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HISTORIC AMENITIES AND HOUSING EXTERNALITIES: EVIDENCE FROM THE NETHERLANDS*

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We study the economic effects of public investments in historic amenities by looking at their impact on house prices. We distinguish between direct and indirect effects of investments. A nationwide housing transaction is used as well as data on investments in cultural heritage. A 1 million euro per square kilometre increase in investments in cultural heritage leads to a price increase of 1.5–3.0% of non-targeted buildings. We do not find evidence that the maintenance state of non-eligible properties is improved, suggesting that any price effect due to investments in cultural heritage is a direct effect of investments.

It has been argued that urban amenities are a crucial determinant of the urban economic growth of many contemporary cities (Brueckner *et al.*, 1999; Glaeser *et al.*, 2001). Roback (1982) was one of the first to argue that differences in amenities, or the quality of life, may cause substantial wage and house price differences between cities. Urban amenities may not only be crucial for the growth of cities but may also impact the urban spatial structure and are a critical factor in location choices of households within the city.

An important example of an urban amenity is the presence of cultural heritage. Historic amenities are thought to contribute to an attractive living environment and may attract shops, restaurants and other modern urban amenities. European cities, in contrast to US cities, generally offer historic amenities to tourists and to their residents.

Historic amenities will most likely imply a positive external effect on the local economy; benefits are not only enjoyed by the users but also by visiting tourists and residents living close to the building. Furthermore, historic amenities may attract high-skilled high-income workers that may generate knowledge spillovers (Brueckner *et al.*, 1999; Koster *et al.*, 2016; Falck *et al.*, 2015; Van Duijn and Rouwendal, 2015). However, costs of maintaining and preserving historic buildings are not necessarily shared among those who enjoy the benefits.[1] The presence of an external effect, therefore, provides a good reason for local and national governments to protect cultural heritage.

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[1] For example, a medieval church in the centre of a square may help to make this an attractive location for cafés and restaurants but the costs of keeping the exterior of the church in good condition may not be paid by the owners. The visitors to religious services in the church may also be unable or unwilling to do so and their willingness to pay for the cultural heritage aspect of the building may be smaller than that of the visitors to the surrounding cafés and restaurants.

Many governments indeed have taken measures to preserve cultural heritage, by designating historic districts and by introducing subsidies for renovation and maintenance (Ahlfeldt *et al.*, 2017). For instance, in the Netherlands these subsidies have been in place since the 1970s, when many listed buildings were in a poor condition. The subsidy programme has been successful in the sense that most (90%) of the listed buildings are now considered to be in a good condition.

In this study, we aim to measure the external effects of these – often substantial – investments in historic amenities on the housing market. There are arguably two external effects of investments in cultural heritage on surrounding properties. First, there is a direct positive effect of the investment on the prices of surrounding houses because a higher quality of historic amenities raises the overall amenity level in the neighbourhood. Second, households may adjust the quality of their houses through private investments in maintenance and outward appearance. This will lead to subsequent changes in prices when housing quality is also enjoyed by neighbouring households (the indirect effect). Rossi-Hansberg *et al.* (2010) predict that the provision of housing quality by individual households will decrease when governments provide funding to improve the neighbourhood, which implies a negative indirect effect on house prices. We show that the latter outcome crucially depends on (arbitrary) functional form assumptions of the utility function. Hence, it is an empirical question whether the level of housing quality provided by households changes due to investments in the neighbourhood.

To distinguish between the direct and indirect external effects of cultural heritage, we not only test the impact of investments in cultural heritage on house prices but also on the maintenance level. We use a data set on investments in individual listed objects since 1985 and a house price transaction data set that covers about 70% of the transactions in the Netherlands since 1985.

To measure the causal impact of changes in the local amenity level due to investments, one faces several endogeneity problems. More specifically, historic amenities are often clustered in attractive locations (e.g. city centres), which may lead to a spurious correlation between historic amenities and house prices. This implies that identifying external effects caused by historic amenities requires an exogenous source of variation in the amenity level of a given location. To control for all unobserved time-invariant housing and neighbourhood attributes, we use repeat sales and temporal variation in investments in cultural heritage. This should strongly reduce the problem of omitted variable bias. Still, the investments may be correlated with unobserved price trends. For example, the investments in city centres may be correlated with a renewed interest in city living. To make it more plausible that we identify a causal external effect of investments in cultural heritage on house prices and the maintenance level, we use exogenous variation in spending in national subsidy programmes in the spirit of Bartik (1991) and Moretti (2010), among others. Based on the stock of listed buildings in 1985 and yearly changes in the total subsidies in cultural heritage, we predict the expected investments in cultural heritage for each neighbourhood. One may argue that unobserved trends may be correlated with the stock of listed buildings in 1985, so we extensively control for interactions of the number of listed buildings in 1985 and time. This implies that we assume that unobserved trends that are related to the number of listed buildings in 1985 are reasonably smooth over time. We subject our conclusions to a wide range of robustness checks. In the sensitivity analysis, we, for example, use an alternative 'quasi-experimental' approach based on the designation of historic districts.

It should be noted that this is not the first study to examine the house price effects of historic amenities (Asabere *et al.,* 1994; Schaeffer and Millerick, 1991; Leichenko *et al.,* 2001; Navrud and Ready, 2002; Coulson and Lahr, 2005; Ahlfeldt and Maennig, 2010; Koster *et al.,* 2016). However, most previous studies are of a limited geographical and temporal scope, do not investigate the effect on housing quality and are cross-sectional. To the best of our knowledge, this article is the first that uses temporal variation in the quality of cultural heritage to identify the effects on house prices. It is also the first article aiming to distinguish between direct and indirect effects of investments in cultural heritage.

The results show a profound impact of cultural heritage investments on house prices but we find no evidence that the maintenance level of non-eligible properties is affected by investments in cultural heritage. This suggests that the main price effect of the investments is a direct effect. We show that a million euro investment per square kilometre (about 1.2 standard deviations) leads to an increase in house prices of 1.5%. A counterfactual analysis suggests that the external benefits of investments in cultural heritage exceed the costs.

The article proceeds as follows. In the next Section, we discuss the theoretical implications of place-based investments. Section 2 discusses the cultural heritage policies in the Netherlands. In Section 3, we elaborate on the empirical estimation strategy and data. Section 4 presents and discusses the results. We also report a counterfactual analysis to gain understanding on the quantitative implications of our results. The final Section concludes.

1. Cultural Heritage, Housing Services and Prices

1.1. *The Model*

To structure our thoughts and motivate the empirical work, we formalise the hypothesised impacts of investments in the built environment in a model. We consider a neighbourhood with houses and other buildings. All houses are assumed to be identical in their physical characteristics, including lot size but may differ in the state of maintenance, quality of the garden etc. The inhabitants of the house determine the values of these attributes; this has been referred to as housing quality in the introduction. To formalise this, we treat housing quality as a single homogeneous commodity, available in arbitrary quantities at a given unit price, and refer to it as housing services (Rossi-Hansberg *et al.*, 2010). Housing services thus refer to the quality of a house as far as it can be affected by its inhabitants through maintenance, improvements in outward appearance, the garden etc., while keeping the (other) physical characteristics unchanged. The level of housing services is determined by the inhabitants of a house but it is observed and appreciated by neighbours and may have an impact on their consumption of housing services, as will be discussed below. There are also other (non-residential) buildings in the neighbourhood with a given (outward) quality. Some of the other buildings are listed and (subsidised) investments in those buildings may occur that increase the quality of the exterior. This is observed by the inhabitants of the neighbourhood and affects their utility as well as – potentially – their own consumption of housing services. We are interested in the impact of such investments on the value of houses in the neighbourhood.[2]

The consumers who inhabit a house at location i derive utility u_i from consumption of a composite good g_i, the housing services of the house they inhabit h_i, the housing services consumed by their neighbours, indicated as A_i, and the quality of the other buildings in the neighbourhood B_i. Each household chooses the amount of housing services for their own house, as well as their consumption of the composite good. They take the housing services consumed by the other inhabitants of the neighbourhood, as well as the quality of the other buildings, as given. Formally, the utility function can be written as $u_i = u(g_i, h_i, A_i, B_i)$. Utility is increasing in all its arguments and the indifference curves are convex. Utility is maximised subject to the budget constraint $w - r_i = g_i + kh_i$, where w denotes income, r_i the rent to be paid for the house and k is the cost per unit of housing services.[3] The rent r_i equilibrates supply and demand in the local market and may depend on the physical characteristics of the house, which are taken as given by the inhabitants of the house. Utility maximisation subject to the budget constraint leads to a demand equation for housing services that can be written as $h_i = h(w - r_i, k, A_i, B_i)$.

