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Abstract

This paper focuses on the channels through which stadium externalities capitalize into property prices. We investigate two of the largest stadium investment projects of the recent decade – the New Wembley and the Emirates stadium in London, UK. Evidence suggests positive stadium externalities, which are large compared to construction costs. Notable anticipation effects are found immediately following the announcement of the final stadium plans. Our results emphasize the role stadium architecture plays in promoting positive spillovers to the neighbourhood. We therefore recommend public funding of large-scale sports facilities to be made conditional on a comprehensive urban design strategy that maximizes the external benefits.

Keywords: Property prices; Stadium impact

JEL Classification: R53; R58

1. Introduction

Major sports events, like the Olympic Games or the FIFA World Cup, and sports facilities/franchises are expected to have multiple impacts on the regional or national economy all of which are closely interrelated. The event has the potential to boost economic growth, create new job opportunities, increase tourism levels, regenerate host regions and boost civic pride (Kasimati, 2003). Multiplier effects are then expected to come into play, distributing these economic benefits to the wider population, while the legacy of the investment in the facilities will allow for future bidding of similar events. This series of arguments have been frequently advanced in order to justify public expenditures into hosting such events or teams, even though the empirical literature has clearly rejected the presence of direct economic benefits to the host community and has seriously questioned these arguments (see Siegfried and Zimbalist (2000) for a relevant overview).

Partially as a result of the disillusion regarding the economic impact of mega-sports events and promising initial evidence more localized effects at the neighbourhood scale have become a central argument of proponents of large investments into professional sports facilities, so in the recent case of the forthcoming London 2012 Olympics. Accordingly, the presence of professional sports facilities may induce direct economy stimuli through spending and indirect effects through a sophisticated architecture and urban landscape design, which together will contribute the revitalization of neighbourhoods (Ahlfeldt and Maennig, 2010).

At the intersection of sports and urban economics, the recent literature has investigated property price effects in the vicinity of existing or newly developed professional sports facilities. The general theme emerging of this young strand of literature is that professional sports facilities tend to impact positively on location desirability of the neighbourhood, which mirrors in the sales/rent prices and land values. The literature, however, has not yet been able to separate direct from indirect effects, which also include for example negative effects related to congestion, noise and crime. An assessment of external effects relegated to a more sophisticated architecture and urban settings, however, is critical to justify the commitment of public funds.

This paper focuses on isolating the channels through which stadium externalities capitalize into property prices. We investigate two of the largest stadium investment projects of the recent years – the New Wembley and the Emirates stadium in London, UK. These stadium projects qualify as interesting cases since (a) both involve massive investments and represent large structures, (b) the New Wembley provides variation in external design and setting, but not in use and location, (c) the Emirates Stadium provides variation in external design and setting *and* location, with the additional feature of relocating within an otherwise comparable neighbourhood, but not in use, and (d) both stadia locate within the same market area (London) ensuring that the market perception of positive and negative externalities is comparable.

These particularities are used to overcome a number of limitations of previous studies, i.e. a separation of direct functionality related effects from indirect effects of the structure and a more thorough isolation of characteristics and trends in the neighbourhood that are correlated with the stadium treatment and may bias estimated stadium effects. As a further major innovation we depart from an a-priori definition of intervention dates and identify the adjustment process to the presence of a new stadium from the data.

Using two micro-level property transaction data sets from the Land Registry and the Nationwide Building Society, we find significant and positive stadium effects. These effects are large, even compared to the huge construction cost of state-of-the-art facilities. Evidence supports both the presence of direct and indirect economic effects, stressing the role of architecture and urban design as a catalyst of stadium externalities and neighbourhood revitalization more generally. Real estate markets tend to value the stadium effects in anticipation, which is an important finding for future intervention analyses, both within and outside the realm of the stadium impact literature.

The rest of this study is structured as follows. Section 2 provides a brief overview of the existing evidence on the impact of sports facilities on property prices and offers a brief historical overview around the construction of the Emirates and New Wembley stadiums. Section 3 describes the data and methodology used. The results are presented in section 4. Section 5 concludes.

2. Background

2.1 Sports Stadia and Surrounding Properties

The urban economics literature has long been investigating the links between property prices and neighbourhood characteristics. To this extent researchers have focused on the impact schools (e.g. Black (1999); Gibbons and Machin (2003, 2006, 2008)), airports (e.g. Tomkins et al., (1998)); rail transport (e.g. Gibbons and Machin (2005); Hess and Almeida (2007)) and crime (Gibbons, 2004), to name but a few.

As a characteristic of the neighbourhood, sports facilities are also likely to have a significant impact on the value of proximate properties of some sort, which is worth examining in more detail. A number of such studies have emerged over the last decade. Carlino and Coulson (2004) study the impact of a National Football League (NFL) franchise on rents of proximate properties. They find that the presence of the NFL franchise increases annual rents by 8 percent in the city, an effect they attribute to civic pride- individuals deriving utility from the franchise relocate to the area thus pushing rent prices upwards. Repeating the analysis on the wider metropolitan area they reach the same conclusion, though the effect is halved. However, they do not find significant evidence of a decrease in wages linked with the inflow of labour power.[1]

The evidence provided in Carlino and Coulson (2004) is unable to show whether the estimated results are attributed to the presence of the stadium or the NFL team. This limitation in their study has important theoretical and policy implications regarding stadium construction. Focusing on the construction of the FedEx Field in Maryland, Tu (2005) attempts to provide a more detailed answer on the impact the stadium has, as at the time of the study the latter was not linked to a specific team. His hedonic analysis provides substantial evidence suggesting that following each completion phase the price of proximate properties had significantly increased by about 5 percent.

Along the same lines, Feng and Humphreys (2008) study the case of the Nationwide Arena and Crew Stadium in Columbus, Ohio. Their estimates indicate a positive effect of both stadiums on prices of proximate properties, although their analysis focuses on 2000 cross-sectional data only. In Europe, Ahlfeldt and Maennig (2010) estimate the impact of the Velodrom and Max-Schmelling Arena on land values in Berlin. For both cases, they find that the stadiums impose a positive effect on land values up to two kilometres away. These findings are confirmed in a study that makes use of a longitudinal data and a quasi-experimental research methodology (Ahlfeldt and Maennig, 2009).

Furthermore, relevant research has also provided evidence suggesting that announcements relating to the construction of sports facilities alone are capable of having substantial price impacts. Dehring et al. (2007) for example, study a series of stadium construction announcements to host an NFL team. Overall, they find that

[1] See also Coates et al. (2006) and Carlino and Coulson (2006) for further methodological discussions. Note that in a recent study examining the same hypothesis based on housing values instead of rents, Kiel et al. (2010) find that the presence of an NFL franchise has no significant effect. In fact, property values significantly decrease the higher the subsidy is.

announcements promoting construction have significant positive impacts on property values in Dallas City and observed sign reversal when the project was cancelled, though statistically insignificant. The same argument though regarding the distinction between the stadium and the team also holds here.

A hedonic study of property prices in London is also performed in Kavetsos (2009) who investigates the impact of the announcement of London's successful bid to host the 2012 Olympic Games in July 2005. Arguing that London was not expected to win the bid as Paris was the favourite to win, he finds a positive and significant impact on property prices in host boroughs and in properties up to 9 miles around the main Olympic stadium.

On the other hand, Coates and Humphreys (2006) study voting preferences regarding the decision to subsidise the construction or renovation of facilities in Green Bay and Houston, US. The evidence here also points towards an appreciation of property wealth, business trade or fandom, as referenda indicate that precincts proximate to the facilities tend to agree on average with the subsidisation plan. Notably, Ahlfeldt et al. (2010) find the opposite effect when investigating the referendum on Munich Allianz-Arena developed for the 2006 FIFA world cup in Germany, indicating that (perceived) proximity cost may vary across sports and countries.

Overall, the existing evidence is indicative of single sports facilities having a positive effect on the value of properties within a range of 3-5km, depending on their size (Ahlfeldt and Maennig, 2010).

2.2 The New Wembley and the Emirates Stadia

In this section we offer a brief overview of the key milestones and timelines related to the construction/renovation of both stadia under examination in this study. These are summarised in Table 1.

