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Assessing the influence of neutral grounds on match outcomes

Liam Kneafsey and Stefan Müller

Department of Political Science, Trinity College Dublin, Republic of Ireland

ABSTRACT
The home advantage in various sports has been well documented. So far, we lack knowledge whether playing in neutral venues indeed removes many, if not all, theoretically assumed advantages of playing at home. Analysing over 3,500 senior men's Gaelic football and hurling matches – field games with the highest participation rates in Ireland – between 2009 and 2018, we test the potential moderating influence of neutral venues. In hurling and Gaelic football, a considerable share of matches is played at neutral venues. We test the influence of neutral venues based on descriptive statistics, and multilevel logistic and multinomial regressions controlling for team strength, the importance of the match, the year, and the sport. With predicted probabilities ranging between 0.8 and 0.9, the favourite team is very likely to win home matches. The predicted probability drops below 0.6 for away matches. At neutral venues, the favourite team has a predicted probability of winning of 0.7. A Coarsened Exact Matching (CEM) approach also reveals very substantive and significant effects for the "treatment" of neutral venues. Overall, neutral venues appear to be an under-utilised option for creating fairer and less predictable competition, especially in single-game knock-out matches.

1. Introduction

A large body of work has documented a home advantage in sports. Across countries, sporting codes, leagues, and over time, the home team is more likely to win a match than the away team (Carroll & Collins, 2012; Pollard, 2008; Pollard & Pollard, 2005; Pollard, Prieto, & Gómez, 2017). However, researchers still struggle to identify the reasons for this phenomenon. A team may win because it plays at home, because it is favoured (based on team quality, tactical matchups or other reasons), or a combination of the above. Leaving aside differences in team strength for the moment, a variety of explanations for the home advantage have been proposed, including crowd effects,

familiarity dimensions and conditions, referee bias, or disadvantages for the away team due to travel distance. However, research often offers inconclusive results. For example, Goumas (2013) has found a relationship between crowd size and home advantage, while other work has identified a home advantage even when attendances are very small, or even zero (Staufenbiel, Riedl, & Strauss, 2018; Van de Ven, 2011). Recent findings suggest that even if the home crowd matters, there is no straightforward relationship between crowd size and the home advantage (Leite & Pollard, 2018). Another possible explanation of home advantage refers to familiarity. The home team might have more experience with particular climatic conditions (Pollard, Silva, & Medeiros, 2008), with the dimensions of the playing area (Clarke & Norman, 1995), or in certain cases the differences between artificial and natural playing surfaces (Da Silva C., Braga, & Pollard, 2018; Trombley, 2016). In addition, home teams may psychologically benefit from a more settled prematch routine that is constant across matches at their own ground. Away performance may also be affected by travel distances. However, the effects are relatively small and are only likely to meaningfully manifest for very long distances or where jet lag is an issue (Carron, Loughead, & Bray, 2005; Goumas, 2014). Given the overlapping effects, the conflicting findings, and the tendency of studies to focus on isolating the effect of one of these causal mechanisms, it has been difficult to clearly identify causes of the home advantage.

In this paper, we make two contributions to the literature. First, we test whether a home advantage exists in Gaelic games (hurling and Gaelic football), where teams are unlikely to be affected by travel distance, difference in climatic conditions, or cultural factors. Moreover, in the case of hurling and Gaelic football, prestigious competitions are played on a largely knockout basis rather than a home-and-away league format. A home advantage is therefore likely to be even more consequential. Secondly, we exploit variation in the venue of matches, since a considerable share of matches are conducted on neutral grounds. Focusing on this "counterfactual", we test whether neutral venues reduce the probability that the favourite team wins a match. If the explanations for the home advantage hold, we should observe less predictable competition in matches on neutral venues, compared to matches in which one of the teams plays at home.

The unique case of Gaelic games allows us to test the moderating impact of neutral venues. 13% of all competitive matches between 2009 and 2018 were played on neutral grounds. These include games at the latter stages of the championship competition with high stakes (quarter-finals, semi-finals, and finals), knockout playoffs at earlier stages (qualifiers[1]), and certain provincial games (provincial quarter-finals, semi-finals, and finals in some cases[2]). Utilising data on the favourite team, the venue, and the result of each of the 3,503 intercounty matches conducted between 2009 and 2018, allows us to estimate the proportions and probabilities of wins for the favourite team at home, away, and at neutral grounds.

