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Abstract
Prestigious sports facilities increasingly feature among the most expensive development projects worldwide. Considerable public funds are often committed based on expected neighbourhood effects. 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 suggest that stadium architecture may play an important role in promoting positive spillovers to the neighbourhood.

Keywords: Property prices, stadium impact
JEL Classifications: 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 (Kavetsos and Szymanski, 2010). 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 has 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 (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 consumption benefits and various forms of image effects, but also a sophisticated architecture and urban landscape design, which together will contribute the revitalization of neighbourhoods (Ahlfeldt and Maennig, 2010).

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 (sophisticated architecture), but not in use and location, (c) the Emirates Stadium provides variation in external design and setting (conventional architecture) 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. Not least, we deliberately choose for the absence of infrastructure investments, which often accompany stadium projects and complicate the evaluation of property price effects.

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 (additional) public funds.

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, a more explicit investigation of stadium related congestion externalities 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 use a flexible estimation strategy that identifies the adjustment process to the presence of a new stadium from the data in order to back up the chosen intervention dates.

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 Literature

2.1 Sports Stadia and Surrounding Properties

The urban economics literature has long been investigating the links between property prices and neighbourhood characteristics, focusing for example on the impact schools (Black, 1999; Gibbons and Machin, 2003, 2006, 2008), airports (Tomkins et al., 1998); rail transport (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 can also potentially have a significant
Ahlfeldt and Maennig (2010b) provide a typology of stadium effects, categorized into effects that are merely related to the functionality of a sports venue or its external design and architecture. Among other things, sports related effects encompass spending effects by sports fans, consumption benefits from attending games and civic pride effects related to a prestigious home team close by. With a sophisticated architecture, an amenity effect related to the aesthetic quality of the neighbourhood can be induced. Additional effects emerge from the spending of tourists, image effects that translate into perceived social capital and consumer optimism, as well as identification and involvement of citizens and fans that are proud of their new landmark. While there are various formal vocabularies featuring the potential for a neighbourhood upgrading and the appropriate strategy may very much depend on the case specific setting, "iconic" elements have been particularly popular in recent stadium projects. One explanation is that iconic architecture serves as a catalyst for the increased identification of citizens and fans and is thus expected to amplify some of the direct stadium effects.

While it is difficult to precisely define the characteristics of an iconic building, Ahlfeldt and Maennig (2010b) summarize the main features of "iconic" architecture into a new and condensed image, a height in figural shape and an often metaphoric character. Accordingly, iconic projects tend to dominate the urban landscape with their spectacular architecture and are usually designed by prominent architects who derive their reputation from prizes and media presence. Recent examples of iconic stadium architecture include Durban’s 2006 FIFA World Cup stadium (Gerkan, Marg and Partners), which resembles the South African National Flag and Beijing’s National Stadium (with the nickname Bird Nest) and the Munich Allianz-Arena, both designed by Herzog and de Meuron. The New Wembley (Foster and Partners) with its iconic arch and the London Aquatics Centre (by Pritzker Prize winner Zaha Hadid) also fall into this category.

A number of studies that aim at identifying stadium externalities in property prices 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 franchise increases annual rents by 8 percent in the city, an effect they attribute to civic pride; i.e. individuals deriving utility from the franchise relocate to the area, 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.
The evidence provided in Carlino and Coulson (2004) is unable to determine whether the estimated results are attributed to the presence of the stadium or the franchise. This limitation 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 construction of the stadium has. His hedonic analysis provides substantial evidence suggesting that following each completion phase the price of proximate properties significantly increases 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, two architectural landmark arenas, on land values in Berlin. They find that both stadiums impose a positive effect on land values up to three kilometres away. These findings are confirmed in a study that makes use of longitudinal data and a quasi-experimental research methodology (Ahlfeldt and Maennig, 2009).

Furthermore, relevant research has also provided evidence suggesting that stadium construction announcements are also capable of having substantial price impacts. Dehring et al. (2007) study a series of stadium construction announcements to host an NFL team. Overall, they find that announcements promoting construction have significant positive impacts on property values in Dallas City. Sign reversal is observed when the project was cancelled, which is however statistically insignificant. The same argument though regarding the distinction between the impact of the stadium and that of the team also holds here. A hedonic study of property prices in London is also performed in Kavetsos (in press) 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, 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.

Moreover, 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 indi-

\footnote{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.}
cate 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 associated with the 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). The literature has not, however, been able to identify whether such effects are mainly related to the functionality of the stadium as a professional sports facility or the (dis)amenity effect exhibited by the design of the usually very large structures. This is a crucial limitation in light of the increasingly important role that iconic design plays in contemporary stadium architecture, especially given that the aesthetic component of a neighbourhood, both regarding the natural as well as the built environment, has been documented to be a significant determinant for the desirability of locations (e.g. Ahlfeldt and Maenning, 2010c; Jim and Chen, 2009; Li and Brown, 1980). Recent research even shows that the perceived beauty or aesthetic character of a location is among the most significant determinants of community satisfaction (Florida et al., 2009).

2.2 The New Wembley and Emirates Stadia

As noted, we choose the subject cases due to the attractive settings that facilitate the separation of direct and indirect stadium effects. Typically, the construction of major sports facilities is accompanied by considerable infrastructural investments, e.g. improvements in transport connectivity, which may partially drive estimated stadium effects. Such secondary effects can be ruled out for both projects. The New Wembley was developed at exactly the same site of the previous stadium where all necessary transport infrastructures were already available. The Emirates Stadium was built on an industrial estate at Ashburton Grove, which lies within a densely populated area just 500m from Highbury- the location of the old stadium. This central London area was already excellently connected by several underground and regional rail stations so that no further improvements were required. A careful analysis of newspapers archives did not indicate any other major development projects that were unrelated to the considered stadium projects and could confound our estimates.