The Old Wembley closed its doors in 2000 with the new stadium intended to operate in 2003. After a number of delays however demolition of the old stadium started in 2002 and the new construction was finally completed five years later. World-renowned architects Foster and Partners designed the stadium whose distinctive feature is the immense steel arch raised on top of it. This reached its currently permanent position and was lightened in June 2004. Wembley is the home of the English national soccer team and hosts various music events.

Arsenal FC, the team commissioning the construction of the Emirates Stadium, announced their intentions to move to a new, modern, purposefully built facility in 1999. Situated in central London and in an adjacent neighbourhood to the old Arsenal stadium, construction of the Emirates Stadium commenced in 2004. By the following year about half of the stadium construction had been already completed and was fully delivered to the team in 2006. The same year saw the start of the redevelopment of the old Arsenal stadium into a block of flats.

3. Data and Methodology

3.1 Data

The main data sources used to identify the property price effects of the subject stadia come from the Land Registry and the Nationwide Building Society. Both data sets identify the transaction price of residential properties during the observation period ranging from January 1995 to July 2008 and provide a range of transaction characteristics, including the postcode as a geographic reference.

The Nationwide data set covers most of the property characteristics that are common in the hedonic literature. This detail comes at the expense of a limited coverage in terms of the total number of transactions. The land registry data set, in turn, covers the full population of residential property transaction at the expense of a lower detail in property attributes. Based on their postcodes, all transactions are georeferenced and merged with electronic maps of the Greater London Authority area in a GIS environment to facilitate the construction of treatment variables. Within the GIS environment, location and environmental control variables could be generated based on electronic maps or merged from other sources. Such important sources include the national pupil database, from which postcode level KS2 results could be obtained and the 2001 census, which features output area data on total housing stock.

3.2 Theoretical Background

We start from a set of basic assumptions derived from standard rent theory. Households maximize their utility by trading non-housing against housing consumption. The utility, which is derived from housing consumption, depends on the size and quality of the unit they inhabit, but also of the quality of the location where they live. Neighbourhood quality is a composite good that encompasses access to employment opportunities, which may or may not be assumed to be concentrated in the central business district, and a range of location specific features, including natural amenities (e.g. green and water spaces), various environmental externalities (e.g. noise and pollution) and the quality of public services (e.g. school quality). Stadia are a specific location amenity and residents may derive a utility from locating close to the services offered by the facility in its function as a stadium and a visual amenity effect related to the external appearance of the structure. As discussed, direct utility effects related to a stadium may be derived from a "civic pride" effect and an emotional attachment to the sports team(s) hosted in the stadium. In addition, residents living closer to a stadium naturally enjoy transport cost savings due to shorter journeys when attending events at a stadium, but given the – on average– relatively low frequency of attendances the direct monetary effects should be marginal and will be subsumed in a broader definition of direct effects.

Given competitive markets' mobile residents, the equal utility constraint requires that the utility derived form the proximity to the stadium as well as all other location and non-location characteristics of the property fully capitalize into households' bid-rent functions.

$$r(S, L, F, V, D) = f(S, L(D)) + F(D) + V(D) \quad (1)$$

where S and L are a vectors of non-location and location specific property characteristics and *F(D)* and *V(D)* are the monetary equivalent of the utility derived from the functionality (F) and visual appearance (V), each assumed to be a function of distance to a stadium (D). As discussed in section 2, a number of studies have attempted to estimate the function *F(D)* on the basis of assessed land values or observed property transaction prices. Estimating the true marginal effect of distance to the stadium dF/dD, however, is empirically challenging in practice given that the slope of the bid-rent dr/dD is a composite effect of the "pure" functionality and the "view" effect as well as potentially correlated location effects.

$$\frac{dr}{dD} = \frac{dr}{dL}\frac{dL}{dD} + \frac{dr}{dF}\frac{dF}{dD} + \frac{dr}{dV}\frac{dV}{dD} \quad (2)$$

, where dr/dL, dr/dF and dr/dV are the marginal effects of location quality, stadium functionality and view on the bid rent and dL/dD, dF/dD and dV/dD reflect the change in the amount of the (dis)amenities as one moves away of the stadium. Clearly, bid rent functions certainly depend on other location characteristics, other than the distance to a stadium, thus $dR/dL \neq 0$. If these location characteristics are correlated with distance to the stadium, i.e. $dL/dD \neq 0$, an estimated marginal effect of stadium distance will be biased. To avoid a bias, a common strategy in the literature has been to hold constant the effect of location characteristics by including as many location characteristics in a regression model as possible. An obvious alternative is to investigate the effect of new stadia in a quasi-experimental setting so that the (unobserved) time-invariant effect of location quality can be differentiated out.

Similarly, if the external appearance exhibits an (dis)amenity effect, and $dR/dV \neq 0$, the "pure" stadium functionality effect will be biased given that both effects are naturally correlated across space $dV/dD \neq 0$. Due to the obvious correlation, separating both effects is empirically even more challenging than the isolation of correlated location effects and has not been resolved in the literature.

The two stadium projects that are subject to analyses in the study have been selected in a way that allows us to overcome a range of limitations of previous studies. First, we investigate the case of the New Wembley, which at the same location replaced the previously existent stadium, while basically maintaining the same functionality. Given that direct neighbourhood effects related to civic pride and external spending, but also crime and congestion, did not change dramatically with the new stadium we can assume $dF/dD = 0$ when solely focussing on variation over time. If location is controlled for appropriately, it is therefore possible to obtain an unbiased estimate on the (marginal) visual amenity effect of the new structure. Our second focus is on the move of the Arsenal London sports club from their old venue at Highbury Road into the new Emirates Stadium, located just about half a kilometre from the old site. This case provides a unique chance to empirically disentangle the stadium proximity effect from correlated location effects as we cannot only control for time-invariant location effects, but also for all kind of shocks that affect the whole neighbourhood and are correlated with distance to each of the sites, but not with the change in distance to the stadium. Given that the old structure at Highbury Road has not been removed, we can further assume $dR/dV = 0$ for the immediate vicinity of the old stadium.[2]

A further contribution compared to previous studies is that we explicitly address the open question related to the timing of the intervention; that is, when the effects related to functionality and appearance capitalize into market prices. One strand of research assumes residents to trade the capitalized value of expected rental incomes/savings, utilities and transport costs, which implies immediate price reactions when new information enter the market (McMillen and McDonald, 2004). Another view is that residents have little incentive to move into a neighbourhood as a result of an

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[2] We note that the structure is hardly visible from adjacent properties. Given that the structure has been modernized to accommodate high quality residential units, visual effects, if at all present, will be positive. The estimated (negative) effect on the loss of the stadium might therefore be regarded as being conservative.

improvement before it has actually taken place (Gibbons and Machin, 2005), which in this case would imply a market reaction that coincides with the inauguration of the new stadia.

Obviously, both views imply a different judgement on the time preference of residents and agents involved in the market. Rather than solving this open question by assumption, we employ flexible empirical specifications that yield time-varying treatment effects throughout our analyses. If structural breaks can be identified from the data and supported by anecdotal evidence, feasible intervention dates can be defined that facilitate the estimation of average treatment effects.

3.3 Empirical Strategy

Our empirical strategy is structured into four basic steps. Similar to Ahlfeldt (2009), we first identify areas that are subject to stadium effects before we estimate time-varying treatment effects. Informed by the second stage, we define an intervention date and estimate an average stadium treatment effect in the third step. Based on the average treatment, the fourth and final step of our strategy consists of estimating the aggregated effect on housing values.