We observe a strong moderating effect of neutral venues when looking at descriptive evidence, when running multivariate logistic and multinomial regression models, and after applying a Coarsened Exact Matching (CEM) procedure. In all of these tests, neutral grounds substantially decrease the likelihood of the favoured team winning, compared to the scenario when the favoured team plays at home. This result is extremely robust across distinct sporting codes, levels of competition, associated stakes, incentives, and over a decade of results with no substantively or statistically significant

difference year-to-year. Therefore, we conclude that especially in single-game knock-out matches, neutral venues appear to be an under-utilised option for fostering more competitive balance.

2. Expectations and previous findings

For several reasons, the existence of games on neutral venues, as well as the nature of competitions in hurling and Gaelic football provide an excellent means of testing for the home advantage and whether neutral venues indeed create less predictable competition. First, the *crowd effect* is the most commonly-hypothesised causal factor for home advantage. This effect may manifest by inspiring or further informing the home team, intimidating the opposition, or alternatively pressuring match officials (e.g. Sutter & Kocher, 2004; Wolfson, Wakelin, & Lewis, 2005). The literature suggests that the relationship between crowd size and home advantage is non-linear, as small crowds are still associated with home advantage (Pollard & Pollard, 2005). The result, however, seems to be inconclusive. Analysing soccer world cup qualification games, Pollard and Armatas (2017) do not find substantial effects of crowd size. An associated issue is the potential psychological impetus of territoriality on the part of the home team and its players. This can potentially explain the stronger home advantage in isolated areas or regions with a history of conflict (e.g. Pollard, Prieto, & Gómez, 2017). In association football (soccer), there are arguments that the territorial nature of the game may have diminished due to an increasingly mobile playing pool. There is little reason to expect this pattern in Gaelic games, since Gaelic football and hurling are amateur sports. Despite the stakes, the playing pool is locally drawn and the games continue to evoke "tribal" passions, and constitute a central component of local identity (Moran, 2007; Rouse, 2016). In a sense, Gaelic games represent a "strong" case of territoriality logic and there are reasons to expect this will constitute a major component of a Gaelic football or hurling team's home advantage. In turn, playing games at neutral venues should mitigate this effect. To be clear, the use of neutral venues as a baseline comparison does not eliminate potential crowd influence if certain teams are supported by larger contingents. Yet, neutral venues provide a baseline against which territoriality, familiarity with the ground, or potential referee bias (Leite & Pollard, 2018; Pollard, 2008) can be compared and enable an assessment of the systematic nature of home crowd effects.

Second, home teams have greater *familiarity with the venue and playing area* than their travelling opponents. Indeed, even within-country club competitions (with little localised climatic variation) home teams with distinct playing surfaces or dimensions tend to have an advantage (Barnett & Hilditch, 1993; Loughead, Carron, Bray, & Kim, 2003). Neutral venues provide no such advantage to either side and are therefore useful in assessing these effects. It is plausible that teams playing at the same neutral venue quite regularly may develop a sense of familiarity with the venue as compared to opponents with less experience. However, the advantages associated with familiarity with the specific dimensions or conditions at a venue will require a substantial period for acclimatisation and learning (Carron, Loughead, & Bray, 2005). In the case of Gaelic games, the limited number of games at neutral venues provides a substantial

bound on such learning effects. Perhaps more importantly, it is highly unusual for a team to hold regular training sessions at a neutral ground so as to acclimatise in this way. Similarly, an advantage of our focus on the Irish case is the absence of major differences in playing surfaces, such as artificial and real turf across venues. A further potential confounding factor could be introduced if certain neutral venues are more culturally familiar to one of the competing teams. Cultural proximity may well be a factor in international competitions, such as the Champions League or FIFA World Cup, but Ireland's small size and cultural homogeneity guards against this explanation.

