size (t-1)	0.073* (0.046)	-0.016 (0.049)	-0.122* (0.066)	-0.011 (0.049)	-0.075 (0.051)	-0.013 (0.049)
log price trend				-0.011 (0.021)		
Δ log vacancy rate (t)					-0.021*** (0.006)	
log vacancy rate (t-1)					-0.022*** (0.010)	
Log listed buildings density					1E-4 (0.004)	
average condition score (1 best, 4 worst)					-0.070*** (0.019)	
average vulnerability score (1 low, 8 high)					-0.045*** (0.017)	
average trajectory score (-2 improving, +2 deteriorating)					0.043 (0.036)	
Δ log degree share (t) x homeownership (t-1)						-0.201*** (0.085)
Constant	0.013 (0.046)	0.052 (0.048)	0.231* (0.119)	0.018 (0.067)	0.039 (0.065)	0.096** (0.051)
TTWA Effects	NO	NO	YES	NO	NO	NO
CHI2		350.753	634.960	368.036	475.892	354.198
EXOG_P		0.000	0.000	0.000	0.000	0.000
OVERID		0.017	.	0.100	0.073	0.009
OVERIDP		0.897	.	0.752	0.787	0.926
Observations	7965	7965	7965	7965	7965	7965

Notes: See the data section for a description of control variables. IVs are station density and employment potential in all models except model (1). Model (4) includes a dummy variable indicating 60 wards for which no price trend could be computed due to insufficient transactions. Standard errors in parentheses. * $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

Further robustness

While our IVs comfortably pass the typical statistical tests, we have experimented with four alternative sets of IVs. We have also split up the 1991–2011 long difference into two shorter differences (1991–2001 and 2001–2011), used the change in income as a proxy for heritage preferences (for 2001–2011) and run the baseline model in OLS keeping only observations with positive changes in shares of designated land. The results are presented in the technical appendix and support those discussed here.

5.2 Pareto optimality

Difference-in-differences

Tab. 2. shows the results from an estimation of the standard DD equation (26) for different selections of control groups and fixed effects. Each model includes controls for property, location, and neighborhood characteristics, year effects and location fixed effects to hold unobserved time-invariant effects constant. Column (1) is a naive DD using the mean price trend of all properties located beyond 500m of a treated conservation area as a counterfactual. Columns (2) to (7) provide more credible counterfactuals by restricting the control group to properties that are presumably similar to the treated properties. Column (2), with ward fixed effects, and (3), with nearest CA fixed effects, provide a spatial matching by restricting the sample to properties within 2km of a treated CA, where many unobserved *location* characteristics are likely to be similar. In column (4) we impose the additional restriction that properties in the control group must fall within 500m of the boundaries of a historically designated conservation area (before 1996), which increases the likelihood of unobserved *property* characteristics being similar. While areas that are designated at any point in time are likely to share many similarities, the diminishing returns to designation in our theoretical framework also imply that heritage-richer areas should generally be designated first. To evaluate whether the designation date of the treated conservation areas, relative to those on the control group, influences the DD estimate, we define CA designated 1996–2002 as a treatment group and form control groups based on CAs designated just before (1987–1994) or right after (2003–2010) in columns (5) and (6). In column (7), finally, we use environmental, property and neighborhood characteristics to estimate the propensity of being in a treated (1996–2010) CA over a historical (<1996) CA. Then the treated CAs are matched to their 'nearest-neighbor', i.e., the most similar non-treated CA, based on the estimated propensity score (Rosenbaum & Rubin, 1983). A fixed effect is defined for each treated CA and its nearest-neighbor control CA such that the treatment effect is estimated by the direct comparison between the treated CA and its nearest-neighbor.

We anticipate that the strength of the counterfactual increases as we match the treatment and control group based on proximity (2 & 3), proximity and qualifying for designation (4, 5, & 6) and qualifying for designation and a combination of various observable characteristics (7). As the credibility of the counterfactual increases, the statistical significance of the treatment effect tends to decrease. Benchmarked against the nationwide property price trend both the internal effect (Inside × Post) and the external effect (Within 500m × Post) are significant at the 5% level. The magnitudes of these effects are of similar size, implying a 2.8% premium for houses inside newly designated conservation areas and a 2.3% premium outside. The spatial matching (2 & 3) renders the internal treatment effect insignificant (2 & 3). With further refinements in the matching procedure the external effect also becomes insignificant. Tab. 2. results, thus, suggest that designation does not lead to significant property price adjustments. Evidence is weak for positive (policy) spillovers to nearby areas.

Tab. 2. Conservation area premium – designation effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	log property transaction price						
Inside treated CA × Post designation	0.028***	0.014	0.014	0.003	-0.024	-0.077	-0.003
	(0.009)	(0.009)	(0.010)	(0.012)	(0.070)	(0.111)	(0.013)
Within 500m buffer of treated CA × Post des.	0.023***	0.013***	0.012***	0.004	0.012	-0.005	-0.005
	(0.004)	(0.004)	(0.005)	(0.006)	(0.027)	(0.022)	(0.010)
Inside treated CA	-0.043***	-0.038***	-0.048***	-0.037***	-0.062	0.029	-0.024
	(0.009)	(0.009)	(0.010)	(0.012)	(0.057)	(0.108)	(0.021)
Within 500m buffer of treated CA	-0.010**	-0.004	-0.011**	0.005	0.003	0.006	-0.002
	(0.004)	(0.004)	(0.005)	(0.005)	(0.030)	(0.023)	(0.013)
Hedonic controls	YES	YES	YES	YES	YES	YES	YES
Location controls	YES	YES	YES	YES	YES	YES	YES
Neighborhood cont.	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES
Ward effects	YES	YES	NO	NO	NO	NO	NO
Nearest treat. CA effects	NO	NO	YES	YES	YES	YES	NO
Matched CA effects	NO	NO	NO	NO	NO	NO	YES
Treatment group: CAs designated	1996-2010	1996-2010	1996-2010	1996-2010	1996-2002	1996-2002	1996-2010
Control group	Full England sample	Within 2km of treated CA	Within 2km of treated CA	Within 500m of CA designated before 1996 & within 2km of treated CA	Within 500m of CA designated 1987-1995 & within 4km of treated CA	Within 500m of CA designated 2003-2010 & within 4km of treated CA	Within 500m of pre-1996 CA matched on propensity score
R^2	0.921	0.922	0.915	0.915	0.861	0.864	0.909
AIC	-587,375	-156,426	-130,469	-67,046	-5,408	-8,475	-41,184
Observation	1,088k	302k	302k	178k	21k	32k	133k

Notes: Standard errors in parentheses are clustered on location fixed effects. Conservation area control groups in columns (4)-(7) have separate fixed effects for the areas inside and outside a conservation area. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Temporal RDD-DD

Tab. 3. illustrates the results of the estimation of the (temporal) RDD-DD outlined in equation (27). We present the results of a variety of models that feature linear (1–5) and quadratic (6–10) trends and several of the control groups utilized in Tab. 2. One important finding across these specifications is that the external (Within 500m × Post) 'dis-in-diff' parameter estimate is significant in four of 10 specifications at the 5% level and in one half of the specifications at the 10% level, whereas, the internal (Inside × Post) parameter is only significant in one specification at the 10% level (column 8). This suggests primarily that there exists a significant treatment effect exactly at the treatment date only for the external area. This interpretation is in line with the predictions of our theoretical model. Another finding illustrated by Tab. 3. is the positive change in the internal price trend after a CA has been designated (Inside treated CA × Post designation × Years designated). The change in trend, which is significant at the 5% level in seven of the 10 models, may be regarded as evidence for a cumulative internal effect of the designation policy. There is also a faster appreciation in the external area post-designation that is significant in four of the 10 models. In short, the temporal RDD-DD has confirmed that designation policy causes no immediate effect inside the conservation area but shows instead that it increases the speed of price appreciation over time. The RDD-DD has also uncovered that areas external to the conservation area receive an immediate shift in prices at the designation date in line with our theoretical hypothesis.

Fig. 2 provides a graphical illustration of the predicted effect of being in the treatment group over the control group against years-since-designation. A horizontal red line is drawn at the mean of the pre-treatment effects in order to illustrate the differences between the RDD-DD results and those of the standard DD. The positive impact of designation on (relative) price trends suggested by the RDD-DD (black lines) is supported by the functionally more flexible semi-parametric estimates for the 'years-since-designation bins' (grey dots).[11] However, the post-treatment effects are never statistically distinguished from the pre-period mean, which is in line with the DD estimates.

Fig. 2. provides an analogical illustration for the external treatment effect, i.e., the spillovers onto areas adjacent to the designated CAs. Again, the post-period estimates do not deviate significantly from the pre-period mean. However, the top-left panel illustrates a large discontinuity at the treatment date that is statistically significant in Tab. 3. As with the internal effects, there is a positive trend shift post-designation.

[11] Confidence bands for the semi-parametric 'bins' model are presented in the appendix.

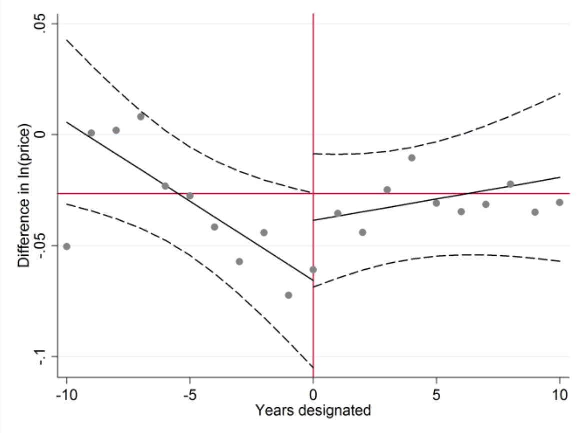
Tab. 3. Regression discontinuity design of differences between treatment and control (RDD-DD)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	log property transaction price									
Inside treated CA × Post designation	0.015	0.022	0.024	0.027	-0.006	0.023	0.033	0.038*	0.036	0.020
	(0.015)	(0.015)	(0.015)	(0.017)	(0.018)	(0.023)	(0.021)	(0.023)	(0.024)	(0.024)
Within 500m buffer of treated CA	0.006	0.013*	0.015**	0.020**	-0.007	0.013	0.017**	0.022**	0.017	0.009
× Post designation	(0.007)	(0.007)	(0.007)	(0.008)	(0.012)	(0.008)	(0.008)	(0.009)	(0.010)	(0.014)
Inside treated CA × Years designated	0.000	-0.004	-0.004	-0.007**	-0.002	-0.010	-0.016*	-0.019*	-0.019*	-0.020*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.010)	(0.009)	(0.010)	(0.010)	(0.011)
Inside treated CA × Years designated^2						-0.001	-0.001	-0.001	-0.001	-0.002*
						(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Inside treated CA × Post designation	0.003	0.007**	0.008**	0.009**	0.008*	0.020	0.026**	0.032**	0.031**	0.031**
× Years designated	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.014)	(0.012)	(0.013)	(0.013)	(0.014)
Inside treated CA × Post Designation						0.000	0.000	0.000	0.000	0.001
× Years designated^2						(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Within 500m of treated CA	0.002	-0.002*	-0.002*	-0.004***	-0.001	-0.001	-0.004	-0.007*	-0.004	-0.009
× Years designated	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.004)	(0.004)	(0.005)	(0.007)
Within 500m of treated CA						-0.000	-0.000	-0.000	0.000	-0.001
× Years designated^2						(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Within 500m of treated CA	0.001	0.004***	0.004***	0.005***	0.003	0.003	0.007	0.011**	0.008	0.009
× Post designation ×Years des.	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.005)	(0.005)	(0.005)	(0.006)	(0.010)
Within 500m of treated CA						0.000	0.000	0.000	-0.000	0.001
× Post designation × Years des.^{2}						(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Hedonic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Location controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Neighborhood controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ward effects	YES	YES	NO	NO	NO	YES	YES	NO	NO	NO
Nearest treated CA effects	NO	NO	YES	YES	NO	NO	NO	YES	YES	NO
Matched CA effects	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
Control group as in Tab. 2, column	(1)	(2)	(3)	(4)	(7)	(1)	(2)	(3)	(4)	(7)
R^2	0.920	0.921	0.912	0.914	0.907	0.920	0.921	0.912	0.914	0.907
AIC	-547,688	-147,818	-120,160	-64,425	-39,321	-548,078	-147,839	-120,191	-64,467	-39,329
Observations	995k	277k	277k	164k	123k	995k	277k	277k	164k	123k

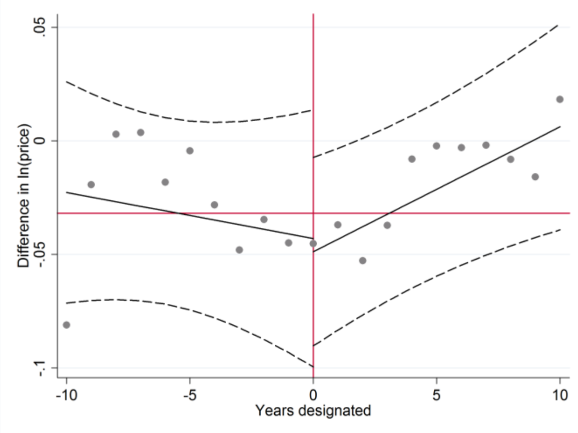
Notes: Standard errors in parentheses are clustered on the location fixed effects. Conservation area control groups in columns (4)-(7) have separate fixed effects for the areas inside and outside a conservation area. Observations dropped if years designated falls outside of range -10 years:+10 years. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Fig. 2. RDD-DD internal estimates