We define A_i as a weighted average of the housing services of i's neighbours and we define B_i as a weighted average of some indicator $\tilde{h}_l$ of the quality of other buildings at l in the neighbourhood:

$$A_i = \int_j \omega_{ij} h_j \mathrm{d}j, \; B_i = \int_l \omega_{il} \tilde{h}_l \mathrm{d}l. \tag{1}$$

The integrations refer to all houses except those inhabited by i and to all other buildings at other locations l, respectively, and ω_{ij} and ω_{il} are non-increasing functions of distance between i and a house or other building at other locations j and l. In most of the empirical work we specify it as a step function that is positive for short distances, and zero otherwise.

In the empirical application, we consider a situation in which B_i changes as a consequence of a subsidy programme for listed buildings. The change in B_i has an immediate impact on well-being as well as a possible effect on the demand for maintenance by households. If the latter effect occurs, A_i will also change, which – similarly – can have an immediate impact on well-being as well as a possible effect on the demand for housing services by households.

Our model is related to Rossi-Hansberg *et al.* (2010), who also assume that households derive utility from the housing services consumed by neighbours. They assume that the housing services of one's own house and the indicator of the housing services consumed by others are perfect substitutes, which rules out the possibility that a change in A_i or B_i has an impact on utility that does not affect the marginal utility of

[2] The setting just described differs from the actual situation that we study because some listed buildings are houses. However, we will not analyse price differences of such houses in our analysis; so, to avoid inessential complication in the model, we assume here that houses are not listed.

[3] The unit of the composite good is chosen so that its price equals one.

housing services h_i, or has a positive impact on the demand for housing services h_i and therefore leads to a higher A_i. One can easily imagine that people appreciate their neighbour's garden or a good state of maintenance of a nearby monument without any change in the demand for housing services for their own house. It may also be that a better condition of the houses and other buildings in the neighbourhood increases the consumption of h_i. For instance, Rypkema (1994) and Listokin *et al.* (1998) have argued that historic preservation has the potential to catalyse renovation activities in the vicinity. Moreover, Ioannides (2003) and Patacchini and Venanzoni (2014) find substantial social interaction and peer effects on the maintenance of houses. This evidence clearly indicates the need for more general specifications of the utility function.

1.2. *Social Interactions, Equilibrium and Investments*

In the remainder of this Section, we assume preferences can be described by a simple variant of the indirect utility function that Hausman (1981) showed to be consistent with a linear demand function:

$$u(w-r_i,k,A_i,B_i)=\mathrm{e}^{-vk}\left[\frac{\tau+v(w-r)+\phi k+\chi A_i+\psi B_i}{v}+\frac{\phi}{v^2}\right]+\rho A_i+\sigma B_i. \qquad (2)$$

The first term on the right-hand side determines the demand for housing services, while the last two terms represent the direct effects of the housing services of one's neighbours and of the quality of other buildings in the neighbourhood on utility respectively. The magnitude of these direct effects is indicated by the parameters ρ and σ. Application of Roy's identity gives the demand function $h_i = \tau + v(w - r_i) + \varphi k + \chi A_i + \psi B_i$, where the parameters τ, v, φ, χ and ψ denote the intercept and the impact of income-minus rent, the price of housing services, housing services consumed by neighbours and the quality of maintenance of other buildings on household i's demand for housing services respectively. This demand function allows for positive as well as negative effects of A_i and B_i on housing services, as the signs of χ and ψ can be negative as well as positive. To make sure that utility is increasing in A_i and B_i, we assume that $v > 0$, which tells us that the demand for housing services is normal, and that $\chi/v + \rho > 0$ and $\psi/v + \sigma > 0$. This utility function allows for a rich set of possible impacts of investment in cultural heritage on utility and the demand for housing services.

The dependence of the demand for housing services on the amount of housing services consumed by others implies a social interaction effect. To see this more clearly, we write the system of equations for all households in matrix notation as $\mathbf{h}=\tau\boldsymbol{\imath}+v(w\boldsymbol{\imath}-\mathbf{r})+\phi k\boldsymbol{\imath}+\chi\boldsymbol{\Omega}_\mathbf{A}\mathbf{h}+\psi\boldsymbol{\Omega}_\mathbf{B}\tilde{\mathbf{h}}$ where we have used bold symbols to indicate vectors and matrices, $\boldsymbol{\imath}$ denotes a vector with all its elements equal to one and $\boldsymbol{\Omega}_\mathbf{A}$, $\boldsymbol{\Omega}_\mathbf{B}$ are matrices with the weights ω_{ij} and ω_{ik} as elements. It then should hold that $\mathbf{h}=(\mathbf{I}-\chi\boldsymbol{\Omega}_\mathbf{A})^{-1}[\tau\boldsymbol{\imath}+v(w\boldsymbol{\imath}-\mathbf{r})+\phi k\boldsymbol{\imath}+\psi\boldsymbol{\Omega}_\mathbf{B}\tilde{\mathbf{h}}]$. This equation shows that the quality of other buildings has a direct impact on maintenance when $\psi \neq 0$. In addition to this direct impact, there is an indirect impact via social interactions if $\chi \neq 0$.

To study the equilibrium on the housing market, we start considering the conventional set-up with renters and absentee landlords and then consider the situation with owner-occupiers, which is more relevant for our empirical work.[4] Rents in the neighbourhood adjust in such a way that utility is equal to a given level $\bar{v}$ for all households. The indirect utility function $v(\cdot)$ must thus reach the same value at all locations, so $v(w - r_i, k, A_i, B_i) = \bar{v}$. Let us evaluate the impact of an investment in the quality of some of the other buildings in the neighbourhood, $\Delta B_i > 0$. This may lead to changes in the housing services of all houses in the neighbourhood ΔA_i as well as changes in rents Δr_i. If the reservation utility $\bar{v}$ remains unchanged, we must have $v(w - r_i - \Delta r_i, k, A_i + \Delta Ai, B_i + \Delta B_i) = \bar{v}$.

For the indirect utility function (2), the change in rent that keeps utility constant is:

$$\Delta r_i = \left(\frac{\chi}{v} + \mathrm{e}^{vk}\rho\right)\Delta A_i + \left(\frac{\psi}{v} + \mathrm{e}^{vk}\sigma\right)\Delta B_i. \tag{3}$$

The two expressions in brackets are positive because utility is increasing in the two neighbourhood quality indicators. Since the quality of other buildings will improve because of the investments we consider, the second term on the right-hand side is clearly positive. However, the sign of the first term is ambiguous because we allow for the possibility that inhabitants of the neighbourhood decrease the consumption of housing services. The changes in the $h_i^{\prime}s$ that underlie the changes in A_i can be written as $\mathbf{\Delta h} = (\mathbf{I} - \chi\mathbf{\Omega_A})^{-1}$ $(-v\mathbf{\Delta r} + \psi\mathbf{\Omega_B}\mathbf{\Delta\tilde{h}})$ and $\mathbf{\Delta A} = \mathbf{\Omega}_A\mathbf{\Delta h}$. Using these equations, it is not difficult to solve for $\mathbf{\Delta r}$ as a function of $\mathbf{\Omega_B}\mathbf{\Delta\tilde{h}} = \mathbf{\Delta B}$.[5] The change in the value of the houses is the net present value of all changes in the present and future rents caused by the investments in other buildings.

