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The effect of football matches on crime patterns in Barcelona

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Should football teams be taxed? Determining crime externalities from football matches*

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Abstract. Given the actual debate, in many European countries, about the need for public administrations to raise their revenues through taxing the crime externalities generated by some private leisure activities, this article analyzes the effect of football matches on crime focusing both on property crimes and interpersonal violent crimes. Our aim is to determine up to what extent a private leisure activity, such as football matches, induces negative crime externalities to the whole society. Using data on both football matches played by Football Club Barcelona (FCB) and geocoded recorded crime data for the City of Barcelona, we firstly evaluate, by means of an Exploratory Spatial Data Analysis (ESDA) at a census tract level, the effect of the number of attendees to football matches on crime by comparing crimes occurring during home and away matches. Secondly, we focus on the effect on the spatial distribution of crime when holding football matches by means of a negative binomial regression. The results regarding property crimes indicate an increase of the number of crimes for the whole city of Barcelona and, specially, in those census tracts that are up to 1 km away from the stadium, indicating that even though there exists a large increase in the number of police officers around the stadium, potential offenders are attracted to crowds where the rewards are higher and the probability of apprehension is lower. These results are confirmed by the low number of recorded crimes on away football matches on the census tracts around the stadium. Regarding violent interpersonal crimes, we find a similar spatial pattern than for property crimes although the overall impact for the whole city is not significant. This result suggests that there exists an important displacement effect towards the census tracts close the FCB stadium.

Key words: Crime, Football, Tax, Negative Externalities, Police Forces.

JEL Classification: K42, H27, R1, L83

1. Introduction

With over 52 million followers on Facebook, 11 million followers on Twitter and a long history of sport success, Football Club Barcelona (FCB, hereafter) is one of the most important football teams in the world. Its present popularity is reflected in the attendance level of its matches with an average of over 70,000 attendants per match. This additional appeal, for the well-known City of Barcelona, is likely to result in large

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economic benefits for the city and its citizens. For instance, it is likely that sport events related to FCB will induce greater tourist arrivals and greater levels of consumption in the retail sector with the consequent positive impacts on, for instance, job creation and tax collection.

Nevertheless, and despite the positive economic effects, some negative externalities may arise for the whole city from holding such an important team and such big events on a regular basis; primarily, it can boost criminal activity. Large crowds can increase the attractiveness of targets and, consequently, offenders may be attracted to such events. Moreover, the increase in the number of social interactions, the involvement of alcohol drinks and the excitement of a win or the upset of a loss can increase the level of interpersonal violence (Montolio and Planells, 2014; Card and Dahl, 2011). Additionally, celebrations can also result in other types of illegal behaviors such as public furniture being damaged or physical attacks to police officers.

To preserve the security of citizens and to prevent crime to occur, a large number of police officers must be placed on duty during football days. For instance, the Catalan police (*Mossos d'Esquadra*) estimates that an average of 246 police officers are needed to ensure security during “hot matches”, such as those played between FCB and its historical rival, Real Madrid FC. This special deployment of officers and police means results in an extra cost that is induced by a private activity but borne by the entire society through general taxation.

In front of such situation, various European governments have tried to levy taxes to cover this negative externalities arising from big events in the form of higher crime rates. For instance, in UK, the Deputy Chief Constable Andy Holt from Yorkshire Police and the Association of Chief Police Officers (ACPO) lead on Football, stated that football teams should cover the full cost of policing football matches, and not just those within and around a certain distance of the stadiums as it is currently done in UK given that the effect of football matches may be spread to other areas.¹

In Spain, and also given that public finances are currently under considerable stress and there is the need for looking for alternative sources of revenues to cover public spending, the debate is open. For instance, for the specific case of the City of Barcelona, the Catalan government budgeted for 2014 a tax to cover extra policing resources

¹ The ACPO found a statistically significant increase in the number of crimes up to 1 km away from the UK football stadiums.

devoted to risky events.² The estimated cost of a police officer has been established at 35 Euros per hour. On average, the cost of a “hot match” is estimated at 54,798 Euros; 35,000 of which will be covered by FCB in concept of extra policing cost. The Catalan Home Office estimates an annual collection around 200,000 Euros with this tax. However, this tax estimates are not based on the real impact of football matches on security issues for the City of Barcelona.

Therefore, the aim of this paper is to analyze, in depth, the impact of FCB matches on different types of crimes. The availability of geocoded data, the approach adopted and the techniques used give novelty to the paper. The obtained results will allow us to fully characterize the impact of football on crime for the case of an important European team in a leading European city. Moreover, it will give rigorous and quantified background to policymakers to properly establish taxes aimed at reducing negative externalities coming from private activities.

More precisely, we study the different impacts that home and away matches played by FCB may have on property crime such as robberies (including thefts), and on violent crimes against the person. By means of a panel dataset (with daily and census tract information), we present a descriptive analysis using GIS techniques to show how crime patterns may be affected by football matches not just around the stadium, but also in the whole City of Barcelona. We also present a spatial confirmatory analysis of the effect of football on crime around the stadium by analyzing up to what extent the agglomeration of people affects each type of crime. To give robustness to our results, we carry out various checks for the crime patterns on away football matches (when the spatial impacts should not be found).

The rest of the paper is structured as follows. Section 2 reviews the existing literature that accounts for the potential effects of football on crime. Section 3 presents the datasets used and the matching process applied to the data previous to the empirical estimations. Section 4 presents both the methodology that will allow us to estimate the impact of football matches on crime, and the spatial analysis used. Section 5 shows the empirical results from the regression analysis. Section 6 presents the descriptive and confirmatory spatial results. Finally, section 7 sum ups the paper and concludes.

² See, the Bill for fiscal, administrative and financial measures that accompanies the regional budget for 2014 of the *Generalitat de Catalunya*: http://www15.gencat.net/ecofin_wpres14/pdf/VOL_P_MES.pdf

2. The multiple effects of football on crime: a look to the existing literature

The effect of holding big sport events may be differentiated in several impacts and can take different forms. Regarding football, a large strand of the literature has focused on the effects of holding a competition such as the FIFA World Cup on employment, tourism, sales, overnight stays (Allmers and Maenning, 2009; Baade and Matheson, 2004; Hagn and Maenning, 2008) and on psychological aspects such as the individual perceptions about economic prospects, both on a personal and economy-wide level (Dohmen *et al.*, 2006; Süßmuth *et al.*, 2010). Additionally, there is also evidence on the effect of football on illegal behaviors. Marie (2010) describes three main channels through which football matches may affect crime.

First, the concentration effect is the straightest and simplest effect to be considered. An agglomeration of individuals in a specific place may lead to a considerable amount of social interactions that can lead to interpersonal violence (brawls, aggressions or fights between individuals).³ Regarding property crimes, the impact of concentration is mainly on robberies and thefts (specially pick pocketing). According to the Routine Activity Theory (Cohen and Felson, 1979), in order a crime to occur, there must converge in time and space a suitable target, a motivated offenders and absence of a capable guardian. Football matches increase exponentially the potential number of targets which can eventually attract a certain amount of motivated offenders, especially those “specialized” in pick pocketing since the rewards can be much higher (more people) and also the agglomeration itself reduces the probability of apprehension (anonymity). If these channels operate, we should observe an increase in the number of property crimes around the stadium in days with football matches.