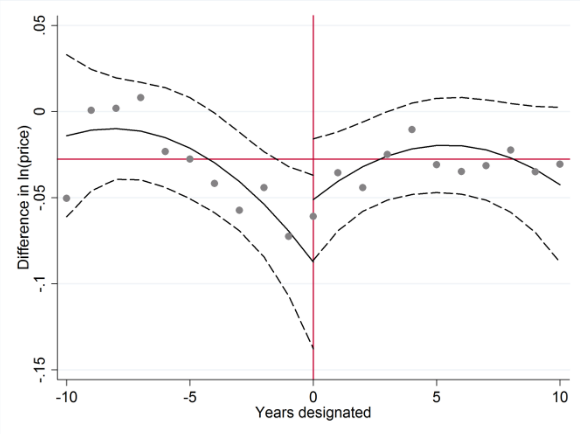
Nearest treated CA (linear trends)
Tab.3, column (4)



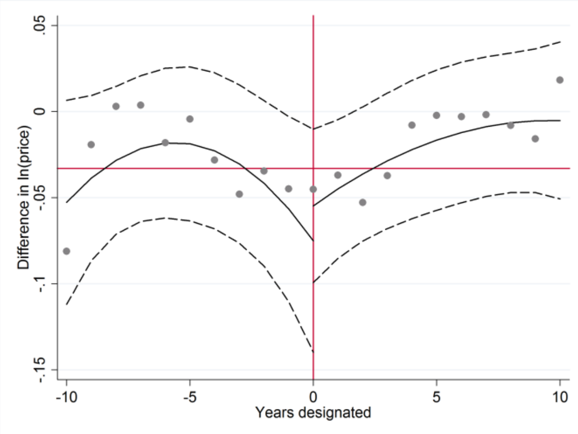
Matched CA (linear trends)
Tab. 3, column (5)



Nearest treated CA (quadratic trends)
Tab. 3, column (9)

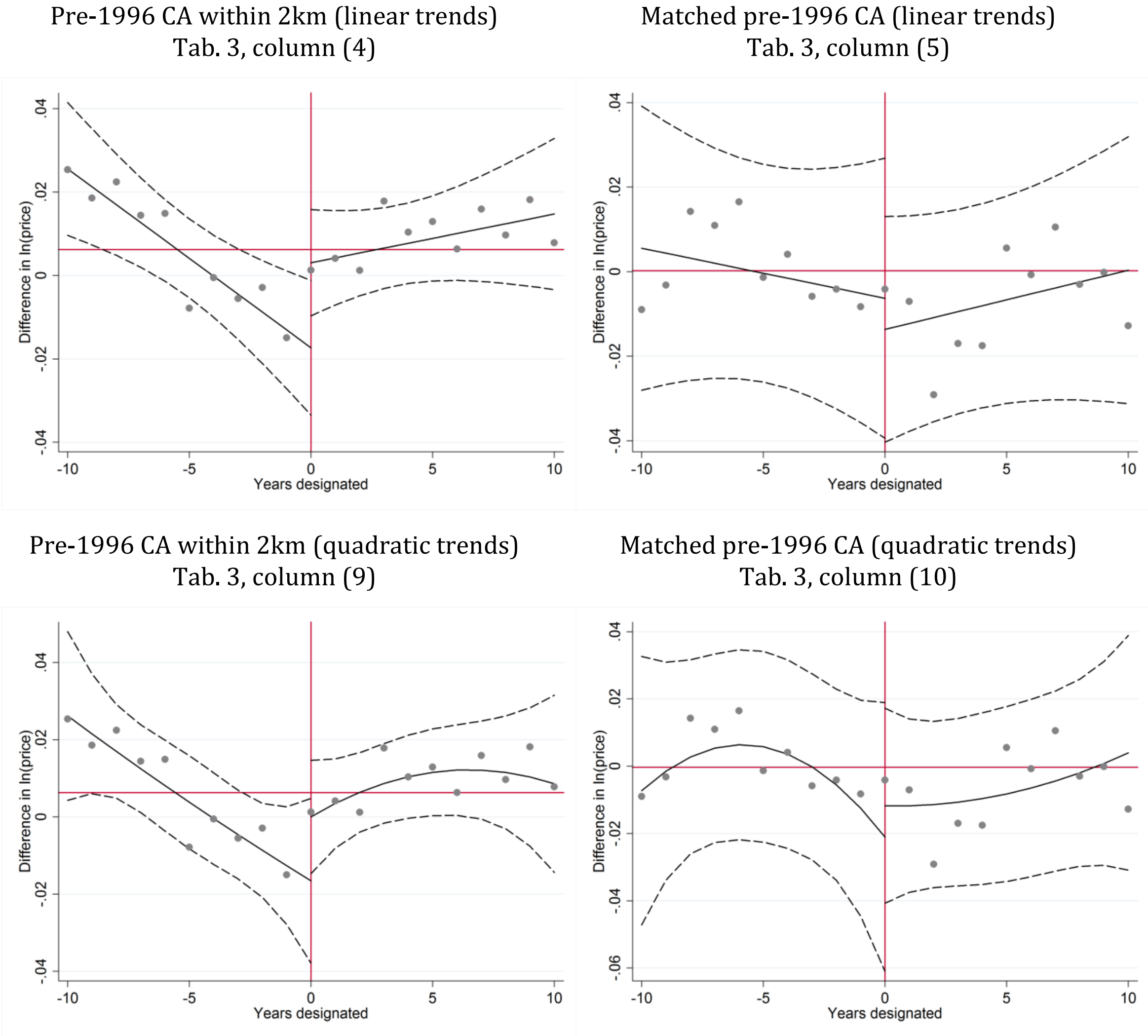


Matched CA (quadratic trends)
Tab. 3, column (10)



Note: The solid lines are graphical illustrations of the parametric estimates presented in Tab. 3. and estimated using equation (27). The dashed lines indicate the 95% CI which are calculated using standard errors of multiplicative interaction terms presented by Aiken and West (1991). The grey dots plot the point estimates of 'years-since-designation bins' effects obtained from separate regression described and presented in more detail in the appendix. The horizontal red line illustrates the mean of the pre-treatment estimates.

Fig. 3. RDD-DD external estimates



Notes: The solid lines are graphical illustrations of the parametric estimates presented in Tab. 3. and estimated using equation (27). The dashed lines indicate the 95% CI which are calculated using standard errors of multiplicative interaction terms presented Aiken and West (1991). The grey dots plot the point estimates of 'years-since-designation bins' effects obtained from separate regression described and presented in more detail in the appendix. The horizontal red line illustrates the mean of the pre-treatment estimates.

Spatial RDD-DD

Tab. 4 shows the results of the estimation of the (spatial) RDD-DD model outlined in equation (28). As with the temporal RDD-DD, we present the results of a variety of models that feature linear (1–5) and quadratic (6–10) trends and several of the control groups utilized in Tab. 2. One interesting and consistent feature of Tab. 4 is that the positive discontinuity coefficient (Outside × Post) matches the expected (positive) sign under the existence of a policy cost inside. However, the parameter is statistically insignificant in all models.

We have argued that the model predictions for capitalization effects under a (locally) efficient designation policy and a spatial decay in heritage externalities hold at the conservation area boundary, i.e., we expect a zero effect just inside and a positive effect just outside the boundary. Fig. 4 illustrates the joint effect of the parametric estimates reported in Tab. 4 at varying (internal and external) distances from the CA boundary. With the control group of historical CAs within 2km of the treatment CA (left panels) we find a positive capitalization effect just inside and outside the boundary, which is in line with the baseline DD result in Tab. 2, column (4). Moreover, the treatment effect increases toward the center for the CA and decreases in external distance to the boundary until it becomes zero at around 700m. This distance is in line with existing evidence on a relatively steep decay in heritage and housing externalities (Ahlfeldt & Maennig, 2010; Lazrak, et al., 2013; Rossi-Hansberg, et al., 2010). However, the effect is statistically indistinguishable from zero at almost all distances. The single exception is a significant (at 5% level) 1.6% effect just outside the CA in the quadratic model. While the effect is only significant within 100m of the CA, this is precisely where we expect a positive effect in a world with spatial decay in heritage (housing) externalities. In the context of the model the lower and not statistically significant effect just inside the CA indicates the presence of a cost that compensates for some of the benefits associated with designation.

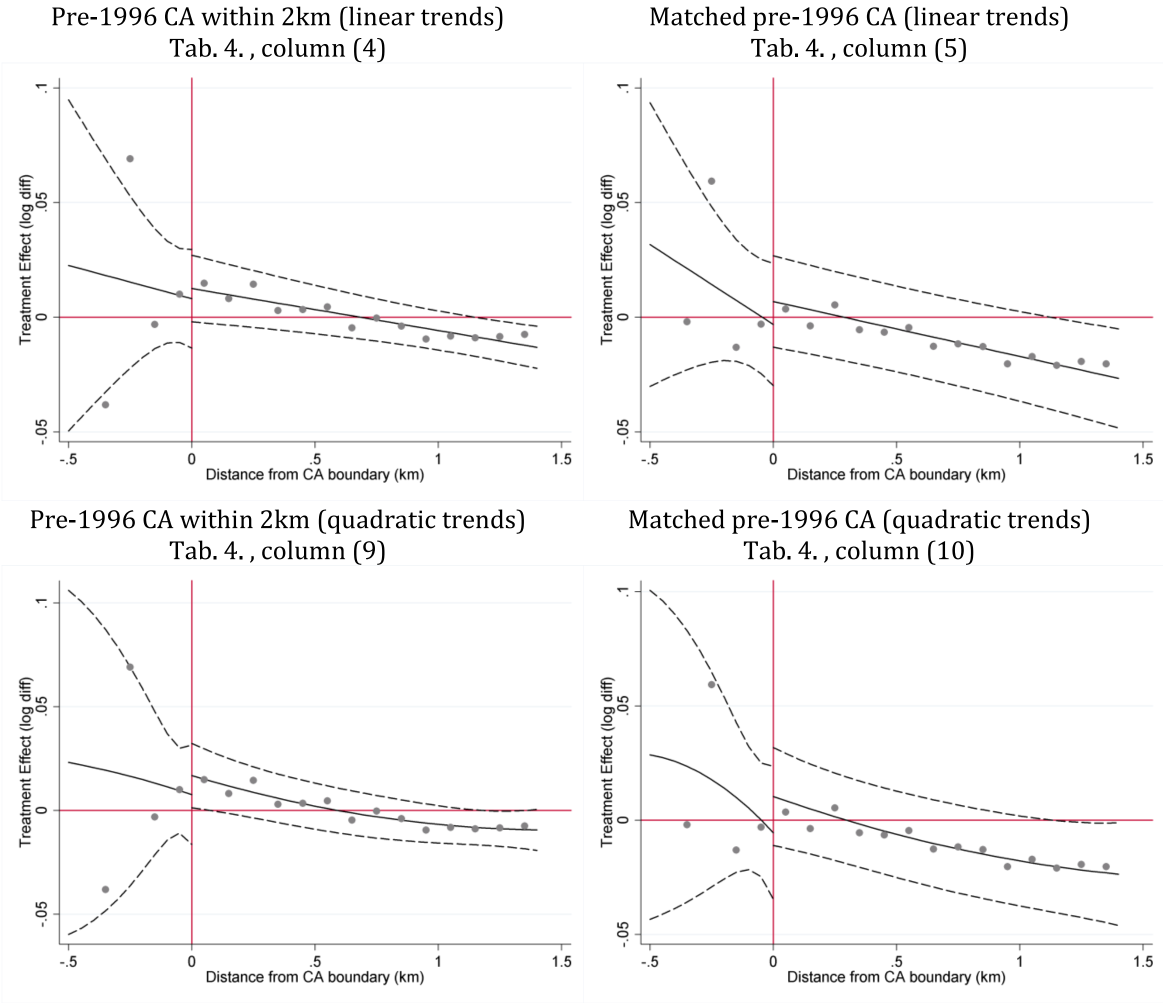
With the control group of matched CAs (right panels) the treatment effect just inside the CA boundary is remarkably close to zero. The joint effect just outside the boundary is positive, although not statistically significant. Briefly summarized, the spatial RDD-DD model suggests that across the treated CAs owners – at least on average – are not harmed by designation. There is some evidence that owners just outside a conservation area receive some benefit.

Tab. 4. Spatial regression discontinuity design of difference-in-differences (RDD-DD)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	log property transaction price									
Within 1400m of treated CA × Post designation	0.027*** (0.010)	0.014 (0.010)	0.012 (0.011)	0.008 (0.011)	-0.003 (0.014)	0.026** (0.011)	0.014 (0.012)	0.012 (0.012)	0.008 (0.012)	-0.005 (0.015)
Within 1400m of treated CA × Distance to boundary x Post des.	-0.057 (0.081)	-0.032 (0.075)	-0.030 (0.080)	-0.029 (0.077)	-0.070 (0.068)	-0.096 (0.156)	-0.046 (0.154)	-0.040 (0.162)	-0.040 (0.157)	-0.118 (0.143)
Within 1400m of treated CA × Distance to boundary^2 × Post des.						-0.059 (0.132)	-0.017 (0.131)	-0.018 (0.140)	-0.017 (0.136)	-0.099 (0.130)
Outside treated CA × Post designation	0.004 (0.010)	0.005 (0.010)	0.005 (0.010)	0.004 (0.009)	0.010 (0.011)	0.009 (0.012)	0.009 (0.012)	0.008 (0.011)	0.009 (0.011)	0.016 (0.012)
Outside treated CA × Distance to boundary × Post des.	0.039 (0.081)	0.016 (0.075)	0.013 (0.080)	0.011 (0.078)	0.046 (0.069)	0.064 (0.157)	0.014 (0.155)	0.013 (0.163)	0.004 (0.159)	0.080 (0.145)
Outside treated CA × Distance to boundary^2 × Post des.						0.070 (0.133)	0.028 (0.132)	0.025 (0.140)	0.029 (0.136)	0.109 (0.130)
Hedonic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Location controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Neighborhood controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ward effects	YES	YES	NO	NO	NO	YES	YES	NO	NO	NO
Nearest treated CA effects	NO	NO	YES	YES	NO	NO	NO	YES	YES	NO
Matched CA effects	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
Control group	Full England sample	Within 2km of treated CA	Within 2km of treated CA	Within 1400km of CA designated before 1996 & within 2km of treated CA	Within 1400m of pre-1996 CA matched on propensity score	Full England sample	Within 2km of treated CA	Within 2km of treated CA	Within 1400m of CA designated before 1996 & within 2km of treated CA	Within 1400m of pre-1996 CA matched on propensity score
R^2	0.921	0.922	0.915	0.914	0.905	0.921	0.922	0.915	0.914	0.921
AIC	-587,538	-156,448	-130,478	-118,076	-101,076	-587,533	-156,444	-130,478	-118,074	-587,538
Observation	1088k	302k	302k	281k	327k	1088k	302k	302k	281k	327k

Notes: Standard errors in parentheses are clustered on the location fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Fig. 4. RDD-DD spatial treatment effects



Notes: The solid lines are graphical illustrations of the parametric estimates presented in Tab. 3. and estimated using equation (28). The dashed lines indicate the 95% CI which are calculated using standard errors of multiplicative interaction terms presented by Aiken and West (1991).