As a prerequisite for this strategy, a set of treatment indicators is developed to capture the location of a property *i* with respect to its distance to a stadium *j*. The simplest definition X_i^a expresses property's *i* relative location in terms of a linear straight-line measure of distance (D_{ij}) between the centroid of the postcode a property falls in and the respective stadium. As an alternative, we define a treatment measure X_i^b based on whether the centroid of a property's postcode falls into one of a number of *n* mutually exclusive distance rings.

$$X_i^b = \sum_n R_{in} \tag{3}$$

, where R_n is an indicator variable for all properties within a given distance ring. The straightforward advantage of this specification is that it facilitates a non-linear effect of the stadium innovation on its surroundings. Throughout the analyses, we choose the number of rings so that the resulting grid cells are well populated. Note that in the Arsenal case, the indicator variables denote areas based on the minimum distance to either the Emirates Stadium or the old Arsenal stadium. Finally, our third treatment measure, which by definition can only be applied to the Arsenal case, expresses the treatment in terms of the change in (log)distance to the stadium in the situations after (*z+1*) and before (*z*) the move of the stadium.

$$X_i^c = \log(D_{ijz+1}) - \log(D_{ijz}) \quad (4)$$

We define two separate study areas based on postcodes whose centroids lie (a) at a maximum distance of 5km to the New Wembley or (b) at a maximum distance of 5km to either the Emirates Stadium or the old Arsenal Stadium. The 5km threshold is chosen based on existing evidence regarding the sphere of influence of large-scale sports facilities (Tu, 2005). Note that when defining the mutual exclusive distance rings in (X^b), we omit a base category at the outer fringe of the study area, e.g. 4.5-5 km, which serves as a control area in our empirical specifications. Figure 1 illustrates the selection of the study areas, distance rings as used in treatment variable X^b and the change in (log)distance to the stadium in the Arsenal neighbourhood as used in X^c.

Following an established strategy in the hedonic house price literature, in the second step of our analysis we estimate our baseline estimation equation, which regresses the log of price (P_{it}) realized for a transaction i at time t on m property characteristics Y_m. We use a full set of yearly time effects φ_t to control for macroeconomic shocks that are common in for the study area and postcode sector fixed effects $\psi_{\square}$ to capture time-invariant location characteristics. By also clustering standard errors on postcode sectors, this specification allows for mean and variance shifting and, thus, accounts for within postcode spatial autocorrelation.

Introducing one of the treatment measures defined above and also interacting it with a full set of yearly time effects, except a base year, our baseline specification yields a set of time-varying treatment effects relative to a base year, which we set to 2000.

$$\log(P_{it}) = \beta_n^N X_i^N + \sum_{t=1995,\ldots,1999,2001}^{t=2008} \beta_{nt}^N X_i^N \times \varphi_t \quad (5)$$

$$+ \sum_m \gamma_m Y_{itm} + \sum_t \varphi_t + \sum_h \psi_h + \varepsilon_{it}$$

where $N = \{a,b,c\}$ and n=1 if N={a,c}, Greek letters are coefficients to be estimated and ε_{it} is a random error term satisfying the usual conditions. Our baseline specifications uses the Nationwide data set discussed in the data section, which features a rich set of structural control variable at the expense of being a subset to the total population of transactions and therefore offering the potential of sample-selection bias. At the expense of a considerably reduced detail in transaction characteristics, we can estimate our baseline specification using the full set of transactions using the Land Registry data set. A further limitation of the Land Registry data set is that the postcode level georeference is only available from 2000 on, while the highest spatial detail on the location of transactions for earlier dates is the postcode sector. Furthermore, information on the timing of the transaction at the sub-year level is only available since 2000. To maximize the precision of our estimates within the constraints of data availability we separately estimate our baseline specification for the two periods 1995-2000 and 2000-2008.

$$\log(P_{it}) = \beta_n^N X_i^N + \sum_{t=g}^{t=h} \beta_{nt}^N X_i^N \times \varphi_t + \sum_o \gamma_o U_{ito} + \sum_t \varphi_t + \sum_h \psi_h + \varepsilon_{it} \quad (6a)$$

$$\log(P_{it}) = \beta_n^N X_i^N + \sum_{t=h}^{t=k} \beta_{nt}^N X_i^N \times \varphi_t + \sum_p \gamma_p Z_{itp} + \sum_t \varphi_t + \sum_h \psi_h + \varepsilon_{it} \quad (6b)$$

where g=1995, h=2000, k=2008 and U_o and Z_p are known property characteristics in the respective period. Note that we use the year 2000 as a common base year in both equations so that the estimated treatment coefficients $\hat{\beta}_{nt}$ are directly comparable to those based on equation (5) and the Nationwide data set.

Informed by the time-varying treatment estimates, a plausible intervention date can be set and the average treatment effect estimated in the third step of our analysis. The reduced specification takes the following form for the Nationwide sample.

$$\log(P_{it}) = \beta_n^N X_i^N + \beta_{nPOST}^N X_i^N \times POST_t + \sum_m \gamma_m Y_{itm} + \sum_t \varphi_t + \sum_h \psi_h + \varepsilon_{it} \quad (7)$$

where $POST_t$ is an indicator variable that the denotes the period after the identified intervention date. The estimated coefficient(s) $\hat{\beta}_{nPOST}^N$ then give the average treatment effects. For the simple distance treatment X^a the coefficient can be interpreted as the percentage increase in the average change of (log)transaction prices between the before (*PRE*) and after (*POST*) periods as one moves one kilometre away of the stadium. A positive treatment effect is expected that will be reflected by a negative sign of the coefficient.

$$\beta_{POST}^a = \frac{\log(\bar{P}_{iPOST}) - \log(\bar{P}_{iPRE})}{D_{ij}} \quad (8)$$

For our second treatment indicator X^b, which is defined based on a set of distance rings, our reduced specification (7) collapses to a more standard difference-in-differences specification. This specification compares changes in average (log)transaction prices within a given treatment ring *n* to the respective changes in the *control* group, which is the omitted base category defined in the treatment variable.

$$\beta_{nPOST}^b = [\log(\bar{P}_{POST}^n) - \log(\bar{P}_{PRE}^n)] - \log(\bar{P}_{POST}^{control}) - \log(\bar{P}_{PRE}^{control}) \quad (9)$$

It can be shown that the coefficient on our third treatment variable X^b provides an estimate on the marginal price effect of (log)distance to a stadium in first-differences form. Due to the log-log functional form it can be interpreted as an elasticity coefficient.

$$\log(\bar{P}_{iPOST}) - \log(\bar{P}_{iPRE}) = \beta^{c}_{POST} X^{c}_{i} = \log(D_{ijz}) - \log(D_{ijz-1}) \quad (10a)$$

$$\beta^{c}_{POST} = \frac{\log(\bar{P}_{iPOST}) - \log(\bar{P}_{iPRE})}{\log(D_{ijz}) - \log(D_{ijz-1})} \quad (10b)$$

In the Arsenal case, treatment variables X^b and X^c will also be introduced jointly into specification (7) to facilitate an estimate of the marginal distance effect, conditional on heterogeneous price trends within the neighbourhood. As an alternative, we introduce a treatment trend interactive term (X^c *x TREND*) to test for a significant level shift, conditional on a linear trend, which corresponds to detecting a sharp discontinuity in conventional regression discontinuity designs.[3] Last, we allow for treatment heterogeneity with respect to whether an area experienced an increase (D_{ijz+1} - $D_{ijz} < 0$) or decrease (D_{ijz+1} - $D_{ijz} > 0$) in stadium accessibility by interacting the treatment variable with indicator variables denoting each of the sub-treatment areas.

Based on the estimated average treatment effects, in the fourth and last step of our analyses, we estimate the aggregate increase in property value caused by the stadium intervention. This measure provides an estimate of the total welfare effect, assuming that the aggregated increase in bid-rents is driven by an increase in utility derived from the stadia and the subsequent willingness of residents to substitute non-housing consumption. The increase in aggregated housing value is estimated in a two-stage strategy. In the first stage we estimate the average dwelling price at output area level in 2000 prices by regressing transaction prices from the 2000-2008 land registry data set on the set of hedonic controls Z_p, a set of output area fixed effects (OA_q) and a set of yearly time effects φ_t omitting 2000 as a base category. Equation (11) is estimated separately for both study areas.

$$P_{it} = \sum_p \delta_p Z_{itp} + \sum_q \theta_q OA_{itq} + \varphi_{t \neq 2000} + \varepsilon_{it} \quad (11)$$

Recovering the fixed effects, the estimated parameters $\hat{\theta}_q$ provide an estimate of the (conditional) mean price, which in the second stage can be used to assess the aggregated welfare effect as the difference between the actual aggregated housing value and the counterfactual value in the absence of the stadium innovation.

$$AI = \sum_p \hat{\theta}_p \times H_p \times \left[1 - e^{-\hat{\beta}^{N}_{nPOST} X^{N}_{i}}\right] \quad (12)$$

, where H_p is the total housing stock in output area p as recoded in the *2001* census statistics.