Finally, *travel distance* and resultant fatigue are typically posited as a major determinant of home advantage. Travel times in other sports have been shown to have weak effects on performance even where distances within countries are sizeable (e.g. Clarke & Norman, 1995; Pollard & Armatas, 2017). Even in international club football where the distances travelled are particularly large, the effect of travel distance varies substantially (Goumas, 2014). Travel times in Ireland are typically low by international standards, there are no time zone changes, and there is little reason to expect any major effect of distance travelled to a neutral venue by different teams. Ponzo and Scoppa (2018) seek to disentangle this effect from the above by focusing on same-stadium derbies where only the size of crowd support varies by team. We adopt a similar strategy in our focus on neutral venues because neutral grounds are usually selected by the GAA based on their similar travel distance for each competing team. In the case of pre-final rounds, the neutral venue is very close to both competing counties. This reduces the potential advantage that one team may have due to geographic proximity to a particular neutral venue.

Overall, neutral venues should then remove many, if not all, theoretically assumed advantages of playing at home. If we find a home advantage in hurling and Gaelic football, it is unlikely that this advantage is caused by playing surfaces, travel distance, or cultural differences between teams. Instead, a home advantage in Gaelic football and hurling is more likely to be attributed to psychological factors or referee bias. Due to the frequent use of neutral venues and information on the relative team strengths for each of the matches, we can also test whether games on neutral venues mediate the winning probability of the favourite teams. Exploiting variation in the venue type, we can systematically assess home advantage and the usefulness of neutral venues as a means to provide for fairer competition.

3. Case selection and data

Only very occasionally has there been the opportunity to examine the "treatment" of home advantage versus the "control group" of neutral venues. Exceptions include research on territoriality and hormone production in players at home and neutral venues, and estimations of relative fan attendance and ticketing availability at college football bowl games (Caudill & Mixon, 2007; Neave & Wolfson, 2003). For most sports, though, the effect of neutral venues is very difficult to identify since games on neutral grounds are rare or non-existent. The pattern in previous research has been to exclude neutral venue games from analysis given their rarity and often unusual nature, e.g. final games without potential for future advancement to further rounds.

We use the case of Gaelic games, hurling and Gaelic football, to examine the effect of neutral venues relative to major posited mechanisms which home teams derive an advantage. Both sports are administered by the Gaelic Athletic Association (GAA), are amateur sports, and have the highest participation rates in Ireland (CSO, 2015; Reilly & Collins, 2008). In terms of attendance, Gaelic football is by a distance the best attended sport in Ireland, while hurling is third behind association football (Sport Ireland, 2015). Beside the competition between local clubs, the 26 counties of the Republic of Ireland and the six Northern Irish counties compete annually in leagues separated into a combined 10 league divisions (four in football and six in hurling) and a prestigious All-Ireland championship.

We analyse all 3,503 competitive senior men's inter-country hurling and Gaelic football matches between January 2009 and June 2018. Almost one in three championship matches and 10% of the less important league matches are played at neutral venues. The raw data are freely available online from the website GAA Rankings (Reilly, 2018a, 2018b). The website owner, Gavan Reilly, collects the results weekly from a variety of open sources including media reports and the GAA website (https://gaa.ie). The data from GAA Rankings is the only comprehensive database of results across all competitions and codes over an extended period of time. The GAA does not prohibit use of match results for research and/or other purposes.

To understand whether and to what degree neutral grounds condition the home advantage, we focus only on the favoured team in each match. If we include both teams, the value for neutral grounds would always equal 0.5 (because one team will lose/win, or the match ends in a tie). In considering the effects of home advantage and neutral venues, it is also critical to address differences in team quality. The difference in the relative strength of teams will play a much larger role in determining the result than home advantage as the better side is more likely to win at any venue (Pollard & Pollard, 2005). This is likely to be of particular importance in amateur Gaelic games where there can be major differences in the quality of different sides. We therefore make use of the Elo ratings (Elo, 1978) to identify a favourite for each match based on real-time team rating scores. The ELO system has proven to be a strong and reliable predictor of GAA results across various levels of competition in published work (Mangan & Collins, 2016). The winning team's rating for the next match (R_{new}) is calculated as follows:

$$R_{new} = R_{old} + W + M \times (O - E)$$

where R_{old} denotes the team's old rating before a fixture, W denotes the relative weight (i.e. importance) of the fixture, M measures the margin of victory (winning score/losing score), O adds the actual outcome of the match, and E denotes the expectation that the side would win. The weighting attached to the fixture, W, is based on the particular competition that the teams face each other in. In Gaelic football and hurling, there are National League and Championship competitions with the Championship traditionally taking precedence. We therefore weight these games more heavily. The earlier rounds of the Championship, that is the provincial (conference-style) games and qualifier matches, are also not as heavily weighted as the latter All-Ireland series games. In hurling, lesser weights are afforded to the secondary competitions for "weaker" counties and the Ulster provincial championship which do not allow teams to qualify directly into the All-Ireland series.