6 Conclusion

Historic preservation policies are among the most restrictive planning policies used to overcome coordination problems in the housing market internationally. These policies aim at increasing social welfare at the cost of constraining individual property rights. From the perspective of owners of properties in conservation areas, the policy may help to solve a collective action problem, preventing owners from freeriding on the heritage character of nearby buildings while inappropriately altering their own property. If property owners value the heritage character of nearby buildings and can influence the designation process they will seek out a (local) level of designation where the marginal costs of designation equate the marginal benefits. An increase in the marginal benefit of designation will lead to an increase in designation activity. If the policy is Pareto-efficient, additional designations in a neighborhood will not lead to an adverse impact on those being designated.

We provide evidence that is supportive of this scenario using two empirical approaches that follow from a simple model of (locally) efficient conservation area designation. First, we present a neighborhood level IV tobit analysis that reveals a positive impact of an increase in degree share, which is presumably (positively) correlated with heritage preferences, on the share of designated land. Gentrification, by increasing the value of neighborhood stability to local owners, can cause designation. Second, we combine the strengths of difference-in-differences (DD) and regression discontinuity designs (RDD) to estimate the capitalization effect of designation on newly designated areas as well as spillovers to adjacent areas. This RDD-DD methodology qualifies more generally as a useful tool for program evaluations where a treatment is suspected to lead to an impact on (spatial or temporal) trends and discontinuities. Within newly designated conservation areas we find no significant short-run effects of designation and some evidence for positive capitalization effects in the long run. There is some evidence for positive spillovers onto properties just outside.

These results are in line with a Pareto-efficient designation policy, at least from the perspective of the local owners. Either, the policy is deliberately Pareto-maximizing local owner welfare or, as suggested in the literature on the political economy of housing markets, homeowners are able to successfully influence the outcome of local policies in their interest. In any case, it is important to note that our results do not imply that the policy is necessarily welfare-enhancing on a wider geographic scale. Depending on the excessiveness of the policy and the general restrictiveness of the planning system, historic preservation may constrain housing supply and generate welfare losses. The net-welfare effect to a wider housing market area is an interesting and important question that we leave to future research.

Literature

Ahlfeldt, G. M. (2011). Blessing or Curse? Appreciation, amenities and resistance to urban renewal. *Regional Science and Urban Economics, 41*(1), 32-45.

Ahlfeldt, G. M. (2013). If we build it, will they pay? Predicting property price effects of transport innovations. *Environment and Planning A, 45*(8), 1977-1994.

Ahlfeldt, G. M., & Kavetsos, G. (2013). Form or Function? The impact of new sports stadia on property prices in London. *Journal of the Royal Statistical Society A, 176*(4).

Ahlfeldt, G. M., & Maennig, W. (2010). Substitutability and Complementarity of Urban Amenities: External Effects of Built Heritage in Berlin. *Real Estate Economics, 38*(2), 285-323.

Ahlfeldt, G. M., & Maennig, W. (2013). Homevoters vs. leasevoters: A Spatial Analysis of Aircraft Noise. *CESIfo Working Paper*.

Ahlfeldt, G. M., Redding, S. J., Sturm, D. M., & Wolf, N. (2012). On the Economics of Density: Evidence from the Berlin Wall. *CEP Discussion Paper 1154*

Ahlfeldt, G. M., & Wendland, N. (2013). How polycentric is a monocentric city? Centers, spillovers and hysteresis. *Journal of Economic Geography, 13*(1), 53-83. doi: 10.1093/jeg/lbs013

Aiken, L. S., & West, S. G. (1991). *Multiple regression: testing and interpreting interactions*: Sage.

Asabere, P. K., Hachey, G., & Grubaugh, S. (1989). Architecture, Historic Zoning, and the Value of Homes. *Journal of Real Estate Finance and Economics, 2*(3), 181-195.

Asabere, P. K., & Huffman, F. E. (1994). Historic designation and residential market values. *Appraisal Journal, 62*(3), 396.

Asabere, P. K., Huffman, F. E., & Mehdian, S. (1994). The Adverse Impacts of Local Historic Designation: The Case of Small Apartment Buildings in Philadelphia. *Journal of Real Estate Finance & Economics, 8*(3), 225-234.

Avrami, E. M., R. and Torre, M. (2000). *Values and Heritage Conservation Los Angeles*: The Getty Conservation Institute.

Bento, A. M., Kaffine, D., & Roth, K. (2010). Clearing the air by promoting hybrids? The unintended consequences of allowing solo-hybrid drives in high. *Working Paper*.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust difference-in-difference estimates? *The Quarterly Journal of Economics, 119*(1), 249-275.

Botrill, C. (2005). *Homes in Historic Conservation Areas in Great Britain: Calculating the Proportion of Residential Dwellings in Conservation Areas*. Environmental Change Institute.

Brueckner, J. K., Thisse, J.-F., & Zenou, Y. (1999). Why Is Central Paris Rich and Downtown Detroit Poor? An Amenity-Based Theory. *European Economic Review, 43*(1), 91-107.

Brunner, E., & Sonstelie, J. (2003). Homeowners, property values, and the political economy of the school voucher. *Journal of Urban Economics, 54*(2), 239-257.

Brunner, E., Sonstelie, J., & Thayer, M. (2001). Capitalization and the Voucher: An Analysis of Precinct Returns from California's Proposition 174. *Journal of Urban Economics, 50*(3), 517-536.

Carlino, G. A., & Saiz, A. (2008). Beautiful City: Leisure Amenities and Urban Growth *FRB of Philadelphia Working Paper* (Vol. 08-22).

Cellini, S. R., Ferreira, F., & Rothstein, J. (2010). The value of school facility investments: Evidence from a dynamic regression discontinuity design. *The Quarterly Journal of Economics, 125*(1), 215-261.

Cheshire, P. C., & Hilber, C. A. L. (2008). Office Space Supply Restrictions in Britain: The Political Economy of Market Revenge*. *The Economic Journal, 118*(529), F185-F221. doi: 10.1111/j.1468-0297.2008.02149.x

Cheshire, P. C., Hilber, C. A. L., & Kaplanis, I. (2011). Evaluating the Effects of Planning Policies on the Retail Sector: Or do Town Centre First Policies Deliver the Goods? *SERC Discussion Papers66*, 1-34.

Cheshire, P. C., & Sheppard, S. (1995). On the Price of Land and the Value of Amenities. [Article]. *Economica, 62*(246), 247-267.
Coulson, N. E., & Lahr, M. L. (2005). Gracing the Land of Elvis and Beale Street: Historic Designation and Property Values in Memphis. *Real Estate Economics, 33*(3), 487-507.
Coulson, N. E., & Leichenko, R. M. (2001). The Internal and External Impact of Historical Designation on Property Values. *Journal of Real Estate Finance & Economics, 23*(1), 113-124.
Davis, M. A., & Ortalo-Magné, F. (2011). Household expenditures, wages, rents. *Review of Economic Dynamics, 14*(2), 248-261. doi: 10.1016/j.red.2009.12.003
Dehring, C. A., Depken, C. A., & Ward, M. R. (2008). A direct test of the homevoter hypothesis. *Journal of Urban Economics, 64*(1), 155-170.
Fischel, F. A. (2001a). *The Homevoter Hypothesis* (Vol. Cambridge, MA.): Harvard Univ. Press.
Fischel, F. A. (2001b). Why Are There NIMBYs? *Land Economics, 77*(1), 144-152.
Florida, R. (2002). Bohemia and economic geography. *Journal of Economic Geography, 2*(1), 55.
Fujita, M., & Ogawa, H. (1982). Multiple equilibria and structural transition of non-monocentric urban configurations. *Regional Science and Urban Economics, 12*(2), 161-196.
Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics, 57*(1), 148-169.
Glaeser, E. L. (2011). *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*: The Penguin Press HC.
Glaeser, E. L., & Gottlieb, J. D. (2006). Urban Resurgence and the Consumer City. *Urban Studies, 43*(8), 1275-1299. doi: 10.1080/00420980600775683
Glaeser, E. L., Kolko, J., & Saiz, A. (2001). Consumer city. *Journal of Economic Geography, 1*(1), 27-50. doi: 10.1093/jeg/1.1.27
Hilber, C. A. L., & Mayer, C. J. (2009). Why Do Households Without Children Support Local Public Schools? *Journal of Urban Economics, 65*(1), 74-90.
Hilber, C. A. L., & Vermeulen, W. (2010). The impacts of restricting housing supply on house prices and affordability. *Department for Communities and Local Governmnet Report*.
HM Government. (2010). *The Government's Statement on the Historic Environment for England*. London: DCMS.
Holman, N., & Ahlfeldt, G. M. (2012). No escape? The coordination problem in heritage preservation. *Working Paper*.
Imbens, G. W., & Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of Econometrics, 142*(2), 615-635.
Koster, H. R. A., Van Ommeren, J. N., & Rietveld, P. (2012). Upscale Neighbourhoods: Historic Amenities, Income and Spatial Sorting of Households. *Mimeo, VU Unversity Amsterdam*.
Lazrak, F., Nijkamp, P., Rietveld, P., & Rouwendal, J. (2013). The market value of cultural heritage in urban areas: an application of spatial hedonic pricing. *Journal of Geographical Systems*, 1-26. doi: 10.1007/s10109-013-0188-1
Leichenko, R. M., Coulson, N. E., & Listokin, D. (2001). Historic Preservation and Residential Property Values: An Analysis of Texas Cities. *Urban Studies, 38*(11), 1973-1987.
Noonan, D. S., & Krupka, D. J. (2011). Making—or Picking—Winners: Evidence of Internal and External Price Effects in Historic Preservation Policies. *Real Estate Economics, 39*(2), 379-407. doi: 10.1111/j.1540-6229.2010.00293.x
Oates, W. E. (1969). The Effects of Property Taxes and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and the Tiebout Hypothesis. *Journal of Political Economy, 77*(6), 957-971.
Pendlebury, J. (2009). *Pendlebury*. London: Routledge.

Rosenbaum, P. R., & Rubin, D. B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika, 70*(1), 41-55. doi: 10.2307/2335942

Rossi-Hansberg, E., Sarte, P.-D., & Owens, R. (2010). Housing Externalities. *Journal of Political Economy, 118*(3), 485-535.

Schaeffer, P. V., & Millerick, C. A. (1991). The impact of historic district designation on property values: An empirical study. *Economic Development Quarterly, 5*(4), 301-312.

Shapiro, J. M. (2006). Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital. *The Review of Economics and Statistics, 88*(2), 324-335. doi: 10.2307/40042998

Silverman, B. W. (1986). *Density Estimation*. London: Chapman and Hall.

Strange, I. a. W., D. (2003). The changing roles and purpose of heritage conservation in the UK. *Planning Practice and Research, 18*(2-3), 219-229.

van Duijn, M., & Rouwendal, J. (2013). Cultural heritage and the location choice of Dutch households in a residential sorting model. *Journal of Economic Geography, 13*(3), 473-500. doi: 10.1093/jeg/lbs028

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Technical appendix:

Game of zones: The economics of conservation areas[*]

1 Introduction

This appendix complements the main paper and is not designed to stand alone or as a replacement. Section 2 provides an illustration of how a planner determines the Pareto-efficient designation share and adds to the theory section of the main paper. Section 3 complements the empirical strategy section of the main paper by providing a more detailed discussion of the control variables in tobit designation process models. The section also links the reduced form difference-in-differences parameters to the marginal policy effect in the theoretical model. Section 4 provides a detailed overview of the data we use, its sources, and how they are processed. Finally, section 5 complements the empirical results section of the main paper by showing the results of a variety of robustness tests and model alterations not reported in the main paper for brevity.