[3] The *TREND* variable has its zero value at the time of the identified intervention.

4. Empirical Results

4.1 New Wembley

We start the discussion of our empirical results by illustrating our estimated time-varying treatment effects based on equation (5), our simple distance measure (X^a) and the Nationwide data set for the New Wembley neighbourhood. For the purposes of visualization we express the estimated treatment effects in terms of a linear function of distance to the stadium, which is set to zero at the outer margin of the 5km study area and increases at a slope that corresponds to the magnitude of the estimated treatment coefficient estimate ($\hat{\beta}_t^a$).

$$\hat{f}_{t2000}(D_j) = -\hat{\beta}_t^a \times (5 - D_j) \qquad (13)$$

Based on the resulting station gradients, we create a 3D surface in Figure 2 (left), where distances to the (New) Wembley, years and estimated treatment effects are on the x-, y- and z-axes. Baseline empirical results for all estimated equation (5) models are in Table A1 in the appendix. From the figure it becomes evident that areas close to the stadium site experienced a negative (relative) trend prior to 1998 before they entered a period of relative stability as indicated by the flat surface between 1998 and 2001. Starting in 2002, we observe a relatively sharp and permanent increase in transaction prices at close locations, with notable peaks in 2004 and 2008. These responses represent plausible market reactions in light of the timeline presented in Table 1. While the beginning of the construction phase in 2002 clearly removed the uncertainty about whether the renovation was to happen, it is plausible that "visual" effects to some degree capitalized into prices when the arch was raised and lightened in 2002 and, eventually, the "iconic" element of the stadium materialized. The 2008 response, in turn, might be interpreted as an inauguration effect. Figure (2) in a similar manner also illustrates the estimated treatment coefficients $\hat{\beta}_{nt}^b$ based on specification (5) and the non-linear treatment measure X^b (right). In order to ensure that all year-t-ring-n grid cells are well populated, we define four 1km rings ranging from 0-1 km, ..., 3-4 km, leaving the 4-5 km ring as a control area. By and large, the results confirm the pattern revealed by the linear gradient estimates.

Similarly, the basic pattern is confirmed when estimating the treatment coefficients based on equations (6a) and (6b) and the Land Registry data, which features the full sample of transactions at the expense of less detail in property characteristics (Figure 3). We note that due to the much increased number of observations, we can increase the number of rings n in treatment measure X^b to nine 0.5km rings ranging from 0.5-1 km, ... , 4-4.5 km, leaving the 4.5-5 km ring as a control area. In order to produce a smooth surface for each year we separately estimate the unknown non-linear function $f_{t2000}(D_j)$ based on the estimated treatment coefficients $\hat{\beta}^b_{nt}$ by means of locally weighted regressions and plot the predicted values in Figure 3 (right). Again, we find a sharp and permanent increase in prices close to the stadium in 2002 and peaks in 2004 and 2008. Compared to Figure 2, Figure 3 suggest that the decrease in prices relative to the base year 2000 at short distances to the stadium is slightly more localized. Similarly we find a more localized "inauguration" effect in 2008 and a dip within the first 0.5 km ring from 2002-2007, which could be indicative of negative externalities during the construction phase. Naturally, the advantages of the more flexible functional form imposed by treatment measure X^b become more evident in Figure 3, where we can increase the number of rings n due to the larger data set.

In any case, evidence from the time-varying treatment estimates suggests that, on average, prices at close locations compared to the pre-construction phase significantly increased by up to 15-20% relative to the base year, which is in line with a significant visual amenity effect. Moreover, all time-distance plots depicted in Figures 2 and 3 consistently point to a discontinuity in 2002, which is in line with the hypothesis laid out in the theory section that real estate markets value improvements in environmental quality as soon as the respective information enters the market.

Taking the presence of anticipation effects as given, in the next step we estimate the average treatment effect as the change in the marginal value of proximity to the stadium in 2002 for all combinations of treatment variables (X^a and X^b) and our two data sets (Nationwide and Land Registry). Results based on the reduced specification (7) and the 2002 intervention data are presented in Table 2. In sum, the results indicate that following the intervention properties at closer distances to the stadium project experienced a significantly higher appreciation compared to those at larger distances. Both data sets yield a statistically significant increase in the value of location closer to the stadium of about 2.5-2.8% per km, on average (columns 1 and 3). Cumulated over the 5km impact area, these point estimates correspond to an increase in prices for properties adjacent the stadium of about 12.5-14% relative to otherwise comparable properties at the outer fringe of the study area.

These results are roughly in line with the estimated treatment effect based on our distance-ring measure X^b, which yields an average increase in property prices for the first 0-1 km distance ring of about 17%.[4] While the estimated treatment effect generally decreases with distance, confirming the negative relationship between appreciation and distance revealed in the linear gradient models, the pattern also indicates some degree of non-linearity in the treatment effect with properties at very close distances gaining disproportionally (column 2). The same treatment variable applied to the larger set of 0.5km distance rings and the land registry data set (column 4) similarly yields positive and significant stadium treatment effects, which diminish with distance to the stadium at a rate that generally corresponds to the marginal 1km effect found in columns (1) and (3). Notably, the largest treatment effect is found for the 0.5-1 km ring where prices– on average– increase by about 11.5% relative to the control group. In contrast, the average treatment effect for the innermost ring is much smaller and not statistically significant at conventional levels, which might be driven by negative construction effects as suggested by the "dip" in the treatment surface presented in Figure 3. We note that if only the post-construction treatment coefficient for 2008 is considered an increase of more than 20% is suggested.

Overall, the results presented in this section clearly support the hypothesis of significantly and positive stadium externalities, which given the special case of New Wembley seem to be driven by a visual amenity effect related to the "iconic" structure.

4.2. The Emirates Stadium

As discussed, the key-feature of the Arsenal case is that the stadium relocation provides micro-level variation in distance to the stadium, which can be exploited to separate the stadium effect from correlated neighbourhood characteristics and trends. Figure 4 plots our estimated treatment effects for the Arsenal study areas based on specification (5), treatment measure X^c and the Nationwide property data (left). As an alternative and robustness check we re-estimate the full set of treatment coefficients conditional on a set of 0.5km ring-year dummies as defined in the treatment measure X^b (right). This specification flexibly controls for neighbourhood trends that are correlated with proximity to the stadia. In any case, the visualized treatment coefficients attribute the change in average property prices in year t relative to the base year 2000 to the experienced change in distance to the stadium as the location moved from Highbury Road to the site of the Emirates arena. Note that for the purposes of a more intuitive

[4] Standard interpretation of dummy coefficients in semi-log models; i.e. exp(b)-1x100 (Halvorsen and Palmquist, 1980).

visualisation we multiply the estimated coefficients $\hat{\beta}_t^c$ by (-1) so that increase in the index reveals a positive stadium proximity effect capitalizing into prices.

Notably, the displayed treatment coefficients reveal an evident trend reversion in 1999. Before, properties within areas that experience an increase (decrease) in stadium proximity tend to sell at a discount (premium) compared to the reference year 2000. Starting in 1999, the index reveals a positive (negative) and permanent increase (decrease) in the average sales price for properties located in the same areas. Figure 4 suggests an adjustment to the stadium "treatment", which largely takes place between 1999 and 2001. As illustrated in the time line in Table 1, this is precisely the period when the plans to move to the new site and the final stadium plans were revealed to the public. The intervention date suggested by the time-varying treatment effects, as in the case of New Wimberley, supports the hypothesis of anticipation effects; i.e. the capitalization of environmental factors as soon as new information enters the market. The same adjustment pattern is consistently found irrespective of whether the estimation specification is extended by year-ring grid cells (right) or not (left). If at all different, the adjustment process is somewhat smoothed around 2001 in the extended specification, but otherwise similar.