Note that agglomeration, although at a lower scale, may also be present in different parts of the city (and not just around the stadium) since supporters usually gather up at public places to watch the match and to celebrate/mourn the result. Therefore, we can also expect that property crimes (thefts and robberies) may also increase on other parts of the city during football days. Moreover, during away football matches we would not expect an impact close to the stadium but a possible impact on places where matches can be watched. The analysis presented in this paper will allow us to precisely characterize these spatio-temporal patterns of crime and football.

³ Although the continuous efforts of FCB to eradicate violent behaviours inside the stadium from hooligans, there still exists a violent group of FCB supporters (*Boixos Nois*) that gather outside the stadium in football days.

Second, the profile of the average football fan is similar to the profile of the potential offender. Specifically, information in our crime dataset regarding known authors of crimes from 2007 to 2011 in Barcelona show that 79% were male; 76% were below 40 years old and 63% below 35 years old. This profile is very similar to the one of the football fans reported in the FA Premier League Fan Survey 1994-1997 for the London case. This coincidence of profiles may have various implications. On one side there could be an incapacitation effect due to the fact that a share of the population with a profile similar to those individuals with a higher propensity to commit illegal behaviors is following the match. This would result in a decrease in the committed crimes.⁴

Third, another effect found previously in the literature, cited in Marie (2010), is the displacement effect due to the allocation of police officers around the stadium during football days. If the police officers allocated to other areas were not reduced during the match, this effect would not exist. However, additional police officers used for the match reduce police officers from other areas, inducing a displacement of police forces to the areas where the match takes place. This turns out to be an opportunity for criminals in areas with lower surveillance due to football days. The spatial analysis we perform at the city level will give us some hints on whether this is the case or not for the City of Barcelona.

3. Data

3.1. Crime data

We use a non-public dataset for the City of Barcelona containing all registered crimes obtained from the autonomous police agency in Catalonia (region where Barcelona is located): the *Mossos d'Esquadra*. The *Mossos d'Esquadra* is the police agency in charge for crime prevention, crime solving and crime specialized investigation in the Catalonia region.⁵ The dataset contains reports made both by

⁴ This incapacitation effect due to the attendance to an event of a part of the population that has a larger propensity to commit crimes has also been studied by Dahl and Della Vigna (2008) for the case of blockbuster violent movies. In our case we expect the incapacitation effect to occur during the time of the match. However, after the match, and as shown in Montolio and Planells-Struse (2014), crime can increase due to both the end of the incapacitation effect combined with the result of the match.

⁵ *Mossos d'Esquadra* hold almost all the police competences. The Spanish National Police (*Cuerpo Nacional de Policía*) and the military police (*Guardia Civil*) still hold some competences regarding administrative purposes (such as identity and passport issuing) and counter-terrorist and mafia related activities.

citizens' and police officers. Additionally, the dataset contains information on all the registered crimes by the local police (known in Barcelona as the *Guardia Urbana*) which holds competences mainly on urban traffic and preventing violations of municipal laws and regulations. The crime dataset specifies the hour of the crime (when known) as well as the exact location and type. The dataset, which extends from September the 1st 2007 to December the 31st 2011, has been limited to the months when the football leagues take place. This means, June, July and August have been removed from the dataset.⁶ From the remaining 635,065 observations, 98.74% (627,037 observations) were geocoded at the 10 meters precision.⁷

The classification of illegal activities is according to the more than 190 articles of the Spanish penal code. In order to reduce the number of categories without creating the aggregation bias (Cherry and List, 2002) that could reduce the effectiveness of our estimations, we add up some of the articles of the penal code according to the type of crime and, specially, paying attention not to mix violent, property or any type of crime that entails a different motivation for the offender. Regarding the main property crimes, we use the variable "*Robberies*" that involves the misappropriation of others' belongings without including any type of violence (mainly minor thefts or pick pocketing). Alternative to the economic motivated offenses, we include those crimes that were more psychologically related. Specifically, we include "*Violent crimes*" to account for the violent crimes between individuals (fights between individuals or injuries caused by other individuals).

After removing all observations belonging to other types of crimes, the final subset of the data is formed by 359,711 geocoded observations. We aggregate all the crime data up to the census tract level. In the city of Barcelona, there are 10 districts divided into 73 neighborhoods which are also divided into 1,061 census tracts according to electoral population.⁸ We use this unit of analysis since it is the smallest one available and can be directly linked to the districts, which are the main spatial units that police

⁶ The main dataset contained data from 2007 to 2011. The total number of observations was 978,218 and the number of observations that could be geocoded was 953,257.

⁷ The data coordinates type was UTM-31N using the European Datum 50 (ED 50) projection although, for the sake of homogeneity with other layers of polygons, we re-projected the coordinates to ETRS89. The geocoding process was partly done by the *Mossos d'Esquadra*, partly done by GIS techniques and around 40,000 observations were geocoded by hand using Google Maps.

⁸ We use the census tracts that belong to the 2011 municipal elections. One advantage of using this spatial division is that census tracts are divided with a minimum of 500 citizens' and a maximum of 2,000. All of the census tracts present population between these two thresholds and, therefore, makes them very homogeneous in terms of number of inhabitants.

chiefs use for policing and strategy decisions. Moreover, since the census tracts are determined according to the population, we indirectly control for the population at risk in each spatial unit.

Table 1 shows the main summary statistics for the panel dataset. The total number of observations is large given that our panel is formed by the 1,061 census tracts across all the days from September 1st to 31st December 2011 (except for the summer months).

Table 1. Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
<i>Crime variables</i>					
Robberies	1,289,115	.266	1.215	0	73
Violent crimes	1,289,115	.0121	.116	0	5
<i>Weather variables</i>					
Rainfall	1,289,115	2.015	6.978	0	79.8
Sun hours	1,289,115	6.517	3.780	0	13.6
Temperature	1,289,115	13.153	5.572	0	27.3
Pressure	1,289,115	951.599	123.314	0	985.85
Wind speed	1,289,115	14.751	6.139	2.16	43.92

Note: weather control variables are averages per day

The number of robberies is much larger than the number of violent crimes as one could expect. Also, the variance is higher specially, across census tracts. The concentration of both robberies and violent crimes is significant since 2% of the census tracts are responsible for 52% of all robberies and 63% of all violent crimes. The spatial analysis will be developed with more detail in Section 6.

3.2. Football data

We merge the above crime dataset with the dataset of the football matches played by the FCB between the 1st of September 2007 and the 31st of December 2011 (excluding the months of June, July and August since generally there is no official competitions).

This data set contains data regarding the exact day, hour, result, number of attendants and location of the match (whether if it was home or away match). Table 2 summarizes the number of matches with a certain level of attendance. It shows that the level of attendance is quite high for the home matches since 75% of them have more

than 60,000 supporters in the stadium while just 7 matches have an attendance of less than 40,000 spectators.⁹

Regarding the characteristics of the matches, our dataset contains in total 125 home matches and 130 away matches. The majority of matches belong to the Spanish domestic league (169). The King's Cup is the second most important domestic competition (32 matches played); however, by far the European Champions League is the competition that attracts the larger amount of spectators (50 matches played). Among all these matches, 10 have been played against the historical rival, Real Madrid CF, and the majority of them belong to the main Spanish domestic league.

