TI 2024-010/V
Tinbergen Institute Discussion Paper

No Novelty Effect but a Honeymoon that Lasts

On the Attendance Effects of New Football Stadiums

Jan C. van Ours[1]

1 Erasmus University Rotterdam, Tinbergen Institute, ECASE and CEPR.

No Novelty Effect but a Honeymoon that Lasts

On the Attendance Effects of New Football Stadiums

Jan C. van Ours*

February 3, 2024

Abstract

In US-based studies focusing on the impact of new sports stadiums on attendance, a recurring observation is the temporary nature of the initial positive effect, commonly described as a novelty or honeymoon effect. This paper revisits the attendance effects of new sports stadiums in a European sports league, i.e. the top tier of Dutch professional football. Analyzing data over a period of three decades the main conclusion is that for many new stadiums the positive attendance effect persists. There is no transient novelty effect but a long-lasting positive attendance effect of new football stadiums.

Keywords: Novelty effect, new sports stadiums, professional football.

JEL Classification: C21, L83, Z20.

Conflict of interest: None.

Data availability: The data and codes used in this paper will be made available through a public database.

*Erasmus School of Economics (Burg. Oudlaan 50, 3062 PA Rotterdam, the Netherlands), Tinbergen Institute (Rotterdam) and ECASE (Erasmus Center for Applied Sports Economics), the Netherlands, CEPR (London); vanours@ese.eur.nl. The author thanks Jesse Korevaar for excellent research assistance and Stefan Szymanski and Francesco Principe for comments on a previous version of the paper.

1 Introduction

Every now and then, a sports club replaces an old stadium with a new one. A common finding is that this causes an increase in stadium attendance. In addition to the hard-core fans who visited the old stadium curious fans who previously watched matches on television want to see and experience the new stadium because it is more comfortable with better views and more facilities (Borland and MacDonald (2003)). The novelty effect – also referred to as honeymoon effect – suggests that a new stadium will only temporarily attract more attendants. The once curious fans get bored and decide to follow their favorite club once more from a distance. Soon stadium attendance is back to where it once was. Empirical studies on the novelty effect of new sports stadiums are mainly from the early 2000s and they are US based.

This paper challenges previous findings of temporary attendance effects of new sports stadiums. It studies attendance effects in a European sports league, i.e. the top tier of professional football in the Netherlands. The focus is on long-term attendance effects of eight new football stadiums. A new stadium is defined as a stadium that was built in a new location (seven stadiums) or completed renovated at the same location (one stadium of which the capacity was strongly reduced). Stadiums that were renovated even if this included an increase in the number of seats are not considered to be a new stadium.

The contribution to the literature is threefold. First, whereas previous novelty studies are based on US sports leagues, the current paper uses information from a European sports league. Second, whereas previous studies were based on a straightforward analysis in which treatment heterogeneity was not taken into account this paper uses various recent difference-in-differences (DID) methods of analysis to get an estimate of the magnitude and the persistence of the effects. Third, the main results of the analysis contradict previous findings. Rather than a transient attendance effect of a new stadium there seems to be a persistent long-term attendance effect.

The paper is set-up as follows. Section 2 gives an overview of previous studies on the novelty effect. Section 3 presents a simple dynamic model of stadium attendance in which the potential persistence of the attendance effects depends on the loyalty of new fans the new stadium attracts. Section 4 provides a description of the data from three decades top league professional football in the Netherlands. Section 5 presents an exploratory analysis comparing attendance averages of the first five years in the new stadium to five years before the new stadium was introduced. By comparing the developments over the same periods for each club with a control group of clubs that did not have a new stadium in the period of analysis first estimates of the short-run attendance effects of new stadiums are presented. Section 6 presents the set-up of the DID analysis and parameter estimates of the effects of new stadiums on stadium attendance. The main finding is that for many new stadiums there is a persistent positive attendance effect rather than a novelty effect that slowly disappears. Section 6 also presents a sensitivity analysis and discusses estimates of the additional effects of a new stadium in terms of home advantage, team quality and seasonal performance. The conclusion is that there are no such additional effects. Section 7 concludes with an exploratory explanation of the potential nature of the differences between the current study and previous US-based studies.

2 Previous Studies

There have been two waves of studies on the novelty effects of sports stadiums, in the early 2000s and in the early 2020s. Both waves of studies deal with major US professional sports, baseball (MLB), basketball (NBL), (American) football (NFL), and hockey (NHL). Howard and Crompton (2003) for example found for these sports that the spike in stadium attendance disappeared immediately after the first year in the new stadium although attendance was still higher than it was in the old stadium after five years. Coates and Humphreys (2005) provided an overview of earlier research arguing that up to then there was little systematic research on magnitude and duration of the novelty effect. They investigated the novelty effect for three US sports using a flexible reduced form approach that included dummy variables for each year after the new stadium was introduced up to ten years after. The main conclusion was that the magnitude and duration of the novelty effect varied across sports.

Clapp and Hakes (2005) studied the novelty effect in MLB finding that the initial increase in stadium attendance disappeared six to ten years after the introduction of a new stadium. They noted that team success may have extended the novelty period. McEvoy et al. (2005) studied the relationship between stadium attendance and age of the stadium in MLB finding a negative age effect. However, there was no mentioning of a novelty effect, i.e. an age at which the original increase in attendance disappeared. Zygmont and Leadley (2005) studied the novelty effect in MLB finding that the initial increase in stadium attendance continued with only a modest decline over the first eight to ten years after the new stadium was introduced to disappear after that. Leadley and Zygmont (2006) studied the attendance effects in NHL concluding that the honeymoon was over after five years.

From an overview of studies on US sports leagues Bradbury (2019) concluded that there was a short-term boost but within ten years after stadium opening the positive attendance effect disappeared. Huang and Soebbing (2022) studied the novelty effect in the Canadian Football League finding that this lasted for five years. Szymanski (2023a) also provided an overview of earlier studies for various professional US sports leagues finding a novelty effect that ranged from four to ten years. Szymanski (2023a) himself studied the novelty effects of new stadiums in MLB. In addition to novelty effects that lasted for twelve years he also found evidence of anticipation effects with attendance starting to rise three years before the opening of a new stadium. Bradbury (2023) studied MLB, NBA, NFL, and NHL over a period of 40 year (1980-2019) finding novelty effects for new stadiums in each of these leagues. The increase in attendance caused by the new stadiums diminished within five to ten years. Although pretty much all previous studies are based on US data Bradbury (2023) concludes that the novelty effect is a universal phenomenon among spectator sports while Bradbury (2019) concluded that a novelty effect is well-documented in all sports leagues.

There have been only a limited number of studies analyzing the novelty effects of new professional stadiums in US Major League Soccer (MLS). Compared to the European football leagues, MLS is somewhat of an outlier as it started with 10 teams in 1996. The expansion later on implies that the attendance effect of new stadiums cannot be measured for new clubs. Furthermore, MLS stadium were often multi-sport and not football-specific. A peculiarity is also that sport teams sometimes left their stadium going to a different city being replaced by a new team in their old stadium. Love et al. (2013) studied whether a novelty effect existed in the MLS finding that the increase in stadium attendance persisted for at least three years. However, because of the relatively young age of the league it was not possible to study longer term effects. DeSchriver et al. (2016) analyzed attendance in five MLS seasons concluding that there was some type of honeymoon period for new MLS franchises that lasted for at least three seasons.

There are no recent studies on the novelty effect in European professional football. In an older study Feddersen et al. (2006) found for professional football in Germany a 10% rise in stadium attendance five years after opening of a new stadium but there was no analysis of what happened in later years. Szymanski (2023b) studied the effects of new stadiums in the four profession football leagues in England on a variety of outcomes including attendances. He mentioned two important differences between US sports leagues and European football leagues: promotion/relegation and competitive player labor market. If a club in a lower league opened a new stadium this may have generated additional income which allowed the club to invest in players and obtain promotion to the next level thus attracting more attendants. So, in the English leagues an immediate increase in attendance due to the new stadium may have been followed by a further increase because of promotion. These promotion effects can be substantial. Promotion comes with additional revenues which a club can invest in attracting better-quality players. Playing in a higher league will attract new fans who want to watch their improved home team play against more skillful opponent teams than in the lower league. Van Ours (2021) for example found for Dutch professional football that averaged of a period of six decades stadium attendance increased with about 35%

when a club was promoted to the top tier.