2 Theory and context

2.1 Theoretical Framework

This section briefly illustrates how a planner determines the Pareto-efficient designation share. The equilibrium between the social marginal benefits (MB) of designation (equation 9 in the

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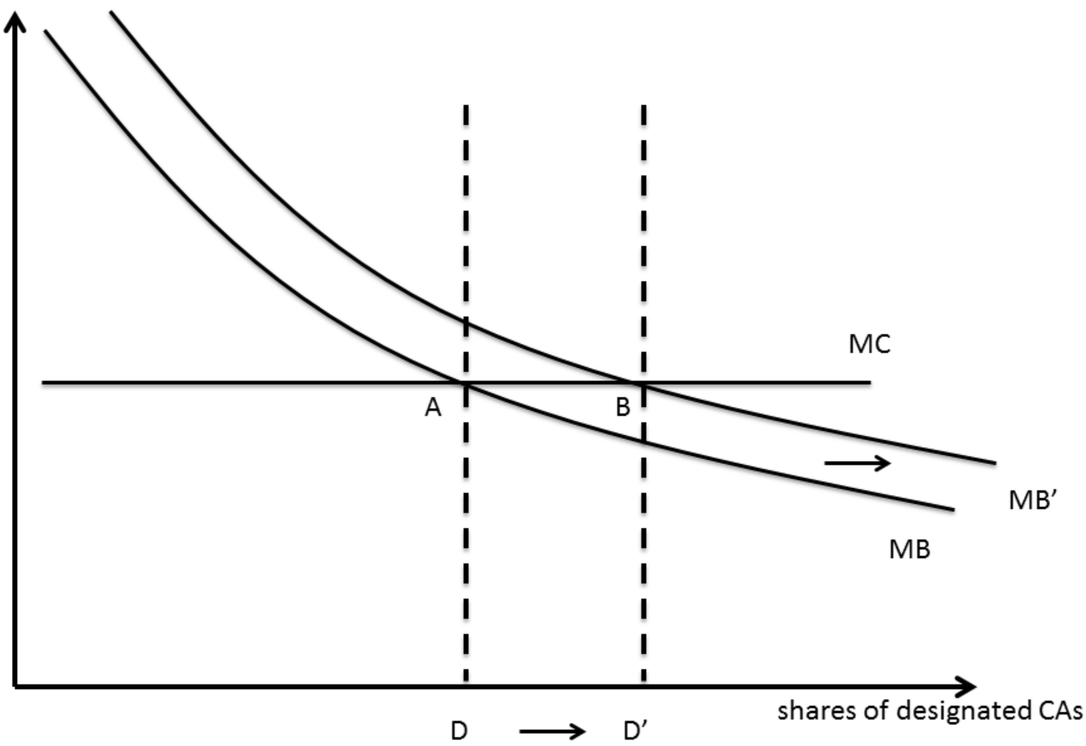
main paper) and the marginal costs (MC) (equation 10) is depicted by Figure A1. At point A the designation share D is Pareto-efficient. Social marginal benefits equal the private marginal costs associated with designation. A further extension would benefit all owners to the left of A as they would profit from increasing the expected heritage in the neighborhood without experiencing a change in marginal cost. To the right of A, however, the social marginal benefit would also increase, but the increase would not compensate for the private marginal costs associated with a change in the designation status from undesignated to designated. The expansion would not be Pareto-optimal.

If there is, for instance, a change in preferences and residents develop a greater taste for external heritage γ their marginal benefits curve shifts to the right. A Pareto-optimal planner adapts to this situation and raises the designation share to set marginal benefits equal to marginal costs again. This new Pareto-optimal equilibrium is illustrated by point B where the designation share increases to D'.

Fig A1. Designation equilibrium



3 Empirical strategy

3.1 Designation process – control variables

This section provides a detailed description and motivation of the control variables we use to account for the determinants of conservation area designation that are unrelated to the mechanisms modeled in our theory. In particular we try to control for composition effects, neighborhood sorting, heterogeneity in terms of homeownership, and whether the heritage in a neighborhood is at particular risk.

We add the initial period (1991) degree share for two reasons. First, we assume that the highly educated derive higher (net-)benefits from neighborhood heritage. To the extent that this group is capable of more efficiently articulating their will in a political bargaining a higher degree share will make the designation more likely. It is important to control for the initial degree share since levels and changes may be correlated in either direction. On the one hand there may be catch-up growth in the degree share of less educated regions, i.e., mean reversion. On the other hand, people with degrees may be more likely to move to areas with an already high share of people with degrees, which would imply a self-reinforcing process leading to spatial segregation.

We also include a control for the extent of designation in the initial period (1991). The share of designated land area in the total ward area would be (positively) correlated with the change in the designation share if designations spark further designations as in a contagion model. Initial designation also helps to control for the possibility that the skilled may be attracted to areas with a lot of designated land. Another set of controls is driven by the interest in homeowners within the designation process. Homeowners experience extra benefits/costs from designation since, unlike renters, they are not compensated for changes in neighborhood quality by increases in degrees or rents. Homeowners, thus have additional incentives to engage in political bargaining. Similar to the other controls, homeownership status enters in lagged levels and differences. In a final specification we also add an interaction of the logged change in degree with homeownership (rescaled to a zero mean to make coefficients comparable). We use average household size (both in differences and lagged levels) to control for the presumption that larger households are more likely to lobby against designation and the resulting constraint on available floor space.

We add a measure of property price appreciation, which we obtain from ward-level regressions of log property prices on a time trend (and property controls).

A larger risk aversion increases the benefit from a policy that increases certainty regarding the future of the neighborhood and, thus, potentially increases the optimal designation share. To control for a potentially positive correlation between owners' risk aversion and the value of their properties – typically their largest assets – we add a measure of neighborhood appreciation. We generate ward-level property price trends in n separate auxiliary regressions of the following type:

$$\log(P_{itn}) = \alpha_n + X_{ni}b_n + \beta_n T_t + \varepsilon_{itn} \tag{A1}$$

where X is a vector of property and neighborhood characteristics and T is a linear time trend. To avoid a reverse effect of designation on the property price trend we only consider transactions that occur outside conservation areas.

A second set of controls deals with potential development risk. Areas that experience development pressure or are in poor and/or declining condition may be more likely to be designated in order to protect against the threats to the heritage character of the neighborhood. We use the vacancy rate, a density measure of listed buildings as well as score measures for a conservation area's condition, vulnerability and trajectory provided by English Heritage to capture development pressure. We expect that neighborhoods with few vacancies will be put under higher development pressure. Vacancies enter the specification both in differences and lagged levels. The reason for the differenced term is that a change in development pressure is likely to lead to a change in designation status as a result. We argue that the lagged level may also capture changes (not just levels) in development pressure. This is because of external factors and conditions (i.e., population growth) that effect areas unevenly depending on their level in certain attributes (e.g., vacant housing). It seems likely that general population growth would put greater development pressure on neighborhoods with lower vacancy rates. The score measures reflect the development risk inside a conservation area and come from a survey provided by English Heritage. The higher the condition score, the worse the heritage conditions. A higher vulnerability as well as a higher trajectory are also indicated by higher scores. Except for the score variables, all control variables enter our empirical specification in logs.

While taking first-differences of the empirical specification will remove all time-invariant ward-specific effects that might impact on the level of designation (including the heritage itself), it will not help if there are location-specific effects that impact on the *changes* in designation status. For example, if there is heterogeneity across Local Authorities (LAs) about how difficult or easy it is to designate arising from different bureaucratic practices then this would affect changes in designation for all wards within a particular LA. We therefore estimate a fixed effects specification for the 166 English Travel To Work Areas (TTWAs). The TTWAs are designed to approximate city regions which can be described as somehow self-contained economic areas from a job market perspective. By applying a TTWA fixed effect model we are therefore able to control for socio-economic heterogeneity across TTWAs.

3.2 Difference-in-differences

This section motivates the difference-in-differences approach for the estimation of the marginal policy effect. Firstly, we illustrate how the policy and heritage effects are difficult to disentangle in a simple cross-sectional hedonic estimation. Secondly, we lay out how the difference-in-differences treatment effect is used to estimate the marginal policy effect laid out in terms of the structural parameters of our model.

Cross-sectional hedonics

Taking logs of the spatial equilibrium price equation (17) from the main paper gives:[1]

$$\ln \theta(x) = \tau + \frac{1}{1-\delta}\ln a(x) + \frac{\varphi h(x)}{1-\delta} + \frac{\gamma E[H|D]}{1-\delta} - \frac{c\widetilde{D}(x)}{1-\delta} \tag{A2}$$

The following heritage and policy effects determine the bid rent:

$$Policy\ cost = \frac{c\widetilde{D}(x)}{1-\delta} \tag{A3}$$

$$External\ heritage\ effect\ (conditional\ on\ designation) = \frac{\gamma E[H|D]}{1-\delta} \tag{A4}$$

$$Internal\ heritage\ effect = \frac{\varphi h(x)}{1-\delta} \tag{A5}$$

Consider the cross-sectional reduced form equation:

$$p_{it} = \aleph I_i + \mathrm{X}_i'\mu + f_n + Y_t + \epsilon_{it} \tag{A6}$$

where p_{it} is the natural logarithm of the transaction price for property i in time period t, I_i is a dummy variable equal to one if the observation is internal to a treated conservation area, X_i is a vector of controls for property, neighborhood, and environmental characteristics, f_n is a set of n location fixed effects and Y_t are year effects. The coefficient $\aleph$ on the CA_i dummy identifies the policy cost associated with the location of a property inside a conservation area $\widetilde{D}(x) = 1$. The policy cost should have a negative effect on logged house prices. The coefficient also partly identifies the internal heritage effect. Specifically, it identifies the value of the difference between the mean internal heritage inside conservation areas and the mean internal heritage outside conservation areas (i.e. $\varphi/(1-\delta)\left(\overline{h_{CA_i=1}} - \overline{h_{CA_i=0}}\right)$). This should be positive because the policymaker would normally designate areas that have the most heritage. Finally, under the existence of some spatial decay in externalities, it will also identify the value of the difference inside and outside conservation areas in the external heritage effect (i.e., $\gamma(1-\delta)\left(\overline{E[H|D]_{CA_i=1}} - \overline{E[H|D]_{CA_i=0}}\right)$). This is a function of internal heritage and will therefore also be positive.

[1] Where τ is a constant and equal to: $\ln(1-\delta) + \frac{\delta}{1-\delta}\ln\delta + \frac{1}{1-\delta}\ln W$.

The coefficient ℵ thus reflects a composite effect of policy costs, policy benefits, and correlated internal heritage effect. Furthermore, in reality the actual distribution of internal heritage is unknown and there is likely a spatial decay to externalities, further complicating the estimate.[2] In practice, ℵ will also be affected by unobserved neighborhood characteristics that are correlated with the distance to the conservation area. A positive ℵ parameter, at best, tells us only that the overall higher levels of heritage (internal and external) combined with the policy benefits of conservation outweigh the policy costs. This does not provide a comprehensive evaluation of the policy effect itself. To try and disentangle these effects we implement a different empirical approach.

Difference-in-differences

Using the difference-in-differences (DD) approach to estimate the marginal effect of a change in designation status offers an improved identification.

Our empirical difference-in-differences specification is equation (26) from the main paper:

$$p_{it} = \beta^I I_i + \beta^E E_i + \beta^{IPost}(I_i \times Post_{it}) + \beta^{EPost}(E_i \times Post_{it}) + X_i'\mu + f_n + Y_t + \epsilon_{it} \qquad \text{(A7)}$$

Tab. A1. illustrates the conditional mean prices (after controlling for time effects) for the treatment and control group in the pre- and post-treatment periods. It is important to note that the year fixed effects Y_t capture the general development of price over time. Without this feature it would be necessary to control for the overall growth in price between the pre- and post-treatment periods via the inclusion of a non-interacted version of $Post_{it}$.

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[2] In a general case the estimate would be equal to:

$$\aleph = \frac{\varphi}{1-\delta}\left(\overline{h_{CA_i=1}} - \overline{h_{CA_i=0}}\right) + \frac{\gamma}{1-\delta}\left(\overline{E[H|D]_{CA_i=1}} - \overline{E[H|D]_{CA_i=0}}\right)$$

Tab. A1.

Conditional mean of prices	Pre	Post
Treated (Internal)	$\bar{p}_{Pre}^{Treat} = \beta^{I}$	$\bar{p}_{Post}^{Treat} = \beta^{I} + \beta^{IPost}$
Control	$\bar{p}_{Pre}^{Con} = 0$	$\bar{p}_{Post}^{Con} = 0$
$Treatment\ Effect = (\bar{p}_{Post}^{Treat} - \bar{p}_{Pre}^{Treat}) - (\bar{p}_{Pre}^{Con} - \bar{p}_{Pre}^{Con})$		
$Treatment\ Effect = ([\beta^{I} + \beta^{IPost}] - [\beta^{I}]) - ([0] - [0])$		
$Treatment\ Effect = \beta^{Post}$		

Notes: The conditional mean of prices in the treatment group in the pre-period is denoted $\bar{p}_{Pre}^{Treat}$. This represents the log of prices conditional on fixed and year effects $(f_n + Y_t)$ and controls X_i. The same notation is used for the other groups.

Our treatment coefficient β^{IPost} essentially differentiates across the treatment and control groups before and after designation and is, thus defined as follows:

$$\beta^{IPost} = (\bar{p}_{Post}^{Treat} - \bar{p}_{Pre}^{Treat}) - \left(\bar{p}_{Post}^{Con} - \bar{p}_{Pre}^{Con}\right) \tag{A8}$$

Let's assume that the relationship between the observed conditional mean and the theoretical bid rent is given by:

$$\bar{p}_{Post}^{Treat} = \theta_{Post}^{Treat} + u_{Post}^{Treat} \tag{A9}$$

where u_{Pre}^{Treat} are partially unobservable factors specific to properties in the Treated-Post cell. The same relationship applies for the other cells (Treated-Pre, Control-Post and Control-Pre). At the heart of our identification strategy we assume that the price trends unrelated to the policy are the same within the treatment and the control group. The typical identifying assumption on which the difference-in-differences identification strategy relies can be expressed as follows:

$$(u_{Post}^{Treat} - u_{Pre}^{Treat}) = \left(u_{Post}^{Con} - u_{Pre}^{Con}\right) \tag{A10}$$

The credibility of the counterfactual rests on the likelihood that the treatment group, in the absence of the intervention, would have followed a trend that is similar to that of the control group. An appropriate definition of the control group is therefore a critical element of the identification strategy. We therefore consider a number of different control groups in which we try to reduce the potential heterogeneity between properties in the treatment and control group.

The first treatment group is a spatial match where we choose the observations that fall within a 2km buffer surrounding conservation areas that changed designation status during the observation period (1995–2010). As an alternative, we consider a number of matching procedures that rest on the idea that properties inside conservation areas generally share similarities. Properties in conservation areas that did not change designation status therefore potentially qualify as a control group. To make the areas in the treatment and control group more similar, we select conservation areas based on similarities with those in our treatment group (Rosenbaum & Ruben, 1983). For the matching procedure we only make use of variables that turn out to have significant impact in the auxiliary propensity score matching regression.[3] We use a nearest neighbor matching procedure, which produces a broader and a narrower group.