Table 2. FC Barcelona football matches 2007 - 2011.

Attendance	# of matches in the sample
> 80.000 spectators	36
> 60.000 and < 80.000 spectators	58
> 40.000 and < 60.000 spectators	24
< 40.000 spectators	7
Total home matches	125
Away matches	130
Type of match	
Domestic League	169
King's Cup	32
European Champions League	50
Spanish and International Super Cup	4

Note: In the overall period FC Barcelona played Real Madrid CF, the biggest rival, 10 times (home and away).

3.3. Matching process

Given the large dataset consisting of 255 days holding a football match and 960 days with no match across the 1,061 census tracts, we opt to carry out a matching process of days holding a football match (home or away) with other similar days. The aim of reducing the main dataset is to be able to compare those days holding a home football match with very similar days with no football match. The matching process of football days with non-football days is based on the highly variation of crime in time.

⁹ FC Barcelona's stadium, Camp Nou, is the fifth football largest stadium in the world with a capacity, at February 2013, of 99,354 spectators.

Montolio and Planells-Struse (2014) show that the hour of the day, the day of the week and the month of the year all appear to play a major role in explaining crime. Weekends are, by far, the days of the week with the higher level of crime. Summer months, are also found to be the highest in terms of crime.

In order to capture this variability across time units, we base our matching on the following process: for each treatment (a day with a football match, either home or away match) we look for a control (a day with no football match) that is the same day of the week in the same month on the same year. After applying these criteria, 206 day matches were matched with other non football days. For the rest of the matches we relax the month requirement. Hence, we match the rest of the football days with days that are the same day of the week and on the same year (but not the same month).¹⁰ With this procedure 21 additional days were matched. For the remaining matches, we relax the year requirement so we look for controls that are days that fall in the same day of the week at any year.

Finally, there were 21 match days left that had to be matched to a control day according to a slightly different rule: the control day was searched just in the same week no matter what the day was. The final result yielded a dataset consisting of 510 days (across the 1,061 census tracts), 255 belong to controls (non-football day) and 255 to treatments (football days).

4. Empirical approach: effects of football matches on crime

4.1. Regression approach

In order to estimate the overall effect of football matches on crime, we estimate a model of the following form:

$$Crime_{it}^m = \beta_1 Match_t + \beta_2 Away_Match_t + \beta_3 X + \gamma + \varphi + \varepsilon_{it} \quad (1)$$

where i denotes the census tract, t the day and m the type of crime (robberies or violent crimes). Hence, $Crime_{it}^m$ represent the count of crimes m each day t at a census tract i . $Match_t$ is the variable capturing the fact of holding a football match or not. Moreover, this variable will take different forms such as dummies for home match days, the number of spectators, or different dummies to account for the level of attendance. For

¹⁰ The month fixed effect we introduce will capture the heterogeneity across months.

the away football matches, we include in Eq. (1) the variable $Away_Match_t$ that takes value 1 when there is a day with an away football match and 0 otherwise. X is a vector containing potential predictors of robberies and violent crimes. Given our daily dataset, we include a set of weather variables such as average rainfall, average number of sun hours, average temperature, average atmospheric pressure and average wind speed (see Table 1 for descriptive statistics). All these weather related variables have been proved to be good explanatory variables for crime (Anderson, 2001; Jacob *et al.*, 2004). For instance, rainfall can reduce the potential number of available targets in the streets since people prefer to stay at home while the number of sun hours can increase it. Higher temperatures can also increase the number of potential targets in the streets since people feel more like going out and stay less at home.

In Eq. (1) γ is a vector that contains time fixed effects to capture any potential heterogeneity across days, months or years. Specifically, it contains a day of the year fixed effect to account for specific dates across the year such as Christmas or New Year's Eve. Additionally, and with the same objective, we include a week of the year fixed effect to account for Easter or specific spring breaks. To account for heterogeneity across months, we introduce a month fixed effect. We also include a day of the week fixed effect to capture the heterogeneity of crime counts across days of the week. In this sense, the weekly crime patterns seem to increase from Wednesday to Sunday, with a clear weekend effect. We also include year fixed effects to reflect the differences in crime across the five years of our data span.

Finally, ϕ in Eq. (1) represents a set of spatial dummies that account for neighborhood and district fixed effects. Finally, ε_{it} represent the error term that is assumed to be normally distributed with constant variance.

Regarding the estimation method, given the non-trivial number of zeros and positive skewed distribution of the count of crimes, we cannot use Ordinary Least Squares (OLS) since our results could be biased. Moreover, the data presents a problem of over-dispersion. This is, the variance of the counts of crimes (both robberies and violent crimes) is larger than their mean. Therefore, we use a negative binomial approach that takes into account all these characteristics that differ from the standard assumptions underlying the OLS estimation. It is worth pointing out that the iteration process rarely converged when introducing census tracts fixed effects. Consequently, we can only approximate the census tracts fixed effects by mean of district and neighborhood fixed effects.

4.2. Spatial approach

After estimating the overall effects of football matches on crime, we are interested in analyzing the changes in the spatial distribution of crime on home and away football days compared to non-football days; to do so; we make use of an Exploratory Spatial Data Analysis (ESDA, hereafter). ESDA technique allows us to analyze the presence of “hot spots” (areas where crime is more concentrated in space) in the City of Barcelona by means of the Kernel density functions average nearest neighbors statistics (Chainey *et al.*, 2008).¹¹ Furthermore, we carry out a confirmatory analysis by means of regressing the crime occurrence as a function of a distance to the FCB stadium. More precisely, we carry out the following regression:

$$Crime_{it}^m = \sum_{k=300}^{1400} \xi_k dist_{ik} + \sum_{k=300}^{1400} \eta_k dist_{ik} Match_t + \beta_1 Match_t + \beta_2 Away_match_t + \beta_3 X + \gamma + \varphi + \varepsilon_{it} \quad (2)$$

where all the variables and parameters that are equal to Eq. (1) represent the same. Eq.

(2) presents two new parameters and variables. The first term, $\sum_{k=300}^{1400} \xi_k dist_k$, is a set of

dummy variables that takes value 1 if the centroid of census tract i is within distance k (in meters) to the FCB stadium and 0 otherwise. This set of dummies captures the impact on crime of being within a certain distance to the stadium both on football days

and non-football days. The second term of the equation, $\sum_{k=300}^{1400} \eta_k dist_k Match_t$, represents

the interaction term of the previous distance variable and a dummy indicating football days at the stadium. Therefore, the parameters η_k capture the effect of being within a certain distance to the stadium when holding a football match. We expect that crime occurrence is higher the closer to the stadium, in part, due to the higher level of social interactions between supporters and, in part, due to the concentration effect that attracts offenders to the crowded areas around the stadium.

¹¹ Using Local Indicators of Spatial Autocorrelation (LISA) would be a very useful tool to identify those census tracts with high/low values of crime surrounded by other census tracts with also high/low values of crime. However, for the case of Barcelona, its city centre distorts the analysis if applying this technique. Focusing only on the surroundings near the FCB stadium reduces the number of spatial units and, hence, the use of LISA technique it is not a plausible solution since it is not recommended for datasets with few number of spatial units (Anselin, 1995).