3 Novelty Effects in a Simple Dynamic Model

Regular fans are loyal to their club but there may be a wide distribution in the persistence of this loyalty.[1] Hoehn and Szymanski (1999) differentiated fans ranging from committed fans on one side of the spectrum of loyalty to less committed “armchair supporters” at the other side of the spectrum. Whereas the committed fan will care only about his or her own team winning, the armchair fan will mainly care about a well-balanced contest. Committed fans spend both time and money on supporting their club in the expectation of long-term sporting success. The armchair fan wants to be entertained and considers only the immediate return on consuming a match. Ben Porat (2010) distinguished between passive and involved fans. Passive fans enjoy games at minimal costs, i.e. watching games on television. For involved fans supporting a football club may be a life-long project that begins at an early age and ends with the life of the fan. For them, being a fan is a way of life. Samra and Wos (2014) distinguished three types of fans: temporary, devoted and fanatical. Devoted and fanatical fans will be loyal to their favorite club and visit all home matches – and perhaps also away matches – for a large part of their lives. The temporary fans may visit home matches for a couple of years and then continue their support to their favorite club through televised matches, internet views or radio broadcasts. Samra and Wos (2014) also mentioned a typology of fans in terms of theatre-goers, fair-weather fans and hardcore fans. The first two types have a temporal and situational involvement while the hardcore fans have an enduring involvement. Tamir (2022) mentioned that fans can be classified based on the strength of their connection to and identification with their team. Supporters are fans who exhibit longstanding solidarity with their team. Being fan of a particular team is frequently passed on from one generation in the family to the next. Being fan may have a life cycle in the sense that the intensity of

[1] The word ‘fan’ is an abbreviation from the word “fanatic” which itself is derived from the Latin “fanaticus” that literally means “a temple servant, a devotee” (Samra and Wos (2014)).

being fan may decline later on in life. This may be related to lack of time due to commitments to family life or career.

In terms of developments over time, turnover of regular stadium attendants is important. Although there may be many casual attendants, a substantial part of the stadium crowd consists of seasonal ticket holders. They decide in between two seasons whether or not to renew their ticket for the new season. Some fans will decide to renew their seasonal ticket while others will decide to no longer visit home matches of their favorite team. In a steady state situation, in every season the number of current attendants who decide to stop visiting the stadium is equal to the number of new attendants. In other words, the 'stock' of attendants is stable if the 'outflow' of incumbent attendants equals the 'inflow' of new attendants. In a simple dynamic steady state model every season a fraction δ^o of current attendants A^o will no longer be attendant in the forthcoming season. Every season I new attendants will start visiting the stadium. In a steady state the flow of new attendants equals the flow of departing attendants:

$$I = \delta^o A^o \tag{1}$$

In a steady state, the number of seasonal attendants is equal to the inflow of new attendants divided by the outflow rate:

$$A^o = I/\delta^o \tag{2}$$

A new football stadium may be attractive for new attendants if the seating arrangements have been improved, the view to the playing field is better and the seats are more comfortable. In the opening season there may be a big inflow of new attendants while in the years thereafter the inflow may still be larger than it initially was. If after the first year the flow of new attendants is constant and so is their loyalty, the steady state of new seasonal attendants is equal to:

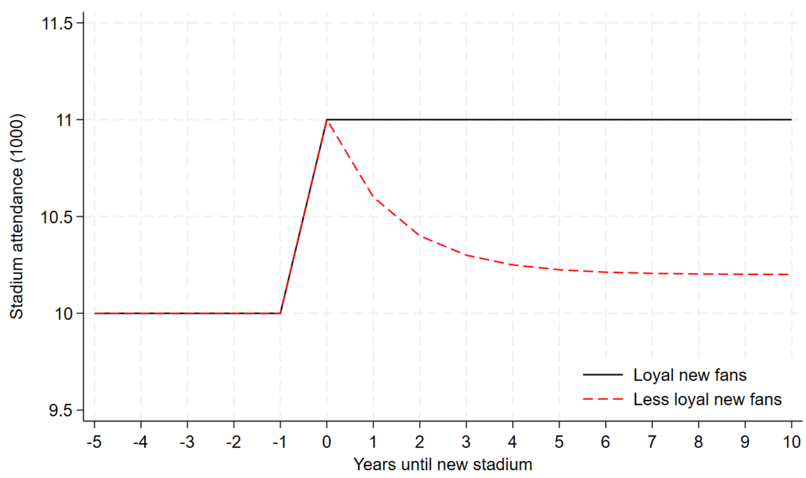
$$A^n = I^n/\delta^n \tag{3}$$

The new fans may or may not be as loyal as the old fans. For the sake of the argument two possibilities are distinguished:

1. New fans are as loyal as old fans: $\delta^n = \delta^o = \delta$. In this case the new steady state seasonal attendance is equal to $A^o + A^n = \frac{I+I^n}{\delta}$.
2. New fans are less loyal than old fans: $\delta^n = \lambda\delta^o$ with $\lambda > 1$. Then, the new steady state seasonal attendance is equal to $\frac{I+I^n/\lambda}{\delta^o}$

To illustrate the differences between these two possibilities Figure 1 shows the outcome of two simulation results for stadium attendance before and after opening a new stadium. As shown with new fans who are as loyal at the old fans the increase in stadium attendance can be permanent. Of course, this does not only depend on the loyalty of the new fans. In the simulation exercise the permanence of the attendance effect also depends on the additional new inflow being permanent. Without this new inflow the increased attendance would also slowly fade away although not as rapidly as in the case of new fans who are less loyal than old fans.

Figure 1: **Average Stadium Attendance for Two Possibilities of Fan Loyalty**



Note: The details of the calculations are presented in the text.

The assumptions in the simulation exercises are the following. First, $I^o = 1000$ and $\delta^o = 0.10$, so $A^o = 10,000$. Furthermore, the inflow in the first year of the new stadium is assumed to be equal to 1000 while in later seasons it is equal to 100. So, in the first year the inflow of new attendants doubles while later on the inflow is 10% higher than it was before. This implies that in the opening year of the new stadium attendance is equal to 11,000. The steady state attendance with new fans who are as loyal as the old fans is equal to (1000+100)/0.1 = 11,000. So, with equal loyal new fans the initial increase stays as high in later seasons.

If the new fans are less loyal the increase in attendance may not be persistent. For example, with $\lambda = 5$, the new steady state is equal to $(1000 + 100/5)/0.1 = 10{,}200$. So, after the initial increase to 11,000 stadium attendance goes down to a level slightly above the attendance before the new stadium was in use.

The situation with a temporary increase of attendance that is quickly fading away describes the situation in US sports leagues with – temporary – novelty effects of new stadiums. Anticipating the results in the current paper, the situation of a permanent increase in stadium attendance due to new fans being as loyal as incumbent fans may resemble European sport leagues. An important question is to what extent US sports fans are different from European sports fans. According to Hoehn and Szymanski (1999) there are two main differences between sports leagues in the US and Europe. First, US leagues are closed. Without promotion or relegation new teams are rarely admitted to a league. Secondly, US leagues are heavily regulated through interventions in the labor market or redistribution of club revenues. Young talent is redistributed over teams, player contracts are longer in US sports than in European football while in the US there are often caps on salaries or overall wage bills of clubs. It is unclear whether this difference in set-up coincides with different fan behavior. According to Fort (2000), US sports teams always compete with other forms of live entertainment but it is unclear to what extent this means that US sports fans behave differently from European sports fans in terms of stadium visits.

4 Data

The data analyzed are from the top tier of Dutch professional football (called "Eredivisie") from season 1989/90 to 2018/19, the last full season before the Covid-19 crisis forced sports stadiums to remain empty. The top league consists of 18 teams which during the season compete against each other twice, once at home and once away. To be able to establish the attendance effects of a new stadium clubs need to be present in the top league for at least five years before the new stadium and ten years thereafter. If a club did not have a new stadium in the period of analysis it had to be present sufficiently long to be part of the control group, i.e. at least five years before the earliest new stadium and at least five years after the latest new stadium (see Appendix A for details).

Table 1 provides summary statistics for the 11 clubs in the sample. Average capacity and attendance vary a lot. The average capacity of the largest stadium (Ajax) is about four times the average capacity of the smallest stadium (NEC). Also the attendance rate varies a lot from about 60% for Roda JC to almost 95% for PSV. Every club played 34 matches in each season obtaining three points for every win and one point for every draw.[2] The average number of points obtained during a season varies from about 40 to about 75. As is to be expected, there is a positive correlation between points and stadium capacity.

The development of average match attendance in the top league over the sample period is presented in Figure 2. Clearly, there is a steady increase in the first decades while in the last decade average match attendance was approximately constant. As indicated in the figure the period during which new stadiums were introduced was expansionary in terms of average match attendance.[3]

[2] The three points for a win rule was introduced in season 1995/96. Up to then it was two points for a win. The calculations in Table 1 are based on three points for a win throughout.

[3] Appendix A shows developments in stadium attendance and stadium capacity for every of the 11 clubs in the analysis.