A brief overview of the key milestones and timelines related to the construction/renovation of both stadia under examination in this study follows. These are summarised in Table 1.

The Old Wembley closed its doors in 2000 with the new stadium intended to operate in 2003.

2We discuss the case of regeneration-related announcements in Section 4.3.
Following a number of delays demolition of the old stadium started in 2002 and the new construction was finally completed five years later. Populous, who also designed the Emirates Stadium, in conjunction with 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 football team and hosts various music events. With a capacity of 90,000 seats the New Wembley is currently the second largest football stadium in Europe after the Camp Nou in Barcelona. In terms of construction costs it holds the first position with £900 million in 2007 prices.

Arsenal FC, the team commissioning the construction of the Emirates Stadium, announced their intention to move to a new, modern, purposefully built facility in 1999. Situated in central London and in an adjacent neighbourhood to the old stadium, construction of the Emirates 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 stadium into a block of flats. While still among the largest recent stadium projects in Europe, the Emirates is somewhat smaller than the New Wembley, featuring a capacity of 60,355 seats and came at a construction cost of £390 million in 2006 prices.

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 covers most of the property characteristics that are common in hedonic studies. This detail comes at the expense of a limited coverage in terms of the total number of transactions. The Land Registry data 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 key-stage 2 (KS2) results could be obtained, and the 2001 census, which features output area
data on the total housing stock.

While the data processing was straightforward for most of the variables some words might be due
on our school quality indicator based on the KS2 test scores. Due to confidentiality restrictions we
obtained a data set which was limited to output areas with at least three registered pupils in the
period from 2002 to 2007. We assume that school quality can be approximated by the average KS2
test score of pupils in the neighbourhood, where pupils living nearby should receive higher weights
as the likelihood of pupils’ attending one school decreases in distance. Based on these assumptions,
a postcode level school quality indicator could be approximated based on a spatial interpolation of
average output area test scores, which also filled a limited number of gaps that had resulted from
confidentiality restrictions.\(^3\)

To give the reader an indication of how large the various geographic entities considered in this
study are, note that for our sample the average number of households per output area is 125. Within
our study area, one output area contains about 37 postcodes, on average. A postcode group at the
two-digit level (e.g. WC2A 2A), which forms the basis for our location fixed effects, covers about 60
postcodes, while a postcode sector (e.g. WC2A 2) covers slightly more than 500 postcodes.

### 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. Utility derived from housing
consumption depends on the size and quality of the unit inhabited, but also on neighbourhood
quality. This 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 utility (a) from locating close to the services
offered by the facility in its function as a stadium and/or (b) from a visual amenity effect related to
their external appearance. As discussed, direct utility effects related to a stadium may be derived
from consumption benefits or a “civic pride” effect and emotional attachments to the sports team(s)
hosted in the stadium, among other reasons. In addition, residents living closer to a stadium naturally

\(^3\)More precisely, we use ordinary kriging based on a spherical semi-variogram model to interpolate between output
area centroids. We then generate an auxiliary grid, which is used to assign the interpolated values to postcodes based
on their geographic centroids.

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enjoy transport cost savings due to shorter journeys when attending events held there, but given the relatively low–on average–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, utility maximization implies that the utility derived from stadium proximity, as well as all other location and non-location characteristics of the property, fully capitalizes into households’ bid-rent functions.

\[ r(S, L, F, V, D) = f(S, L(D) + F(D) + V(D)) \]  

(1)

where \( S \) and \( L \) are 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 (\( V \)), respectively, 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 \( \frac{dF}{dD} \), however, is empirically challenging in practice given that the slope of the bid-rent \( \frac{dr}{dD} \) is a composite effect of the “pure” functionality and the “view” effect, as well as potentially correlated location effects.

\[ \frac{dr}{dD} = \frac{dr}{dL} \frac{dL}{dD} + \frac{dr}{dF} \frac{dF}{dD} + \frac{dr}{dV} \frac{dV}{dD} \]  

(2)

where \( \frac{dr}{dL} \), \( \frac{dr}{dF} \) and \( \frac{dr}{dV} \) are the marginal effects of location quality, stadium functionality and view on the bid rent and \( \frac{dL}{dD} \), \( \frac{dF}{dD} \) and \( \frac{dV}{dD} \) reflect the change in the amount of the (dis)amenities as one moves away of the stadium. Clearly, bid-rent functions depend on other location characteristics than the distance to a stadium, thus \( \frac{dr}{dL} \neq 0 \). If these location characteristics are correlated with stadium distance, i.e. \( \frac{dL}{dD} \neq 0 \), 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 observable 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, i.e. \( \frac{dr}{dV} \neq 0 \), the “pure” stadium functionality effect will be biased given that both effects are naturally correlated across space, \( \frac{dV}{dD} \neq 0 \). 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 examined in this 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 \( \frac{dF}{dD} = 0 \) 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 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 has not been entirely removed, we can further assume \( \frac{dr}{dV} = 0 \) for the immediate vicinity of the old stadium.\(^4\) For the new stadium we define a view variable to identify, to the extent possible, properties with a potential for direct views on the structure so that this indirect effect can be isolated from direct stadium effects.

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 (e.g. McMillen and McDonald, 2004). Another view is that residents have little incentive to move into a neighbourhood as a result of an improvement before it has actually taken place (e.g. 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. Given the large dimensions of the stadium projects and the correspondingly strong signal associated with the project announcements, we expect capitalization effects that commence when the critical information enters the market. This view is backed up by time-varying treatment effects retrieved from a flexible estimation strategy.