Under the assumptions made it is straightforward to demonstrate that the DD treatment coefficient gives the pure policy effect we are interested in. Combining the theoretical bid rent of equation (17) from the main paper with the definition of $\bar{p}_{Post}^{Treat}$ in equation (A9) gives the conditional mean price of (treated) properties inside newly designated conservation areas before (pre) and after (post) designation can be expressed as follows[4]:

$$\bar{p}_{Pre}^{Treat} = \tau + \frac{1}{1-\delta}\ln a_i + \frac{\varphi h_i}{1-\delta} + \frac{\gamma E[H|D]}{1-\delta} + u_{Pre}^{Treat} \tag{A11}$$

$$\bar{p}_{Post}^{Treat} = \tau + \frac{1}{1-\delta}\ln a_i + \frac{\varphi h_i}{1-\delta} + \frac{\gamma}{1-\delta}\left(E[H|D] + \frac{dE[H|D]}{dD}\right) - \frac{c\widetilde{D}_i}{1-\delta} + u_{Post}^{Treat} \tag{A12}$$

where a new designation is represented as an increase in designation share D. For a control group sufficiently far away to not be exposed to the heritage externality we similarly get:

$$\bar{p}_{Pre}^{Con} = \tau + \frac{1}{1-\delta}\ln a_i + \frac{\gamma E[H|D]}{1-\delta} + u_{Pre}^{Con} \tag{A13}$$

$$\bar{p}_{Post}^{Con} = \tau + \frac{1}{1-\delta}\ln a_i + \frac{\gamma E[H|D]}{1-\delta} + u_{Post}^{Con} \tag{A14}$$

where there is (by definition) no new designation. Given the common trend assumption of equation (A10), β^{IPost} identifies the pure net policy effect of designation:

$$\beta^{IPost} = \frac{\gamma}{1-\delta}\frac{dE[H|D]}{dD} - \frac{c\widetilde{D}(x)}{1-\delta} \tag{A15}$$

[3] A list of significant controls in propensity score matching regressions is included in the next subsection.

[4] Where the theoretical locations x have been replaced by observed housing transactions i.

In the empirical implementation of the DD strategy we also consider alternative treatment groups that consist of properties just outside conservation areas, which are potentially exposed to spillovers, but not to the cost of designation. The interpretation of the external treatment coefficient can be derived analogically where designation leads to benefits but without the associated costs:

$$\bar{p}_{Pre}^{Treat} = \tau + \frac{1}{1-\delta}\ln a_i + \frac{\gamma E[H|D]}{1-\delta} + u_{Pre}^{Treat} \tag{A16}$$

$$\bar{p}_{Post}^{Treat} = \tau + \frac{1}{1-\delta}\ln a_i + \frac{\gamma}{1-\delta}\left(E[H|D] + \frac{dE[H|D]}{dD}\right) + u_{Post}^{Treat} \tag{A17}$$

Under the common trends assumption the treatment coefficient reflects the pure policy benefit associated with the reduction in uncertainty as predicted by the stylized theory:

$$\beta^{EPost} = \frac{\gamma}{1-\delta}\frac{dE[H|D]}{dD} \tag{A18}$$

Propensity score matching regression

In order to determine the control group for the difference-in-differences specification a propensity score matching approach was employed. We used a stepwise elimination approach in order to determine which variables have a significant impact on propensity score. With a significance level criterion of 10% the following variables remained in the final CA propensity score estimation:

CA characteristics: Urban, Commercial, Residential, Industrial, World Heritage Site, At Risk and Article 4 Status.

Environmental characteristics: Land Cover Type 9 (Inland bare ground), Land Cover Type 3 (Mountains, moors and heathland), distance to nearest National Nature Reserve, distance to nearest National Park, National Park (kernel density) and Area of Outstanding Natural Beauty (kernel density).

Neighbourhood characteristics: Median Income and Ethnicity Herfindahl index

Amenities: Distance to nearest Bar, distance to nearest Underground Station, distance to nearest Hospital, distance to nearest Motorway and distance to nearest TTWA centroid.

Semi-parametric temporal and spatial estimations of treatment effects

We estimate a semi-parametric version of (27) that replaces the YD_{it} variables with a full set of years-since-designation bins. We group transactions into bins depending on the number of years that have passed since the conservation area they fall into or are near to had been designated. Negative values indicate years prior to designation. These bins (b) are captured by a set of dummy variables PT_b:

$$p_{it} = \sum_b \beta_b^I \left(PT_i^b \times I_i\right) + \sum_b \beta_b^E \left(PT_i^b \times E_i\right) + \sum_b \beta_b PT_i^b + \mathrm{X}_i'\mu + f_n + Y_t + \epsilon_{it} \qquad \text{(A19)}$$

The parameters β_b^I and β_b^E give the difference in prices between treatment and control groups in each years-since-designation bin b. The results of this semi-parametric estimation are plotted in Fig A2. in Appendix 5.2. In order to allow for a casual inspection of the fit of the parametric models the semi-parametric point-estimates are also plotted in Fig. 2 (internal) and Fig. 3 (external) of the main paper.

As with the temporal models, we relax the parametric constraints of the spatial estimations by replacing the distance variable in equation (28) with distance bins:

$$p_{it} = \sum_d \beta_d \left(DB_i^d \times T_i\right) + \sum_d \beta_d^{Post}\left(DB_i^d \times T_i \times Post_{it}\right) + \mathrm{X}_i'\mu + f_n + Y_t + \epsilon_{it} \qquad \text{(A20)}$$

where DB_i^d are positive (external) and negative (internal) distance bins from the designation area boundary and β_d^{Post} are d treatment effect parameters at different distances inside and outside the conservation area. If the planner designates in a Pareto-optimal manner then the bin that corresponds to the locations just inside the treated conservation area should indicate a zero treatment effect. This may or may not be associated with a positive effect for the bins deepest inside the conservation area. Furthermore, if there are significant externalities associated with the designation (and heritage in general) then the bins just outside the boundary should indicate a positive effect. A lower effect for further out bins would indicate a spatial decay to this externality. The results from this specification are presented Fig A3. in Appendix 5.2 and in Fig. 4 of the main paper.

4 Data

4.1 Data sources

Housing transactions

The transactions data relates to mortgages for properties granted by the Nationwide Building Society (NBS) between 1995 and 2010. The data for England comprise 1,088,446 observations and include the price paid for individual housing units along with detailed property characteristics. These characteristics include floor space (m^2), the type of property (detached, semi-detached, flat, bungalow or terraced), the date of construction, the number of bedrooms and bathrooms, garage or parking facilities and the type of heating. There is also some buyer information including the type of mortgage (freehold or leasehold) and whether they are a first-time buyer.

Importantly, the transaction data includes the full UK postcode of the property sold allowing it to be assigned to grid-reference coordinates. With this information it is possible within a Geographical Information Systems (GIS) environment to calculate distances to conservation area borders and to determine whether the property lies inside or outside these borders. Furthermore it is possible to calculate distances and other spatial measures (e.g., densities) for the amenities and environmental characteristics that will be used as control variables. Since the data set refers to postcodes rather than individual properties, it is not possible, however, to analyze repeated sales of the same property. This is a limitation shared with most property transaction data sets available in England, including the land registry data.

Neighborhood characteristics

The main variables used for estimating capitalization effects of neighborhood characteristics are median income and ethnic composition. The income data is a model-based estimate of median household income produced by Experian for Super Output Areas of the lower level (LSOA). This is assigned to the transaction data based on postcode. The data on ethnicity was made available by the 2001 UK Census at the level of Output Area (OA). Shares of each of the 16 ethnic groups and a Herfindahl index[5] were computed to capture the ethnic composition of neighborhoods.

[5] The Herfindahl index (HI) is calculated according to the following relation: $HI = \sum_{i=1}^{N} s_i^2$, where s_i is the share of ethnicity i in the LSOA, and N is the total number of ethnicities.

Environmental variables

The environmental variables capture the amenity value of environmental designations, features of the natural environment, different types of land cover and different types of land use.

Geographical data (in the form of ESRI shapefiles) for UK National Parks, Areas of Outstanding Natural Beauty, and National Nature Reserves are available from Natural England. National Parks and Areas of Outstanding Natural Beauty are protected areas of countryside designated because of their significant landscape value. National Nature Reserves are "established to protect sensitive features and to provide 'outdoor laboratories' for research" (National England website). Straight line distances to these designations were computed for the housing units as geographically located by their postcodes. Furthermore, density measures that take into account both the distance to and the size of the features were created. We apply a kernel density measure (Silverman, 1986) with a radius of 2km which is considered to be the maximum distance people are willing to walk (Gibbons & Machin, 2005).

The location of lakes, rivers and coastline are available from the GB Ordinance Survey. The distance to these features is also computed for the housing units from the transaction data. The UK Land Cover Map produced by the Centre for Ecology and Hydrology describes land coverage by 26 categories as identified by satellite images. We follow Mourato et al. (2010) who construct nine broad land cover types from the 26 categories. Shares of each of these nine categories in 1km grid squares are calculated and the housing units take on the value of the grid square in which they reside.

The generalized Land Use Database (GLUD) available from the Department for Communities and Local Government gives area shares of nine different types of land use within Super Output Areas, lower level (LSOA). These nine land use types are domestic buildings, non-domestic buildings, roads, paths, rail, domestic gardens, green space, water, and other land use. These shares are assigned to the housing units based on the LSOA in which they are located.

Amenities

The locational amenities variables capture the benefits a location offers in terms of accessibility, employment opportunities, schools quality, and the proximity of cultural and entertainment establishments.

Employment accessibility is captured both by the distance to Travel to Work Area (TTWA) centroid and a measure of employment potentiality. TTWAs are defined such that 75 per cent of employees who work in the area also live within that area. Thus they represent independent employment zones and the distance to the center of these zones is a proxy for accessibility to employment locations. A more complex measure of accessibility is the employment potentiality index (Ahlfeldt, 2011).[6] This is computed at the Super Output Area, lower level (LSOA) and represents an average of employment in neighboring LSOAs weighted by their distance.

Key Stage 2 (ages 7–11) assessment scores are available from the Department for Education at the Super Output Area, middle layer (MSOA). School quality is thus captured at the housing unit level by computing a distance-weighted average of the KS2 scores of nearby MSOA centroids.[7]

Geographical data on the locations of motorways, roads, airports, rail stations and rail tracks are available from the GB Ordinance Survey. Distances were computed from housing units to motorways, A-roads, B-roads and rail stations to capture accessibility. Buffer zones were created around the motorways and roads along with distance calculations to rail tracks and airports in order to capture the disamenity noise effects of transport infrastructure.

Further data on local amenities were taken from the Ordinance Survey (police stations, places of worship, hospitals, leisure/sports centers) and OpenStreetMap (cafés, restaurants/fast food outlets, museums, nightclubs, bars/pubs, theaters/cinemas, kindergartens and monuments, memorials, monuments, castles, attractions, artwork). The number of listed buildings was provided by English Heritage. Kernel densities for these amenities were computed for housing units using a kernel radius of 2km and a quadratic kernel function (Silverman, 1986). The radius of 2km is consistent with amenities having a significant effect on property prices only when they are within walking distance.

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[6] Further detail on the construction of the employment potentiality measure is provided in section 4.2.

[7] This is calculated as an Inverse Distance Weighting (IDW) with a threshold distance of 5km and a power of 2.

Tab. A2. Variable description

Dependent Variable	
Price	Per square meter transaction price in € of the corresponding plot of land (expressed as natural logarithm). Transaction data from the Nationwide Building Society (NBS).
Independent Variables	
CA Effects	Dummy variables denoting property transactions taking place within the boundaries of an currently existing conservation area, in a conservation area at the time when designated or where the designation date is unknown as well as various buffer areas surrounding current or treated conservation areas.
Fixed Effect Control	Travel to Work Areas, nearest conservation area catchment areas and inter-actives with year effects.
Housing information	Set of property variables from the NBS including: Number of bedrooms, number of bathrooms, floor size (in square meter), new property (dummy), building age (years), tenure (leasehold/freehold), central heating (full: gas, electric, oil, solid fuel), central heating (partial: gas, electric, oil, solid fuel), garage (single or double), parking space, property type (detached, semi-detached, terraced, bungalow, flat-maisonette).
Neighborhood information	Set of neighborhood variables including: media income (2005, LSOA level), share of white population at total population (2001 census, output area level), share of mixed population at total population (2001 census, output area level), share of black population at total population (2001 census, output area level), share of Asian population at total population (2001 census, output area level), share of Chinese population at total population (2001 census, output area level), Herfindahl of ethnic segregation (including population shares of White British, White Irish, White others, Mixed Caribbean, Mixed Asian, Mixed Black, Mixed other, Asian Indian, Asian Pakistani, Asian others, Black Caribbean, Black African, Black other, Chinese, Chinese other population, 2001 census output area).
Conservation area Characteristics	Set of characteristic variables for conservation areas from English Heritage including: Conservation area land use (dummy variables for residential, commercial, industrial or mixed land use), conservation area type (dummy variable for urban, suburban or rural type), conservation area size (dummy for areas larger than mean of 128,432.04 square meters), conservation area (square meter), conservation area has an Article 4 Direction implemented (dummy), oldness of conservation area (dummy for areas older than mean of 1981), conservation area at risk (dummy), conservation area with community support (dummy), conservation area is World Heritage Site (dummy).
Environment Characteristics and Amenities	Set of locational variables processed in GIS including: National Parks (distance to, density), Areas of Outstanding Beauty (distance to, density), Natural Nature Reserves (distance to, density), distance to nearest lake, distance to nearest river, distance to nearest coastline, land in 1km square: Marine and coastal margins; freshwater, wetland and flood plains; mountains, moors and heathland; semi-natural grassland; enclosed farmland; coniferous woodland; broad-leaved/mixed woodland; urban; inland bare ground.
Other amenities	Set of locational variables created in GIS including: Average key stage 2 test score (MSOA averages as well as interpolated in GIS), distance to electricity transmission lines, A-Roads (distance to, buffer dummy variables within 170m), B-Roads (distance to, buffer dummy variable within 85m), motorway (distance to, buffer dummy variable within 315m; buffer distances refer to the distance were noise of maximum speed drops drown to 50 decibel), distance to all railway stations, distance to London Underground stations, dis-

	tance to railway tracks, distance to bus stations, distance to airports, densities of cafés, restaurants/fast food places, museums, nightclubs, bars/pubs, theaters/cinemas, kindergartens, monuments (memorial, monument, castles, attraction, artwork), hospitals, sports/leisure centers, police stations and worship locations, distance to Travel to Work Areas, employment potentiality (based on Travel to Work Areas with an time decay parameter of 0.073).
Neighborhood Distance Controls	Set of neighborhood distance dummy variables created in GIS including: Distances outside conservation area border (up to 50m, 100m, 150m, 200m, 250m, 300m, 350m, 400m, 1km, 2km and 3km), distances inside conservation area border (up to 50m, 100m, 150m, 200m).