We use two approaches to capture the distance decay effect. A first approach consists of looking at how crime counts increase within cumulative rings of distance k (where $k = 300, 400, \dots, 1,400$). This is, we construct cumulative rings that include crime counts at census tracts of inferior distances. In order to estimate this distance effect, we have to regress k times Eq. (2) with the k distance dummy since rings of upper order are surely correlated to the ones of lower order. An alternative approach we use is to estimate the non-cumulative rings. This is, we focus on how crime counts are varied between census tracts at distance k and $k-100$ (in meters). We expect in both cases a distance decay pattern since individuals are expected to be more spread the further away we move from the stadium. It is worth pointing out that the approach using the cumulative rings is more likely to show an effect of football matches on crime at greater distances since with this approach all rings include the census tracts that are close the stadium, those that precisely are very likely to show a significant increase in terms of crime counts.

5. Regression results

We estimate Eq. (1) using different definitions for the home matches and a negative binomial approach. The results presented are the incidence rate ratios from the negative binomial estimations which are easily interpretable as percentage changes. We first present the results in Table 3 for the impact of an additional 10,000 spectators on the count of robberies. The first column includes neither district nor neighborhood fixed effects while column 2 includes just the district fixed effects. Column 3 and 4 present the results including only the neighborhood fixed effect and both the district and neighborhood fixed effect.¹² As it may be seen, an increase of 10,000 spectators increases the number of robberies about 1.8% $((1-1.018) * 100)$. The results seem to be slightly changed when taking into account the district and neighborhood fixed effects. On average, when FCB plays away the number of robberies increases by 8-10%. The same approach for violent crimes is presented in Table 4. The results seem to indicate that holding football matches in the City of Barcelona or having the local team playing away does not significantly increase the number of violent crimes. Table A1, in the

¹² Introducing census tracts fixed effects would be the most efficient approach but the large amount of observations makes, unfortunately, the convergence of the iteration process tend to infinite.

appendix, present the detailed results corresponding to the control variables used for Table 3 and 4.

Table 3: Negative binomial. Number of spectators effect on robberies.

	(1)	(2)	(3)	(4)
Spectators/10,000	1.018*** (0.00580)	1.021** (0.00901)	1.020** (0.00987)	1.020** (0.00987)
Away match	1.080*** (0.0275)	1.104** (0.0450)	1.087* (0.0515)	1.087* (0.0515)
Constant	9.589*** (1.185)	4.708*** (1.399)	3.194*** (0.813)	3.194*** (0.813)
Observations	541,110	541,110	541,110	541,110
Climate controls	YES	YES	YES	YES
Time controls	YES	YES	YES	YES
Seasonal controls	YES	YES	YES	YES
Derby dummy	YES	YES	YES	YES
Domestic League	YES	YES	YES	YES
District FE	NO	YES	NO	YES
Neighborhood FE	NO	NO	YES	YES

Note: Climate controls include: average rainfall, average number of sun hours, average temperature, average pressure and average wind speed. Time controls include: day of the week, day of the year, week of the year, weekend, month and year. Seasonal controls include dummies for summer (mainly September) and winter. Coefficients reported as incidence rate ratios. Standard errors clustered at the district level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Negative binomial. Number of spectators effect on violent crimes.

	(1)	(2)	(3)	(4)
Spectators/10,000	0.980 (0.0314)	0.984 (0.0304)	0.983 (0.0304)	0.983 (0.0304)
Away match	0.896 (0.206)	0.920 (0.204)	0.913 (0.204)	0.913 (0.204)
Constant	9.399*** (1.024)	5.657*** (1.976)	4.054*** (1.150)	4.054*** (1.150)
Observations	541,110	541,110	541,110	541,110
Climate controls	YES	YES	YES	YES
Time controls	YES	YES	YES	YES
Seasonal controls	YES	YES	YES	YES
Derby dummy	YES	YES	YES	YES
Domestic League	YES	YES	YES	YES
District FE	NO	YES	NO	YES
Neighborhood FE	NO	NO	YES	YES

Note: See Table 3.

In order to make the impact of home and away football matches comparable, we present Table 5 and 6 for robberies and violent crimes, respectively. In these tables, both the home and away matches are represented by a dummy variable. The average effect of holding a match on robberies in the FCB stadium is estimated at around 9-12% while for violent crimes it seems there is not a significant effect.

Table 5. Negative binomial. Type of match effect on robberies.

	(1)	(2)	(3)	(4)
Dummy home match	1.092** (0.0389)	1.109*** (0.0432)	1.121*** (0.0409)	1.121*** (0.0409)
Away match	1.041 (0.0313)	1.056* (0.0299)	1.061** (0.0289)	1.061** (0.0289)
Constant	9.590*** (1.185)	4.709*** (1.399)	3.195*** (0.813)	3.195*** (0.813)
Observations	541,110	541,110	541,110	541,110
Climate controls	YES	YES	YES	YES
Time controls	YES	YES	YES	YES
Seasonal controls	YES	YES	YES	YES
Derby dummy	YES	YES	YES	YES
Domestic League	YES	YES	YES	YES
District FE	NO	YES	NO	YES
Neighborhood FE	NO	NO	YES	YES

Note: See Table 3.

Table 6. Negative binomial. Type of match effect on violent crimes.

	(1)	(2)	(3)	(4)
Dummy home match	0.831 (0.145)	0.842 (0.152)	0.833 (0.148)	0.833 (0.148)
Away match	0.858 (0.141)	0.869 (0.146)	0.861 (0.144)	0.861 (0.144)
Constant	9.400*** (1.022)	5.660*** (1.970)	4.056*** (1.146)	4.056*** (1.146)
Observations	541,110	541,110	541,110	541,110
Climate controls	YES	YES	YES	YES
Time controls	YES	YES	YES	YES
Seasonal controls	YES	YES	YES	YES
Derby dummy	YES	YES	YES	YES
Domestic League	YES	YES	YES	YES
District FE	NO	YES	NO	YES
Neighborhood FE	NO	NO	YES	YES

Note: See Table 3.

As shown in Table 2, not all home football matches have the same attendance level. There are 36 matches in our sample that can be considered as “hot” in terms of crime since the registered attendance at the stadium is larger than 90% of its capacity. Similarly, there are also some less attractive matches that hold less than 60,000 spectators. This variance in the number of attendees may affect how potential offenders perceive their opportunities to commit crimes. For instance, competitive football matches may attract a large number of criminals given that they believe that there will be a crowd that increases their opportunities and rewards of any illicit committed. On the other hand, if police deployment is large during these “hot” matches, pick pocketers may perceive that it is worth just moving to the football matches when police deployment is less intense. Regarding violent crimes, “hot” football matches may increase the number of potential violent supporters and boost their anger. Tables 7 and 8

present the impact of home football matches on robberies and violent crime when using dummies for the different levels of attendance.

Table 7. Negative binomial. Levels of attendance effect on robberies.