Table 1: Summary Statistics Data Used in the Analysis

Club	Sample period		New stadium	Capacity (1000)	Match attendance (1000)	rate (%)	Points (season)
Ajax	1990	2019	1997	49.1	41.1	82.4	74.6
AZ	1999	2019	2007	13.8	12.7	91.6	56.5
Feyenoord	1990	2019	–	47.5	36.3	76.4	63.8
FC Groningen	2001	2019	2006	19.5	17.9	92.3	44.8
NEC	1995	2014	2001	17.8	9.9	71.3	38.9
PSV	1990	2019	–	32.2	30.5	94.7	75.0
Roda JC	1990	2014	2001	17.3	10.8	60.3	48.7
FC Twente	1990	2018	1999	18.6	15.7	81.7	54.1
FC Utrecht	1990	2019	–	21.9	14.8	66.3	46.5
Vitesse	1990	2019	1998	24.3	15.9	63.3	51.1
Willem II	1990	2011	1996	16.0	10.8	70.9	40.9

Note: Sample period: calendar year is second year of the season, i.e. 1990 = 1989/90; points based on three points for a win and one point for a draw.

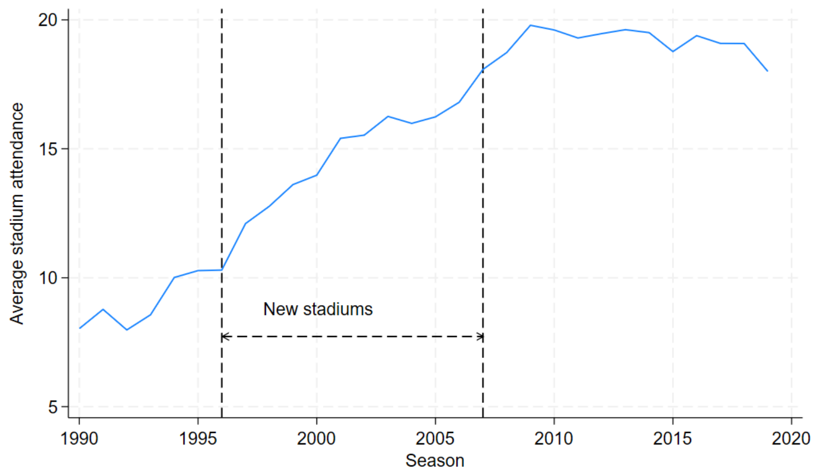
5 Exploratory analysis

This section shows the results of an exploratory DID analysis. For each of the eight clubs with a new stadium there is a control period of five years before and a treatment period of five years after. The control group consists of Feyenoord, PSV and FC Utrecht. Because new stadiums were introduced in different years the control group covers different periods in line with the treated clubs.

Table 2 shows the DID analysis with in panel a attendance (in 1000) and in panel b log(attendance). The first row of panel a in Table 2 shows the situation for Ajax who introduced a new stadium in season 1996/97. In the treatment period there were on average 42,300 attendants per match, in the control period this was 21,800. Due to the new stadium there was an increase in average stadium attendance of 42,300-21,800=20,500. Over the same time periods, stadium attendance in the control group increased with 5,200. Therefore, the net effect is equal to 20,500-5,200 = 15,300. Panel b shows the outcome of the same exercise with log(attendance) in which the DID-effect is equal to 0.42.

As shown in panel a of Table 2 the net increase in the control group varies a lot. Depending on the exact timing of the treatment and control periods the increase is from a low 2,300 to a high 7,000. Using absolute changes in stadium

Figure 2: **Average Stadium Attendance Top Tier Dutch Professional Football; 1990-2019**



Note: Match attendance averaged over all 18 clubs in each season

attendance as an indicator causes a problem because the changes in the control group are substantial while the changes in stadium attendance for some of the clubs in the treatment group are large in relative terms but small in absolute terms. For example, for NEC the introduction of a new stadium almost doubled stadium attendance but because in absolute terms the number was not so high (5,400) the DID-effect was even negative. The bottom line of panel a shows that stadium attendance increased on average with 9,000 for the treatment group and 5,000 for the control group. So, the difference-in-differences effect is 4,000.

The DID-effects in panel b are all positive. So, doing a DID in relative terms gives more consistent effects than a DID in absolute terms. This is due to the big difference in stadium attendance in the control group and some of the treated groups. The bottom line of panel b shows that stadium attendance increase on average with 0.66 log-points for the treatment group and 0.22 for the control group leading to an average difference-in-differences increase of 0.45 log-points (57%).

Clearly, whereas the analysis in relative terms shows positive attendance effects for all new stadiums, the analysis in absolute terms shows that for half of the new stadiums there was a negative attendance effect. The latter effects are driven

Table 2: Descriptives of Stadium Attendance (1000) in Treatment and Control Periods of Five Years

	Control period (CP)	Treatment period (TP)	Treatment Group CP	Treatment Group TP	Treatment Group Δ	Control Group CP	Control Group TP	Δ	ΔΔ
a. Attendance (1000)									
Ajax	1992-1996	1997-2001	21.8	42.3	20.5	18.8	23.9	5.2	15.3
AZ	2002-2006	2007-2011	7.7	16.3	8.6	30.1	32.4	2.3	6.3
FC Groningen	2001-2005	2006-2010	12.0	19.6	7.6	29.4	32.1	2.8	4.8
NEC	1996-2000	2001-2005	5.7	11.1	5.4	22.4	29.4	7.0	-1.6
Roda JC	1996-2000	2001-2005	7.5	13.3	5.8	22.4	29.4	7.0	-1.1
FC Twente	1994-1998	1999-2003	7.5	12.9	5.4	20.5	27.0	6.5	-1.1
Vitesse	1993-1997	1998-2002	7.0	22.4	15.4	19.9	25.2	5.3	10.1
Willem II	1991-1995	1996-2000	7.1	10.6	3.5	18.1	22.4	4.3	-0.7
Average			9.5	18.6	9.0	22.7	27.7	5.0	4.0
b. Log(attendance)									
Ajax	1992-1996	1997-2001	9.99	10.65	0.66	9.84	10.08	0.24	0.42
AZ	2002-2006	2007-2011	8.95	9.70	0.75	10.31	10.39	0.07	0.68
FC Groningen	2001-2005	2006-2010	9.39	9.88	0.49	10.29	10.38	0.09	0.40
NEC	1996-2000	2001-2005	8.65	9.31	0.67	10.02	10.29	0.27	0.39
Roda JC	1996-2000	2001-2005	8.92	9.50	0.57	10.02	10.29	0.27	0.30
FC Twente	1994-1998	1999-2003	8.92	9.46	0.54	9.93	10.20	0.28	0.27
Vitesse	1993-1997	1998-2002	8.85	10.02	1.16	9.90	10.13	0.24	0.93
Willem II	1991-1995	1996-2000	8.87	9.27	0.40	9.80	10.02	0.21	0.19
Average			9.07	9.72	0.66	10.01	10.22	0.21	0.45

Note: The control group consists of Feyenoord, PSV and FC Utrecht; calendar year indicates the last year of the season.

by the differences in magnitude of the attendance in the control group and the treatment group. On average attendance in the control group is about twice the average attendance in the treatment group. For this reason, the empirical analysis in the next section has log(attendance) as the main variable of interest.[4]

6 Empirical Analysis

6.1 Set-up

To establish the causal effect of a new stadium on stadium attendance a DID analysis is used. A control group and a treatment group are observed in a control

[4]Previous studies vary in the use of absolute attendance or relative, i.e. log(attendance). Relative attendance is used for example in Clapp and Hakes (2005), Howard and Crompton (2003), Leadley and Zygmont (2006) and Zygmont and Leadley (2005).

period and a treatment period. The treatment effect is equal to difference of the differences between treatment group and control group in both periods. The main assumption is that in the absence of the treatment (a new stadium) unobserved differences between the treatment group and the control group are the same. The treatment group consists of the eight clubs that built a new stadium in the period of analysis. The control group consists of the three clubs that did not build a new stadium during this period.

A DID-analysis can be implemented using a two-way fixed effect regression (TWFE):[5]

$$A_{it} = \alpha_i + \beta_t + \gamma D_{it} + \varepsilon_{it} \tag{4}$$

where A_{it} is the (log of) stadium attendance for club i in season t, dummy variable D_{it} is equal to 1 for the treatment group in the treatment period and 0 otherwise. Furthermore, α_i represent club-specific fixed effect, β_t are season-specific fixed effects and ε_{it} are idiosyncratic and time-varying unobservables. Under a parallel trends assumption, no anticipation and homogeneous treatment effects, γ measures the ATET (average treatment effect for the treated) of a new stadium on attendance.

Recent research has pointed out some problems with this approach. When treatment effects are time-varying and heterogeneous using a simple TWFE model may lead to biased parameter estimates.[6] To account for these problems, new methods of DID-analysis have been introduced. Three of them are used here:

[5] Stadium attendance may also be influenced by performance, for example home wins or league ranking. However, since the performance measures may be influenced themselves by the use of a new stadium these are not included in the analysis. Section 6.4 presents an analysis of the effects of a new stadium on a number of performance measures.