4.2 Further notes on data methods

Employment potentiality

The employment potentiality index is computed at the Super Output Area, lower level (LSOA) and represents an average of employment in neighboring LSOAs weighted by their distances. Employment potentiality is calculated for each Lower Layer Super Output Area i (LSOA) based on employment in all other LSOAs j using the following equation:

$$\mathrm{EP_i} = \sum_{\mathrm{j}} \mathrm{E_j e^{-a\, d_{ij}}}, with\ i \neq j \tag{A21}$$

where d measures the straight line distance converted into travel time assuming an overall average speed of 25km/h (Department for Transport, 2009) and Employment the absolute number of workers in the respective LSOA. The indicator is weighted by a decay parameter of a = -0.073 estimated by Ahlfeldt (in press). Internal distances are calculated as:

$$\mathrm{d_{ii}} = \frac{1}{3}\sqrt{\frac{\mathrm{Area_i}}{\pi}} \tag{A22}$$

Kernel densities for National Parks, Areas of Outstanding Natural Beauty and National Nature Reserves

The kernel density is a measure that takes into account both the proximity and the size of NPs, AONBs and NNRs. Every 100x100m piece of designated area is assigned a point and the density of these resulting points calculated for 10km kernels and a quadratic kernel function (Silverman, 1986, p. 76, equation 4.5) around each housing unit using a kernel density method. The result is similar to calculating a share of NP area within a circle, the one difference being that the points are additionally weighted by distance to the housing units according to a normal distribution.

Buffers for motorways and roads

The buffer sizes for the different roads are as follows: B-Road (85m), A-Road (170m) and Motorway (315m). These distances are calculated based on how far it is expected that the noise from traffic travelling at the speed limit of the respective roads (Steven, 2005) would decline to an assumed disamenity threshold level of noise of 50db (Nelson, 2008).

Land cover map Broad Categories

Tab. A3. Land Cover Broad categories as defined by Mourato et al. (2010)

1	Marine and coastal margins
2	Freshwater, wetlands, and flood plains
3	Mountains, moors, and heathland
4	Semi-natural grasslands
5	Enclosed farmland
6	Coniferous woodland
7	Broad-leaved/mixed woodland
8	Urban
9	Inland bare ground

5 Estimation results

5.1 Designation process

In order to test our theoretical implication that changes in heritage preferences lead to changes in designation we estimate the regression modeled as outlined in section 3.1. The prediction of the model is that positive changes in heritage preferences should lead to negative changes in the share of undesignated land in a neighborhood. OLS regression results are reported in Table A4. We drop all zeros and identify the effect based on the sample of observations with observable changes in conservation area shares. The standard OLS estimates without (1) and with a basic set of composition controls (2) are insignificant. Due to the potential sources of bias in OLS discussed in the main paper (section 3.1) we re-estimate the two models using our instrumental variables. The 2SLS estimates (3) and (4) are in line with the tobit results reported in the main paper and support the theory that a positive change in degree share leads to higher designation.

Tab. A4. Designation regressions: OLS/2SLS models

	(1) OLS Δ log designation share (t)	(2) OLS Δ log designation share (t)	(3) 2SLS Δ log designation share (t)	(4) 2SLS Δ log designation share (t)
Δ log degree share (t)	-0.009	-0.017	-0.674***	-0.279***
	(0.012)	(0.015)	(0.113)	(0.085)
log degree share (t-1)		-0.009		-0.106***
		(0.013)		(0.033)
log designation share (t-1)		0.169***		0.147***
		(0.010)		(0.023)
Δ log homeownership (t)		0.120***		0.148***
		(0.029)		(0.035)
log homeownership (t-1)		0.025		-0.030
		(0.022)		(0.026)
Δ log average household size (t)		-0.015		-0.067
		(0.064)		(0.052)
log average household size (t-1)		0.005		-0.041
		(0.030)		(0.064)
Constant	-0.044***	-0.033	0.430***	-0.017
	(0.012)	(0.031)	(0.081)	(0.062)
IV	NO	NO	YES	YES
Controls	NO	YES	NO	YES
R^2	0.000	0.075	-1.023	0.015
F	0.604	139.420	35.637	19.008
AIC	-931.737	-1045.816	210.758	-944.019
OVERID	.	.	0.966	2.372
OVERIDP	.	.	0.326	0.124
Observations	1621	1621	1621	1621

Notes: See the data section for a description of control variables. IVs are station density and employment potential. Standard errors in parentheses and clustered on fixed effects. $^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$.

Table A5 reports the first stage results to the second-stage results reported in Table 1 in the main paper. Both IVs are (conditionally) positively correlated with the change in degree share, as expected.

Tab. A5. Standard IV models – First stage regressions

	(1) Δ log degree share (t)	(2) Δ log degree share (t)	(3) Δ log degree share (t)	(4) Δ log degree share (t)	(5) Δ log degree share (t)	(6) Δ log degree share(t) x homeownership (t-1)
rail station density	0.124***	0.112***	0.124***	0.103***	0.128***	-0.007***
	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)	(0.002)
employment potentiality	3.2E-08***	2.5E-08***	3.2E-08***	3.8E-08***	3.2E-08***	9.5E-10***
	(2.3E-08)	(2.7E-09)	(2.3E-09)	(2.3E-09)	(2.2e-09)	(4.2E-10)
predicted Δ log degree share (t) x homeownership (t-1)					-0.403***	1.118***
					(0.048)	(0.009)
log degree share (t-1)	-0.409***	-0.454***	-0.409***	-0.429***	-0.400***	0.002***
	(0.013)	(0.009)	(0.004)	(0.004)	(0.004)	(0.001)
log designation share (t-1)	-0.021	-0.020	-0.021***	-0.001	-0.025***	-0.005***
	(0.017)	(0.015)	(0.008)	(0.008)	(0.008)	(0.001)
Δ log homeownership (t)	0.293***	0.339***	0.294***	0.376***	0.275***	0.012***
	(0.060)	(0.065)	(0.016)	(0.017)	(0.016)	(0.003)
log homeownership (t-1)	0.016	0.054	0.016*	0.073***	0.210***	-0.060***
	(0.021)	(0.031)	(0.011)	(0.011)	(0.025)	(0.005)
Δ log average hh. size (t)	-0.075	-0.140*	-0.075***	-0.032*	-0.052***	0.020***
	(0.084)	(0.055)	(0.024)	(0.024)	(0.024)	(0.004)
log average hh. size (t-1)	-0.170	-0.315***	-0.169***	-0.070***	0.171***	0.018***
	(0.087)	(0.090)	(0.028)	(0.005)	(0.028)	(0.005)
Log price trend			0.004			
			(0.012)			
Δ log vacancy rate (t)				0.024***		
				(0.004)		
log vacancy rate (t-1)				0.070***		
				(0.005)		
Log listed buildings				0.017***		
				(0.002)		
average condition score (1 best, 4 worst)				0.011		
				(0.014)		
average vulnerability score (1 low, 8 high)				-0.013		
				(0.013)		
average trajectory score (-2 improving, +2 deteriorating)				0.002		
				(0.027)		
Constant	0.017	0.136	0.025	0.316***	0.106***	-0.032***
	(0.098)	(0.107)	(0.039)	(0.034)	(0.030)	(0.005)
Controls	YES	YES	YES	YES	YES	YES
FE	NO	YES	NO	NO	NO	NO
Price Trend	NO	NO	YES	NO	NO	NO
Housing Cond.	NO	NO	NO	YES	NO	NO
Observations	7965	7965	7965	7965	7965	7965
F	420.662	.	1756.16	1320.37	2093.28	18708.76
R^2	0.688	0.732	0.688	0.699	0.703	0.955

Notes: See the data section for a description of control variables. IVs are station density and employment potential in all models. Model (4) includes a dummy variable indicating 60 wards for which no price trend could be computed due to insufficient transactions. We derive the instrument (predicted Δ log degree share (t) x homeownership (t-1)) for the interaction term in model (5) by interacting homeownership (t-1) with the predicted values of an auxiliary regression where we regress Δ log degree share on the exogenous variables, i.e. on the standard IVs and controls. Standard errors in parentheses and clustered on fixed effects. $^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$.

We have tried four alternative IV models which are based on the benchmark model, i.e., including the set of controls (Table 1, column 2 in the main paper). The coefficient estimates reported in Table A6 remain qualitatively similar and quantitatively close to the main model. First stage results are reported in Table A7 in the appendix. The alternative instruments, again, pass the validity tests. Only the overidentification test is failed by specification (1) using employment potentiality and museum density as instruments.

Tab. A6. Alternative IV models

	(1) *Δ* log designation share (t)	(2) *Δ* log designation share (t)	(3) *Δ* log designation share (t)	(4) *Δ* log designation share (t)
Δ log degree share (t)	-0.488***	-0.512***	-0.502***	-0.557***
	(0.063)	(0.065)	(0.063)	(0.070)
log degree share (t-1)	-0.265***	-0.274***	-0.270***	-0.291***
	(0.025)	(0.025)	(0.025)	(0.027)
log designation share (t-1)	-0.020	-0.022*	-0.022*	-0.021
	(0.013)	(0.013)	(0.013)	(0.013)
Δ log homeownership (t)	0.259***	0.263***	0.262***	0.251***
	(0.029)	(0.029)	(0.029)	(0.028)
log homeownership (t-1)	0.065***	0.061***	0.061***	0.046**
	(0.018)	(0.018)	(0.018)	(0.019)
Δ log average household size (t)	0.033 (0.040)	0.033 (0.040)	0.032 (0.040)	0.013 (0.039)
log average household size (t-1)	-0.009 (0.049)	-0.014 (0.050)	-0.012 (0.049)	-0.010 (0.050)
Constant	0.049	0.052	0.051	0.040
	(0.048)	(0.048)	(0.048)	(0.048)
Controls	YES	YES	YES	YES
IV	YES	YES	YES	YES
Observations	7965	7965	7965	7968
CHI2	340.356	341.226	342.655	331.908
EXOG_P	0.000	0.000	0.000	0.000
OVERID	3.544	0.078	0.752	0.201
OVERIDP	0.060	0.780	0.386	0.654
Instruments (as densities except employment pot.)	Employment potentiality Museum	Employment potentiality Coffee place	Employment potentiality Bar	Rail station Coffee place

Notes: See the data section for a description of control variables. Standard errors in parentheses and clustered on fixed effects. *$p< 0.05$, **$p< 0.01$, ***$p< 0.001$.

Tab. A7. Alternative IV models – first stage regressions

	(1) *Δ* log degree share (t)	(2) *Δ* log degree share (t)	(3) *Δ* log degree share (t)	(4) *Δ* log degree share (t)
employment potentiality	4.4E-08***	4.3E-08***	4.1E-08***	
	(1.9E-09)	(1.9E-09)	(1.9E-09)	
museum density	0.142***			
	(0.034)			
coffee place density		0.004***		-0.011***
		(0.001)		(0.003)
bar density			0.006**	
			(0.002)	
rail station density				0.282***
				(0.022)
log degree share (t-1)	-0.406***	-0.406***	-0.408***	-0.399***
	(0.012)	(0.012)	(0.012)	(0.010)
log designation share (t-1)	-0.019	-0.022	-0.018	-0.031*
	(0.015)	(0.016)	(0.016)	(0.012)
Δ log homeownership (t)	0.285***	0.274***	0.285***	0.260***
	(0.065)	(0.063)	(0.068)	(0.061)
log homeownership (t-1)	0.007	-0.002	0.011	-0.038
	(0.024)	(0.024)	(0.025)	(0.031)
Δ log average household size (t)	-0.101	-0.098	-0.088	-0.040
	(0.078)	(0.077)	(0.079)	(0.108)
log average household size (t-1)	-0.192*	-0.204*	-0.188*	-0.127
	(0.083)	(0.084)	(0.082)	(0.086)
Constant	0.039	0.051	0.035	-0.015
	(0.092)	(0.094)	(0.091)	(0.091)
Controls	YES	YES	YES	YES
Observations	7965	7965	7965	7968
F	396.188	517.118	441.850	552.553
R^2	0.686	0.685	0.686	0.681

Notes: See the data section for a description of control variables. Standard errors in parentheses and clustered on fixed effects. *p< 0.05, **p< 0.01, ***p< 0.001.