It is reasonable to expect that teams' performances in the major competitions and in the latter stages of these competitions to more substantively reflect the quality of the teams than League games that take place early in the season or provincial games that are not strictly "knockout". With regard to the size of the victory, M, we cap the threshold at "double scores" to prevent a lopsided result from exerting disproportionate influence on the results. Given the nature of the scoring system in Gaelic games, "double scores" is a useful cut-off point to indicate the scale of a result. A more detailed description is provided in Section C of the Supplementary Material.

4. Statistical analysis

We proceed with the analysis in three steps. First, descriptive evidence ensures that our results make the study comparable to previous studies on the home advantage. Second, multilevel logistic regressions allow us to control for important mediating factors, such as the relative strength of each team, the sports, the type of competition, and the year. Third, matching methods allows for balancing covariates in order to focus on the "treatment" of neutral venues. All data analyses were conducted using the R statistical programming language (R Core Team, 2018).[3]

We follow the common conceptualisation of the home advantage (e.g. Pollard, 1986; Pollard, Prieto, & Gómez, 2017). A value of 1 indicates that the home team always wins at home, while a value of 0.5 indicates that the home and away team are equally likely to win (or draw). While Pollard uses percentages (ranging from 0 to 100), we opt for proportions (ranging from 1 to 0) to make the descriptive results comparable with subsequent results from the logistic regression models. Moreover, we report boot-strapped confidence intervals (Efron & Tibshirani, 1986) for the estimated values of the home advantage. Since standard errors depend on the sample size, it is important to take confidence intervals into consideration to check whether the evidence of a home advantage is robust or not more than "random noise".

Second, we run multilevel logistic regressions (Bates et al., 2015) with *Result* as the dependent variable and use the favourite team as the reference category. The dependent variable takes the value 1 (0) for the winning (losing) team. Note that we opt for a binary logistic regression with "win/lose" of the favourite team as the dependent variable, dropping ties from the analysis. This approach eases the interpretation of the regression results. Ultimately, the results remain unchanged when we opt for a multinomial regression model with draws as a third category (see extensively Section B of the Supplementary Material).

The *Type of ground* (Home, Away, Neutral) is the main independent variable. A factor variable for each *Year* and the *Elo Difference* – a proxy for the relative strength of the favourite team compared to the opponent – serve as important control variables. Because the *Elo* variable is highly skewed, we use the logged difference between the *Elo* ranking of the favourite and underdog of each match. The results do not change if we use the absolute difference instead. Considering stadium-specific effects is not feasible for Gaelic games. First, successful counties usually have larger stadiums resulting in problems of reversed causality. Second, for most matches the official attendance is not reported, but the number of spectators differs tremendously. Controlling for the *Type of competition* (less important league games vs. more important championship games),

however, offers a proxy for the importance of a match. To take into account unobserved heterogeneity and strengths between county teams, we add random intercepts for each hurling and football team. Since odds ratios or logged odds regression coefficients are difficult to interpret, especially if a model includes interaction terms (Brambor, Clark, & Golder, 2006), we estimate predicted probabilities (see extensively, e.g. Gelman & Hill, 2007, chapter 5).

Finally, although we include important control variables in our regression model, the results could depend on the type of teams that play on neutral grounds. For instance, if the very best teams usually play at home or away, the selection of teams, not necessarily the type of venue (home, away, neutral), might drive the findings. In addition to the regression models, we therefore try approximate the effect of the ground type by employing Coarsened Exact Matching (CEM), a frequently used method in the social sciences. CEM (Iacus, King, & Porro, 2012, 2018) allows to match two groups – a treatment and a control group – based on relevant covariates, and offers a way to reduce model-dependence and bias by selecting only observations (i.e. games) for which close "counterfactuals" exist. Counterfactuals are observations that are very similar in all independent variables (e.g. the favourite team, the relative difference in strength between the teams, the type of competition), but differ in terms of the "treatment". In our case, the treatment is the venue of a match.