As common in the hedonic property literature, our analyses focus on the demand side of property

\(^4\)We note that the old 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.
markets, implicitly assuming supply to be inelastic in the short-run. In defence of this strategy we note that direct supply effects of the New Wembley and Emirates stadiums can largely be ruled out. The New Wembley replaced the old pre-existing structure while the Emirates was built on an industrial site so that no residential properties were bought out or demolished. Still, the (re)development of stadia could trigger second-order supply effects in response to changes in demand, which we cannot observe as housing stock is only recorded in the national census on a 10-year basis at a sufficiently disaggregated scale. It is noteworthy, however, that if housing supply responded to a positive demand shock, price effects would be mitigated, implying a conservative character of our estimated stadium effects.

One concern when measuring stadium externalities might be that some of the observable stadium effects are not attributable to the form and function of the stadium facility exclusively, but be related to endogenous amenities like bars, restaurants and other services that settle in the neighbourhood due to the demand induced by an inflow of spectators. On the one hand, one could argue the stadium effect will be overestimated if residents are willing to pay a significant proximity premium for these amenities. On the other hand, any attempt to condition estimated stadium effects on the presence of such amenities may result in the inclusion of bad controls (Angrist and Pischke, 2009) which downward bias the estimated stadium effect if their existence is caused by the stadium. Our approach in this paper, therefore, is to control carefully for exogenous amenities, but ignore endogenous amenities, which are causally related to the location of a stadium.

3.3 Empirical Strategy

Our empirical strategy is structured into four basic steps. Similar to Ahlfeldt (2010), we first identify areas that are subject to stadium effects before we estimate time-varying treatment effects. Backed up by the second stage, we estimate the stadium post-treatment effect following the stadium announcement in the third step. Based on the post-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 $X_{ia}^a$ 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 $X_{ib}^b$ based on whether the centroid of a property’s postcode falls into one of $n$ mutually exclusive distance rings.
\[ X_i^b = \sum_n R_{in} \]  

(3)

where \( R_n \) is an indicator variable for all properties within a given distance ring \( n \). 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 Emirates 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 Emirates 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.

\[ X_i^c = \log(D_{ijz+1}) - \log(D_{ijz}) \]  

(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 Emirates 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, \(\varphi_t\), to control for macroeconomic shocks that are common in the study area and location fixed effects, \(\psi_q\), that we define for groups of postcodes at the two-digit level (e.g. WC2A 2A) 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. Note that while we hold unobserved time-invariant characteristics constant at the postcode sector level via fixed effects, we also control for observable location characteristics at the postcode level to account for within postcode sector variation. The employed location controls subsumed in \(Y_m\) are: distance to the central business district (tube station Holborn), distance to the nearest tube station,
distance to the nearest water body, average KS2 test scores as defined above and distance to a prison in the Emirates neighbourhood that serves as a prominent disamenity.

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.

\[
\log(P_{it}) = \beta_n^N X_i^N + \sum_{t=1995,...,2001} \beta_{nt}^N X_i^N \times \varphi_t + \sum_m \gamma_m Y_{itm} + \sum_t \varphi_t + \sum_q \psi_q + \varepsilon_{it} \quad (5)
\]

where \( N = \{a,b,c\} \) and \( n = 1 \) if \( N = \{a,c\} \). Greek letters are coefficients to be estimated and \( \varepsilon_{it} \) is a random error term satisfying the usual conditions. Our baseline specifications uses the Nationwide data set which, as discussed, 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 Land Registry data. 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 (\( \psi_r \)). 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.

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

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

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.

A reduced specification can be used to then estimate the announcement effect in the third step of

\footnote{We note that the location controls mentioned above could be merged to the observations in the first period due to the missing geo-reference a sub-postcode area level.}
our analysis, taking the following form for the Nationwide sample.

\[
\log(P_{it}) = \beta_n^N X_i^N + \beta_{nPOST}^N X_i^N \times POST_i + \sum_m \gamma_m Y_{itm} + \sum_t \varphi_t + \sum_q \psi_q + \varepsilon_{it} \tag{7}
\]

where \(POST_i\) is an indicator variable denoting the period after the identified intervention date. The estimated coefficient(s) \(\hat{\beta}_{nPOST}^N\) then give the post-treatment effect(s). For the simple distance treatment \(X^a\) this 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 from the stadium. A positive treatment effect is expected that will be reflected by a negative sign of the coefficient

\[
\beta^a_{POST} = \frac{\log(\bar{P}_{iPOST}) - \log(\bar{P}_{iPRE})}{D_{ij}} \tag{8}
\]

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.

\[
\beta^b_{nPOST} = \left[ \log(\bar{P}_{POST}^n) - \log(\bar{P}_{PRE}^n) \right] - \left[ \log(\bar{P}^{control}_{POST}) - \log(\bar{P}^{control}_{PRE}) \right] \tag{9}
\]

It can be shown that the coefficient on our third treatment variable, \(X^c\), 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.

\[
\log(\bar{P}_{iPOST}) - \log(\bar{P}_{iPRE}) = \beta_{POST}^c X_i^c = \log(D_{ijz+1}) - \log(D_{ijz}) \Rightarrow \\
\beta_{POST}^c X_i^c = \log(\bar{P}_{iPOST}) - \log(\bar{P}_{iPRE}) \cdot \frac{\log(D_{ijz+1})}{\log(D_{ijz})} \tag{10}
\]

In the Emirates 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 \((X^c \times TREND)\) to test for a significant level shift, conditional on a linear trend, which corresponds to
detecting a sharp discontinuity in conventional regression discontinuity designs. Finally, 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 post-treatment effects, in the fourth and last step of our analysis, we estimate the aggregate increase in property values 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. Admittedly, this is a rather rough measure and should be interpreted with some care. On the one hand, it will tend to overestimate the true welfare effect if demand was simply shifted away from other areas. On the other hand, it will tend to underestimate the true effect if supply responds to the positive demand shock and exercises a downward pressure on prices. While both effects may, to some degree, cancel each other out, it would only be by chance if the neutralization worked perfectly.