In our application, we consider an owner-occupied market. This implies that there is no increase in rents (or user cost) that keeps utility constant. The change in rent in the housing services equation therefore vanishes, which leads to:

$$\mathbf{\Delta h} = (\mathbf{I} - \chi\mathbf{\Omega_A})^{-1}\psi\mathbf{\Omega}_B\mathbf{\Delta\tilde{h}}. \tag{4}$$

Hence, the change in housing services is larger in the owner-occupied market, which may be interpreted as a positive impact of homeownership on neighbourhood quality.[6] Substitution of (4) into (3) gives:

$$\mathbf{\Delta r} = \left[\left(\frac{\chi}{v} + \mathrm{e}^{vk}\rho\right)\mathbf{\Omega_A}(\mathbf{I} - \chi\mathbf{\Omega_A})^{-1}\psi + \left(\frac{\psi}{v} + \mathrm{e}^{vk}\sigma\right)\right]\mathbf{\Delta B}. \tag{5}$$

This is the compensating variation in the impact of the investment in other buildings on the utility of the homeowners and the net present value of these compensating variations is the increase in the value of the houses in the neighbourhood. Our empirical work takes (5) as the starting point and attempts to measure the change in house prices that is caused by investments in listed buildings.

It is clear that (5) incorporates all effects of such investments: the direct effect on utility as well as indirect effects that occur via adjustments in the demand for housing

[4] Note that, we assume that the rent is determined by the housing characteristics that are given, whereas the housing services are determined by the household through decisions on maintenance of the house and perhaps the garden. The tenant has to pay these expenses.

[5] The equation is cumbersome and does not offer any new insights; so, we do not show it here.

[6] It may be argued that this is an underestimate because there may be a positive effect of the higher housing wealth of the homeowner on their demand for housing services. Note, moreover, that tenants may be more restricted than homeowners in changing the level of housing services (due to restrictions imposed by the landlord) in reaction to changes in the neighbourhood situation.

services. In an attempt to shed some light on the composition of this total effect, we also estimate an equation based on (4) that relates the consumption of housing services – proxied by the state of maintenance of houses as reported by the estate agent – to investments in listed buildings. Estimation of this equation provides us with information about the importance of the first term in square brackets on the right-hand side of (5). For instance, if we find no impact of the investments on the state of maintenance of houses in the neighbourhood, this would suggest that such investments do not invoke a direct impact on the demand for housing services ($\psi = 0$) but there may still be a sizeable direct effect on utility ($\sigma > 0$) that is reflected in house prices.

2. Cultural Heritage in the Netherlands

Cultural heritage policies in the Netherlands aim at protection and preservation of the historical building stock. An important instrument is to list individual objects, which gives the object a special status. The procedure for listing buildings in the Netherlands started with the determination of a shortlist referring to a particular period. In the early 1960s heritage dating back to the period before 1850 was considered. In the early 1980s a shortlist for heritage from the period 1840–1940 was completed and currently the buildings of the post-Second World War period are taken into consideration.

Listed buildings face several restrictions. Of course, they cannot be demolished but also (small) changes to the exterior or interior of the house (e.g. changing window frames) are often not allowed. On the positive side, one may deduct the maintenance costs from taxable income and the listed building status may imply positive reputation effects. However, arguably the most important benefit of listing is that the building is eligible for subsidies for renovation and maintenance.

Subsidies on cultural heritage were introduced in the 1970s. Total public expenditures on renovation subsidies since then are more than a billion euro. Figure 1 reports the spending on renovation subsidies of cultural heritage in the Netherlands over time. After the 1990s, concerns were raised about the poor condition of many historic buildings, so

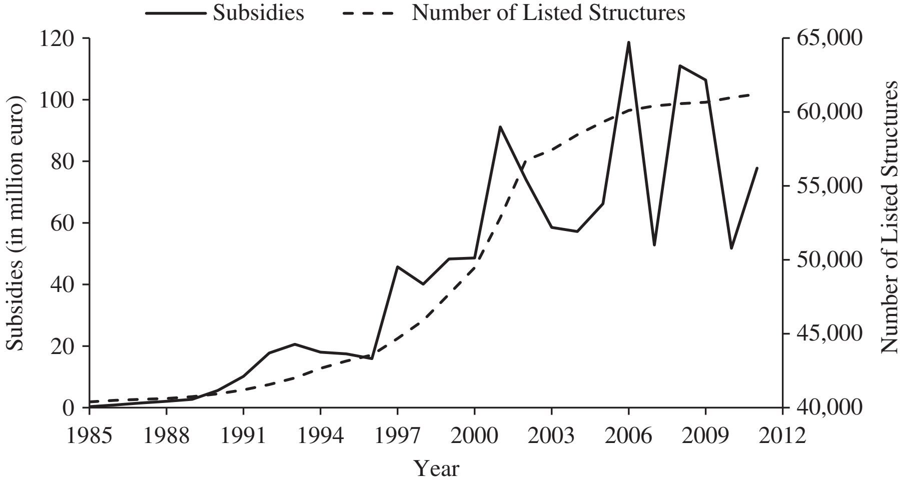

Fig. 1. *Investments in Cultural Heritage Over Time*

several subsidy programmes were introduced. Public spending on cultural heritage was the highest in 2006 due to the launch of a new subsidy programme. It is observed that there is a strong correlation with the upward trend in the number of listed buildings $\rho = 0.878$, which might indicate the increased societal awareness for cultural heritage. Note that the collective spending cannot be influenced by local policy makers or house owners. Most spending occurs in general subsidy programmes but, from 2000 onwards, spending is more often targeted at specific types of listed buildings. About 40% of the spending on cultural heritage is on these latter types of programmes. For example, there is a programme specifically targeted at extensive renovations of large listed buildings (e.g. castles, churches), while another programme entirely focuses on historic country estates (see online Appendix A for more details).

Figure 2 shows that investments in cultural heritage are far from evenly spread over the country but are concentrated in larger cities (Amsterdam, Utrecht,

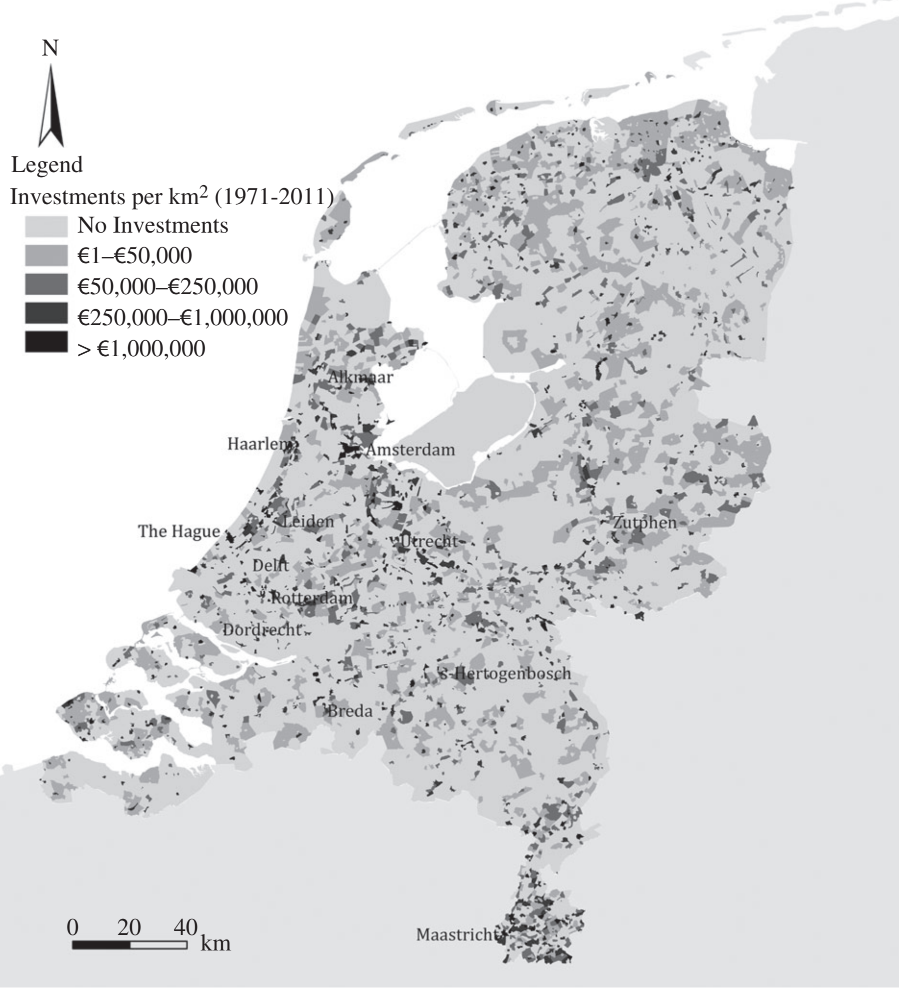

Fig. 2. *Cultural Heritage Investments in the Netherlands*

The Hague, Leiden), which have a substantial stock of listed buildings. Also, some medium-sized cities such as Maastricht, Breda and 's-Hertogenbosch received substantial subsidies for cultural heritage preservation. Because urban development in the Middle Ages was also very concentrated, it is not too surprising that listed buildings and the related investments in cultural heritage are very concentrated.