5. Results

First, we analyse whether the previously reported home advantage also exists for hurling and Gaelic football. Recall that a value of 1 indicates that the home team always wins at home, while a value of 0.5 indicates that the home and away team are equally likely to win (or draw). Indeed, when excluding games at neutral venues the home team tends to win more matches than the away team (Figure 1). Across all four scenarios (hurling/football and championship vs. other matches) we observe a home advantage ranging between 0.55 and 0.6. The effect sizes are virtually identical when we exclude ties (Figure A1 in the Supplementary Material).

Next, we analyse whether neutral grounds mediate this home ground advantage. We estimate the probability that the favourite team, defined as the county with the higher Elo ranking, wins the match separately for each ground type. Model 1 combines the
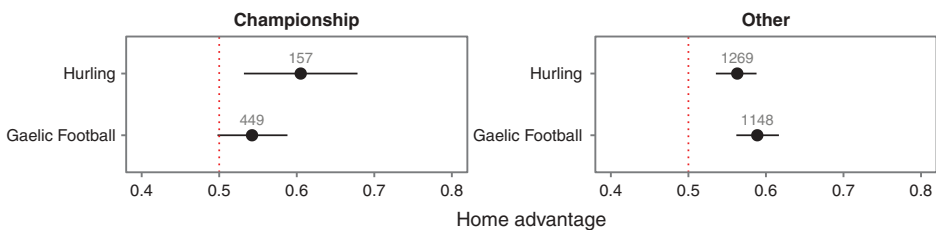

Figure 1. Assessing the home advantage in hurling and Gaelic football.
Note: The horizontal lines show bootstrapped 95% confidence intervals based on 1,000 resamples to account for the variation in the number of observations in each category. The circle marks the mean values, the numbers above the circle show the number of analysed matches in each category. Wins are coded as 1, defeats as 0, draws as 0.5.

datasets for hurling and Gaelic football games, but adds a dummy for each sport, as well as interactions between each sport and the type of ground. Model 2 restricts the sample to football games, whereas Model 3 includes only hurling games. The logged odds for the favourite team to win are substantively and statistically significantly higher for *Home* matches than *Away* games ($p < 0.001$ across all models). The coefficients for matches on *Neutral Grounds* are positive and significant. The favourite is more likely to win on neutral grounds, but less likely than when playing in the home stadium. The positive and highly statistically significant coefficients for the logged Elo Difference underline that the favourite team indeed has a higher probability of winning.

To interpret the substantive effects of venues, we calculate predicted probabilities from the coefficients of the pooled model. Figure 2 plots the predicted probabilities of the interaction term between the type of ground and the sport the probabilities of winning based on Model 1. All other independent variables are held at their means (continuous variables) or modes (nominal or ordinal variables). Controlling for the type of competition, Elo scores, years and unobserved team-effects, the favourite has a predicted probability of around 0.8 (football) and 0.9 (hurling) of winning at home. The probability drops to around 0.5 (Gaelic football) to 0.55 (hurling) for away matches meaning that the chances of a win or a loss of the favourite team are almost the same on average. Importantly, the predicted probabilities for games on neutral grounds amount to around 0.6 and 0.7. Neutral venues clearly mediate the home advantage both for important championship matches and less important league games. Despite the unequal number of observations in each group, the differences between home, away, and neutral are highly statistically and substantively significant.

Next, we present the results from CEM. Control variables are coarsened (if continuous), sorted into strata with same values, and observations that do not include more than one control and treated unit are removed from the sample (see extensively Iacus, King, & Porro, 2012). We matched the data of the favourite teams based on the sport, the team, the logged Elo difference, as well as the type of competition. Afterwards, we estimate two separate
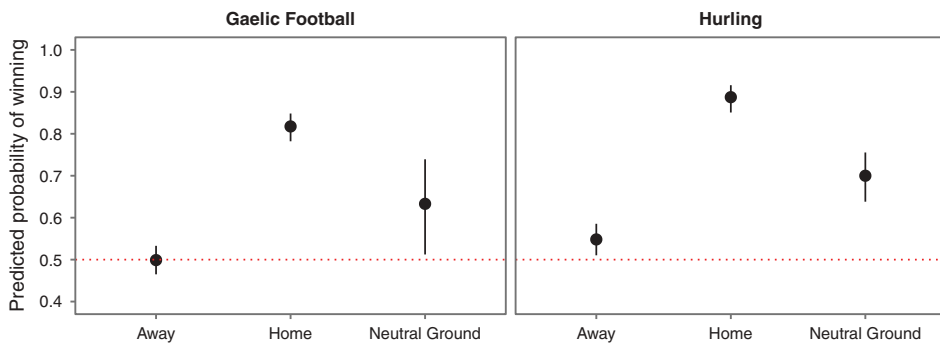