Within the constraints of these limitations, 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 2007 prices, the year when construction of both stadia was finished, 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, \(OA_s\), and a set of yearly time effects, \(\varphi_t\), omitting 2007 as a base category. Equation (11) is estimated separately for both study areas.

\[
P_{it} = \sum_p \delta_p Z_{itp} + \sum_s \theta_s OA_{its} + \varphi_{t\neq2007} + \varepsilon_{it}\tag{11}
\]

Recovering the fixed effects, the estimated parameters \(\hat{\theta}_s\) provide an estimate of the (conditional) mean price at output area for the residual property category (flats). Assuming a constant markup for other property categories within each study area, the respective mean prices are given by \((\hat{\theta}_s + \hat{\delta}_p)\).

In the second stage these average prices 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.

---

6: The \textit{TREND} variable has its zero value at the time of the identified intervention.

7: Note that besides dummies for property types, we include a dummy variable for dwellings that are transacted in leasehold since the related price discounts should not affect the estimated welfare effects. In contrast we do not distinguish between new and old properties (and other characteristics) since these features are not available for the total housing stock. We assume that the samples of transferred dwellings are representative.
\[ AI = \sum_u \sum_s \left[ \left( \hat{\theta}_s + \hat{\delta}_{sp} \right) \times H_{sp} \times \left( 1 - e^{-\hat{\beta}_{nPOST}^N X_N^s} \right) \right] \] (12)

where \( H_{sp} \) is the total housing stock in a property category \( p \) in an output area \( u \) as recoded in the 2001 census statistics and \( 1 - e^{-\hat{\beta}_{nPOST}^N X_N^s} \) is a factor that deflates current dwelling prices to the counterfactual in the absence of stadium innovations. This factor is calculated based on the treatment estimates presented in Table 2 column (2) (Wembley) and Table 3 column (2) (Arsenal).

4 Empirical Results

4.1 New Wembley Stadium

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 \( \hat{\beta}_a^t \).

\[ \hat{f}_{2000} (D_j) = -\hat{\beta}_a^t \times (5 - D_j) \] (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 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 persistent 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 capitalized, to some degree, into prices when the arch was raised and lightened in 2004 and, eventually, the “iconic” element of the stadium materialized. The 2008 response, in turn, might be interpreted as an inauguration effect. Figure 2 (right) also illustrates the estimated treatment coefficients, \( \hat{\beta}_{nt}^b \), based on specification (5) and the non-linear treatment measure \( X^b \). 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 in Figure 3 when estimating the treatment coefficients based on equations (6a) and (6b) using the Land Registry data. Notably, 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, ... , 4.5-5 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 \( f_{2000(D_j)} \) 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 suggests 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 section 3.2; 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 post-treatment effect as the change in the marginal value of proximity to the stadium in 2002 for all combinations of treatment variables \( (X^a \text{ and } X^b) \) 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 2.7-2.9% 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 13.5-14.5% 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%. 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 post-treatment effect for the inner-most 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 clearly support the hypothesis of positive and significant stadium externalities which, given the special case of New Wembley, seem to be driven by a visual amenity effect related to the “iconic” structure of the stadium.

4.2 The Emirates Stadium

As discussed, the key-feature of the Emirates 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 Emirates study areas based on specification (5), treatment measure \( X^c \) and the Nationwide 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 to its current site. Note that for the purposes of a more intuitive

\[ \text{Standard interpretation of dummy coefficients in semi-log models; i.e. } [\exp(\beta) - 1] \times 100 \text{ (Halvorsen and Palmquist, 1980).} \]
visualisation we multiply the estimated coefficients $\hat{\beta}_t$ 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 Wembley, 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 (Figure 4, right) or not (Figure 4, left). If at all different, the adjustment process is somewhat smoothed around 2001 in the extended specification, but otherwise similar.

As discussed in section 3.2, 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 being 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 1999 announcement, 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 post-treatment effect. Post-treatment
effects for the 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% in-
creases 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 - column
(3).

For reasons discussed above, we allow for treatment heterogeneity between positively ($POS$)
and negatively ($NEG$) affected areas - column (4). 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).

In order to test for a significant net effect in the neighbourhood we replace the (log)change in
distance to the stadium, $X^c$ treatment variable, with a set of 0.5 km ring cells, $X^b$ - column (5).
Compared to the case of the 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.

One of the ambitions of this paper is to disentangle direct stadium effects, which are assumed to
be more or less inherent to its function as a sport venue, from indirect effects on the neighbourhood
that emerge from the visual appearance of the structure. Compared to the New Wembley, the
absence of iconic elements, a prominent architect or particular architectural ambitions makes an
amenity effect less likely in the case of the Emirates stadium. Still, the new stadium represents a
large and dominating structure that changes the visual setting in the neighbourhood. No matter into
what direction, however, visual effects should be more localized than for the New Wembley as the
surrounding neighbourhood is quite densely developed and the stadium does not feature an iconic
element, such as an arch, that would be widely visible.

It is relatively difficult in practice to perfectly identify properties with a direct view onto the stadium. Backed up by an inspection of the site, our approach makes use of the boundaries of postcode N7 7JD, which defines a sparsely developed strip of land in between two railway lines from which the stadium is relatively clearly visible. We calculate buffer distances from each postcode’s centroid to that boundary and define an indicator variable for all transactions within a 100m buffer to account for second row effects. This dummy variable is also interacted with the POST \( (\text{year} \geq 1999) \) variable defined above to isolate changes in prices that are specific to the view area. Both variables are introduced jointly into a column-(2)-type specification. Results presented in column (6) do not support a significant view effect, nor do the additional controls affect the point estimate for the primary treatment variable.\(^9\)

Taken together, our results 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 upgrade in terms of neighbourhood image or an emotional attachment to the venue and the home team 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 similar ambitiously designed arenas.