3. Econometric Framework and Data

3.1 *Estimation Procedure and Identification*

We are interested in the causal effect of investments in cultural heritage, denoted by z_{nt}, on house prices or housing services, denoted by y_{int}, where i refers to a property in neighbourhood n, and t is the transaction year. We proxy for housing services of non-eligible houses using the maintenance state of the house. The basic specification yields:

$$y_{int} = \alpha z_{nt} + \beta x_{it} + \theta_t + \epsilon_{int}, \tag{6}$$

where α and β are parameters to be estimated, z_{nt} refers to cumulative investments and x_{it} to house characteristics, θ_t are year fixed effects and ε_{int} is an identically and independently distributed error term.[7] The cumulative investments in z_{nt} year t in a certain neighbourhood n in year t are given by:

$$z_{nt} = \sum_{s=\underline{t}}^{t} \sum_{m=1}^{M} \omega_{nm} c_{ms}/a_m, \tag{7}$$

where $\underline{t}$ is the start year of the study period, c_{ms} are the investments in neighbourhood m, where $m = 1, \ldots, M$, in year s, a_m is the area size of the neighbourhood, and ω_{nm} denotes a spatial weight. We emphasise that z_{nt} captures the cumulative effects over time of investments in cultural heritage, which implies that the effects of investments have a permanent effect on house prices and the maintenance level. We also assume that investments in a specific project occur if the specific project is finished, and are zero otherwise. We focus on effects of investments in the same neighbourhoods, so we define $\omega_{nm} = 1$ if $n = m$ and $\omega_{nm} = 0$ otherwise. In the sensitivity analysis, we investigate whether there are spatial spillovers.[8]

If investments in cultural heritage were randomly allocated over space, estimation of (6) would identify a causal effect of α. However, if listed buildings are disproportionally located in attractive areas (e.g. city centres), this may imply a correlation between ε_{int} and z_{nt} that would lead to an overestimate of α. We therefore employ a first-difference

[7] Note that this implies that the error terms referring to subsequent transaction of the same house are not autocorrelated.

[8] It has been argued that external effects of amenities are continuous over space. Rossi-Hansberg *et al.* (2010) use semiparametric methods to estimate a distance decay function. However, although the semiparametric econometric approach clearly offers flexibility and does not put any restrictions on the functional form of the spatial decay of the investments, Rossi-Hansberg *et al.* (2010) can only focus on the effects of the closest impact area. This seems a valid procedure if there are a few impact areas, so that one property is not influenced by multiple investment projects. However, in our application, house prices can be influenced by many proximate investments in cultural heritage.

(repeat-sales) approach, where the change in the dependent variable y_{nt} is regressed on the change in the investment potential z_{nt}.[9] This approach implies that we control for all unobserved time-invariant housing and neighbourhood attributes. To control for changes to the house (e.g. changes in house size that disproportionally occur outside historic districts due to restrictions), we also include changes in housing attributes x_{it}, implying:

$$\Delta y_{int} = \alpha\Delta z_{nt} + \beta\Delta x_{it} + \Delta\theta_t + \Delta\epsilon_{int}. \tag{8}$$

Note that if we had two transactions for each property, the above equation would deliver identical estimates compared to a specification of (6) if we included property fixed effects. Because we rely on unbalanced panel data, we emphasise that the differences refer to differences over multiple years, as properties are usually not sold every year.[10] Hence, we analyse the difference in variables of interest of the same property at two different dates.[11]

The crucial identifying assumption for consistent estimation of α in the above equation is that unobserved trends are uncorrelated with the change in treatment z_{nt}. This assumption may be problematic, for example, because of trends in gentrification in historic city centres. The second concern is that z_{nt} is measured with error. It might be that z_{nt} includes substantial investments to the interior of the building, which are expected not to lead to external benefits. Furthermore, if anticipation effects are important, or when part of the benefits accrues during the renovation process, this implies a measurement error that will bias the estimated coefficient towards zero.

To deal with these issues, we construct an instrument to predict the change in investments that should be uncorrelated with local shocks. We use national changes in spending on cultural heritage to predict local changes in cultural heritage investments using information on the (time-invariant) stock of listed buildings, in the spirit of Bartik (1991), Saks (2008) and Moretti (2010), among others. The identifying assumption is that unobserved trends are uncorrelated with the stock of listed buildings in the base year, denoted by $\underline{t}$. As described in the previous section, the national government launched several subsidy programmes which differ vastly over time in terms of budget, which implies that the predicted investments of each listed object to receive money changes considerably over the years. We then calculate the predicted investments e_{nt} as:

$$e_{nt} = \sum_{s=\underline{t}}^{t} \sum_{m=1}^{M} \frac{l_{m\underline{t}}}{L_{m\underline{t}}} \omega_{nm} C_t / a_m, \tag{9}$$

[9] Note that the change in the dependent variable can only be observed between two points in time at which the property is sold. For this reason the method is often referred to as the repeat-sales approach.

[10] The average elapsed time between subsequent sales in our data is 5.65 years.

[11] Although we consider the repeat-sales estimator as the preferred estimator because it controls for all time-invariant housing attributes, we have also tested whether our results are robust to the use of a fixed-effects estimator (see online Appendix B).

where C_t is the total money spent on cultural heritage subsidies in year t, $l_{m\underline{t}}$ is the number of listed buildings in neighbourhood m in year $\underline{t}$ and $L_{m\underline{t}}$ is the total number of listed buildings in the listed building register in year $\underline{t}$. Equation (9) implies that we estimate the predicted share of the national budget that is spent in neighbourhood n, based on the initial stock of listed buildings. Hence, if an area initially has more cultural heritage, the probability that it will receive subsidies later on is higher. The first stage is then given by:

$$\Delta z_{nt} = \tilde{\alpha}\Delta e_{nt} + \tilde{\beta}\Delta x_{it} + \Delta\tilde{\theta}_t + \Delta\tilde{\epsilon}_{int}, \tag{10}$$

where the $\sim$ indicate first-stage coefficients. Note that the second stage will be identical to (8), except for the fact that we include the predicted value of Δz_{nt}.

It seems plausible to suppose that the instrument is uncorrelated with different sources of measurement error in z_{nt}, which mitigates the problem of unobserved trends. However, one may argue that listed buildings are not randomly distributed over space, but are disproportionally located in city centres of larger cities. It might, therefore, be that the stock of listed buildings in year $\underline{t}$ is correlated with unobserved price trends (e.g. the fact that city centre living has gained increased attention in recent years). To alleviate this problem, we include neighbourhood fixed effects η_n. The inclusion of fixed effects at a low level of spatial aggregation will partly solve the problem of unobserved trends but definitely leaves the option open that ε_{int} is still correlated with e_{nt} if price trends are non-linear. We therefore will also include a function of the number of listed buildings $l_{n\underline{t}}$ interacted with a flexible time trend:

$$\Delta y_{int} = \alpha\Delta z_{nt} + \beta\Delta x_{it} + \Delta\theta_t + \eta_n + \Upsilon\left[l_{n\underline{t}}, (t - \underline{t})\right] + \Delta\epsilon_{int}, \tag{11}$$

with:

$$\Upsilon\left[l_{n\underline{t}}, (t - \underline{t})\right] = \sum_{q=1}^{P}\sum_{p=1}^{P} \rho_{qp} l_{n\underline{t}}^{q} (t - \underline{t})^{p}, \tag{12}$$

where P denotes the order of the polynomial, $q = 1, \ldots, P$ and $p = 1, \ldots, P$ and ρ_{qr} are parameters to be estimated. $\Upsilon(\cdot)$ should be flexible enough to capture all price trends that are correlated with the stock of listed buildings in n in $\underline{t}$. On the other hand, when $\Upsilon(\cdot)$ is fully non-parametric in the sense that it changes discretely over time, there would be perfect multicollinearity with the instrument e_{nt}. In practice, this will imply that we assume that unobserved trends that are correlated with l_{nt} are reasonably smooth over time, so that they are captured by $\Upsilon(\cdot)$. For most demographic trends that may be correlated with e_{nt}, such as gentrification, this is most likely the case. Note that these trends may also pick up some of the identifying variation related to changes in the predicted investments e_{nt}, which may lead to an underestimate of α.