As discussed in section 3, the shock to the immediate catchment areas of the old Arsenal and the Emirates Stadium was not entirely symmetric given that the old structure was not removed entirely, besides been hardly visible from public space. This asymmetry raises the possibility of treatment heterogeneity in our study area, which we accommodate by interacting our treatment-year interactive terms with two indicator variables, each denoting positively and negatively affected areas. As a result we obtain similar indices as in Figure 4 for both areas, which we display in Figure 5. Note that we multiply the estimated treatment coefficients by (-1) for the positively affected area (left), but not for the negatively affected area (right), so that in both illustrations a positive shift in the index corresponds to an increase in relative prices where distance to the sports venue diminishes. While both graphs exhibit shifts that point into consistent directions, some notable differences are evident. Within the catchment area of the Emirates Stadium there is a positive and relatively abrupt reaction to the announcement of the relocation plans in 1999. While the catchment area of the old Arsenal stadium enters a negative trajectory path following the announcement in 1999, which is in line with the hypothesis of positive stadium effects, the adjustment process is somewhat smoother than in the surroundings of the new stadium. Baseline statistics for the discussed models are in Table A2 in the appendix.

As in the case of the New Wembley, the visual inspection of the estimated time-varying treatment coefficients facilitated the definition of a plausible intervention date. Since our results, again, support the presence of anticipation effects, we set the intervention date to 1999 when estimating a reduced equation (7) type specification to obtain an estimate of the average treatment effect. Average treatment effects for relocation of the Arsenal stadium to the site of the Emirates Stadium are presented in Table 3. Column (1) presents the baseline estimate based on specification (5) with the (log)change in distance to the stadium (X^c) as the treatment variable. As expected, we find that a reduction in distance to the stadium is associated with an increase in average property prices, which is in line with the presence of positive stadium externalities. Our estimated treatment effect, which satisfies conventional significance criteria, indicates that a reduction in distance to the stadium by 1% increases the price of properties by about 0.17%. This estimate is not very sensitive to the control for neighbourhood trends captured by a full set of 0.5km ring-year cells (column 2). If we test for a significant shift, conditional on a linear trend, we still yield a significant treatment effect, despite the treatment-trend interactive picking up a considerable proportion of the stadium treatment.

For reasons discussed above, we allow for treatment heterogeneity between positively (*POS*) and negatively (*NEG*) affected areas. We find consistent treatment effects within the catchment areas of the new as well as the old site. Despite the more immediate reaction within the catchment area of the Emirates stadium suggested by Figure 5, the magnitude of the adjustment is relatively smaller than that of the old stadium. This may be due to the positive effects around the Emirates Arena being partially cancelled out by negative externalities linked to the much increased stadium capacity (potentially more noise, crime and congestion).

Finally, we replace the (log)change in distance to the stadium (X^c) treatment variable by the 0.5 km ring-year cells to test for a significant net effect in the neighbourhood. Compared to the case of New Wembley, we find considerably smaller treatment effects, which also point into the opposite direction. The areas within 1km of either of the two stadia experience a significant decline in property prices relative to more distant areas.

Taken together, our results, thus, point to a shift of demand that occluded within the neighbourhood at a very micro-level. Net-effects to the broader neighbourhood are either very small, or even negative. This pattern might be comprehensive in light of countervailing externalities of different range. Positive effects related to an emotional attachment to the venue and the home team and the visual amenity effect –given the absence of a widely visible "iconic" element– seem to dominate at close distances, while negative externalities related to noise, crime and congestion dominate at intermediate distances. Note that the new stadium has a much increased capacity, with correspondingly larger disamenity effects related to spectators that pass the neighbourhood on their way to and from the stadium, or stay within the neighbourhood after the games. At the same time the structure of the stadium does not represent a visual amenity to the same degree as the New Wembley or similarly ambitiously designed arenas.

4.3 Aggregated Effects

As discussed, localized effects at the neighbourhood scale have become a central argument of proponents of large investments into professional sports facilities. In light of (public) expenditures, which as in the case of the New Wembley, can amount to about a billion Euros for construction cost alone, this argument heavily relies on support by empirical evidence on sizable welfare effects. Property market adjustments to new stadia reflect stadium utility effects as valued by the resident population and, hence, qualify as a basis for a welfare analysis.

As laid out in our empirical strategy, the aggregated welfare effect can be approximated by applying estimates on the marginal effect of a stadium to the total value of the housing stock. This value, in turn, can be approximated taking the housing stock as recoded in census statistics and an estimated average property price at output area level as a basis. Table A4 summarizes the results of two equation (11) type auxiliary regressions, which we run to estimate the average property price at output area level in 2000 prices. Estimated property prices are visualized in Figure A1 in the appendix. Using these estimates, total housing stock and the estimated set of treatment coefficients $\hat{\beta}^{b}_{nPOST}$ from Table 2, (2), the aggregated increase in housing value associated with the New Wembley amounts to about £2.12 billion. Notably, this is a large value even compared to total construction costs that amounted to £1.4 billion, including expenditures on infrastructure and financing.

A similar estimate for the Arsenal neighborhood using the estimated treatment coefficients $\hat{\beta}^{c}_{POST}$ from Table 3, (1), instead, reveals a negative net-effect of about £0.44 billion, which is in line with the negative net-effect suggested by $\hat{\beta}^{b}_{nPOST}$ coefficients in Table 3, (5). Note that the net-effect is the result of a £1.78 billion increase within the catchment area of the Emirates stadium and a £2.2 billion decrease in the catchment area of the old Arsenal stadium. Thus, the net-effect to the neighborhood is much larger in the case of the New Wembley than for the Arsenal neighborhood. Possible explanations include the visual amenity effect related to the iconic architecture of the New Wembley and negative externalities related to the broader Arsenal neighborhood due to a considerable increase in the capacity and, hence, spectator flows.

5. Concluding Remarks

This paper contributes to the emerging literature on the impact of sports stadia on local property prices as well as to the broader discussion on whether (public) expenditures on construction and modernization of large-scale professional sports facilities can be justified on the grounds of significant neighbourhood spillovers. We investigate two of the largest stadium projects of the recent decade, the New Wembley and the Emirates stadium, both located in London, UK. The selection is motivated by case-specific particularities that allow for a separation of direct and indirect stadium effects and a more efficient isolation of stadium effects from correlated neighbourhood effects and trends.

In the case of the New Wembley, we find a significant increase in property prices close to the stadium of up to 15%, which gradually decreases in distance to the stadium. Even at relatively large distances of 3 km significant spillovers were still found. The magnitude of the effect is roughly in line with results from previous studies. In contrast to previously investigated cases, the New Wembley replaced a pre-existing stadium of about the similar size with roughly the same functionality. Many of the direct external effects of the stadium, including positive effects related to civic pride and emotional attachments as well as negative externalities arising from increased noise, crime and congestion are held constant. Given the "iconic" architecture and the prominent architects that serve as credentials for the quality of the design, positive stadium effects are therefore likely to be mainly driven by a "visual amenity" effect as it has previously been revealed for various views on natural and built amenities. The distinctive iconic element of the new stadium, a widely visible arch of about 130m high, can also explain the presence of significant stadium effect at relatively far distances.

The relocation of the Arsenal home venue from Highbury Road to the Emirates Stadium provides micro-level variation in distance to the stadium over time, which we use to disentangle stadium effects from correlated neighbourhood effects and trends. We find a robust increase in property prices where distance to the stadium location is reduced, which is in line with positive (net-)externalities. Our results indicate a 1.7% increase in property prices for any 10% decrease in distance to the stadium. Moreover, we find that price adjustments are considerably larger, although less abrupt, in areas that experience an increase in stadium distance. Given that the old structure was not removed but modernized, these effects point to the existence of (a) significant effects related to the functionality of stadium and (b) a negative externality that partially cancels out positive effects and may be related to the increased capacity and correspondingly increased noise, crime and congestion effects.