4.3 Robustness Checks

In this section we consider some extended versions of the models previously discussed to evaluate the sensitivity of the results and gain further insights into the nature of the revealed stadium effects.

As discussed, the selection criteria for both studies included the absence of the most obvious alternative explanations for observable market adjustments, e.g. infrastructure improvements, unrelated construction projects and other major urban interventions. Still, a detailed regeneration masterplan approved by Brent Council- the borough hosting the Wembley Stadium- was released in 2004; al-

\(^{9}\text{We experimented with various buffer distances to evaluate the sensitivity of these findings to the definition of the view variable. While smaller buffers yield negative coefficients that are not statistically significant, larger buffers hardly affect the point estimate, but inflate the standard error.}\)
though not implemented until its final revision in 2009. The regeneration plan, illustrated in Figure 6, will be completed in stages and includes the construction of new housing and office space units, the majority of which are part of the Quintain Stage 1 phase. Note that the plan also involves the renovation of existing transport infrastructure; e.g. of proximate tube stations, bicycle and pedestrian walkways, improvement in lighting, bus stops, etc.

We test the possible impact the regeneration plans, first announced in 2004, might have had on property prices by including three dummy variables denoting the regeneration areas depicted in Figure 6. Following evidence on spillover effects of regeneration, we additionally control for a 1km buffer area around the outer regeneration area (Rossi-Hansberg et al., 2010). We interact these dummy variables with post-2004 period dummies to allow for regeneration effects in these areas. Results are presented in Table 4, column (1). Note there are no transactions observed in the inner regeneration area (stage 1) and in the masterplan area post-2004. The remaining regeneration treatment coefficients are statistically insignificant. The stadium distance interactive however, although marginally reduced, is still significant at the 1% level.

From the results presented so far no considerable view effects seem to be evident for the conventionally designed Emirates stadium. Of course, modelling the view effect precisely is not trivial. One obvious concern is that view effects will vary with the height of a building. Flats in high-rise apartment buildings could realize particularly high premiums and, if the distribution of such buildings was correlated with our main stadium treatment variable, drive the estimated stadium effect, even though the average view effect is insignificant. While there is probably no perfect solution to the problem, as we cannot observe the storey of a transacted property, we are able to distinguish between flats and other properties types. Since properties in high rise residential buildings fall into the “flat” category, it is possible to further investigate heterogeneity in the view effect by interacting the view dummy variable with a dummy for flats plus interacting the resulting variable with the POST period dummy. Results for an extended Table 3, under the specification of equation (6) are in Table 4, column (2). Again, none of the view treatment coefficients is significant while the major stadium treatment estimate remains almost unaffected.

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12Following Brent Council’s intentions to publish a development framework for the future of the area surrounding Wembley in 2003, a similar analysis on the effects of the regeneration announcement plans was conducted post-2002 (i.e. jointly with the construction of the New Wembley). Results on the Wembley distance effect does not change, although we find a positive treatment effect associated with the masterplan regeneration area, suggesting that some properties were sold between 2002 and 2004 for a significant premium.
As noted above, the transport infrastructure did not change with the construction of the projects and, thus, no direct accessibility effects are expected. The change in location of the Arsenal home venue, albeit within the same neighbourhood, did affect the pathways, which spectators choose when going from stations to the stadium and the other way round. These changes may affect the attractiveness of places in either direction, depending on whether negative effects from disturbances or positive effects from increased spending dominate. It is relatively simple to identify the typical current paths in fieldwork and compare them to the most obvious ways to the old stadium. To reach the Emirates stadium, the most likely pathway used are Hornsey Road and Drayton Park, for fans exiting from Holloway Road and Arsenal tube stations, respectively. To reach the old Arsenal stadium, fans exiting from Arsenal’s tube station would most probably walk along Avenell Road, Gillespie Road (up to Avenell Road), and Highbury Hill (up to Aubert Park). See for details Figure A1 in the appendix.

Based on these assumed paths, it is possible to control for systematic effects within areas that experience either an increase or decrease in spectator flowing the same way performed for the view effect. Results are presented in columns (3) and (4), where we allow for heterogeneity in the treatment effect of the variable of primary interest. We also consider a model where changes in spectator flows and potential view effects are accounted for jointly - column (5) - as the respective areas overlap to some degree, particularly along Drayton Park. Taking property price effects as a benchmark, football fans seem to exhibit a negative net-externality. From the estimates, a remarkable increase in prices of about 30% is evident for areas that were, but no longer are, heavily frequented by spectators. There is weak evidence for negative effects (about 12%) along roads where the respective frequency increased. These findings are in line with previous evidence that pointed to localized congestion externalities, but could not show them explicitly (Ahlfeldt and Maennig, 2009, 2010a).

If emotional attachments to a sportsteam and an image effect that spills over to the neighbourhood are driving the observed stadium effects, one natural question to ask is whether the strength of the attraction depends on the performance of the team. If team performance was correlated with a move into a new stadium the estimated stadium effect could be affected. In order to control for the potential effect of team performance on the desirability of living close to a stadium we introduce an interactive term of distance to the stadium and the rank Arsenal FC hold at the end of any given Premier League season. Notably, this variable represents a bad control if team performance is influenced by the stadium, e.g. by increased fan support.¹³ Note that in the generation of this variable we use the minimum distance of a postcode to either the former Arsenal or the Emirates stadium, as the

¹³The effect could also work in the opposite direction; e.g. if the stadium project committed funds that were required to improve the quality of the squad.
distance component is meant to be constant in postcodes over time so that the only variation over time results from changes in team performance. Column (6) results indicate that team performance does not exhibit a significant effect on the stadium proximity effect, which might be partially due to the relatively stable performance of the club over the study period. Again, the treatment coefficient of primary interest remains fairly robust to the inclusion of this control.