Although we think the above approach is a convincing strategy to identify a causal effect of cultural heritage investments on the maintenance state and prices, we will extensively check for robustness in the sensitivity analysis, for example, by focusing on a shorter time period and using a different identification strategy (see online Appendix B).

3.2 *Data and Descriptives*

Our analysis relies upon two data sets. The first contains investments in cultural heritage from 1971 to 2011 for which funding from the national government is requested. The data on investment in cultural heritage that we use are from the Department of Cultural Heritage (in Dutch: *Rijksdienst voor Cultureel Erfgoed,* RCE). They refer to renovation of listed buildings. At the level of individual objects, we have information on the total investment, the total amount of subsidy provided, the date when the work was started and the date when it was finished. The investments are also accompanied by a short description. On the basis of this description, we remove investments that entirely refer to renovations of the interior (almost 7% of the observations), because we do not expect that these renovations will have any external effects on the surrounding neighbourhood.

It should be noted that our investment data only cover projects for which a subsidy was given. These data do not include private investments for which no additional funding is requested. However, because eligible buildings have a high probability of receiving subsidies when they apply for subsidies, there is hardly an incentive not to apply for subsidies on renovations, in particular, for larger investments. Furthermore, we think it is unlikely that investors would not know about the programme given its large scale. Our data set is, therefore, expected to include most of the investments in cultural heritage. We should also mention that we consider only subsidies for national listed buildings. Buildings are sometimes only listed by local governments. Specific subsidies for the latter type of structures may then be provided by local governments. However, anecdotal evidence suggests that these programmes are of very limited size relative to the national programmes that we study here.

We group the investments by meaningful neighbourhoods, based on the most detailed definition of neighbourhoods used by Statistics Netherlands. The median number of inhabitants per neighbourhood is 665 and the median size is 0.85 square kilometres. The investment data are positively skewed: some areas with a large number of listed buildings receive substantial investments (e.g. the historic city centre of Amsterdam), whereas many others receive small amounts or nothing. To avoid the problem that our results are driven by a few impact areas, we exclude the neighbourhoods that have received more than €2 million per square kilometre in one year once during the entire study period, so that approximately 2.5% of the neighbourhoods are excluded. We investigate the robustness of the results to this particular assumption in online Appendix B.[12]

The second data set contains information on more than 2 million housing transactions between 1985 and 2011. The data are obtained from the NVM (Dutch Association of Real Estate Agents) and contain information on the large majority (about 70%) of all private housing transactions. We notice that we do not have information on rents. Data on rents would not provide any information on the economic effects of cultural heritage investments, as in the Netherlands about 80% of the rental transactions refer to rent-controlled markets. For every transaction, we know

[12] One may also focus on a specific (large) investment (Van Duijn *et al.*, 2016). However, we are interested in the average effect of cultural heritage investments and not in the effect of some specific projects.

the transaction price, the exact address and location, the size, number of rooms, construction year and maintenance quality, among other details. We omit transactions with prices that are over €1 million or below €25,000 and have a price per square metre which is over €5,000 or below €500. We furthermore leave out transactions that refer to properties that are larger than 250 square metres or smaller than 25 square metres. These selections refer to less than 1% of the data and do not influence our results. Moreover, because we are interested in the external effects of investments in cultural heritage, we exclude transactions of residential properties that are listed (which are directly eligible for subsidies).

Table 1 reports descriptive statistics. It can be shown that the full sample and repeat-sales sample are similar. There are, however, some notable differences. First, the house price is about 12% lower. This may be because the share of apartments, which are usually cheaper, is higher. Of course, the share of recently constructed houses in the repeat-sales sample is lower, because the probability that they are transacted more than once is lower. More importantly, the average investments in cultural heritage are about the same (about €85,000 per km^2). The predicted investments are also very similar between the full sample and repeat-sales sample. In Figure 3, we plot the house price trends for our study period. It is shown that the price trends of the full sample and repeat-sales sample are very similar and only deviate a little in recent years.

The state of maintenance of a house is assessed by the broker in eight classes running from 'poor' to 'excellent'. We have scaled this variable to numerical values in the [0, 1] interval.[13] One class is defined as 'maintenance quality good, or not filled in' and it appears that about 80% of the transactions have been given this assessment. Because this will lead to a very noisy dependent variable, we only focus on observations that have a score that deviates from 0.75 (which refers to a potentially missing maintenance quality) for either the inside maintenance quality or outside maintenance quality. The idea is that estate agents will have filled in either both indicators or none.[14] In Table 1, one may see that the share of missing observations for the state of maintenance is then 67%.

Figure 4 presents histograms of the dependent variables we intend to use. The distribution of log house prices follows approximately a normal distribution (left panel). The distribution of the outside state of maintenance is not normally distributed and it seems that estate agents tend to round maintenance scores to 0.5, 0.75 or 1. As long as this rounding error is random, this will not affect the consistency of our results.

4. Results

4.1 *Baseline Results – House Prices*

We start analysing the effects of investments in cultural heritage on house prices. In Table 2, we report the main regression results. We consider the impact of a 1 million euro increase in investments per square kilometre. The average size of investment

[13] That is, a poor maintenance quality is given the value 0.000, excellent 1.000.

[14] It should be noted that if we include all maintenance scores of 0.75, the results are essentially the same (see online Appendix B.3).

Table 1

Key Descriptive Statistics

	Full sample				Repeat-sales sample			
	Mean	SD	Min	Max	Mean	SD	Min	Max
House price (in €)	192,847	113,364	25,000	1,000,000	169,755	93,549	25,000	1,000,000
Investments (in million € per km²)	0.089	0.436	0.000	12.330	0.080	0.389	0.000	12.330
Subsidies (in million € per km²)	0.033	0.161	0.000	3.920	0.030	0.147	0.000	3.920
Targeted buildings (per km²)	0.594	3.201	0.000	177.694	0.529	2.909	0.000	177.694
Predicted investments (in million € per km²)	0.040	0.452	0.000	30.842	0.032	0.367	0.000	30.842
Number of listed buildings 1985 (per km²)	3.247	27.420	0.000	1,889.311	3.023	24.665	0.000	759.874
Size (in m²)	118.803	37.321	26.000	250.000	108.830	33.293	26.000	250.000
Rooms	4.369	1.294	0.000	25.000	4.112	1.217	0.000	17.000
Central heating	0.903	0.296			0.920	0.272		
Maintenance level – inside	0.784	0.248	0.000	1.000	0.822	0.226	0.000	1.000
Maintenance level – outside	0.794	0.224	0.000	1.000	0.808	0.206	0.000	1.000
Maintenance level – missing	0.670	0.470			0.719	0.449		
House type – apartment	0.253	0.435			0.346	0.476		
House type – terraced	0.323	0.468			0.334	0.472		
House type – semi-detached	0.289	0.453			0.247	0.431		
House type – detached	0.134	0.341			0.073	0.260		
Garage	0.348	0.476			0.257	0.437		
Garden	0.664	0.472			0.623	0.485		
Construction year <1945	0.229	0.420			0.210	0.408		
Construction year 1945–60	0.075	0.263			0.074	0.262		
Construction year 1961–70	0.168	0.374			0.201	0.401		
Construction year 1971–80	0.192	0.394			0.200	0.400		
Construction year 1981–90	0.156	0.363			0.175	0.380		
Construction year 1991–2000	0.132	0.338			0.124	0.330		
Construction year >2000	0.049	0.216			0.016	0.124		
Year of observation	2002	5.907	1985	2011	2002	5.673	1985	2011

Notes. The number of observations for the full sample is 2,104,012 and for the repeat-sales sample it is 656,744. For the corrected maintenance score, the number of observations is, respectively, 695,046 and 184,430. We exclude observations in areas that have faced changes in investments larger than €2 million per square kilometre in one year once during the study period.