Furthermore, we have split the long difference between 1991 and 2011 into two shorter differences of 1991 to 2001 and 2001 to 2011. For the latter short difference we moreover used the change in income instead of change in degree as a proxy for heritage preferences. The coefficient estimates remain qualitatively similar to the main model and are reported with their first stages in tables A8 and A9. The coefficient of the key variable is slightly smaller in the benchmark specification of the short different between 1991 and 2001 (column 4) and considerably larger for the period between 2001 and 2011 (column 8). In columns (9)–(12) we use income as a proxy of heritage preference. Focusing on the benchmark specification in the final column, doubling income more than quadruples the designation share. The respective instruments are valid and sufficiently strong. Overall, the results are in line with our theory; increases in heritage preferences, proxied by change in degree or change in income, lead to increases in designation shares.

Tab. A8. Short differences and income model

	(1) 1991-2001 Δ log designation share (t)	(2) 1991-2001 Δ log designation share (t)	(3) 1991-2001 Δ log designation share (t)	(4) 1991-2001 Δ log designation share (t)	(5) 2001-2011 Δ log designation share (t)	(6) 2001-2011 Δ log designation share (t)	(7) 2001-2011 Δ log designation share (t)	(8) 2001-2011 Δ log designation share (t)	(9) 2001-2011 Δ log designation share (t)	(10) 2001-2011 Δ log designation share (t)	(11) 2001-2011 Δ log designation share (t)	(12) 2001-2011 Δ log designation share (t)
Δ log degree share (t)	-0.013	-0.229***	-0.064***	-0.193***	0.464***	1.618***	-0.066	-2.790***				
	(0.008)	(0.022)	(0.011)	(0.031)	(0.051)	(0.124)	(0.077)	(0.910)				
log degree share (t-1)			-0.063***	-0.092***			-0.140***	-0.689***				
			(0.005)	(0.008)			(0.022)	(0.186)				
log designation share (t-1)			-0.034***	-0.050***			0.022	0.036			0.032*	-0.019
			(0.011)	(0.012)			(0.018)	(0.022)			(0.018)	(0.028)
Δ log homeownership (t)			0.109***	0.152***			0.225***	0.895***			0.278***	0.134
			(0.024)	(0.026)			(0.084)	(0.236)			(0.082)	(0.113)
log homeownership (t-1)			0.061***	0.028**			0.185***	0.390***			0.225***	0.244***
			(0.010)	(0.013)			(0.025)	(0.074)			(0.026)	(0.036)
Δ log average household size (t)			0.039	0.031			-0.220*	-0.813***			-0.227*	0.774***
			(0.034)	(0.035)			(0.132)	(0.257)			(0.130)	(0.276)
log average household size (t-1)			0.090***	0.046			0.108	-0.140			0.198***	0.671***
			(0.031)	(0.033)			(0.068)	(0.107)			(0.070)	(0.145)
Δ log income									-0.204***	-9.152***	-0.210***	-4.357***
									(0.068)	(1.981)	(0.067)	(0.959)
log income (t-1)											-0.201***	-0.498***
											(0.026)	(0.078)
Constant	0.153***	0.231***	-0.024	-0.011	0.311***	-0.125***	0.246***	0.615***	0.535***	2.825***	1.702***	4.203***
	(0.005)	(0.010)	(0.031)	(0.031)	(0.021)	(0.042)	(0.066)	(0.140)	(0.026)	(0.513)	(0.179)	(0.630)
Controls	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES
IV	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Observations	7968	7965	7968	7965	7969	7966	7969	7966	7969	7966	7969	7966
CHI2		106.812		215.197		171.695		169.534		21.347		122.739
EXOG_P		0.000		0.000		0.000		0.001		0.000		0.000
OVERID		2.165		1.188		1.485		15.948		13.591		0.061
OVERIDP		0.141		0.276		0.223		0.000		0.000		0.805

Notes: See the data section for a description of control variables. Standard errors in parentheses. * $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

Tab. A9. Short differences and income model – First stage regressions

	(1) 1991-2001 Δ log degree share (t)	(2) 1991-2001 Δ log degree share (t)	(3) 2001-2011 Δ log degree share (t)	(4) 2001-2011 Δ log degree share (t)	(5) 2001-2011 Δ log income (t)	(6) 2001-2011 Δ log income (t)
rail station density	0.117***	0.102***	-0.061***	0.038***	-0.012	0.018
	(0.032)	(0.012)	(0.010)	(0.007)	(0.037)	(0.029)
employment potentiality	5.14E-8***	4.99E-8***	-2.35E-8***	-1.87E-9	5.69E-9*	5.44E-9
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log degree share (t-1)		-0.262***		-0.209***		
		(0.011)		(0.009)		
log designation share (t-1)		-0.040*		0.006		-0.011*
		(0.018)		(0.006)		(0.005)
Δ log homeownership (t)		0.411***		0.253***		-0.017
		(0.083)		(0.029)		(0.064)
log homeownership (t-1)		-0.038		0.092***		0.040*
		(0.022)		(0.009)		(0.017)
Δ log average household size (t)		-0.145*		-0.217***		0.220***
		(0.064)		(0.065)		(0.037)
log average household size (t-1)		-0.236**		-0.069*		0.130**
		(0.077)		(0.030)		(0.044)
Log income (t-1)						-0.095***
						(0.020)
Constant	0.327***	-0.036	0.390***	0.112***	0.255***	0.741***
	(0.008)	(0.083)	(0.005)	(0.030)	(0.004)	(0.113)
Controls	NO	YES	NO	YES	NO	YES
Observations	7965	7965	7966	7966	7966	7966
F	34.876	443.629	74.997	544.976	8.308	12.770
R^2	0.103	0.504	0.095	0.602	0.004	0.068

Notes: See the data section for a description of control variables. Standard errors in parentheses and clustered on fixed effects. $^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$.

5.2 Pareto optimality

Tab. A10. below reports the conservation area effects as well as the full set of hedonic controls for the difference-in-differences estimation given by equation (26) in the main paper. Column (7) shows that housing units with more bathrooms and bedrooms fetch higher prices, as do detached, semi-detached, and bungalows (over the omitted category flats/maisonettes). The sales price of terraced housing is insignificantly different from flats/maisonettes. Larger floor spaces are associated with higher price but with significant diminishing effects. There is a premium for new properties. Leased properties are of less value than those owned. Properties with parking spaces, single garages and double garages sell for higher prices than those without any parking facilities. There is a house price premium for properties with central heating over other types of heating. In order to control for a potentially non-linear relationship between housing age and house prices we included a series of house age bins. In order to separate the effects of pure building age (which may be associated with deterioration) from the build date (which may strongly determine the architectural style) we allow for age cohort and building data cohort effects. Since the 'New property' variable identifies all properties where the build age is zero years, the omitted category from the age variables is 1–9 years. All of the bins for properties older than this indicate significant negative premiums. The negative premium increases with age, mostly quickly over the first few categories and then more slowly until the penultimate category and finally decreases for buildings over 100 years. The effect of the build date is also non-linear. The general tendency is for buildings built in earlier periods to have higher prices than buildings built in the omitted period 2000–2010. However, this effect becomes insignificant in the 60s and 70s; periods associated with the architectural styles of the post-ward reconstruction phase that are today less appreciated than other styles. The greatest premium is attached to houses built pre-1900, the earliest category.

Tab. A10. Conservation area premium – designation effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Inside treated CA	0.028***	0.014	0.014	0.003	-0.024	-0.077	-0.003
× Post designation	(0.009)	(0.009)	(0.010)	(0.012)	(0.070)	(0.111)	(0.013)
Within 500m buffer of	0.023***	0.013***	0.012***	0.004	0.012	-0.005	-0.005
treated CA × Post des.	(0.004)	(0.004)	(0.005)	(0.006)	(0.027)	(0.022)	(0.010)
Inside treated CA	-0.043***	-0.038***	-0.048***	-0.037***	-0.062	0.029	-0.024
	(0.009)	(0.009)	(0.010)	(0.012)	(0.057)	(0.108)	(0.021)
Within 500m buffer of	-0.010**	-0.004	-0.011**	0.005	0.003	0.006	-0.002
treated CA	(0.004)	(0.004)	(0.005)	(0.005)	(0.030)	(0.023)	(0.013)
Number of bathrooms	0.007***	0.007***	0.006***	0.013***	0.057***	0.059***	0.014***
	(0.000)	(0.001)	(0.001)	(0.002)	(0.008)	(0.006)	(0.002)
Number of bedrooms	0.166***	0.172***	0.169***	0.165***	0.170***	0.179***	0.158***
	(0.002)	(0.004)	(0.005)	(0.005)	(0.014)	(0.011)	(0.006)
Number of bedrooms	-0.019***	-0.020***	-0.020***	-0.019***	-0.019***	-0.019***	-0.018***
squared	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Detached house	0.254***	0.222***	0.211***	0.194***	0.235***	0.216***	0.193***
	(0.003)	(0.005)	(0.008)	(0.007)	(0.015)	(0.014)	(0.007)
Semi-detached house	0.119***	0.097***	0.088***	0.070***	0.082***	0.066***	0.073***
	(0.003)	(0.004)	(0.007)	(0.006)	(0.014)	(0.012)	(0.006)
Terraced	0.040***	0.026***	0.015**	0.001	0.002	-0.013	-0.000
house/Country cottage	(0.003)	(0.004)	(0.006)	(0.006)	(0.013)	(0.012)	(0.006)
Bungalow	0.311***	0.285***	0.281***	0.257***	0.292***	0.269***	0.257***
	(0.003)	(0.006)	(0.008)	(0.009)	(0.019)	(0.016)	(0.009)
Floorsize (m^2)	0.006***	0.006***	0.007***	0.007***	0.008***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Floorsize (m^2)	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
× Floorsize (m^2)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
New property	0.084***	0.087***	0.088***	0.088***	0.047**	0.076***	0.077***
	(0.002)	(0.004)	(0.005)	(0.006)	(0.024)	(0.017)	(0.006)
Leasehold	-0.054***	-0.067***	-0.065***	-0.073***	-0.100***	-0.104***	-0.070***
	(0.003)	(0.004)	(0.006)	(0.006)	(0.014)	(0.012)	(0.006)
Single garage	0.112***	0.097***	0.100***	0.097***	0.096***	0.097***	0.098***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.007)	(0.005)	(0.003)
Double garage	0.190***	0.162***	0.161***	0.159***	0.160***	0.156***	0.158***
	(0.002)	(0.003)	(0.005)	(0.005)	(0.015)	(0.010)	(0.005)
Parking space	0.076***	0.063***	0.065***	0.061***	0.052***	0.049***	0.063***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.007)	(0.005)	(0.003)
Central heating	0.089***	0.094***	0.098***	0.100***	0.085***	0.094***	0.095***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.007)	(0.007)	(0.003)
Building age: 10–19	-0.047***	-0.063***	-0.062***	-0.075***	-0.071***	-0.068***	-0.069***
years	(0.002)	(0.003)	(0.004)	(0.005)	(0.016)	(0.015)	(0.005)
Building age: 20–29	-0.079***	-0.106***	-0.104***	-0.125***	-0.133***	-0.126***	-0.113***
years	(0.002)	(0.005)	(0.007)	(0.008)	(0.026)	(0.021)	(0.007)
Building age: 30–39	-0.092***	-0.127***	-0.123***	-0.150***	-0.169***	-0.141***	-0.133***
years	(0.003)	(0.006)	(0.010)	(0.011)	(0.032)	(0.027)	(0.009)
Building age: 40–49	-0.104***	-0.148***	-0.142***	-0.180***	-0.199***	-0.165***	-0.158***
years	(0.004)	(0.008)	(0.012)	(0.013)	(0.036)	(0.031)	(0.011)
Building age: 50–59	-0.121***	-0.171***	-0.167***	-0.207***	-0.232***	-0.204***	-0.175***
years	(0.004)	(0.009)	(0.015)	(0.016)	(0.044)	(0.038)	(0.014)
Building age: 60–69	-0.135***	-0.198***	-0.194***	-0.238***	-0.320***	-0.265***	-0.215***
years	(0.005)	(0.011)	(0.019)	(0.020)	(0.051)	(0.042)	(0.018)
Building age: 70–79	-0.136***	-0.213***	-0.207***	-0.263***	-0.326***	-0.273***	-0.234***
years	(0.006)	(0.013)	(0.021)	(0.022)	(0.053)	(0.046)	(0.019)
Building age: 80–89	-0.132***	-0.218***	-0.213***	-0.277***	-0.339***	-0.313***	-0.243***
years	(0.007)	(0.014)	(0.023)	(0.024)	(0.062)	(0.054)	(0.021)
Building age: 90–99	-0.111***	-0.208***	-0.204***	-0.280***	-0.360***	-0.304***	-0.248***
years	(0.008)	(0.016)	(0.025)	(0.027)	(0.068)	(0.063)	(0.023)
Building age: Over 100	-0.083***	-0.176***	-0.176***	-0.261***	-0.348***	-0.284***	-0.227***