[6] With staggered treatment, the TWFE-estimator is a weighted average of all possible two-clubs/two-seasons DID-estimators that compare one club that opened a new stadium in a particular season with another club that did not do this in the same or different season or did this in the past (Goodman-Bacon (2021)). Using a previously treated club as control group for a late treated club can lead to a bias if treatment effects are time-varying. With time-invariant treatment effects this seems to be less problematic. See Wing et al. (2024) for a recent overview of the literature.

DID-imputation (DID-I), CSDID and Synthetic DID (SDID).[7] In DID-I (Borusyak et al. (2022)) club and seasonal fixed effects are estimated using information from the not-treated clubs (never-treated and not-yet-treated clubs). These fixed effects are then used to impute the treated potential outcomes and obtain the treatment effect for each observation. The overall treatment effect is the weighted sum of the separate treatment effects. CSDID is outlined in Callaway and Sant' Anna (2021) and Sant'Anna and Zhao (2020) and uses weighted averages of the ATET for various times and cohorts. In SDID (Arkhangelsky et al. (2021)) pre-trends are reweighted and matched to relax the parallel trend assumption whereby constant differences between treatment and control clubs are allowed. The downside is that SDID requires a balanced panel.

A DID-analysis assumes no-anticipation and parallel trends. The fact that the building of a new stadium is announced does not necessarily mean that the no-anticipation assumption is violated. Knowing that something will happen in the near future even when knowing exactly when this will happen does not necessarily mean that people will respond to this. The no anticipation assumption implies that the causal effect of a treatment that is adopted at time t is equal to zero for all periods prior to t. A potential problem could be that the building of a new stadium depends on the attendance rate. High attendance rates may be caused by excess demand. If so the building of a new stadium is more likely to have an effect on stadium attendance than in the case of low attendance rates. To investigate whether this might be the case a logit model with club fixed effects was estimated with whether or not there was a new stadium in season t was related to average stadium attendance rate in season $t-1$. The lagged attendance rate does not have a significant effect on the introduction of a new stadium.[8] This is no surprise as a new stadium did not always mean an increase in capacity and the capacity rate was not always very high shortly before a new stadium was introduced (see Figure A.1). To investigate the parallel trend assumption a model with club fixed effects

[7] All of them are available as STATA-codes.

[8] The parameter estimate of lagged capacity rate is 0.024 with a standard error of 0.024. The estimate is based on 68 observations.

was estimated with log attendance as dependent variable and time-to-treatment dummy variables as right-hand side variables using only data from the time period before a new stadium was introduced. None of the coefficients related to these dummy variables was significantly different from zero suggesting that the parallel trend assumption is not violated.[9]

Table 3: Parameter Estimates Log Stadium Attendance

a. ATET various methods	All			Balanced panel		
DID-I	0.33	(0.10)	***	0.34	(0.13)	***
CSDID	0.36	(0.10)	***	0.42	(0.12)	***
SDID	–			0.42	(0.18)	**
TWFE	0.39	(0.10)	***	0.36	(0.15)	**
b. By timing new stadium						
1-5 years before	-0.09	(0.07)		-0.09	(0.10)	
0-4 years	0.39	(0.07)	***	0.42	(0.08)	***
5-9 years	0.30	(0.10)	***	0.23	(0.14)	
10-14 years	0.29	(0.13)	**	0.34	(0.15)	**
c. By club						
Ajax	0.26	(0.13)	**	0.26	(0.13)	**
AZ	0.58	(0.04)	***	–		
FC Groningen	0.39	(0.04)	***	–		
NEC	0.34	(0.10)	***	–		
Roda JC	0.24	(0.12)	**	0.23	(0.12)	**
FC Twente	0.44	(0.13)	***	0.37	(0.13)	***
Vitesse	0.42	(0.13)	***	0.47	(0.13)	***
Willem II	0.02	(0.12)		–		

Note: ATET = Average Treatment Effect on the Treated. All estimates contain club and seasonal fixed effects; standard errors in parentheses; *** (**,*): significant at 1% (5%,10%); panel a and b: All 286 observations; Balanced panel 175 observations (from 1990 to 2014 excluding AZ, FC Groningen, NEC, Willem II). Panel c: All 109-120 observations; Balanced Panel: 100 observations; Panel b and c: using DID-I.

6.2 Parameter estimates

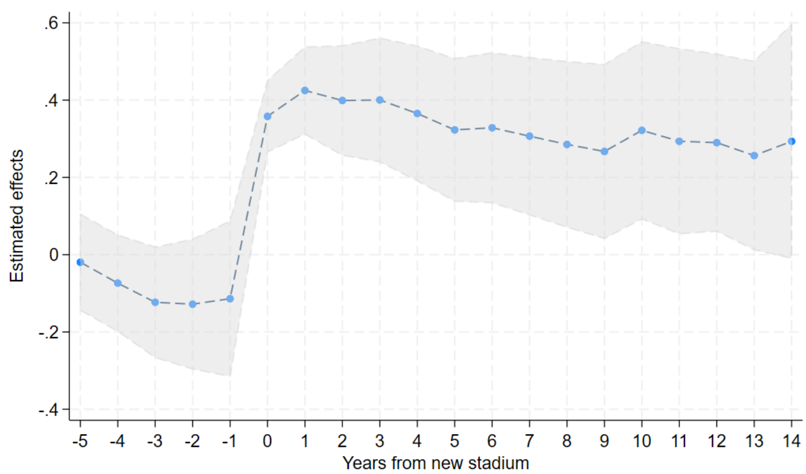
The first column of Table 3 shows ATET estimates for the full sample comparing DID-I, CSDID and traditional TWFE. As shown in panel a the parameter estimates are all positive and significantly different from zero ranging from 0.33 in DID-Imputation to 0.39 in TWFE. This would imply that a new stadium on average increased stadium attendance with 40-50%. The second column shows pa-

[9] If β_{-t} represents the coefficient of the dummy variable t seasons before the introduction of a new stadium, the parameter estimates are the following (standard errors): β_{-5}=-0.019 (0.064), β_{-4}=-0.073 (0.064), β_{-3}=-0.123 (0.073), β_{-2}=-0.128 (0.086), β_{-1}=-0.114 (0.103). The estimate is based on 150 observations.

rameter estimates for the balanced panel also showing the SDID results. Again, all ATET are positive, significant and hardly different from each other. Apparently, the bias of the simple TWFE-approach is limited.[10]

Figure 3 shows the ATET by years from the new stadium using DID-I. Clearly, a new stadium significantly increases attendance. The attendance effect is present even 15 years after the new stadium was introduced. Panel b of Table 3 is related to Figure 3 showing the estimated ATET after grouping the time from a new stadium in intervals. There are no effects before the introduction of a new stadium so there is no anticipation effect (as Szymanski (2023a) found). The average treatment effect is strongest in the first five years but it remains positive and significant in later periods. The parameter estimates of the first, second and third 5 years are very similar.

Figure 3: **Estimated Effects by Years From New Stadium**



Note: Presented are the point estimates of the ATT (using DID-I) and their 95% confidence intervals. Horizontal axis: 0 = year of new stadium opening. Appendix B shows similar graphs using CSDID and TWFE.

[10]In the Bacon-decomposition (Goodman-Bacon (2021)) the treatment-versus-never-treated DID have an 85% probability with an estimated treatment effect of 0.31 while cross-treatment (late-early & early-late) DID have a 15% probability with a estimated treatment effect of 0.61. Together this leads to an average effect of 0.36.

Panel c of Table 3 shows separate ATET-estimates by club. Although in absolute terms stadium capacity was expanded mostly for Ajax the ATET for Ajax is relatively small though still significantly different from zero measured over the 15 years after introduction. Stadium attendance at Ajax increased substantially but so did stadium attendance in the control group. The new stadium of Ajax made it possible to absorb the additional attendance and add a smaller permanent rise relative to the control group.[11] The relative attendance effect is strongest for AZ. For the other clubs – with the exception of Willem II – the ATET over the 15 years time period are positive and significant.

Table 4: Parameter Estimates by Timing of the New Stadium; by Club

	1-5 yrs before	0-4 years	5-9 years	10-14 years
Ajax	0.03 (0.21)	0.36 (0.10)***	0.18 (0.15)	0.16 (0.18)
AZ	-0.13 (0.05)**	0.61 (0.05)***	0.61 (0.03)***	0.53 (0.03)***
FC Groningen	-0.05 (0.06)	0.36 (0.06)***	0.46 (0.03)***	0.37 (0.02)***
NEC	-0.16 (0.14)	0.36 (0.06)***	0.33 (0.11)***	0.32 (0.09)***
Roda JC	-0.05 (0.12)	0.26 (0.10)***	0.21 (0.14)	0.21 (0.13)
FC Twente	-0.02 (0.12)	0.22 (0.10)**	0.06 (0.15)	0.69 (0.16)***
Vitesse	-0.23 (0.18)	0.76 (0.10)***	0.43 (0.15)***	0.23 (0.17)
Willem II	-0.20 (0.24)	0.09 (0.08)	0.03 (0.14)	-0.13 (0.18)

Note: Some estimates of the 10-14 years period are over shorter time intervals; see Figure A3 for details.