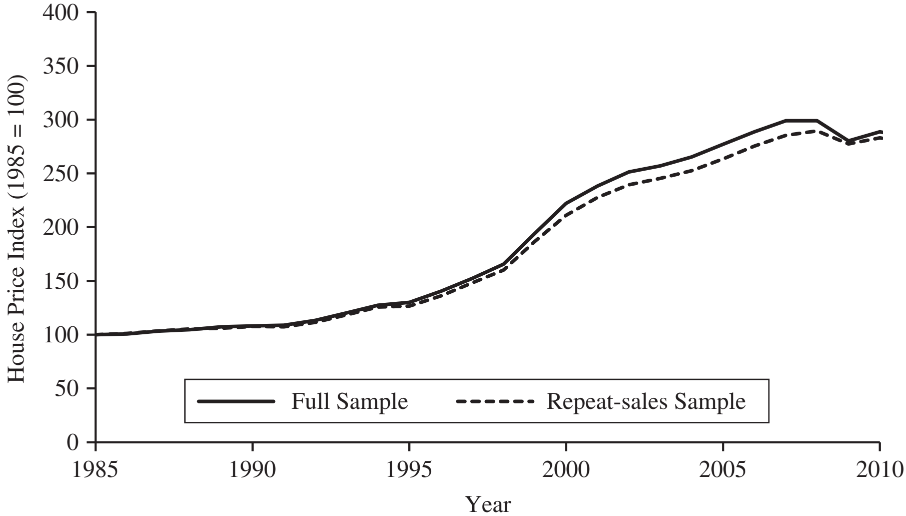

Fig. 3. *House Price Trends*

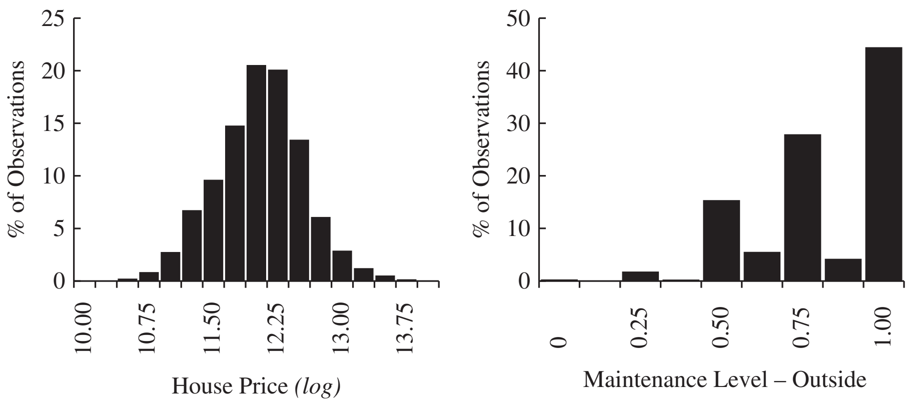

Fig. 4. *Histograms of Variables of Interest*

Note. The right panel only includes observations for which the outside or inside maintenance level deviates from 0.75.

projects is about €250,000 (with a standard deviation of €782,000) and the neighbourhood median size is 0.85 square kilometres, so the results can be interpreted as the effect of multiple projects in a neighbourhood (which often happens) or the effect of a single relatively large investment project.[15] In all specifications, the standard errors are clustered at the neighbourhood level.

In column (1), we estimate a naive regression of the change in house price on the change in investments, while controlling for national price trends. The results seem to

[15] Of course, we may also have investigated the effects of an average investment project but this will not impact the qualitative conclusions.

Table 2

Baseline Results for House Prices – Dependent Variable: Δ Price (log)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	2SLS	2SLS	2SLS	2SLS
Δ Investments (in million € per km²)	0.0182***	0.0152***	0.0332***	0.0297**	0.0168**	0.0539***
	(0.00546)	(0.00497)	(0.00948)	(0.0120)	(0.00771)	(0.0112)
Δ House size (log)		0.114***	0.114***	0.113***	0.113***	0.0960***
		(0.00443)	(0.00443)	(0.00401)	(0.00400)	(0.00555)
Δ Rooms		0.00226***	0.00229***	0.00350***	0.00348***	0.00224***
		(0.000404)	(0.000405)	(0.000346)	(0.000346)	(0.000454)
Δ Central heating		0.0766***	0.0763***	0.0591***	0.0591***	0.0474***
		(0.00176)	(0.00178)	(0.00121)	(0.00121)	(0.00155)
Δ Maintenance level – inside		0.252***	0.252***	0.243***	0.243***	0.269***
		(0.00321)	(0.00321)	(0.00283)	(0.00283)	(0.00393)
Δ Maintenance level – outside		0.0747***	0.0747***	0.0671***	0.0671***	0.0457***
		(0.00326)	(0.00326)	(0.00293)	(0.00293)	(0.00404)
Δ Maintenance level – missing		0.271***	0.271***	0.256***	0.256***	0.261***
		(0.00271)	(0.00271)	(0.00249)	(0.00248)	(0.00345)
Δ Year fixed effects (27)	Yes	Yes	Yes	Yes	Yes	Yes
Neighbourhood fixed effects (7,080)	No	No	No	Yes	Yes	Yes
Trend of listed building density, ϒ(·)	No	No	No	No	Yes	Yes
Number of observations	360,602	360,602	360,602	360,602	360,602	144,152
R^2	0.813	0.843				
First-stage F-statistic			19.73	25.33	55.29	40.22

Notes. We exclude observations that are in listed buildings. In columns (3)–(6), the instrument is the change in the predicted investments. We set $P = 3$ in columns (5) and (6). Standard errors are in parentheses and clustered at the neighbourhood level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

suggest that a million euro increase in investments per square kilometre increases house prices by 1.82%. When we include housing attributes in column (2), the coefficient is very similar, albeit slightly lower. The control variables have plausible signs. A 1% increase in house size leads to an increase in house price of 0.11%. This is at the lower end of the spectrum of plausible values. However, note that the coefficient refers only to floor space and should therefore be interpreted under *ceteris paribus* conditions, whereas changes in house size in practice almost always is associated with having more rooms, bathrooms etc.[16] The number of rooms, the maintenance quality and whether the house has central heating – all imply a (strong) positive price effect. Note also that, when maintenance quality is missing, prices are higher, suggesting that estate agents do not always report when houses are well maintained.

Our results may be biased if unobserved price trends are correlated with investments in cultural heritage. We therefore instrument the change in investments with the change in the predicted investments. The first-stage results are reported in online Appendix B. The instrument is strong and relevant, as the first-stage F-statistic is always well above the rule-of-thumb value of 10. The first-stage results suggest that a million euro per square kilometre increase in the predicted investments increases investments by 0.384 million euro per square kilometre. Note that this coefficient is much smaller than 1, so the actual investments are usually lower than predicted. This is not too surprising, as some very large investments are made in (large) county estates (e.g. Kasteel de Haar) with relatively few properties in the neighbourhood, which implies that the remaining listed buildings receive fewer investments than predicted. Furthermore, we exclude neighbourhoods that have received these very large investments.

In Table 2, column (3), the coefficient suggests a positive price effect of investments in cultural heritage on house prices: a 1 million euro increase in investments per square kilometre leads to an increase in house prices of 3.32%. One may observe that the coefficient is higher than the OLS estimates, which suggests that the instrumental variables approach addresses, at least to some extent, the downward bias caused by the measurement error in the investments variable. However, this approach may not fully address the potential correlation with unobserved shocks because areas that had more listed buildings in 1985 may have different price trends from neighbourhoods with fewer listed buildings. In column (4), we therefore include neighbourhood fixed effects, leading to a very similar price effect of cultural heritage investments. Column (5) also controls for a flexible trend in the listed building density by including a polynomial function of the listed building density in 1985 interacted with the time trend.[17] So, this approach controls

[16] Another possibility is that, in contrast to our assumption, there are dynamic effects in the residuals in (6) and hence in (8). Then the impact of a change in the house size would differ from the long run multiplier, the latter embodying the full effect. If that is the case, we would also underestimate the effect of changes in other variables, including cultural heritage. Note, however, that the coefficients we find for changes in central heating and the level of maintenance do not appear to be underestimates of their total impact. It might also be that there is measurement error in the changes in house size, as the numbers are not based on exact measurement but on an estimate of the real estate agent. These errors are most likely random, leading to a downward biased coefficient.