In principle, a similar argument regarding the potential of team performance on a stadium proximity effect could be made for the case of Wembley; the traditional venue of the English national football team. As with a Premier League club, whether fan attachment varies with the success of the national team seems like a rather empirical issue. In any case, we control for possible effects in the same way as in the case of the Arsenal FC, using annual averages of the FIFA world rankings as a performance benchmark. The results presented in column (7) hold some surprise as the performance-stadium distance interactive comes out statistically significant, but with a negative sign. At the same time, however, the estimated stadium effect increases from close to 3% to more than 4%. Again, team performance does not explain the change in the value of stadium proximity revealed in property prices following the redevelopment of the stadium.

In our last robustness check we are not concerned with stadium effects within the defined 5 km study areas, but with the appropriateness of the definition of this threshold for the margin of the study area. Our empirical specifications implicitly or explicitly compare property price appreciation at close locations to a stadium relative to the margin of a study area, which is used to determine the counterfactual in this quasi-experimental research design. Hence, if stadium effects spilled over to areas outside a study area our estimated stadium treatment effects would be downward biased. In order to evaluate whether the 5km margin represents a plausible control area, as suggested by the literature, our last feasibility check tests for a significant space-time discontinuity along the 5km rings at the identified intervention dates. The empirical specification corresponds to equation (7) where the treatment variable \( X \) takes the form of an indicator variable denoting properties within 5km of a stadium. We estimate this difference-in-difference estimation separately for both stadia as well as samples of properties that lie within a 500m or 250m buffer around each of the 5km rings. Results, presented in Table A3 in the appendix, do not reject the hypothesis of homogeneity in (conditional) mean prices across the 5km rings as well as changes in mean price following the interventions. Even though this is not a statistical proof in a strict sense, these results indicate that spillover effects beyond our study areas are not a major concern.

14Since higher performance corresponds to a smaller number (i.e. higher rank in the FIFA ranking), we would expect the stadium gradient to become less steep (with a negative sign) if the rank increases.
4.4 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 costs 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 by various property types as recoded in census statistics and an estimated average property price at output area level as a basis. Table A4 in the appendix summarizes the results of two equation (11) type auxiliary regressions, which we run to estimate the average property price at output area level in 2007 prices. Estimated property prices, weighted by the share of residents living within different property types, are visualized in Figure A2 in the appendix. Using these estimates, total housing stock and the estimated set of treatment coefficients $\hat{\beta}_{nPOST}$ from Table 2, (column 2), the aggregated increase in housing value associated with the New Wembley amounts to about £1.91 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 Emirates neighborhood using the estimated treatment coefficients $\hat{\beta}_{POST}$ from Table 3, (column 1), reveals a negative net-effect of about £0.37 billion, which is in line with the negative net-effect suggested by $\hat{\beta}_{nPOST}$ coefficients in Table 3, (column 5). Note that the net-effect is the result of a £1.04 billion increase within the catchment area of the Emirates stadium and a £1.41 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 Emirates neighborhood. Possible explanations include the visual amenity effect related to the iconic architecture of the New Wembley and negative externalities related to the broader Emirates 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 3km, significant spillovers are 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 at least partially 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. No view effects could be associated with the Emirates Stadium, which compared to the New Wembley is a much more conventionally designed stadium. 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. A negative externality emerging from spectators going
to and away from the stadium could be identified using the change in their typical walkways after the
stadium had moved, confirming that stadia are not only associated with positive but also negative
neighbourhood externalities.

Our study also features an additional important innovation in the research design. Our empirical
strategy yields an index of the effects of the stadium treatment, which confirms 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 £1-2 billion each, 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.

The results open an avenue for potential policy recommendations. If stadia impact positively on
the intrinsic value of a neighbourhood, then the expectation that stadium (re)development projects
will contribute to the neighbourhood (re)vitalization may be justified, especially if a comprehensive
urban and building design quality is used. A critical question, however, is who should pay for the
incremental cost related to good design, which benefits the neighbourhood but not the owner of
a stadium. Given that it is difficult to convince a profit-maximizing investor to undertake private
investments to benefit the public, commitment of public funds may become necessary. Then, however,
a distributional conflict arises if costs are spread equally across taxpayers, but benefits are capitalized
locally. Moreover, renters will usually be more than compensated for the benefits by increases in rent
levels (Ahlfeldt, 2011), leaving the local owners, occupiers and landlords as the effective profiteers,
which further increases inequality.

These are concerns that more generally apply to a wider range of local policies, including transport
facilities, public spaces or any other infrastructures, which are difficult to address in practice. One
way would be to levy compensations, in case of owner occupied buildings, possibly after a property is sold or inherited, although heavy opposition should be expected. These concerns are, obviously, not raised to dismiss any approach to neighbourhood revitalization policies in general, and stadium related ones in particular, but to raise the awareness for the potential distributional consequences.
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).
Notes: Own illustration based on own calculation. Estimated treatment coefficients correspond to specification (6a, 6b), Land Registry data and treatment variables $X^a$ (left) and $X^b$ (right).

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

Notes: Figure illustrates estimated treatment coefficients based on specification (5), 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 4: Time-varying treatment effects: Entire study area- Emirates
Notes: Figure illustrates estimated treatment coefficients based on an extended specification (5), 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.

Figure 5: Time-varying treatment effects: Treatment heterogeneity- Emirates
Notes: Own illustration, sourced from the Wembley Masterplan (2009), Section 3. (http://www.brent.gov.uk/regeneration.nsf/Wembley/LBB-282).