years	(0.009)	(0.017)	(0.027)	(0.030)	(0.074)	(0.065)	(0.025)
Build date: 1900–1909	0.040***	0.121***	0.128***	0.208***	0.256***	0.222***	0.173***
	(0.009)	(0.018)	(0.028)	(0.031)	(0.077)	(0.067)	(0.025)
Build date: 1910–1919	0.074***	0.153***	0.158***	0.226***	0.262***	0.256***	0.196***
	(0.008)	(0.016)	(0.027)	(0.028)	(0.071)	(0.059)	(0.024)
Build date: 1920–1929	0.093***	0.157***	0.162***	0.215***	0.225***	0.189***	0.190***
	(0.007)	(0.014)	(0.024)	(0.025)	(0.062)	(0.050)	(0.021)
Build date: 1930–1939	0.082***	0.128***	0.130***	0.168***	0.187***	0.163***	0.151***
	(0.006)	(0.013)	(0.021)	(0.023)	(0.058)	(0.045)	(0.020)
Build date: 1940–1949	0.040***	0.078***	0.078***	0.111***	0.063	0.053	0.096***
	(0.005)	(0.012)	(0.018)	(0.021)	(0.058)	(0.048)	(0.018)
Build date: 1950–1959	0.017***	0.033***	0.041***	0.057***	0.017	-0.004	0.046***
	(0.004)	(0.010)	(0.016)	(0.018)	(0.047)	(0.039)	(0.015)
Build date: 1960–1969	0.001	0.007	0.018	0.023	-0.017	-0.012	0.011
	(0.004)	(0.009)	(0.013)	(0.015)	(0.044)	(0.037)	(0.013)
Build date: 1970–1979	-0.015***	-0.016**	-0.008	-0.004	-0.059	-0.046	-0.011
	(0.003)	(0.007)	(0.011)	(0.012)	(0.042)	(0.033)	(0.011)
Build date: 1980–1989	0.013***	0.017***	0.025***	0.029***	-0.023	-0.010	0.024***
	(0.003)	(0.006)	(0.008)	(0.010)	(0.038)	(0.029)	(0.008)
Build date: 1990–1999	0.022***	0.020***	0.022***	0.029***	-0.020	-0.008	0.017**
	(0.002)	(0.005)	(0.006)	(0.008)	(0.034)	(0.025)	(0.008)
Build date: pre 1900	0.098***	0.149***	0.162***	0.244***	0.312***	0.259***	0.216***
	(0.009)	(0.018)	(0.029)	(0.031)	(0.081)	(0.070)	(0.026)
Location cont.	YES	YES	YES	YES	YES	YES	YES
Neighborhood cont.	YES	YES	YES	YES	YES	YES	YES
Year effects	YES	YES	YES	YES	YES	YES	YES
Ward effects	YES	YES					
Nearest treated CA effects			YES	YES	YES	YES	
Matched CA effects							YES
Treatment group: CAs designated	1996-2010	1996-2010	1996-2010	1996-2010	1996-2002	1996-2002	1996-2010
Control group	Full England sample	Within 2km of treated CA	Within 2km of treated CA	Within 500m of pre-1996 CA & within 2km of treated CA	Within 500m of CA designated 1987-1995 & within 4km of treated CA	Within 500m of CA designated 2003-2010 & within 4km of treated CA	Within 500m of pre-1996 CA matched on propensity score
R^2	0.921	0.922	0.915	0.915	0.861	0.864	0.909
AIC	-587375	-156426	-130469	-67044	-5410	-8475	-41206
Observation	1088k	302k	302k	178k	214k	323k	133k

Notes: Standard errors in parentheses are clustered on location fixed effects. Conservation area control groups in Columns (4)-(7) have separate fixed effects for the areas inside and outside a conservation area. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

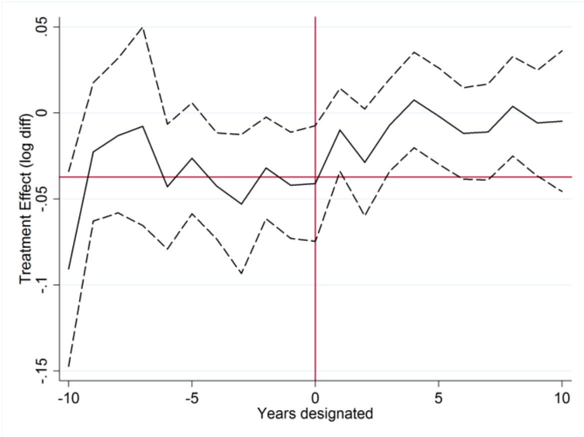
Semi-parametric temporal and spatial treatment effects

Fig A2. reports the results for the semi-parametric estimation of the temporal effects of designation using equation (A19). Instead of simply presenting our two strongest specifications, as we do in the main paper, here we present a different dimension to the results bin by comparing the bin estimates for the naïve DD in the left panels to the matched CA control group in the right panels. The left charts show that the post-period internal and external estimates deviate significantly from the pre-period mean (hence the significant DD estimates) but that this is driven by a general upward trends. This corroborates the results in Tab. 2., column (1) of the main paper where no significant discontinuity nor shift in trend for the naïve control group exists and hence the advantages of the RDD-DD over the standard DD method is highlighted. The charts in the right panels also corroborate the evidence presented using the parametric trends equations in the main paper. Specifically, they show that for the internal effects the post-treatment estimates tend not to deviate significantly from the pre-treatment effects but that there are upward shifts in the trend when compared to the pre-treatment trend. For the external effects there is a general upward trend in the less carefully matched control groups and a downward trend in the stronger control groups but no shift in the trend at the designation date.

Fig A2. Semi-parametric temporal bins estimates

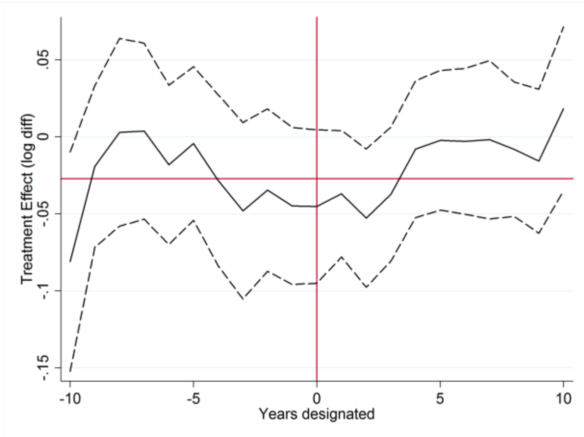
Internal effects: Full dataset

Tab. A10. column (1)



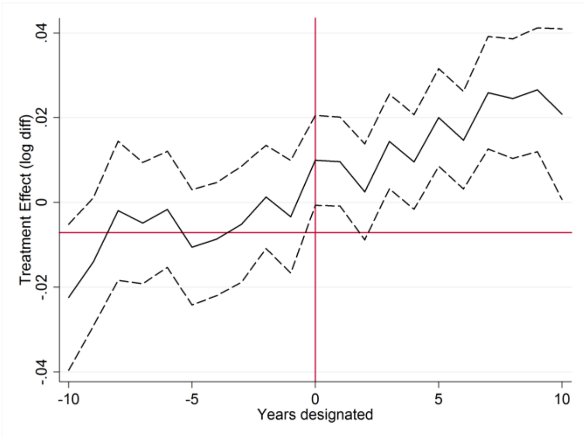
Internal effects: Matched CA

Tab. A10. column (7)



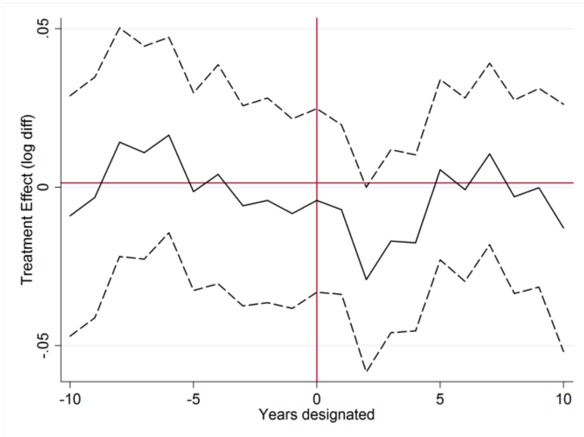
External effects: Full dataset

Tab. A10. column (1)



External effects: Matched CA

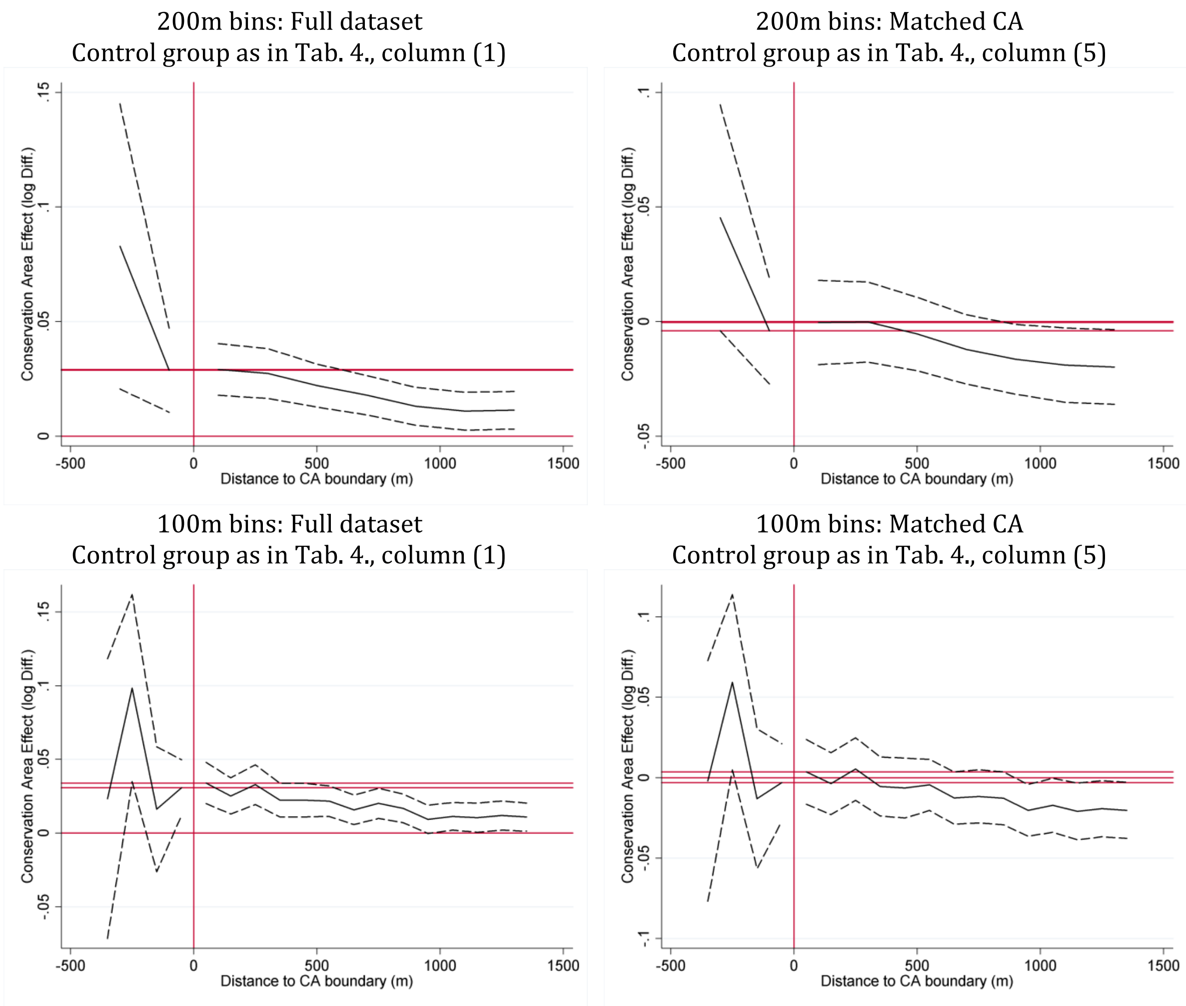
Tab. A10. column (7)



Notes: The solid black line plots the estimated differences between treatment group and control group against year since designation date using equation (A19). The dashed lines indicate the 5% confidence intervals. The left charts show results for the control group used in column (1) of appendix Tab. A10. . The right charts show results for the control group used in column (7) of appendix Tab. A10. . The horizontal red line illustrates the mean of the pre-treatment estimates.

Fig A3. demonstrates the semi-parametric spatial effects using different bin sizes of 100m and 200m using appendix equation (A20). These semi-parametric charts closely resemble their parametric counterparts. Notably, there is no significant and positive effect in the first bin outside the conservation area when using the preferred specification of column (7) from Tab. A10. This is consistent with the parametric findings and baseline DD findings that there is no significant external policy effect and that our second hypothesis cannot be accepted. There is, however, one significant bin inside the conservation area at 200–300m. This provides some support for the idea that heritage externalities are stronger deeper within the conservation areas such that there may be a positive policy effect. This effect then declines to zero for the deepest bin of greater than 300m.

Fig A3. Semi-parametric spatial bins estimates



Notes: The solid black line plots estimate the difference-in-differences treatment effect at different distances from the conservation area boundary using appendix equation (A20). The dashed lines indicate the 5% confidence intervals. The left charts show results for the control group used Tab. 4., column (1). The right charts show results for the control group used in Tab. 4., column (5). The horizontal red lines illustrate the mean of the pre-treatment estimates, the final pre-period bin and the first post-period bin.

6 Literature

Ahlfeldt, G. M. (2011). If Alonso was right: Modeling Accessibility and Explaining the Residential Land Gradient. *Journal of Regional Science, 51*(2), 318-338.

Ahlfeldt, G. M. (in press). If we build it, will they pay? Predicting property price effects of transport innovations. *Environment and Planning A*.

Department for Transport. (2009). *Transport Statistics Bulletin, Road Statistics 2008: Traffic, Speeds and Congestion*. London.

Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics, 57*(1), 148-169.

Mourato, S., Atkinson, G., Collins, M., Gibbons, S., MacKerron, G., & Resende, G. (2010). Economic Analysis of Cultural Services. In U. N. E. A. Report (Ed.).

Nelson, J. (2008). Hedonic Property Value Studies of Transportation Noise: Aircraft and Road Traffic. In A. Baranzini, J. Ramirez, C. Schaerer & P. Thalmann (Eds.), *Hedonic Methods in Housing Markets* (pp. 57-82): Springer New York.

Rosenbaum, P. R., & Ruben, D. B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrica, 70*(1), 41-55.

Silverman, B. W. (1986). Density Estimation For Statistics and Data Analysis. *Monographs on Statistics and Applied Probability*.

Steven, H. (2005). *Investigations on Noise Emission of Motor Vehicles in Road Traffic: Research Project 200 54 135 ; Final Report*: RWTUEV Fahrzeug, Inst. for Vehicle Technology, Division noise, measurement technique, modelling.

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