[17] We set the order of the polynomial to three and will check robustness of this choice in the sensitivity analysis.

for all smooth time-varying unobservables that are correlated with the number of listed buildings in a neighbourhood but it may also capture some of the identifying variation related to changes in the predicted investments. The coefficient is now somewhat lower: a million euro increase in investments per square kilometre leads to an increase in prices of 1.68%. One might argue that most of the identifying variation comes from observations after 2000, as fluctuations in national budgets were more pronounced in the last decade of our sample (see Figure 1). In column (6), we therefore only include observations for which both transactions occur after 2000. This also increases the probability that the flexible function of number of listed buildings and time picks up unobserved shocks, and because the national investments in listed buildings were much more volatile, it is now unlikely that the polynomial trends capture the identifying variation related to the instrument. Although this greatly reduces the number of observations, the coefficient is statistically significant at the 1% level. The impact of investments in cultural heritage is now higher: a 1 million euro increase in investments leads to an increase in prices of 5.39%. Hence, this might indicate that the previous estimates are underestimates.

On the basis of these results, we conclude that there is a price effect of investments in cultural heritage on house prices. However, we do not yet know whether this price effect is mainly due to the direct investments in cultural heritage, or via the increased housing quality of neighbours. If the latter is the case, the maintenance state should have been increased due to the investments, which we will test in the next subsection. If we are only interested in the direct effect of investments on prices, one may argue that we should also control for the average maintenance quality of the neighbourhood. We have calculated the average maintenance quality of houses that are sold in each neighbourhood in each year and have included that in the regressions. Although the coefficient of neighbourhood maintenance quality is positive and statistically significant, the coefficient related to investments is virtually unchanged.[18]

4.2 *Baseline Results – State of Maintenance*

We investigate whether public investments in cultural heritage have implied a change in the maintenance level of the exterior of the house, as a proxy for changes in the provision of housing services. Because maintenance quality is often missing, we have a substantially lower number of observations compared to the price regressions. Table 3 reports the results.

In column (1), we provide a simple regression of the change in the maintenance level on the change in investments. The results suggest that there is no statistically (and economically) significant effect of investments on the state of maintenance. When we control for the change in house size and the number of rooms, the coefficient is very similar (column (2)). Due to endogeneity issues, we instrument for investments with the predicted investments. The first-stage estimates are almost identical to the first

[18] The results are reported in online Appendix B. We note that one should be careful with interpretation, because neighbourhood maintenance quality may be endogenous, as it may be correlated with unobserved neighbourhood-specific trends.

Table 3

Baseline Results for Maintenance Level – Dependent Variable: ΔMaintenance Level – Outside

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	2SLS	2SLS	2SLS	2SLS
Δ Investments (in million € per km²)	0.00178	0.00248	0.0171	0.0262	0.00892	0.0793
	(0.00545)	(0.00542)	(0.0189)	(0.0160)	(0.0133)	(0.143)
Δ House size (log)		0.214***	0.215***	0.207***	0.207***	0.200***
		(0.0182)	(0.0182)	(0.0184)	(0.0184)	(0.0324)
Δ Rooms		−0.000484	-0.000530	0.00176	0.00180	0.00209
		(0.00144)	(0.00144)	(0.00154)	(0.00154)	(0.00231)
Δ Year fixed effects (27)	Yes	Yes	Yes	Yes	Yes	Yes
Neighbourhood fixed effects (7,080)	No	No	No	Yes	Yes	Yes
Trend of listed building density, ϒ(·)	No	No	No	No	Yes	Yes
Number of observations	42,728	42,728	42,728	42,728	42,728	17,326
R^2	0.023	0.031				
First-stage F-statistic			51.77	181.1	389	19.09

Notes. We exclude observations that are in listed buildings. In columns (3)–(6), the instrument is the change in the predicted investments. We set $P = 3$ in columns (5) and (6). Standard errors are in parentheses and clustered at the neighbourhood level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

stages of the house price regressions despite the lower number of observations. In Table 3, the coefficient implies that a million euro increase in investments per square kilometre increases the maintenance score by 1.71% points. The effect in the second stage is again statistically insignificant. In column (4), we add neighbourhood fixed effects, so we identify the effect of investments in cultural heritage using deviations from the general trend in prices in each neighbourhood. The coefficient is statistically insignificant again, also if we control for a flexible trend of the number of listed buildings in a neighbourhood in column (5). Because most of the fluctuations in public spending on cultural heritage occur after the year 2000, in column (6), we only include observations for which both transactions occur after the year 2000. The results confirm that investments in cultural heritage did not lead to changes in the state of maintenance, which suggests that social interaction effects are not very important in this case. That is, our results are consistent with our theoretical model when $\sigma > 0$ and $\psi = 0$. Hence, the consumption of (own) housing services and quality of buildings in the neighbourhoods do not seem to be perfect substitutes. This is also confirmed by the regressions that control for average maintenance quality in the neighbourhood, which lead to almost identical price effects of investments in cultural heritage.

One may argue that because we have a much lower number of observations, it might be a matter of efficiency that we cannot detect an effect of investments on the maintenance state. However, except for the coefficient presented in column (6), the implied impact of the investments is very close to zero with reasonably small standard errors, suggesting that the absence of a statistically significant effect is not an issue of efficiency.[19]

4.3 *Counterfactual Analysis*

To gain a better understanding on the quantitative implications of the results, we conduct a counterfactual simulation using the baseline results. It should be noted that the results of this counterfactual analysis should be interpreted with caution, because we have to make several simplifying (and sometimes somewhat crude) assumptions to be able to come up with an estimate of the total external benefits of investments in cultural heritage. Furthermore, it is important to recognise that these results crucially depend on the exogeneity of investments in cultural heritage. More specifically, it matters critically that investments in cultural heritage were financed from sources exclusively outside the municipality and were not at the expense of other budgets, which seems reasonable to assume in this context. In the analysis, we again focus on properties in neighbourhoods that did not receive large investments and are not listed.

Our transactions' data refer to about 70% of owner-occupied housing stock. To calculate the number of properties that are owned, we multiply the number of properties in our data by 1.43. Second, only about 55% of the properties are owner-occupied (Dröes and Koster, 2016). To get an estimate of the total effect, we assume that the price effect is identical for rental properties. To include these social benefits, we have to estimate the market value of rental housing. It appears that the rental

[19] We have subjected this conclusion to some additional robustness checks in online Appendix B.

housing value is 67.9 and 69.3% of the median house price, in Amsterdam and Rotterdam respectively (Van Ommeren and Koopman, 2011; Van Ommeren and Van der Vlist, 2016). On the basis of these figures, we assume that the median value of rental housing is 68.5% of the median house price in each neighbourhood. Including rental properties will probably lead to an upper bound of the total benefits of investments in cultural heritage because the price effect on rental housing is probably lower (see (4) and (5) and Rossi-Hansberg *et al.*, 2010). Third, we estimate the benefits and costs in 2011 prices by deflating house prices, investments and subsidies by the consumer price index, obtained from Statistics Netherlands.

Table 4 reports back-of-the-envelope calculations of the total benefits of investments in cultural heritage. We first take the baseline price effect obtained from Table 2, column (5). When we take the lower bound estimate of external effects, the total external benefits of investments in cultural heritage are 1.85 billion euro. This is more than the 1.63 billion euro investments in cultural heritage. More specifically, the results suggest that the benefits are about 14% higher than the costs. If we take the upper bound price effect of 5.39% (Table 2, column (6)), the benefits-to-costs ratio is 1.77. Owner-occupied houses are about 55% of the total housing stock. If one is willing to assume that this share is reasonably constant across space and that the price effect is identical for rental housing, we may estimate the total external benefits of investments in cultural heritage on the housing market. The calculations show that the external benefits range then from 5.94 billion euro to 6.98 billion euro. The benefits-to-costs ratios are then between 3.64 and 4.28, which provides even more convincing evidence that investments in cultural heritage generate positive benefits to society. However, because the price effects are probably lower for rental housing, these latter effects are best interpreted as upper bound estimates of the external effects of investments in cultural heritage.