Figure 6: Wembley Regeneration Area
### Table 1: Key Timelines and Milestones

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Wembley Stadium</th>
<th>Emirates Stadium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun 2004</td>
<td>Arch raised and lightened.</td>
<td></td>
<td>Feb 2004 Commencement of construction of stadium.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jun 2005 Construction reaches halfway stage.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Post-Treatment Effects - New Wembley

<table>
<thead>
<tr>
<th>Distance Treatment</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Treatment $X^a \times POST$)</td>
<td>-0.027**</td>
<td>-0.029**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.008)</td>
<td>(0.004)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ring 0-0.5 [0-1] km Treatment 0.164* 0.046
(POST $\times R_{0-0.5}$) (0.063) (0.034)

Ring 0.5-1 [0-1] km Treatment 0.115*
(POST $\times R_{0.5-1}$) (0.046)

Ring 1-1.5 [1-2] km Treatment 0.064* 0.094*
(POST $\times R_{1-1.5}$) (0.025) (0.039)

Ring 1.5-2 [1-2] km Treatment 0.115*
(POST $\times R_{1.5-2}$) (0.030)

Ring 2-2.5 [2-3] km Treatment 0.070** 0.058**
(POST $\times R_{2-2.5}$) (0.024) (0.021)

Ring 2.5-3 [2-3] km Treatment 0.038*
(POST $\times R_{2.5-3}$) (0.019)

Ring 3-3.5 [3-4] km Treatment 0.045* 0.031
(POST $\times R_{3-3.5}$) (0.019) (0.026)

Ring 3.5-4 [3-4] km Treatment 0.014
(POST $\times R_{3.5-4}$) (0.023)

Ring 4-4.5 km Treatment -0.008
(POST $\times R_{4-4.5}$) (0.018)

Basic Hedonic Controls  Yes Yes Yes Yes
Extended Hedonic Controls  Yes Yes
Location Controls  Yes Yes 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.
Observations  | 5,263 | 5,263 | 50,819 | 50,819
$R^2$  | 0.9 | 0.9 | 0.77 | 0.72

Notes: Dependent variable is log of purchasing price in all models. Robust standard errors (in parenthesis) are clustered on postcode groups.
+ significant at 10%; * significant at 5%; ** significant at 1%.
Table 3: Post-Treatment Effects - Emirates

<table>
<thead>
<tr>
<th>Treatment $X^c \times POST$</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$([-\log(D_{ijz+1}) - \log(D_{ijz})] \times POST)$</td>
<td>-0.166**</td>
<td>-0.189**</td>
<td>-0.116*</td>
<td>-0.19**</td>
<td>(0.037)</td>
<td>(0.039)</td>
</tr>
<tr>
<td>Treatment $X^c \times TREND$</td>
<td>-0.011</td>
<td>(0.009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$([-\log(D_{ijz+1}) - \log(D_{ijz})] \times TREND)$</td>
<td>-0.096*</td>
<td>(0.046)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment $X^c \times POST$ (Positive)</td>
<td>-0.273**</td>
<td>(0.080)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$([-\log(D_{ijz+1}) - \log(D_{ijz})] \times POST \times POS)$</td>
<td>(0.009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment $X^c \times POST$ (Negative)</td>
<td>-0.076+</td>
<td>(0.04)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$([-\log(D_{ijz+1}) - \log(D_{ijz})] \times POST \times NEG)$</td>
<td>-0.071*</td>
<td>(0.030)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 0-0.5 km Treatment</td>
<td>-0.030</td>
<td>(0.026)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{0,0.5}$)</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 0.5-1 km Treatment</td>
<td>-0.032</td>
<td>(0.025)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{0.5,1}$)</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 1-1.5 km Treatment</td>
<td>-0.057*</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{1,1.5}$)</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 1.5-2 km Treatment</td>
<td>-0.042+</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{1.5,2}$)</td>
<td>(0.029)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 2-2.5 km Treatment</td>
<td>-0.018</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{2,2.5}$)</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 2.5-3 km Treatment</td>
<td>-0.032</td>
<td>(0.024)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{2.5,3}$)</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 3-3.5 km Treatment</td>
<td>-0.018</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{3,3.5}$)</td>
<td>(0.029)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring 3.5-4 km Treatment</td>
<td>0.007</td>
<td>(0.029)</td>
<td></td>
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</tr>
<tr>
<td>(POST × $R_{3.5,4}$)</td>
<td>(0.141)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ring 4-4.5 km Treatment</td>
<td>0.007</td>
<td>(0.141)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(POST × $R_{4,4.5}$)</td>
<td>(0.027)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ring Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>View Dummy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>9,933</td>
<td>9,933</td>
<td>9,933</td>
<td>9,933</td>
<td>9,933</td>
<td>9,933</td>
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<tr>
<td>$R^2$</td>
<td>0.89</td>
<td>0.9</td>
<td>0.9</td>
<td>0.89</td>
<td>0.89</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Notes: Dependent variable is log of purchasing price in all models. Regressions are based on the Nationwide data set.

Robust standard errors (in parenthesis) are clustered on postcode groups.