The differences between the clubs are illustrated in Table 4. In the five years prior to the new stadium there is no significant effect on stadium attendance except for AZ suggesting that the development in stadium attendance was not parallel for AZ and the control group. Except for Willem II the treatment effect is significantly positive for all clubs in the first five years after the introduction of a new stadium. Also in later periods many of the effects are positive and significantly different from zero. For AZ, FC Groningen, NEC, Roda JC the treatment effects do not become smaller suggesting that there is a permanent effect. For Twente the biggest effect is 10 to 14 years after the introduction of the new stadium which probably has to

[11]See Appendix D for a long term perspective of stadium attendance at Feyenoord and Ajax.

do with extension of the stadium later on. For Ajax and Vitesse the effects are smaller later on. This is probably due to the strong increase in attendance for the clubs in the control group.

The treatment effects presented in Table 4 are quite constant over time. This may explain why the particular method of analysis DID-I, CSDID or SDID do not generate outcomes that are very different from the TWFE approach.

6.3 Sensitivity analysis

To investigate the robustness of the main findings two sensitivity analyses were done. In the first sensitivity analysis information is included about the seasons – some of the – clubs in the analysis were in the second tier.[12] This adds 44 observations and generates a balanced sample of 330 observations (30 seasons – 11 clubs). In the second sensitivity analysis the two biggest clubs in terms of stadium attendance, Feyenoord and Ajax, are excluded from this balanced panel. Feyenoord had a big increase in attendance despite not having a new stadium while Ajax had a big increase related to the new stadium (see also Appendix D).

Table 5: Sensitivity Analysis Parameter Estimates Log Stadium Attendance

	Including second tier			No Feyenoord or Ajax		
DID-I	0.34	(0.11)	***	0.38	(0.13)	***
CSDID	0.32	(0.11)	***	0.35	(0.14)	***
SDID	0.39	(0.19)	**	0.44	(0.20)	**
TWFE	0.38	(0.04)	***	0.41	(0.05)	**
Observations	330			270		
Aggregate TWFE	0.30	(0.05)	***	0.28	(0.06)	***
Observations	16			14		

Note: ATET = Average Treatment Effect on the Treated. Aggregate TWFE: see Bertrand et al. (2004). All estimates contain club and seasonal fixed effects; standard errors in parentheses; *** (**,*): significant at 1% (5%,10%); panel a and b:

[12] As shown in Appendix A relegation had a big effect on stadium attendance.

Table 5 presents the main parameter estimates. As shown in the first column including information about attendances in the second tier hardly affects the parameter estimates while the parameter estimates are again very similar across the various estimation methods. The same holds for the parameter estimates shown in the second column of Table 5.

The bottom row of Table 5 shows parameter estimates following the aggregation procedure suggested by Bertrand et al. (2004). This is based on information from five years before and five years from the new stadium (as in Table 2). Using this information and the information from the control clubs a regression is performed of log(attendance) on club effects and seasonal dummies. The residuals from the treatment clubs are averaged over the before and after period and then used in an OLS regression. Thus, for the full data 16 observations are available. As shown the estimated effect of a new stadium is now 0.30 log-points. If Feyenoord and Ajax are removed the estimated effect is 0.28 log-points.

The main conclusion from the sensitivity analysis is that the attendance effects of a new stadium are quite robust. The magnitude of the estimated effect depends on the estimation method and the sample used but the differences are small.

6.4 Home advantage, team quality and seasonal performance

In addition to the attendance a new stadium may influence the performance of a team in terms of home advantage, team quality and seasonal performance. Because a team needs to get accustomed to their new stadium home advantage may go down initially. Furthermore, since the increased number of stadium attendants may affect the outcome of a home match directly, it may cause an improvement of club revenues thereby allowing for the quality of the team to be improved and thus increase overall performance.

One of the issues addressed in previous research is whether a new stadium had an effect on home advantage. Some studies found a negative effect while others found no effect. To the extent that a new stadium leads to an increase in stadium attendance one might even speculate that there could be a positive effect.

Pollard (2002) studied the effects on home advantage of within-city movement of 37 teams from various sports – but not football – to a new stadium. Almost all teams played for a larger crowd in their new stadium but nevertheless home advantage decreased. Pollard attributed this to the teams being less familiar with the new stadium. Quinn et al. (2003) investigated whether a new stadium affected team performance finding no effects for NBA, NFL, and NHL teams but significant effects for MLB teams. This difference was attributed to the differences in organization of the leagues. NBA, NFL and NHL have revenue-sharing and salary caps so the economic rewards to winning a limited. This is not the case for MLB which has limited gate revenue sharing, no salary cap and high local media revenues. Therefore, MLB teams can use the additional revenues of a new stadium to invest in the quality of the team. Wilkinson and Pollard (2006) found that baseball, basketball and hockey teams experienced a decline in home advantage but only in the first year in their new stadium. Studying the effect on new stadiums in Canadian football, Huang and Soebbing (2022) concluded that these did not significantly affect team performance.

For MLB, the absence of performance effects was also established by Szymanski (2023a). Leite et al. (2023) studied 98 new stadiums in 25 different professional (UEFA) football leagues comparing three seasons after with three seasons before the new stadium was used. The main finding was no effect on home advantage. There was a positive effect on attendance but given the set-up of the study no conclusions about the duration of novelty effects could be drawn.

Appendix C gives a graphical representation of the estimated treatment effects of a new stadium for home advantage, quality of the team and overall performance measured as the goal balance in a season. Most of the parameter estimates are insignificantly different from zero and although some of the estimates are significantly different from zero in some years but there is no clear pattern. All in all, the conclusion is that a new stadium does not affect any of the performance measures neither in the short run nor in the long run.

7 Conclusions

Previous studies on the attendance effects of new sports stadiums are mainly US based. The current study analyzes the attendance effects of new stadiums in a European sports league, i.e. the top tier of professional football in the Netherlands. Contrary to previous studies the current study does not find evidence of a transient novelty effect for new sports stadiums. Rather than declining after an initial increase, attendance in many new stadiums stayed high for several decades. The question is where this difference comes from. It is probably not related to a difference in methodology. Older US studies may have not taken staggered and heterogeneous treatment effects into account but more recent US studies have. The difference could be related to the behavior of fans. The line of reasoning in previous studies was that new fans were attracted to the new stadium out of curiosity. After their curiosity was fulfilled they were no longer interested in a visit. This line of reasoning does not hold for Dutch professional football where new stadiums persuaded potential fans to come and watch the matches life rather than via television or internet. Apparently, new fans found the entertainment sufficiently interesting to keep coming to the stadium and turn into permanent fans. It may be that the difference between American and European sports fans is at least part of the explanation for the divergence in outcomes. It could be that fan behavior is different on both sides of the Atlantic. The attendance effects of a new stadium may depend on the loyalty of fans who were newly attracted. If they are as loyal as the old fans the initial increase in attendance may be become permanent. If for American fans stadium fun competes with other forms of life entertainment they may be less loyal. If they are the attendance effect may slowly fade away in the US but not in Europe were fans have a different stadium experience.

References

Arkhangelsky, D., S. Athey, D. Hirshberg, G. W. Imbens, and S. Wager (2021). Synthetic differences-in-differences. *American Economic Review 111*, 4088–4118.

Ben Porat, A. (2010). Football fandom: a bounded identification. *Soccer & Society 11*(3), 277–290.

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

Borland, J. and R. MacDonald (2003). Demand for sport. *Oxford Review of Economic Policy 19*(4), 458–502.

Borusyak, K., X. Jaravel, and J. Spiess (2022). Revisiting event study designs: Robust and efficient estimation. *CEPR Discussion Paper No 17247*.

Bradbury, J. C. (2019). Determinants of revenue in sports leagues: An empirical assessment. *Economic Inquiry 57*(1), 121–140.

Bradbury, J. C. (2023). Revisiting the novelty effect from new stadiums: An event study approach. *SSRN paper 4458549*.

Callaway, B. and P. H. C. Sant' Anna (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics 225*(2), 200–230.

Clapp, C. M. and J. K. Hakes (2005). How long a honeymoon? The effect of new stadiums on attendance in Major League Baseball. *Journal of Sports Economics 6*(3), 237–263.

Clarke, S. R. and J. M. Norman (1995). Home ground advantage of individual clubs in English soccer. *The Statistician 44*(4), 509–521.

Coates, D. and B. R. Humphreys (2005). Novelty effects of new facilities on attendance at professional sporting events. *Contemporary Economic Policy 23*(3), 436–455.