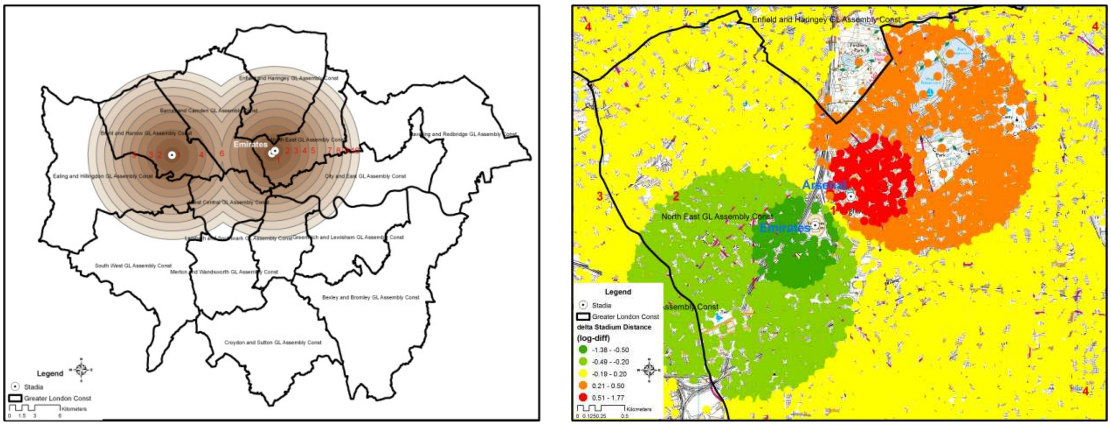
Our study also features an additional important innovation in the research design. Instead of assuming an intervention date a priory based on behavioural assumptions on real estate agents, our empirical strategy yields an index of the effects of the stadium treatment, which can be used to identify the intervention. In both cases, we find an adjustment that coincides with the communication of the final stadium plans, which supports the presence of anticipation effects and shows that real estate markets tend to value changes in the environmental quality of locations as soon as new information enters the market.

Aggregating the identified property market reactions based on estimated treatment effects, average property prices and housing stock at output area, we find substantial stadium effects in absolute terms, even compared to the large (public) investments into the new facilities. For all three stadium locations, the estimated change in aggregated value amounts to about £2 billion, leaving a positive net-effect to the neighborhood of the New Wembley and a close to zero net-effect to the broader neighborhood of the Arsenal venues as the effects within the catchment areas of the Emirates Stadium and Highbury Road cancel out each other.

These results support the presence of both a direct stadium effect related to the functionality of a stadium as a sports venue, as well as the presence of an indirect effect related to the design of the structure. On the one hand, "iconic" designs as in the case of the Wembley stadium may induce a visual amenity and utility effect. On the other, such a formal vocabulary, by promoting identification of spectators and fans with "their" stadium, may amplify a range of direct stadium effects. In any case, our results support the potential of stadium projects to increase the attractiveness of local areas. Given the relevance of the stadium design for the external value, commitment of public funds for future stadium projects should be made conditional on a comprehensive architectural and urban design strategy that seeks to maximize the external benefits to the neighbourhood.

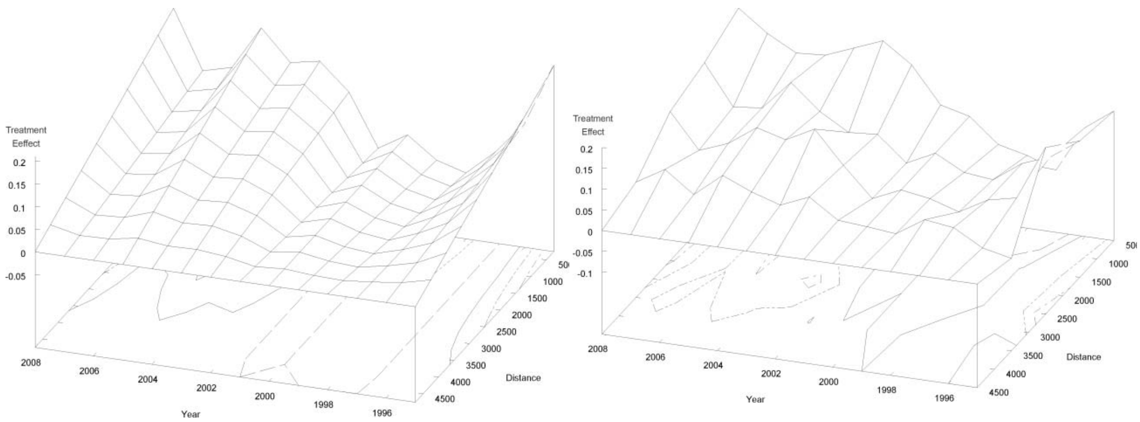
FIGURES

Figure 1: Stadium locations and treatment variables



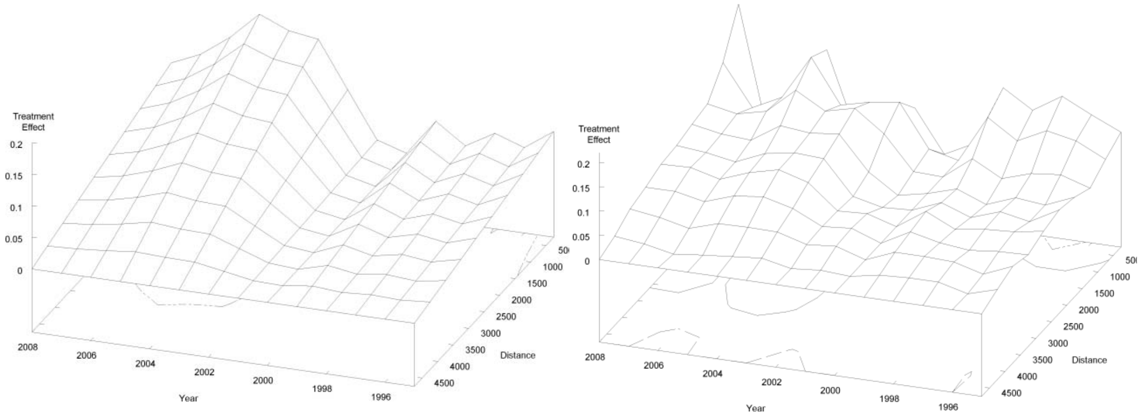
Notes: Own illustrations

Figure 2: Time-varying treatment effect: New Wembley (Nationwide data)



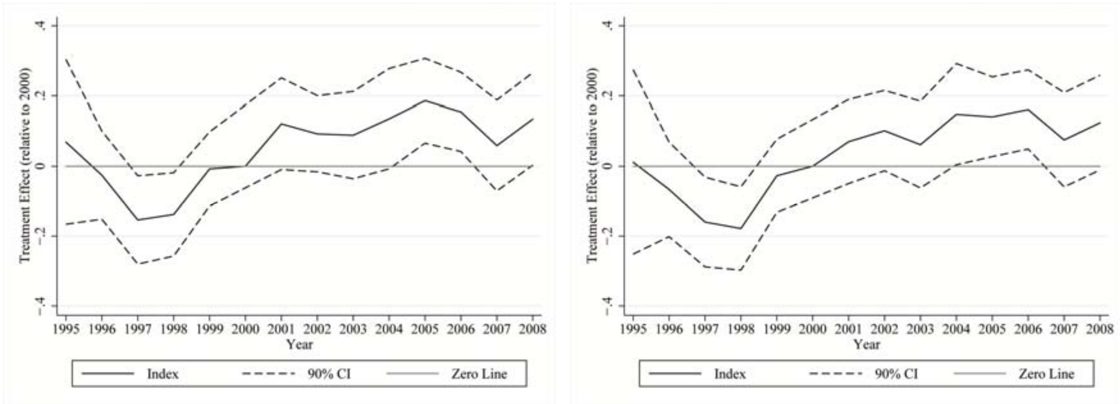
Notes: Own illustration based on own calculation. Estimated treatment coefficients correspond to specification (5), Nationwide data and treatment variables X^a (left) and X^b (right).