+ significant at 10%; * significant at 5%; ** significant at 1%.
Table 4: Robustness Checks

<table>
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<tr>
<th>(1)</th>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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</thead>
<tbody>
<tr>
<td>Wembley</td>
<td>Emirates</td>
<td>Emirates</td>
<td>Emirates</td>
<td>Emirates</td>
<td>Emirates</td>
<td>Wembley</td>
</tr>
<tr>
<td>Distance Treatment</td>
<td>-0.025**</td>
<td>-0.041**</td>
<td>(0.009)</td>
<td>-0.041**</td>
<td>(0.009)</td>
<td></td>
</tr>
<tr>
<td>(Treatment $X^a \times POST$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment $X^c \times POST$</td>
<td>-0.191**</td>
<td>-0.184**</td>
<td>-0.188**</td>
<td>-0.190**</td>
<td>(0.039)</td>
<td>(0.039)</td>
</tr>
<tr>
<td>$([\log(D_{ijz}+1) - \log(D_{ijz})] \times POST)$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment $X^c \times POST$ (Positive)</td>
<td>-0.092*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.045)</td>
</tr>
<tr>
<td>$([\log(D_{ijz}+1) - \log(D_{ijz})] \times POST \times POS)$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment $X^c \times POST$ (Negative)</td>
<td>-0.264**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.079)</td>
</tr>
<tr>
<td>$([\log(D_{ijz}+1) - \log(D_{ijz})] \times POST \times NEG)$</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Stage 1×POST</td>
<td>0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masterplan×POST</td>
<td>0</td>
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<td></td>
</tr>
<tr>
<td>Regeneration×POST</td>
<td>0.057</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Buffer (1 km)×POST</td>
<td>0.017</td>
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</tr>
<tr>
<td>View×POST</td>
<td></td>
<td>-0.037</td>
<td>(0.247)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(Dummy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>View×POST×FLAT</td>
<td>0.072</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Dummy)</td>
<td></td>
<td></td>
<td>(0.253)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectator Decr.×POST</td>
<td>0.295*</td>
<td>0.307+</td>
<td>0.299*</td>
<td>(0.141)</td>
<td>(0.179)</td>
<td>(0.144)</td>
</tr>
<tr>
<td>(Dummy)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Spectator Incr.×POST</td>
<td>-0.1</td>
<td>-0.130*</td>
<td>-0.111</td>
<td>(0.079)</td>
<td>(0.059)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Stadium Distance×Performance Rank</td>
<td>0.012</td>
<td>-0.003*</td>
<td>(0.01)</td>
<td>(0.001)</td>
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<td></td>
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<tr>
<td>Basic Hedonic Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Extended Hedonic Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Location Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$log(D_{ijz}+1) - log(D_{ijz})$</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Distance to Wembley</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ring×Year Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Location Effects</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Year Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Regeneration Dummies</td>
<td>Yes</td>
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</tr>
<tr>
<td>View Dummy</td>
<td>Yes</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>View×Flat</td>
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<tr>
<td>Spectator Increase</td>
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<td>Yes</td>
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<td>Spectator Decrease</td>
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<td>9,933</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.901</td>
<td>0.897</td>
<td>0.897</td>
<td>0.895</td>
<td>0.897</td>
<td>0.897</td>
</tr>
</tbody>
</table>

Notes: Dependent variable is log of purchasing price in all models. Regressions are based on the Nationwide data set. Robust standard errors (in parenthesis) are clustered on postcode groups.

+ significant at 10%; * significant at 5%; ** significant at 1%.
Appendix

Notes: Figure taken from Google Maps. Blue (red) arrows indicate a reduction (increase) in spectator flows.

Figure A1: Pathways to Arsenal and Emirates Stadia
Notes: Own calculation and illustration. Average property prices are based on Table A3 results and weighted by the share of residents living within various property types.

Figure A2: Estimated Average Property Prices
Table A1: Time-varying Treatments & Hedonic Estimates - New Wembley

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Bedrooms</td>
<td>0.194**</td>
<td>0.196**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.006)</td>
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<td>Number of Bathrooms</td>
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<td>0.058**</td>
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<tr>
<td></td>
<td>(0.012)</td>
<td>(0.012)</td>
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<tr>
<td>Floor Size</td>
<td>0.001**</td>
<td>0.001**</td>
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<tr>
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<td>(0.0001)</td>
<td>(0.0001)</td>
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</tr>
<tr>
<td>Age</td>
<td>0.001**</td>
<td>0.001**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age squared</td>
<td>-0.001**</td>
<td>-0.001**</td>
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**Notes:** Dependent variable is log of purchasing price in all models. Base category of property type is “flat”. Robust standard errors (in parenthesis) are clustered on postcode groups, except (4) and (6) where postcode sectors are used.

+ significant at 10%; * significant at 5%; ** significant at 1%.
Table A2: Time-varying Treatments & Hedonic Estimates - Emirates

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<tr>
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<tr>
<td>Year×Treatment ((X^c)) \times NEG Effects</td>
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<td>Year×Ring Effects</td>
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Notes: Dependent variable is log of purchasing price in all models. Regressions are based on the Nationwide data set. Base category of property type is “flat”. Robust standard errors (in parenthesis) are clustered on postcode groups, except (4) and (6) where postcode sectors are used.
+ significant at 10%; * significant at 5%; ** significant at 1%.
Table A3: Robustness Check - Control Area

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<td>Emirates</td>
<td>Wembley</td>
<td>Wembley</td>
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<td>(0.022)</td>
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<td>Yes</td>
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Notes: Dependent variable is log of purchasing price in all models. The study area is limited to a 500m or 250m distance band around the 5km radius from a stadium. POST denotes a period starting in 1999 (2002) in the Emirates (Wembley) case. Robust standard errors (in parenthesis) are clustered on postcode areas.

+ significant at 10%; * significant at 5%; ** significant at 1%.
### Table A4: Average Property Prices at Output Area Level

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**Output Area Effects**

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**Notes:** Dependent variable is log of purchasing price in all models. Regressions are based on the Nationwide data set for the period 2000-2008. Base category of property type is “flat”. Robust standard errors (in parenthesis) are clustered on postcode output areas.

+ significant at 10%; * significant at 5%; ** significant at 1%.
References


SERC is an independent research centre funded by the Economic and Social Research Council (ESRC), Department for Business Innovation and Skills (BIS), the Department for Communities and Local Government (CLG) and the Welsh Assembly Government.