DeSchriver, T. D., D. A. Rascher, and S. L. Shapiro (2016). If we build it, will they come? Examining the effect of expansion teams and soccer-specific stadiums on Major League Soccer attendance. *Sport, Business and Management: An International Journal 6*(2), 205–227.

Feddersen, A., W. Maennig, and M. Borcherding (2006). The novelty effect of new soccer stadia: The case of Germany. *International Journal of Sport Finance 1*(3), 174–188.

Fort, R. (2000). European and North American sports differences. *Scottish Journal of Political Economy 47*, 431–455.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics 225*, 254–277.

Hoehn, T. and S. Szymanski (1999). The Americanization of European football. *Economic Policy 14*(28), 205–240.

Howard, D. R. and J. L. Crompton (2003). An empirical review of the stadium novelty effect. *Sport Marketing Quarterly 12*(2), 111–116.

Huang, Y. and B. P. Soebbing (2022). The novelty effect and on-field team performance in new sports facilities: The case of the Canadian football league. *Sport Management Review 25*(1), 188–205.

Leadley, J. C. and Z. X. Zygmont (2006). When is the honeymoon over? National Hockey League attendance, 1970-2003. *Canadian Public Policy 32*(2), 213–232.

Leite, W., M. Giardina, C. H. Almeida, and R. Pollard (2023). Home advantage in football after moving to a new stadium: Evidence from European professional teams. *International Journal of Sport and Exercise Psychology 21*(4), 750–760.

Love, A., A. N. Kavazis, A. Morse, and K. C. Mayer (2013). Soccer-specific stadiums and attendance in Major League Soccer: Investigating the novelty effect. *Journal of Applied Sport Management 5*(2), 32–41.

McEvoy, C. D., M. S. Nagel, T. D. DeSchriver, and M. T. Brown (2005). Facility age and attendance in Major League Baseball. *Sport Management Review 8*(1), 19–41.

Peeters, T. and J. C. van Ours (2021). Seasonal home advantage in English professional football; 1974-2018. *De Economist 169*, 107–126.

Pollard, R. (2002). Evidence of a reduced home advantage when a team moves to a new stadium. *Journal of Sports Sciences 20*(12), 969–973.

Quinn, K., P. B. Bursik, C. P. Borick, and L. Raethz (2003). Do new digs mean more wins? The relationship between a new venue and a professional sports team's competitive success. *Journal of Sports Economics 4*(3), 167–182.

Samra, B. and A. Wos (2014). Consumer in sports: Fan typology analysis. *Journal of Intercultural Management 6*(4), 263–288.

Sant'Anna, P. H. C. and J. Zhao (2020). Doubly robust difference-in-differences estimators. *Journal of Econometrics 219*(1), 101–122.

Szymanski, S. (2023a). Anticipating the honeymoon: Event study estimation of new stadium effects in Major League Baseball using the imputation method. *Economic Inquiry 61*, 1077–1102.

Szymanski, S. (2023b). New stadiums and capital-skill complementarity: An event study. *Unpublished*.

Tamir, I. (2022). The natural life cycle of sports fans. *Sport in Society 25*(2), 338–352.

Van Ours, J. C. (2021). Common international trends in football stadium attendance. *PLos ONE 16*, e0247761.

Wilkinson, T. and R. Pollard (2006). A temporary decline in home advantage when moving to a new stadium. *Journal of Sport Behavior 29*(2), 190–197.

Wing, C., M. Yozwiak, A. Hollingsworth, S. Freedman, and K. Simon (2024). Designing difference-in-difference studies with staggered treatment adoption: Key concepts and practical guidelines. *Annual Review of Public Health 45*(1), forthcoming.

Zygmont, Z. X. and J. C. Leadley (2005). When is the honeymoon over? Major League Baseball attendance 1970-2000. *Journal of Sport Management 19*(3), 278–299.

Appendix A. Details about the sample

In the main sample all clubs are in the top tier because relegation may have a big effect on stadium attendance. To get an impression about the consequences of relegation a simple a two-way fixed effect regression is used:

$$A_{it} = \alpha_i + \beta_t + \gamma S_{it} + \varepsilon_{it} \tag{5}$$

where A_{it} is the (log of) stadium attendance for club i in season t, dummy variable S_{it} is equal to 1 for the seasons in which the club played in the second tier and 0 otherwise. Furthermore, α_i represent club-specific fixed effect, β_t are season-specific fixed effects and ε_{it} are idiosyncratic and time-varying unobservables. For the clubs with a new stadium Equation (5) is estimated separately for the time period in the old stadium and the seasons in the new stadium. The estimated effects of relegation are presented in Table A.1

Table A.1: Attendance Effects of Relegation; sample 1989/90-2018/19

	Old stadium			Seasons	New stadium			Seasons
AZ	-0.31	(0.13)	**	8				
FC Groningen	-0.55	(0.04)	***	2				
NEC	-0.69	(0.06)	***	3	-0.24	(0.07)	***	3
Roda JC					-0.49	(0.06)	***	2
FC Twente					0.42	(0.07)	***	1
Willem II					-0.39	(0.09)	***	2

Note: Number of observations (clubs) old stadium: 175 (11) – new stadium: 155 (8). Seasons = Number of seasons in second tier. Year = second year of the season; *** (**,*): significant at 1% (5%,10%)

The effects of relegation differ substantially. For AZ relegating while playing in their old stadium the attendance drop was 0.31 log-points while for FC Groningen it was 0.55 log-points. NEC relegated while playing in their old stadium as well as while playing in their new stadium. The effect of the second period was much smaller than the first period of relegation. Also for the other clubs, relegation while playing in their new stadium had different attendance consequence. FC Twente even had an increase in stadium attendance when playing in the second tier.

Because of the heterogeneity in the relegation effects in the baseline sample only observations were included if the promotion occurred at least five seasons before the new stadium was used for the first time and relegation occurred at least five seasons after the new stadium was used for the first time. For clubs without a new stadium only observations were used if they could serve as a control group with the same rules as at least one of the clubs that occupied a new stadium over the period of analysis. Table A.2 shows there are 11 clubs in the sample with sufficient presence in the top league. Of these eleven clubs, eight started using a new stadium. Of the eight new stadiums seven were built on a different location while one stadium was completely renovated strongly reducing capacity.

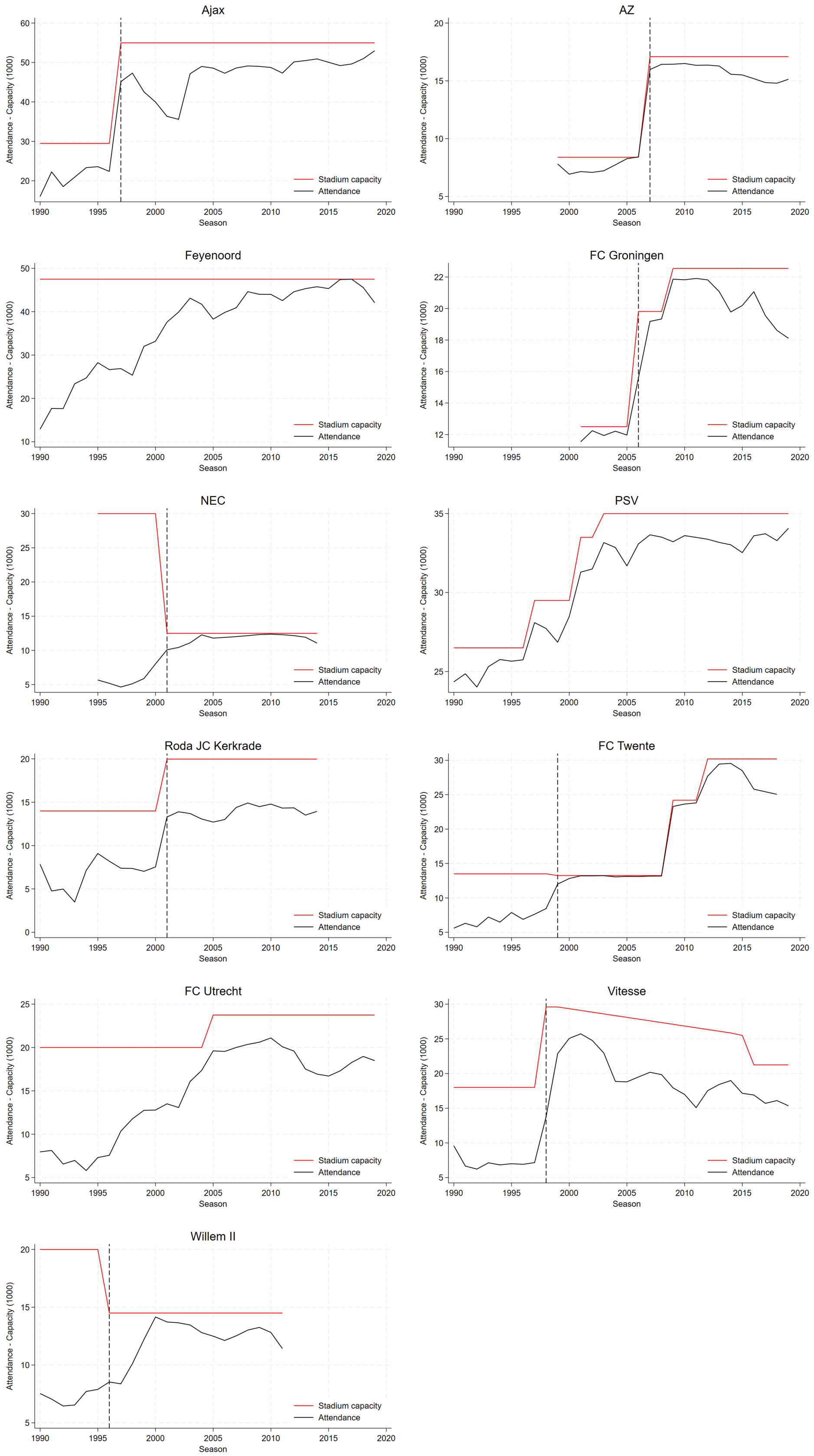
Table A.2: Professional Football Clubs and Stadiums in the Netherlands; 1990-2019