Figure 3: Time-varying treatment effect: New Wembley (Land Registry data)



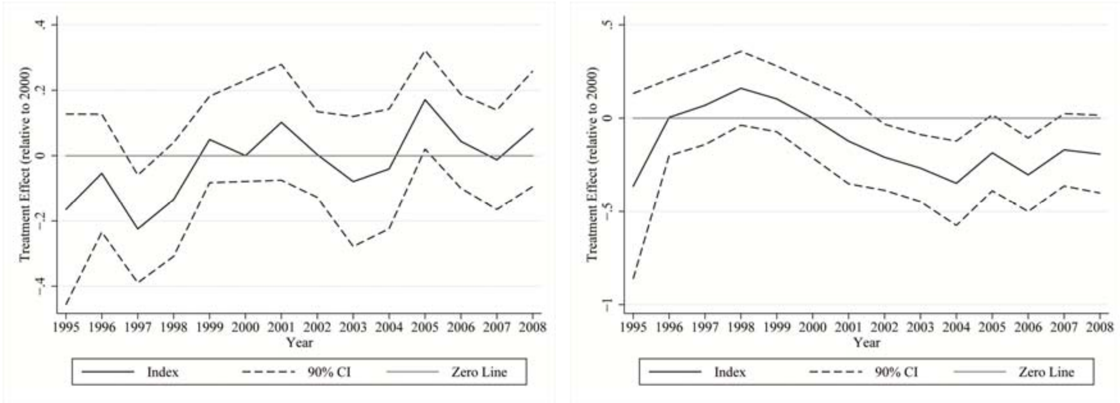
Notes: Own illustration based on own calculation. Estimated treatment coefficients correspond to specification (6a/b), Land Registry data and treatment variables X^a (left) and X^b (right).

Figure 4: Time-varying treatment effects: Entire study area



Notes: Figure illustrates estimated treatment coefficients based on specification (€), treatment measure X^c, and the nationwide property data set, with (right) and without (right) controlling for year-ring effects (left). Standard errors for the base year 2000 are interpolations based on 1999 and 2001. Estimated treatment coefficients are multiplied by (-1).

Figure 5: Time-varying treatment effects: Treatment heterogeneity



Notes: Figure illustrates estimated treatment coefficients based on an extended specification (€), treatment measure X^c, and the nationwide property data set, where treatment heterogeneity is allowed for positively (left) and negatively (right) affected areas. Standard errors for the base year 2000 are interpolations based on 1999 and 2001. Treatment coefficients are multiplied by (-1) in the left illustration

TABLES

Table 1: Key Timelines and Milestones

Wembley Stadium		*Emirates Stadium*	
Oct 2000	Closure of Old Wembley.	Nov 1999	Proposals to move to a new stadium, situated where the Emirates Stadium is actually located, are announced.
Oct 2002	Commencement of demolition of Old Wembley and construction of New Wembley.	Nov 2000	Planning application submitted to Islington Council. Stadium project unveiled to the public.
Jun 2004	Arch raised and lightened.	Feb 2004	Commencement of construction of stadium.
Mar 2007	Completion of New Wembley.	Oct 2004	New stadium officially named Emirates Stadium.
		Jun 2005	Construction reaches halfway stage.
		Aug 2006	Inauguration of Emirates Stadium/Commencement of redevelopment of (old) Arsenal Stadium.

Source: Official stadium websites- www.wembleystadium.com and www.arsenal.com/emirates-stadium .

Table 2: Average treatment effects: New Wembley

	(1)	(2)	(3)	(4)
Distance Treatment	-0.025**		-0.028**	
(*POST* x *D*)	(0.008)		(0.004)	
Ring 0-0.5 [0-1] km Treatment		0.149*		0.046
(*POST* x $R_{0\text{-}0.5}$)				(0.03)
Ring 0.5-1 [0-1] km Treatment		(0.06)		0.111*
(*POST* x $R_{0.5\text{-}1}$)				(0.045)
Ring 1-1.5 [1-2] km Treatment		0.057*		0.095*
(*POST* x $R_{1\text{-}1.5}$)				(0.039)
Ring 1.5-2 [1-2] km Treatment		(0.026)		0.071*
(*POST* x $R_{1.5\text{-}2}$)				(0.029)
Ring 2-2.5 [2-3] km Treatment		0.066**		0.062**
(*POST* x $R_{2\text{-}2.5}$)				(0.021)
Ring 2.5-3 [2-3] km Treatment		(0.024)		0.037+
(*POST* x $R_{2.5\text{-}3}$)				(0.019)
Ring 3-3.5 [3-4] km Treatment		0.040*		0.032
(*POST* x $R_{3\text{-}3.5}$)				(0.025)
Ring 3.5-4 [3-4] km Treatment		(0.02)		0.012
(*POST* x $R_{3.5\text{-}4}$)				(0.022)
Ring 4-4.5 km Treatment				-0.007
(*POST* x $R_{4\text{-}4.5}$)				(0.017)
Basic Hedonic Controls	Yes	Yes	Yes	Yes
Extended Hedonic Controls	Yes	Yes		
Gradient Effect	Yes		Yes	
Ring Effects		Yes		Yes
Location Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Monthly Trend			Yes	Yes
Daily Trend			Yes	Yes
Data	Nationwide	Nationwide	Land Reg.	Land Reg.
Period	1995-2008	1995-2008	2000-2008	2000-2008
Observations	5263	5263	50819	50819
R-squared	0.9	0.9	0.76	0.71

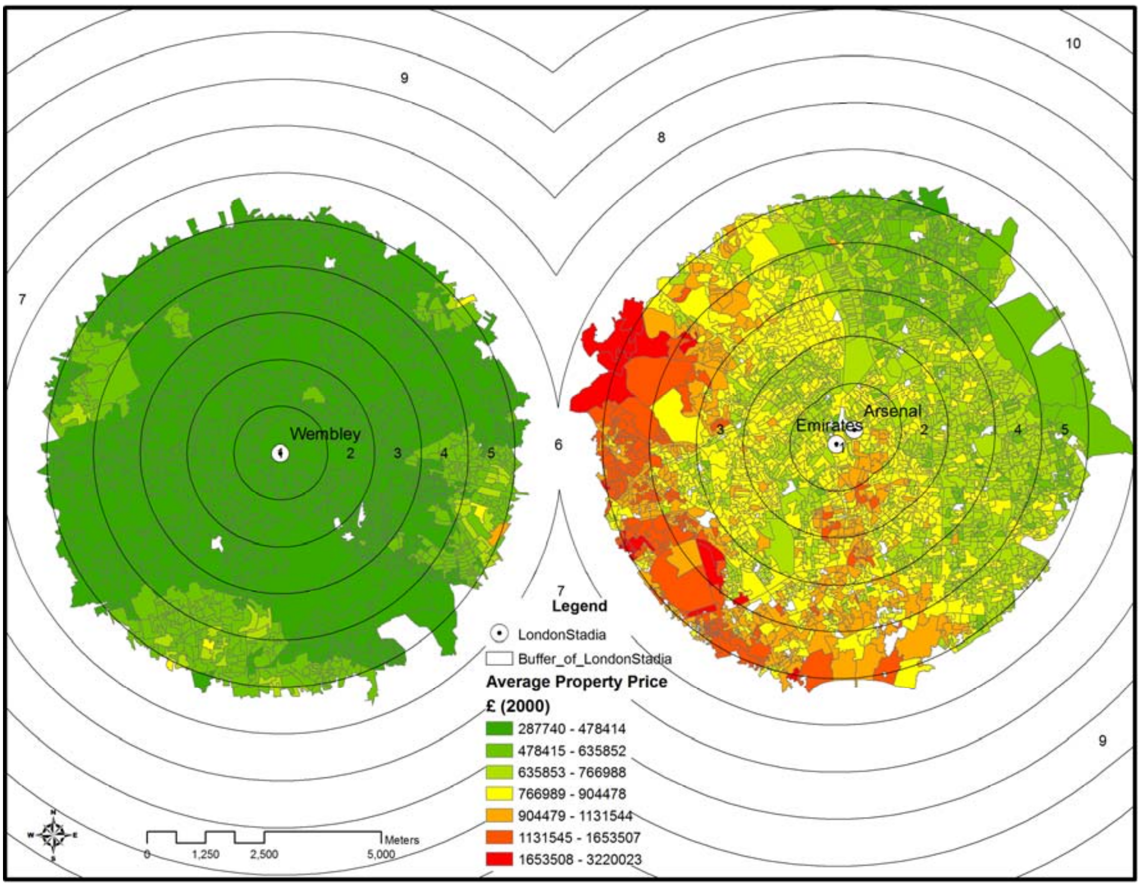
Notes: Dependent variable is log of purchasing price in all models. Robust standard errors (in parenthesis) are clustered on postcode sectors. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 3: Average treatment effects: Arsenal