Table 4

Estimates of External Effects of Investments in Cultural Heritage

	Owner-occupied houses		All houses	
Assumed price effect	1.68%	5.39%	1.68%	5.39%
External benefits, total (in million €)	1,852	2,890	5,941	6,979
External benefits/project total (in €)	160,711	250,782	515,614	605,686
Investments, total (in million €)	1,630	1,630	1,630	1,630
Investments/project (in €)	141,493	141,493	141,493	141,493
External benefits/investments	1.14	1.77	3.64	4.28
Subsidies, total (in million €)	626	626	626	626
Subsidies/project (in €)	54,347	54,347	54,347	54,347
External benefits/subsidies	2.96	4.61	9.49	11.14

Notes. We only focus on the price effects of neighbourhoods that did not receive more than €2 million investment per square kilometre in one year once during the study period and we exclude listed buildings. We deflate house prices, investments and subsidies using the consumer price index, so all values are in 2011 prices. We calculate the average house price per neighbourhood in 2011 prices, count the number of properties in each neighbourhood and multiply that by 1.43. We then calculate the investments and subsidies in 2011 prices per square kilometre. Together with the implied price effects (1.68% and 5.39%) we have all the information to calculate the benefits and costs.

4.4 *Sensitivity Analysis*

In online Appendix B, we investigate whether our results are robust to a wide range of robustness checks. First, we test whether the absence of a social interactions effect holds if we define the maintenance state differently (e.g. including the interior maintenance state) or when we exclude apartments. The latter may be important, because apartment residents may not be able to adjust the quality of the exterior themselves. However, we show that the effect of investments on the state of maintenance remains statistically insignificant.

Second, we pursue another identification strategy based on historic district designation to select areas that are likely similar in unobservables. The main threat to identification of a causal effect is that unobserved price trends are correlated with investments in cultural heritage. To mitigate the problem of correlated unobserved trends, we should measure the effects of investments in cultural heritage in 'comparable' neighbourhoods. In the Netherlands, designation of historic districts is the responsibility of the national government. The procedure for an area to be converted into a historic district (in Dutch: *beschermd stadsgezicht*) is prepared by the RCE. It is important to note that in contrast to the UK and the US, municipality and house owners cannot influence this process, so the location of historic districts is thought to be exogenously determined (from the house owner perspective) (Ahlfeldt *et al.*, 2017; Koster *et al.*, 2016). After having designated the most important historic districts (such as the city centre in Amsterdam), in 1990, the RCE compiled a shortlist with other potential historic districts, labelled as MSP districts. This list was not made public. A total of 129 MSP districts are officially designated, 21 districts are still under consideration and 14 MSP districts have eventually not qualified as historic districts. It seems reasonable to assume that the latter 'runner-up' historic districts will have similar unobserved traits to the designated historic districts. We therefore only select observations that are either in designated MSP districts or in runner-up MSP districts. Although historic district designation officially does not imply changes in the probability of receiving subsidies and becoming a listed building, informally, the probabilities of becoming listed and receiving investments are probably higher when an area is officially designated, for which we show there is suggestive evidence. Because unobserved trends between designated and runner-up MSP districts may differ after 1995, we also estimate a specification where we only focus on designated MSP districts. The results confirm the baseline results: the coefficients imply that a million euro increase in investments per square kilometre increases house prices by about 5%.

Third, we test robustness of our results to several assumptions made in the empirical set-up. For example, we test whether choosing a different order of the polynomial for the trend of listed building density affects the results, which is not the case. We also experiment using a shift-share instrument based on types of listed buildings, as some building types (e.g. castles) were more likely to receive subsidies in certain years.

Fourth, we inspect the magnitude of potential spatial spillovers of the investment programme by including a variable indicating the average investments in neighbourhoods that are within 250 metres of the own neighbourhood and a variable indicating the average investments for neighbourhoods that are between 250 and 500 metres from the own neighbourhoods. The instruments are then predicted investments and the average predicted investments in nearby neighbourhoods. The results seem to suggest that the spatial decay of investments is quite strong, so that investments are mainly important in the own neighbourhood, in line with Rossi-Hansberg *et al.* (2010).

Fifth, we test whether the price effect is robust if we include the average maintenance level in the neighbourhood, so as to provide additional evidence that the investments in cultural heritage have mainly a direct effect on prices of surrounding properties. The maintenance level in the neighbourhood seems to have a small positive effect, but the coefficient related to investments is hardly affected.

Sixth, we test whether our results are sensitive to the inclusion of areas that have received large investments. In the analysis, we have excluded the upper 2.5% of the neighbourhoods that have received more than €2 million investment per square kilometre in one year once during the study period. We test whether results are robust to this particular assumption and use another proxy for investments by looking at the change in the number of targeted buildings. The number of targeted buildings is less skewed than the absolute value of investments, so the likelihood that our results are driven by some large investments is then much lower. The results suggest that a standard deviation increase in the number of targeted buildings leads to an increase in the house price of 1.46%, confirming the importance of investments in cultural heritage.

Finally, we test whether heteroscedasticity caused by a difference between house sales is a problem for the estimated standard errors, using the approach proposed by Case and Shiller (1989). This leads to almost identical coefficients and standard errors. Further, in the analysis, we do not take into account depreciation of investments. To the extent this is not included in the neighbourhood trends and year fixed effects, as a robustness check, we recalculate (7) assuming a depreciation rate of 3%. The OLS results are very similar. The results using instrumental variables suggest somewhat stronger effects. Given that the first-stage estimates are less strong and the choice of depreciation rate is arbitrary, we prefer the baseline estimates. The last check is whether using subsidies instead of total investments leads to different results. Almost no project is fully covered by subsidies, but requires own contributions. The average share of subsidies for investments in cultural heritage is almost 50%, but it ranges from 10 to (in a few cases) 100%. We therefore expect that a 1 euro subsidy has a larger effect than a 1 euro investment, because every subsidy requires an additional investment made by the applicant. The results indeed indicate that the effect of 1 euro subsidy is more than twice as large as a 1 euro investment in cultural heritage.

Overall, the results of the sensitivity analyses are robust and confirm the initial findings that there is a direct effect of investments in cultural heritage on surrounding house prices, while an indirect effect via changes in the state of maintenance seems to be absent.

5. Conclusions

In this article, we study the impact of investments in cultural heritage on house prices in surrounding areas. From an economic point of view, a main reason for subsidising these investments is the presence of a positive external effect from the heritage on surrounding properties. Finding a positive causal impact of such investment on surrounding house prices would, therefore, provide strong support for the subsidies given.

In this article, we make a distinction between the direct price effect of investments in cultural heritage and the indirect effect, via changes in the consumption of housing services of properties that are not eligible for subsidies. We proxy for housing services using the maintenance state of the exterior of the house. To identify a causal effect of investments in cultural heritage, we use repeat sales and exploit variation in spending on cultural heritage by the national government. We further control for unobserved traits by including neighbourhood fixed effects; so, we identify the effect of investments that deviate from neighbourhood-specific price trends. We also include a flexible function of the stock of listed buildings in 1985 interacted with the time trend, to control for price trends that are correlated with the concentration of listed buildings in space.

Our estimation results confirm the presence of a positive external impact of investments in cultural heritage on house prices. A 1 million euro increase in investments per square kilometre leads to an increase in house prices of 1.5–5.5%. This seems to be mainly a direct effect of the investments in cultural heritage, rather than an indirect effect. More specifically, we cannot detect any effects of investments in cultural heritage on the maintenance state of houses, which suggests that the main impact of these investments on utility is a direct one that operates independent of the demand for housing services. Hence, the argument that historic preservation can act as a catalyst for renovation activity is not supported by our data.

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Additional Supporting Information may be found in the online version of this article:

Appendix A. Data Appendix.
Appendix B. Sensitivity Analysis.
Data S1.

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