	(1)	(2)	(3)	(4)
>80,000	1.152*** (0.0442)	1.166*** (0.0556)	1.173*** (0.0528)	1.173*** (0.0528)
60,000 - 80,000	1.079** (0.0418)	1.101** (0.0453)	1.116*** (0.0434)	1.116*** (0.0434)
40,000 - 60,000	1.037 (0.0279)	1.041 (0.0291)	1.051* (0.0269)	1.051* (0.0269)
20,000 - 40,000	1.075** (0.0374)	1.062 (0.0404)	1.086* (0.0517)	1.086* (0.0517)
Away match	1.039 (0.0306)	1.053* (0.0292)	1.058** (0.0283)	1.058** (0.0283)
Constant	9.588*** (1.185)	4.708*** (1.399)	3.194*** (0.813)	3.194*** (0.813)
Observations	541,110	541,110	541,110	541,110
Climate controls	YES	YES	YES	YES
Time controls	YES	YES	YES	YES
Seasonal controls	YES	YES	YES	YES
Derby dummy	YES	YES	YES	YES
Domestic League	YES	YES	YES	YES
District FE	NO	YES	NO	YES
Neighborhood FE	NO	NO	YES	YES

Note: See Table 3.

Table 8. Negative binomial. Levels of attendance effect on violent crimes.

	(1)	(2)	(3)	(4)
>80,000	0.880 (0.179)	0.902 (0.185)	0.889 (0.180)	0.889 (0.180)
60,000 - 80,000	0.788 (0.133)	0.796 (0.139)	0.788 (0.136)	0.788 (0.136)
40,000 - 60,000	0.847 (0.171)	0.857 (0.180)	0.852 (0.178)	0.852 (0.178)
20,000 - 40,000	1.029 (0.173)	1.023 (0.177)	1.016 (0.177)	1.016 (0.177)
Away match	0.862 (0.142)	0.873 (0.148)	0.865 (0.145)	0.865 (0.145)
Constant	9.391*** (1.020)	5.656*** (1.971)	4.053*** (1.146)	4.053*** (1.146)
Observations	541,110	541,110	541,110	541,110
Climate controls	YES	YES	YES	YES
Time controls	YES	YES	YES	YES
Seasonal controls	YES	YES	YES	YES
Derby dummy	YES	YES	YES	YES
Domestic League	YES	YES	YES	YES
District FE	NO	YES	NO	YES
Neighborhood FE	NO	NO	YES	YES

Note: See Table 3.

Results show that for the case of robberies, the most crowded football matches (more than 80,000 attendees) increase robberies by about 15% to 17%. Matches with more than 60,000 attendees and less than 80,000 still present a significant effect although is quantitatively lower. The effect of less crowded matches seems to be less significant and lower in quantitative terms. Regarding the effect of football matches on violent crime, again, we do not find any impact no matter how crowded the match is.

So far, the overall effects of football matches on crime seem to indicate a significant increase on robberies, both for home matches and away matches, but no significant effect on violent crimes. In the next section, we focus on the spatial analysis in order to asses up to what point holding football matches may modify crime patterns in the City of Barcelona and in the areas surrounding the FCB stadium.

6. Spatial results

6.1. Exploratory Spatial Data Analysis

We first present an ESDA to show the main crime patterns on home football day matches, away football day matches and non-football day matches. We show the Kernel density estimations to analyze the riskiest places in the City of Barcelona during those days.

Kernel density estimations are simply a smooth estimate of the point process derived by means of a moving window (bandwidth) over the data. In this sense, the objective is to estimate how event levels vary continuously across a study area based on an observed point pattern for a sample of points (Bailey and Gatrell, 1995; Williamson *et al.* 1998). The estimated Kernel values represent the predictive risk surface for each type of crime analyzed. This is, the potential number of event per square km when taking into account potential contagious effects from other areas.

The decision of the area that affects the risk of a certain crime is called the bandwidth decision problem or, in other words, the radius of the circle centered on each grid cell containing the points that contribute to the Kernel density calculation. Large bandwidths will result in over smoothing with low density values and, therefore, an over generalized view. On the contrary, small radius will result in very spiky maps given the jumps between spatial units. Consequently, the image will be similar to the point patterns. Several rules of thumb have been suggested by Williamson *et al.* (2000) or Bailey *et al.* (1995) mostly based in the k-nearest neighbor mean distances, and on the detail of analysis the researcher is interested (cities, counties, neighborhood, streets,

parking lots, etc). However, the bandwidth must also be theoretically justified since it reflects the contagious of the crimes across space. For instance, theft from vehicle may be clustered in a specific car park because it does not have surveillance cameras. It is reasonable to think that theft from vehicles will be likely to occur in the car park with the same probability around them. If the car park has an extension of 250 meters long, a 250 or 300 meters bandwidth would be capturing the potential contagious effect. However, choosing larger bandwidths will only result in extending the probability of theft from vehicle in other areas where there are no cars parked. Another example would be domestic violence, which is very focused on specific houses. Therefore, the bandwidth of the Kernel density estimation will have to be very small.

Given our matching process, we present the results for robberies and violent crimes for the sum of the two types of treated days (home match day and away match day) as well as for the sum of all control days (non football days),¹³ see maps 1A to 1F in Figure 1. For the case of robberies, we may see that the days with football matches (map 1C), robberies are slightly less spread than in days with no football matches or away matches (map 1A and 1B respectively). Also, the higher density around the stadium (green dot) seems to show an increase in the number of robberies. Regarding violent crimes, the pattern is less clear. The lower bandwidth joint with the lower number of events show more dispersed violent crimes across the city.

Table 9. Average nearest neighbor.