		Name Stadium			Capacity		
Club	Obs	Old	Current	Year	Old	New	2019
Ajax	30	De Meer	Johan Cruijff Arena	1997	29.5	55.0	55.0
AZ	21	Alkmaarderhout	AFAS	2007	8.5	17.0	17.0
Feyenoord	30		De Kuip				47.5
FC Groningen	19	Oosterpark	Euroborg	2006	12.5	20.0	22.6
NEC	20	Goffert	Goffert	2001	30.0	12.5	12.5
PSV	30		Philips stadium				35.0
Roda JC	25	Kaalheide	Parkstad Limburg	2001	14.0	20.0	20.0
FC Twente	29	Het Diekman	De Grolsch Veste	1999	13.5	13.5	30.2
FC Utrecht	30		Nieuw-Galgenwaard				23.8
Vitesse	30	Nieuw Monnikenhuize	GelreDome	1998	18.0	30.0	21.2
Willem II	22	Gemeentelijk Sportpark	Koning Willem II	1996	20.0	14.5	14.5

Note: Obs = number of seasons in top league. The names of the stadium are those from the beginning and the end of the period. Capacity in 1000. Capacity in 2019 or latest year in the sample: 2010 for Willem II, 2013 for NEC and Roda JC, 2018 for FC Twente. The new stadium of FC Groningen was used for the first time in January 2006. Year = second year of a season: 1990 = 1989/90.

Figure A.1 shows the developments in stadium attendance and stadium capacity over the period of analysis separate for every club. Over time for every club stadium attendance increased with very different developments of stadium capacity. With the introduction of a new stadium, for many clubs capacity increased. However, this was not always the case. The stadium capacity of NEC and Willem II went down a lot with the new stadium. The NEC-stadium was the only stadium that was completely renewed at the same location. Also the developments for the clubs in the control group were different. The capacity of the Feyenoord stadium was constant over the period of analysis while the capacity of FC Utrecht and PSV increased through renovations.

Figure A.1: **Developments Stadium Attendance and Stadium Capacity**

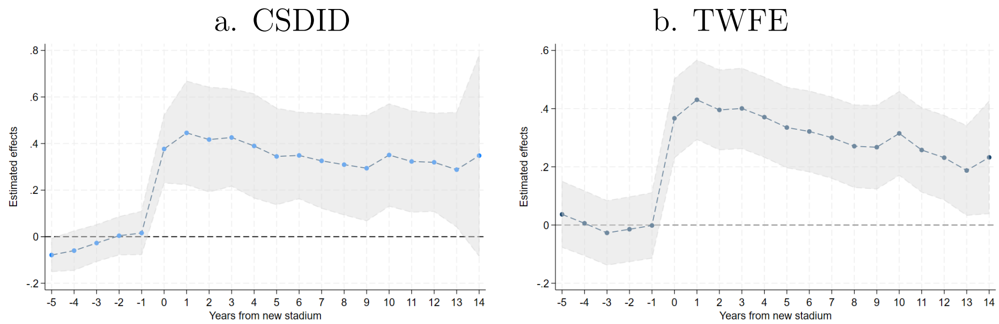


Note: The vertical dashed line indicates the first season of a new stadium.

Appendix B. Effects estimates and estimation routine

The results in Figure 3 are obtained using DID-I. Figure B.1 shows the estimates obtained by CSDID and TWFE. In the TWFE-specification $\gamma D_i t$ is replaced by $\sum_{k=-5}^{14} \gamma_k D_{ikt}$ whereby k=0 for the year of the new stadium opening. The average of γ_{-5} to γ_{-1} is imposed to be equal to zero.

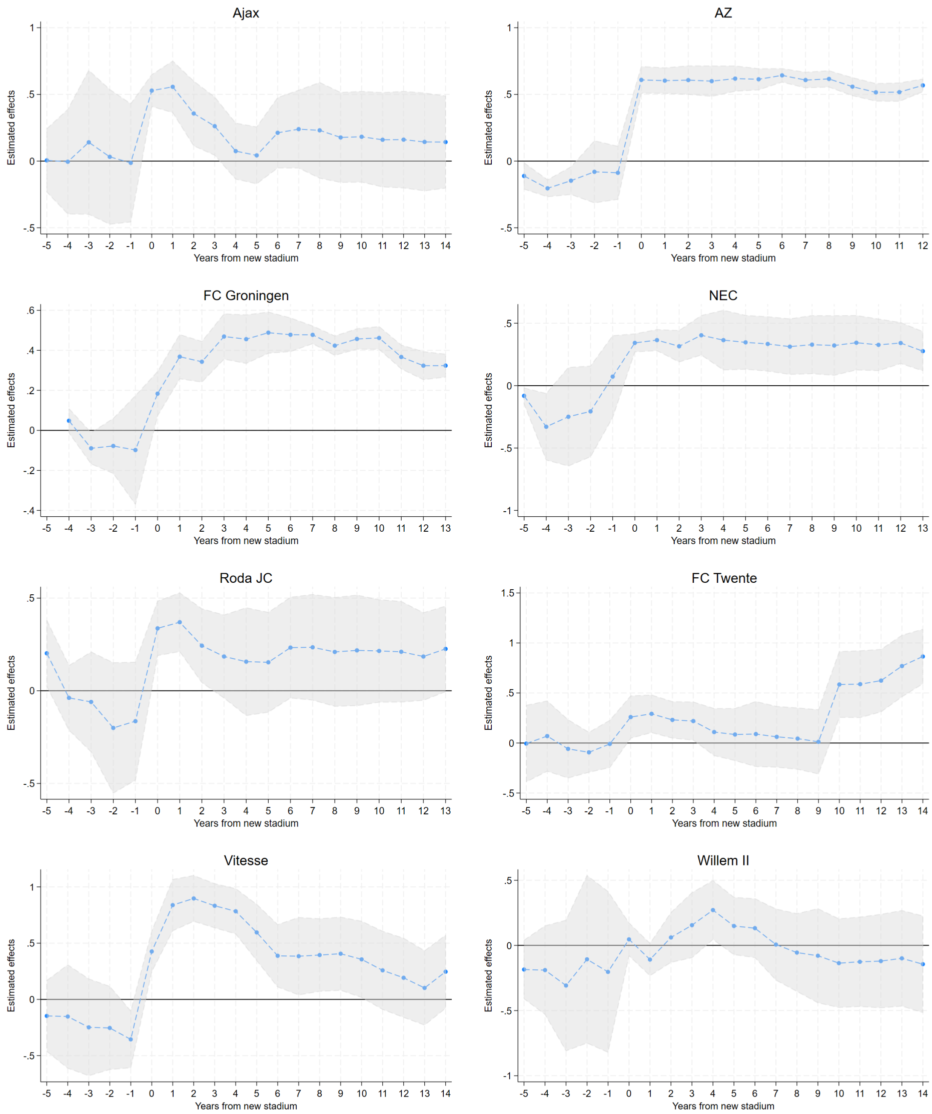
Figure B.1: **Effect Estimates Log Attendance**



Note: Presented are the point estimates of the ATT and the 95% confidence intervals. Horizontal axis: 0 = year of new stadium opening.

Figure B.2 shows separate estimates for each club of the attendance effects of a new football stadium using DID-I. For most – but not all – clubs there is a permanent positive attendance effect of a new stadium.

Figure B.2: **Estimated Effects by Years From New Stadium**



Note: Presented are the point estimates of the ATT (using DID-I) and their 95% confidence intervals. Horizontal axis: 0 = year of new stadium opening.