	(1)	(2)	(3)	(4)	(5)
Treatment (X^c) x Post	-0.168**	-0.190**	-0.119*		
$\log(D_{ijz+1}) - \log(D_{ijz}) \times POST$	(0.037)	(0.039)	(0.057)		
Treatment (X^c) x TREND			-0.011		
$\log(D_{ijz+1}) - \log(D_{ijz}) \times TREND$			(0.009)		
Treatment (X^c) x Post (positive)				-0.104*	
$\log(D_{ijz+1}) - \log(D_{ijz}) \times POST \times POS$				(0.047)	
Treatment (X^c) x Post (negative)				-0.266**	
$\log(D_{ijz+1}) - \log(D_{ijz}) \times POST \times NEG$				(0.079)	
Ring 0-0.5 km Treatment					-0.077+
($POST$ x $R_{0\text{-}0.5}$)					(0.041)
Ring 0.5-1 km Treatment					-0.070*
($POST$ x $R_{0.5\text{-}1}$)					(0.03)
Ring 1-1.5 km Treatment					-0.03
($POST$ x $R_{1\text{-}1.5}$)					(0.026)
Ring 1.5-2 km Treatment					-0.031
($POST$ x $R_{1.5\text{-}2}$)					(0.026)
Ring 2-2.5 km Treatment					-0.057*
($POST$ x $R_{2\text{-}2.5}$)					(0.024)
Ring 2.5-3 km Treatment					-0.041+
($POST$ x $R_{2.5\text{-}3}$)					(0.025)
Ring 3-3.5 km Treatment					-0.018
($POST$ x $R_{3\text{-}3.5}$)					(0.027)
Ring 3.5-4 km Treatment					-0.032
($POST$ x $R_{3.5\text{-}4}$)					(0.029)
Ring 4-4.5 km Treatment					0.007
($POST$ x $R_{4\text{-}4.5}$)					(0.027)
Basic Hedonic Controls	Yes	Yes	Yes	Yes	Yes
Extended Hedonic Controls	Yes	Yes	Yes	Yes	Yes
$\log(D_{ijz+1}) - \log(D_{ijz})$	Yes	Yes	Yes	Yes	
Ring Effects					Yes
Ring x Year Effects		Yes			
Location Effects	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Data			Nationwide		
Observations	9933	9933	9933	9933	9933
R-squared	0.89	0.9	0.9	0.89	0.89

Notes: Dependent variable is log of purchasing price in all models. Robust standard errors (in parenthesis) are clustered on postcode sectors. + significant at 10%; * significant at 5%; ** significant at 1%.

Fig A1: Estimated average property prices



Notes: Own calculation and illustration.

Table A1 – Time-varying treatments and hedonic estimates: New Wembley

	(1)	(2)	(3)	(4)	(5)	(6)
Number of bedrooms	0.197**	0.199**				
	(0.005)	(0.005)				
Number of bathroms	0.062**	0.061**				
	(0.013)	(0.013)				
Floor size	0.001**	0.001**				
	(0.0001)	(0.0001)				
Age	0.001**	0.001**				
	(0.0001)	(0.0001)				
Age quared	-0.0001**	-0.0001**				
	(0)	(0)				
Central heating (full)	0.092**	0.091**				
	(0.008)	(0.008)				
Central heating (partial)	0.061*	0.058*				
	(0.027)	(0.025)				
Garage	0.079**	0.076**				
	(0.01)	(0.01)				
Parking space	0.054**	0.052**				
	(0.009)	(0.008)				
Poperty type:						
Detached	0.290**	0.288**	0.581**	1.041**	0.652**	1.041**
	(0.038)	(0.039)	(0.025)	(0.037)	(0.042)	(0.038)
Semi-detached	0.067**	0.065**	0.219**	0.644**	0.239**	0.644**
	(0.018)	(0.018)	(0.014)	(0.022)	(0.022)	(0.023)
Terassed	-0.013	-0.014	0.113**	0.461**	0.102**	0.461**
	(0.021)	(0.022)	(0.014)	(0.016)	(0.022)	(0.016)
Cottage or bungalow	0.108+	0.102+				
	(0.059)	(0.059)				
New Property	0.102	0.109+	0.143**		0.216**	
	(0.067)	(0.06)	(0.021)		(0.023)	
Leasehold	-0.194**	-0.195**	-0.405**		-0.390**	
	(0.022)	(0.022)	(0.015)		(0.021)	
Location Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year x Gradient Effects	Yes		Yes	Yes		
Year x Ring Effects		Yes			Yes	Yes
Monthly Trend			Yes		Yes	
Daily Trend			Yes		Yes	
Data	Nationwide	Nationwide	Land Reg.	Land Reg	Land Reg.	Land Reg
Period	1995-2008	1995-2008	2000-2008	1995-2000	2000-2008	1995-2000
Observations	5263	5263	50819	1415	50819	1415
R-squared	0.9	0.9	0.76	0.94	0.71	0.94

Notes: Dependent variable is log of purchasing price in all models. Robust standard errors (in parenthesis) are clustered on postcode sectors. + significant at 10%; * significant at 5%; ** significant at 1%

Table A2 – Time-varying treatments and hedonic estimates: Arsenal

	(1)	(2)	(3)
Number of bedrooms	0.174**	0.175**	0.174**
	(0.006)	(0.006)	(0.006)
Nnumber of bathroms	0.105**	0.105**	0.105**
	(0.011)	(0.011)	(0.011)
Floor size	0.001**	0.001**	0.001**
	(0)	(0)	(0)
Age	0.002**	0.002**	0.002**
	(0)	(0)	(0)
Age quared	-0.000**	-0.000**	-0.000**
	(0)	(0)	(0)
Central heating (full)	0.108**	0.110**	0.109**
	(0.014)	(0.014)	(0.014)
Central heating	0.069**	0.071**	0.070**
(partial)	(0.021)	(0.021)	(0.021)
Garage	0.047**	0.050**	0.047**
	(0.015)	(0.015)	(0.015)
Parking space	0.083**	0.082**	0.082**
	(0.013)	(0.013)	(0.013)
Poperty type:			
Detached	0.168**	0.168**	0.166**
	(0.051)	(0.052)	(0.052)
Semi-detached	0.098**	0.099**	0.098**
	(0.017)	(0.016)	(0.017)
Terassed	0.126**	0.126**	0.126**
	(0.014)	(0.014)	(0.014)
Cottage or bungalow	-0.032	-0.026	-0.024
	(0.086)	(0.09)	(0.087)
New Property	0.207**	0.205**	0.206**
	(0.033)	(0.034)	(0.033)
Leasehold	-0.145**	-0.145**	-0.144**
	(0.013)	(0.013)	(0.013)
Location Effects	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes
Treatment (X^c)	Yes	Yes	Yes
Year x Treatment (X^c) Effects			
Year x Treatment (X^c) x *POS* Effects		Yes	Yes
Year x Treatment (X^c) x *NEG* Effects			Yes
Year x Ring Effects		Yes	
Observations	9,933	9,933	9,933
R-squared	0.89	0.9	0.9

Notes: Dependent variable is log of purchasing price in all models. Robust standard errors (in parenthesis) are clustered on postcode sectors. + significant at 10%; * significant at 5%; ** significant at 1%

Tab A3: Average property prices at output area level

	(1)	(2)
	New Wembley	Arsenal
Property Type:		
Flat	-255,735.150**	-537,896.124**
	(3,362.26)	(8,681.88)
Semi-detached	-192,027.392**	-305,317.565**
	(2,364.87)	(8,320.06)
Terraced	-225,967.956**	-438,372.573**
	(2,431.66)	(7,763.26)
New Property	29,779.692**	18,591.133**
	(2,271.31)	(3,185.21)
Output Area Effects	Yes	Yes
Year Effects	Yes	Yes
Monthly Trend	Yes	Yes
Daily Trend	Yes	Yes
Data	Land Registry	Land Registry
Period	1995-2008	1995-2008
Observations	50,819	90,356
R-squared	0.67	0.55

Notes: Dependent variable is log of purchasing price in all models. Robust standard errors (in parenthesis) are clustered on postcode sectors. + significant at 10%; * significant at 5%; ** significant at 1%

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