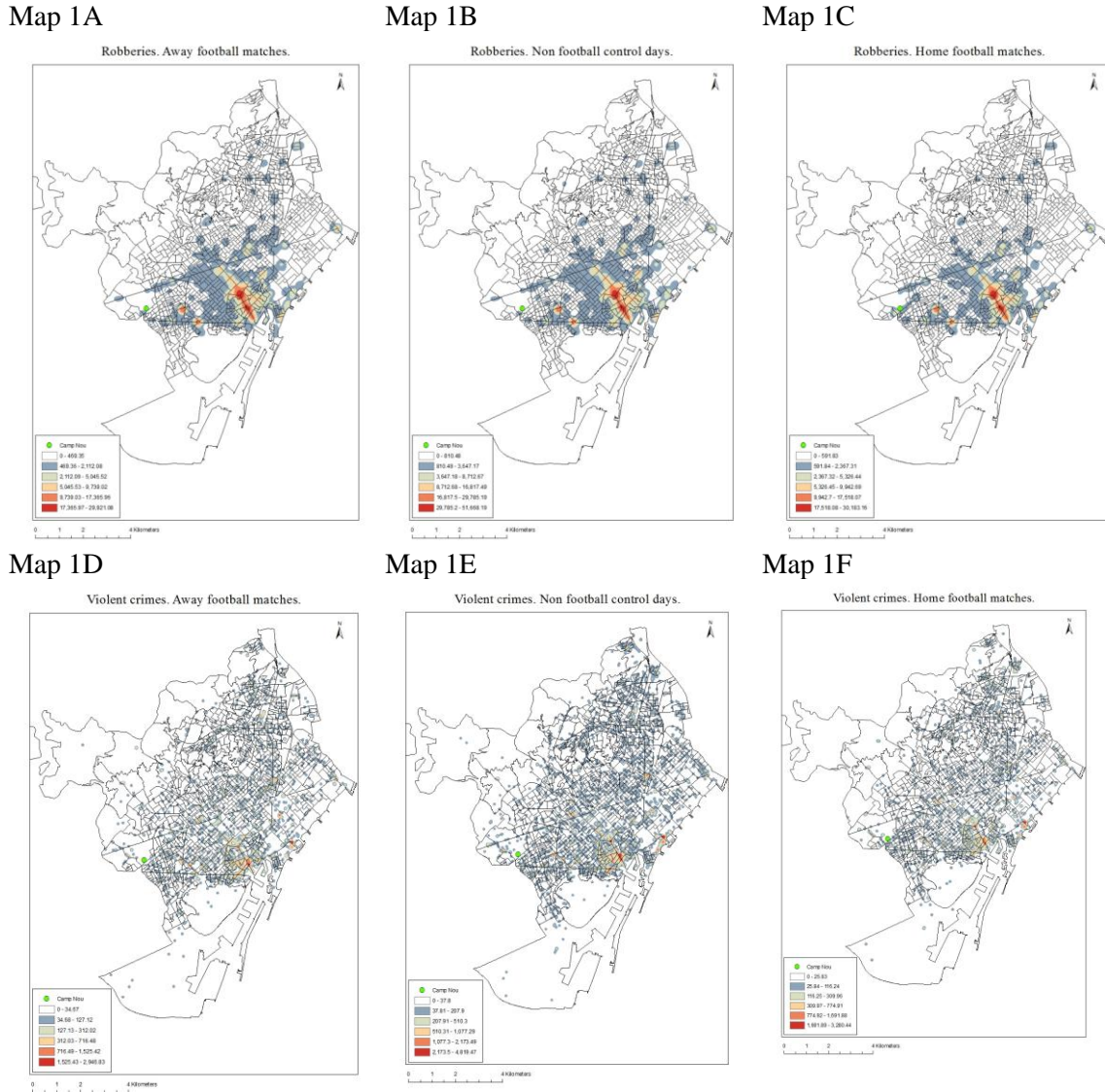
Robberies	Observed mean	Expected mean	Significative
Away matches	5.823	30.973	YES
Control matches	3.864	23.824	YES
Home matches	5.999	30.531	YES
Violent crimes	Observed mean	Expected mean	Significative
Away matches	64.87	131.384	YES
Control matches	45.332	104.083	YES
Home matches	66.286	125.475	YES

In order to test the spatial autocorrelation of the crime events across census tracts, we report in Table 9 the average nearest neighbor values as well as the expected mean. This statistic computes the average of the nearest neighbor for robberies and violent

¹³ The maps with the number of control days represent both the controls for the home match days and away match day. Therefore, the robberies and violent crimes for the control day map are the sum of the 255 control days. This does not modify the relative results of the Kernel density functions nor the spatial autocorrelation indexes.

crimes and compares it to a random distribution of the events. If the observed mean is significantly higher than the expected mean (which is constructed with complete spatial randomness of the events) then the data present general spatial autocorrelation.

Figure 1: Kernel density functions. Away matches, control days and home matches for robberies and violent crimes.

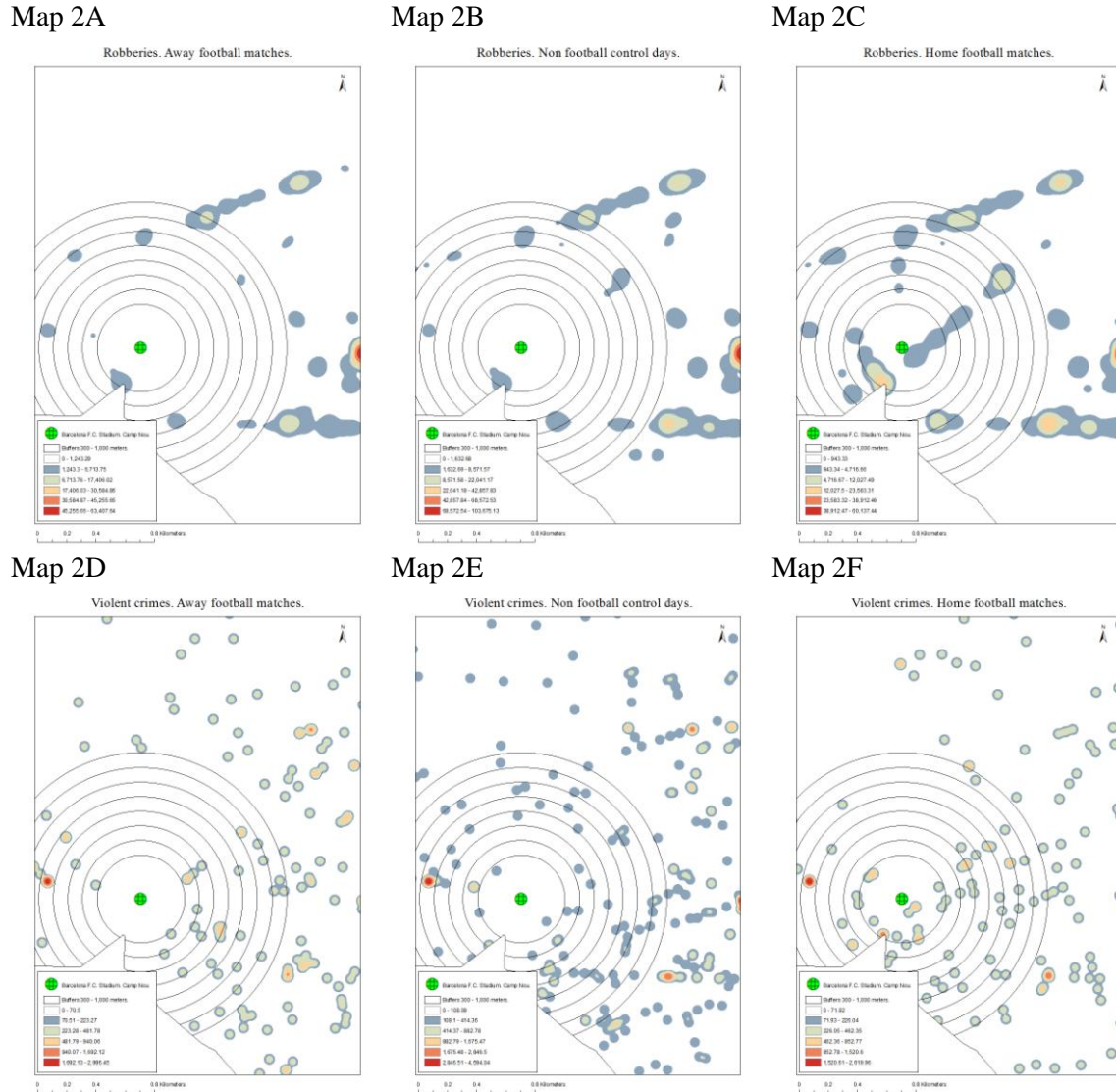


Note: Quadratic kernel functions. The representation is the density function per square km using natural breaks to properly show outliers. Bandwidths have been set to 300 meters for the case of robberies and 100 for the case of violent crimes. Cell size is set to 25 meters to show as much detail as possible.