Appendix C. Home advantage, team quality and overall performance

Clarke and Norman (1995) presented a simple method to disentangle the performance of a team in a particular season into the quality of a team and its home advantage. In terms of goal difference, this works as follows.[13] At the end of the season the home goal balance (HGD) of team i depends on the quality q_i of the team, the quality of its opponents q_j and the home advantage of the team h_i:

$$HGD_i = (N-1)q_i - \sum_{j(j \neq i)}^{N} q_j + (N-1)h_i \tag{6}$$

where N is the number of teams in the league. Therefore, team i has $N-1$ home matches. Similarly the away goal difference (AGD) of team i is equal to:

$$AGD_i = (N-1)q_i - \sum_{j(j \neq i)}^{N} q_j - \sum_{j(j \neq i)}^{N} h_j \tag{7}$$

Quality is normalized such that average quality over the teams in a league is zero: $\sum_{i=1}^{N} q_i = 0$. Furthermore, H is defined as the total home advantage aggregated over all teams: $H = \sum_{i=1}^{N} h_i = N\overline{h}$ where $\overline{h}$ is the average home advantage over all teams in the league. Therefore:

$$\sum_{j(j \neq i)}^{N} q_j = -q_i \quad \text{and} \quad \sum_{j(j \neq i)}^{N} h_j = N\overline{h} - h_i \tag{8}$$

Using equations (8) we can rewrite equations (6) and (7) as:

$$HGD_i = Nq_i + (N-1)h_i \quad \text{and} \quad AGD_i = Nq_i + h_i - N\overline{h} \tag{9}$$

From this it is easy to find for the home advantage and the quality of team i:

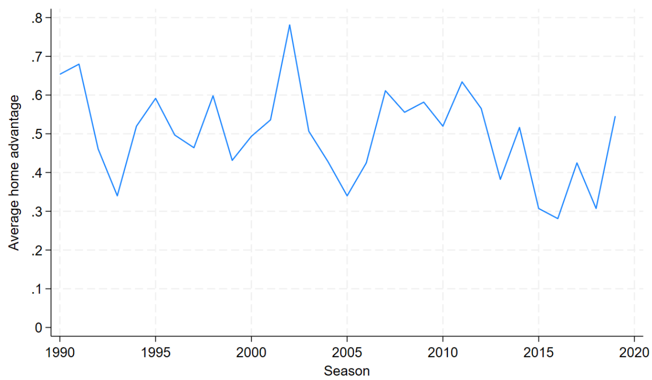
$$h_i = \frac{HGD_i - AGD_i - H}{N-2} \quad \text{and} \quad q_i = \frac{HGD_i - (N-1)h_i}{N} \tag{10}$$

[13]This exposition is taken from Peeters and van Ours (2021) who present the line of reasoning using obtained points as outcome measure.

Using end of season league tables we can calculate the quality and home advantage for every team in the league.

Figure C.1 shows the development of home advantage over the sample period. There are many fluctuations and a slightly downward sloping trend. Such a trend is also present in the home advantage in English profession football (see Peeters and van Ours (2021)).

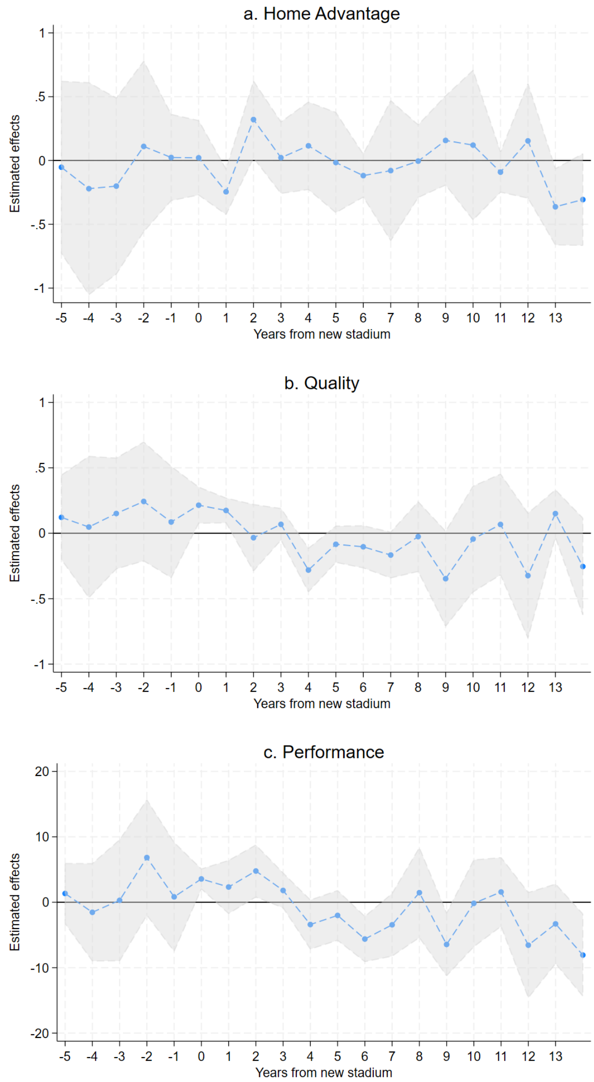
Figure C.1: **Average Seasonal Home Advantage in Goal Difference; Top Tier Dutch Professional Football (1990-2019)**



Panel a of Figure C.2 shows the treatment effects of a new stadium for home advantage. The results obtained using DID-I (but are very similar to using TWFE or CSDID). Most of the parameter estimates are insignificantly different from zero. Some of the estimates are significantly different from zero but there is no clear pattern in this. A new stadium does not affect home advantage neither in the short run nor in the long run.

Panel b of Figure C.2 shows that also the quality of the team – normalized to 0 for all the clubs in the league in a particular year – is not affected by the introduction of a new stadium. The same holds for performance measured as the overall goal balance achieved in a season (panel c of Figure C.2).

Figure C.2: **Effect Estimates Home Advantage, Quality & Overall Performance by Duration From New Stadium**



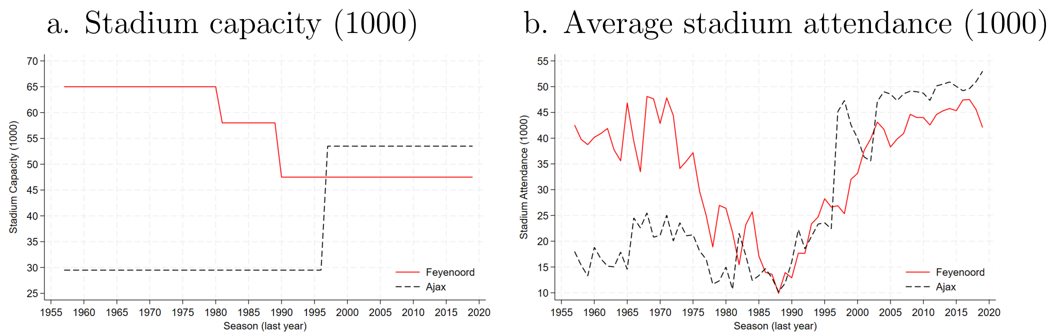
Note: Home advantage, Quality and Overall Performance in goal difference per season; graphs created by DID-I; presented are the point estimates of the ATET and the 95% confidence intervals; horizontal axis: 0 = year of new stadium opening.

Appendix D. Long-term attendances at Feyenoord & Ajax

To facilitate the interpretation of the main findings of this paper this appendix describes long-term attendance developments for two Dutch top clubs with a long-term rivalry since the start of professional football in the Netherlands, Feyenoord and Ajax.

Feyenoord always played in the same stadium but got a smaller stadium capacity due to renovations and the introduction of seating only. Ajax started playing in a new stadium (current named Johan Cruijff Arena) in 1996. One of the complications is that Ajax played some of the top matches in a different stadium with a higher capacity (Olympic stadium Amsterdam). This is not presented in panel a of Figure D.1. In the analysis Ajax belongs to the treatment group and Feyenoord to the control group.

Figure D.1: **Developments of stadium capacity and average stadium attendance (per match) of Ajax and Feyenoord; 1956/57-2018/19**



Panel b of Figure D.1 shows average stadium attendance per match of both clubs. There is a strong cyclical component (see also Van Ours (2021)) with a big drop in attendance between 1970 and the mid 1980s. Between the mid-1980s and the early 2000s there was a strong increase in stadium attendance that occurred for most clubs in the Netherlands. The difference between Ajax and Feyenoord materialized in season 1996-97 but the initial increase is much bigger than later on when the developments in stadium attendance are sort of parallel. Clearly, average match attendance for Ajax increased substantially after the opening of the new stadium but also for Feyenoord despite not having a new stadium attendance went up substantially; from about 10,000 in the mid 1980s to about 45,000 in the 2010s. The capacity of the Feyenoord stadium was sufficient to accommodate this increase while for Ajax the new stadium was a necessity to facilitate the big increase.