Regarding the differences between the spatial association for different days, it may be seen, as previously spotted on the maps, that for the case of robberies the spatial autocorrelation is lower on days holding a home football match comparing to other days. Robberies are less concentrated on days holding a home or away football match than in days not holding a football match or holding away football matches. This is,

robberies are significantly closer to other robberies especially on non-football days. For the case of violent crimes, it may be seen the same pattern than for robberies. Violent events are closer to each other, especially on days holding no matches. A possible explanation, both for robberies and violent crimes, could be that on home football days crime is spread to areas where there normally is not any crime activity consequently extending, on average, the distance to the nearest neighbor.

Figure 2: Kernel density functions around FCB stadium. Away matches, control days and home matches for robberies and violent crimes.



Note: Quadratic kernel functions. The representation is the density function per square km using natural breaks to properly show outliers. Bandwidths have been set to 100 meters for the case of robberies and 50 meters for the case of violent crimes. Cell size is set to 10 meters to show as much detail as possible.

In order to focus our analysis on the surrounding of the stadium, we also present Figure 2 with maps that are based just on the crime that occur within a certain distance

from the stadium, allowing us to better understand what are the changes in criminal activity around where football takes place. For the case of robberies, as shown in map 2C (that shows a higher kernel density values around the green dot that represents the stadium) the number of robberies seems to considerably increase on days holding football home matches. Specially in those streets leading to the stadium. In general, it seems that football days attracts potential offenders close to the stadium, such as pick pocketers, given that large crowds can reduce the awareness of potential targets about their presence and also reduces the probability of apprehension (although of the possibility of higher police forces around the stadium). Note that for both non-football days (control days) and away football matches the observed patterns are not substantially different to each other and there are barely density values around the stadium.

For the case of violent crimes (maps 2D to 2F) it can be seen an increase in this type of crimes very close to the (entrance of the stadium) when FCB plays homes. As previously mentioned, this result could reflect the increase in the level of social interactions that together with the average profile of supporters (and offenders) could lead to an increase in the level of violent crimes.

6.2. Confirmatory analysis

In order to confirm the crime concentration patterns around the football stadium when holding home football matches, we estimate Eq. (2) for both robberies and violent crimes using the cumulative and non-cumulative rings (or buffers). Tables 10 and 11 present the results for the cumulative and non-cumulative rings, respectively. This means that each ring represents an increase of 100 meters from the stadium and includes all additional census tracts which centroid falls inside the ring (for the cases of cumulative rings, all census tracts up to the distance ring are included).¹⁴

Regarding the results using the cumulative rings, for the case of robberies, it can be seen a clear distance decay pattern as one moves further away from the stadium; being in a census tract which centroid is closer to 300 meters on home football days increases the number of robberies by 382%. This impact is decreasing as one moves away from the stadium. In fact, the largest drops are between census tracts within 300 meters and

¹⁴ In appendix, Figure A.1 presents a map with a representation of the rings used, while Table A.2 shows the number census tracts included in each ring.

400 meters probably because the former includes the census tracts where the stadium is located.

Table 10: Distance decay effect. Cumulative rings.

Variables	Robbery	Violent crimes
<300 m	4.827*** (0.179)	15.54*** (0.206)
< 400 m	2.488*** (0.0749)	1.912*** (0.0209)
< 500 m	2.574*** (0.168)	1.812*** (0.201)
< 600 m	2.527*** (0.241)	1.881*** (0.319)
< 700 m	2.617*** (0.0761)	1.698* (0.477)
< 800 m	2.546*** (0.110)	1.745*** (0.299)
< 900 m	2.321*** (0.140)	1.729*** (0.324)
< 1,000 m	2.135*** (0.226)	1.716*** (0.283)
< 1,100 m	2.002*** (0.257)	1.589** (0.337)
< 1,200 m	1.842*** (0.194)	1.373* (0.257)
< 1,300 m	1.725*** (0.246)	1.251 (0.282)
< 1,400 m	1.666*** (0.248)	1.230 (0.257)
Observations	541,110	541,110
Climate controls	YES	YES
Time controls	YES	YES
Seasonal controls	YES	YES
Derby dummy	YES	YES
Domestic League	YES	YES
District FE	YES	YES
Neighborhood FE	YES	YES

Note: see notes to Table 3. Each distance has been separately estimated in order to avoid correlation between rings of different distances. Coefficients reported as incidence rate ratios. Standard errors clustered at the district level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Regarding violent crimes, the distance decay pattern seems to be very similar to the one observed for robberies. There is a sharp decrease of violent crimes, again, between the census tracts located within 300 meters of the stadium and those located at 400 meters. The intuition behind the high increase of violent crimes in the very nearest census tracts to the stadium is that brawls and the huge increase of social interactions in the stadium and just outside the stadium give rise to this increase of 1400% more violent crimes.

Table 11. Distance decay effect. Non-cumulative rings.

Variables	Robbery	Violent crimes
<300 m	5.013*** (0.0738)	15.68*** (0.193)
>300 and < 400 m	2.353*** (0.0356)	1.557*** (0.0183)
>400 and < 500 m	2.820*** (0.429)	1.678** (0.424)
>500 and < 600 m	2.285*** (0.557)	3.094 (3.493)
>600 and < 700 m	2.674*** (0.0803)	0.917 (0.196)
>700 and < 800 m	2.215*** (0.232)	2.520 (3.023)
>800 and < 900 m	1.823*** (0.0952)	1.636** (0.372)
>900 and < 1,000 m	1.261*** (0.0171)	1.558*** (0.191)
>1,000 and < 1,100 m	1.403*** (0.0187)	1.066 (0.142)
>1,100 and < 1,200 m	1.116*** (0.0307)	0.579** (0.154)
>1,200 and < 1,300 m	0.835 (0.0997)	0.428*** (0.0279)
>1,300 and < 1,400 m	1.046 (0.120)	0.981 (0.203)
Observations	541,110	541,110
Climate controls	YES	YES
Time controls	YES	YES
Seasonal controls	YES	YES
Derby dummy	YES	YES
Domestic League	YES	YES
District FE	YES	YES
Neighborhood FE	YES	YES

Note: see Table 10.

In order to analyze the effect at certain distances without taking into account the census tracts that are in lower distances we present table 11. This non-cumulative distance rings presents the impacts of home football matches between census tracts located 100 meters away from the previous one. These results help to better understand at what distance the impact of football on crime vanishes. For robberies the distance decay is clear although not homogeneous in the sense that there are specific rings that present higher level of robberies than the previous rings. An explanation for these results may reside in the fact that there may be specific aspects of the areas that may increase the number of robberies. For instance, the ring that account for the census tracts located between 600 and 700 meters present a larger impact than previous rings of lower distances. The explanation behind this result might be, for instance, the largest car

parking located at 612 meters from the stadium. The overall effect of robberies may seem to vanish on census tracts located after 1,200 meters from the stadium.

Regarding violent crimes the largest increase during home football matches is, as previously found, in the census tracts located within 300 meters from the stadium. It is likely that the majority of these incidents are produced in the same census tract as the stadium is located. The effects seem to vanish for the census tracts located after 500 meters. However, it seems to reappear for the census tracts located within 800 and 1,000 meters. A final result, that can confirm the concentration of this type of crime in areas really close to the stadium is that the results for census tracts located between 1,100 meters and 1,300 meters have estimated incidence rates lower than 1.

Table 12. Placebo test.

Variables	Robbery	Violent crimes
<300 m	0.184*** (0.00318)	1.29e-08*** (1.37e-08)
>300 and < 400 m	1.163*** (0.0198)	1.187*** (0.0192)
>400 and < 500 m	0.667*** (0.0248)	0.762*** (0.0335)
>500 and < 600 m	0.338** (0.161)	0.585 (0.591)
>600 and < 700 m	0.374*** (0.0222)	0.854*** (0.0378)
>700 and < 800 m	0.147*** (0.0121)	0.191*** (0.0933)
>800 and < 900 m	0.955 (0.769)	0.468 (0.232)
>900 and < 1,000 m	0.470*** (0.0311)	0.696** (0.110)
>1,000 and < 1,100 m	0.413*** (0.0989)	0.629** (0.119)
>1,100 and < 1,200 m	0.559 (0.300)	0.897 (0.0657)
>1,200 and < 1,300 m	0.357*** (0.0400)	0.954 (0.170)
>1,300 and < 1,400 m	0.480** (0.167)	0.719 (0.225)
Observations	541,110	541,110
Climate controls	YES	YES
Time controls	YES	YES
Seasonal controls	YES	YES
Derby dummy	YES	YES
Domestic League	YES	YES
District FE	YES	YES
Neighborhood FE	YES	YES

Note: see Table 10.

6.3. Placebo test

A final exercise to give robustness to the above presented results is conducted by estimating the following equation:

$$Crime_{it}^m = \sum_{k=300}^{1400} \xi_k dist_k + \sum_{k=300}^{1400} \eta_k dist_k Awaymatch_t + \beta_1 Match_t + \beta_2 Away_match_t + \beta_3 X + \gamma + \varphi + \varepsilon_{it} \quad (3)$$

where the only difference with respect to Eq. (2) is that we now estimate the impact of being in a census tract at a certain distance from the stadium on away football days. The results are shown in table 12. As it may be seen, on days holding away football matches, the count of violent crimes is significantly lower in those areas around the stadium, both for robberies and violent crimes, giving robustness to the causality effects of holding home football matches obtained above.

7. Conclusions

This paper has analyzed the overall effects and spatial displacement effects of football matches on robberies and violent crimes. Using a negative binomial regression we estimated the impact of holding home football matches for the whole city of Barcelona; the results show clear evidence of an increase in robberies. Although the increase in robberies is also present when FCB plays away, this increase is half than when FCB plays at its stadium. For the case of violent crimes, the results show no effect of holding football matches on crime indicating that, for the whole City of Barcelona, holding a football match does not increase significantly the number of violent crimes.

In order to deepen in the analysis of how crowds of people attending football matches can alter criminal behavior, we analyze crime patterns around the stadium finding that both robberies and violent crimes are significantly increased. This pattern is observed using a ESDA analysis and, also, undertaking a confirmatory analysis we find that robberies are significantly increased up to 1.3 km from the stadium while the increase in violent crimes seem to be more related to those areas that are very close to the entrance of the stadium.

The combination of the overall effects jointly with the spatial crime patterns point out to different crime generating processes. First, the spatial patterns suggest that there is a clear concentration effect for both types of crime. For the case of robberies, the crowd attracts, especially, pick pocketers that see their rewards higher and the

probability of apprehension lower despite the increase of police presence around the stadium. Since also during away matches there is an increase in the number of robberies (although in a less substantial way) there seem to be concentration effect in other parts of the city (for instance bars and place where football matches can be watched).

For the case of violent crimes, there exists a concentration effect around the stadium on home football matches. More precisely in those census tracts very close to the stadium (or even in the census tract where the stadium is located) the number of violent crimes is significantly increased. However, the non-existent effects for the whole city (for both home and away matches) suggest that there exists an important displacement effect from other areas of the city to the stadium on football days. The profile similarities between football fans and potential offenders already anticipated this result.

It is worth pointing out that the results obtained in this study do not control for the extra policing staff during football days since there is no data available. However, we have been able to show the significant increase in robberies even if there is a higher presence of police officers on football days.

So, should football teams be taxed? We present solid evidence on the increase of some types of crime due to the fact of holding football matches in the city of Barcelona, and especially around the FCB stadium. Illegal activities positively respond to a private leisure activity such as football and, hence, additional public resources must be devoted to control for these negative externalities.

Although it is true that private institutions already contribute to public budgets through other regular taxes, the extra cost they provoke to society with certain activities need to be balanced. In this sense, there is still much to learn to adapt taxation to the real cost due to the impact of football on illegal behaviors. For instance, the real cost should take into account not only extra police officers on football matches around the stadium but also the need for extra police officers also on other crowded places around the city that on football days register an increase in robberies. Moreover, police officers should not only monitor crowds at the entrance of the stadium, as they do now. As we show in this study, the impact of football matches extends to more than 1 km for the case of the robberies and for about 500 meters for the case of violent crimes. In sum, the tax should take into account the direct costs of extra police units spatially distributed around the stadium up to the point that there is a significant impact of football on crime.

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Appendix

Table A1. Negative binomial. Control variables.

VARIABLES	(1) Robberies	(2) Violent crimes
Derby dummy	1.114** (0.0550)	1.155 (0.205)
Rainfall	0.998*** (0.000615)	0.999 (0.00178)
Sun hours	1.006*** (0.00143)	1.008* (0.00471)
Temperature	1.006** (0.00291)	1.000 (0.00564)
Pressure	1.000 (4.06e-05)	1.000 (9.04e-05)
Wind speed	0.998*** (0.000341)	0.995** (0.00204)
Bank holiday	0.869*** (0.0252)	1.113** (0.0509)
Constant	3.195*** (0.813)	4.056*** (1.146)
Observations	541,110	541,110
Seasonal controls	YES	YES
Domestic League FE	YES	YES
District FE	YES	YES
Neighborhood FE	YES	YES
Day week FE	YES	YES
Day year FE	YES	YES
Week of the year	YES	YES
Weekend FE	YES	YES
Month FE	YES	YES
Year FE	YES	YES

Note: Coefficients reported as incidence rate ratios. Standard errors clustered at the district level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2. Buffers from the FCB stadium. Census tracts included in each ring.

Distance from Barcelona Camp Nou	# of census tracts
<300 m	2
>300 m and <400 m	4
>400 m and <500 m	6
>500 m and <600 m	4
>600 m and <700 m	4
>700 m and <800 m	7
>800 m and <900 m	9
>900 m and <1,000 m	7
>1,000 m and <1,100 m	10
>1,100 m and <1,200 m	10
>1,200 m and <1,300 m	8
>1,300 m and <1,400 m	7

Map A1. Cumulative rings (buffers) around FCB’s stadium.