Figure 2. Predicted probability that the favourite teams wins conditional on the ground type and sport.
Note: Predicted probabilities are estimated based on Model 1 of Table 1. Vertical lines display 95% confidence intervals. The other independent variables are held at their mean or mode value. Control variables include the Elo difference, year and the interaction between the type of competition and the sport. Random intercepts for teams are added.

Table 1. Predicting that the favourite team wins the match. Multilevel logistic regressions with random intercepts for teams and sports (for the combined model).

	(1) Combined	(2) Football	(3) Hurling
(Intercept)	−2.62 (0.27)***	−2.49 (0.36)***	−3.08 (0.39)***
Other Competition (ref: Championship)	−0.41 (0.16)**	−0.42 (0.16)**	0.13 (0.23)
Home (ref: Away)	1.28 (0.25)***	1.26 (0.26)***	2.39 (0.54)***
Neutral Ground (ref: Away)	0.67 (0.23)**	0.65 (0.23)**	1.01 (0.31)**
Hurling (ref: Gaelic Football)	−0.22 (0.25)		
Elo Difference (log)	0.56 (0.04)***	0.49 (0.05)***	0.66 (0.06)***
2010	−0.16 (0.16)	−0.00 (0.23)	−0.37 (0.24)
2011	0.30 (0.17)	0.46 (0.24)	0.10 (0.24)
2012	0.21 (0.17)	0.40 (0.23)	0.01 (0.25)
2013	0.10 (0.17)	0.27 (0.24)	−0.14 (0.25)
2014	0.23 (0.17)	0.61 (0.24)*	−0.22 (0.25)
2015	0.14 (0.17)	0.34 (0.24)	−0.11 (0.24)
2016	0.22 (0.17)	0.37 (0.24)	0.03 (0.25)
2017	0.09 (0.17)	0.38 (0.24)	−0.23 (0.24)
2018	0.35 (0.17)*	0.90 (0.26)***	−0.20 (0.24)
Other Competition * Home	0.30 (0.30)	0.28 (0.30)	−0.58 (0.56)
Other Competition * Neutral Ground	−0.16 (0.41)	−0.15 (0.41)	−0.38 (0.37)
Hurling * Other Competition	0.56 (0.27)*		
Hurling * Home	1.04 (0.58)		
Hurling * Neutral Ground	0.30 (0.38)		
Other competition * Home * Hurling	−0.92 (0.62)		
Other competition * Neutral Ground * Hurling	−0.27 (0.55)		
Log likelihood	−1906.74	−983.07	−915.03
N	3302	1687	1615
N (Team/Sport)	69		
N (Team)		32	37

***p < 0.001, **p < 0.01, *p < 0.05.

"sample average treatment effects on the treated" (SATT), i.e. (1) the treatment of playing away versus playing on a neutral ground, and (2) the treatment of home games versus playing on a neutral ground. Unmatched observations are removed from the analysis which should improve the similarity between the treatment and control groups.

The weighted matching procedure assigns weights to each category to control for imbalance between the groups (there are much more home/away games than games on neutral venues in our dataset). The balanced matching employs a *k-to-k* match which removes observations within each stratum until the treatment (neutral) unit and contains the same number of observations as the control units (home/away). The SATT is the log odds of changing the venue type from away/home to neutral. A positive (negative) value indicates that neutral venues increase (decrease) the probability of winning. We expect that moving from *Away* to *Neutral* increases the logged odds of winning, while moving from *Home* to *Neutral* decreases the logged odds.

Figure 3 plots the coefficients from the matching analysis. The homogenous treatment effects show in the expected direction and are highly statistically significant. The treatment of playing at a neutral venue versus playing at home significantly reduces the probability of winning for the favourite team, while the treatment playing on a neutral ground versus playing away increases the probability of winning. These findings do not depend on the choice of matching procedure. Even when the sample is reduced to around 30% of the observations to have the same number of games in the treatment and control group, the coefficients and 95% confidence intervals remain remarkably similar. Adding covariates
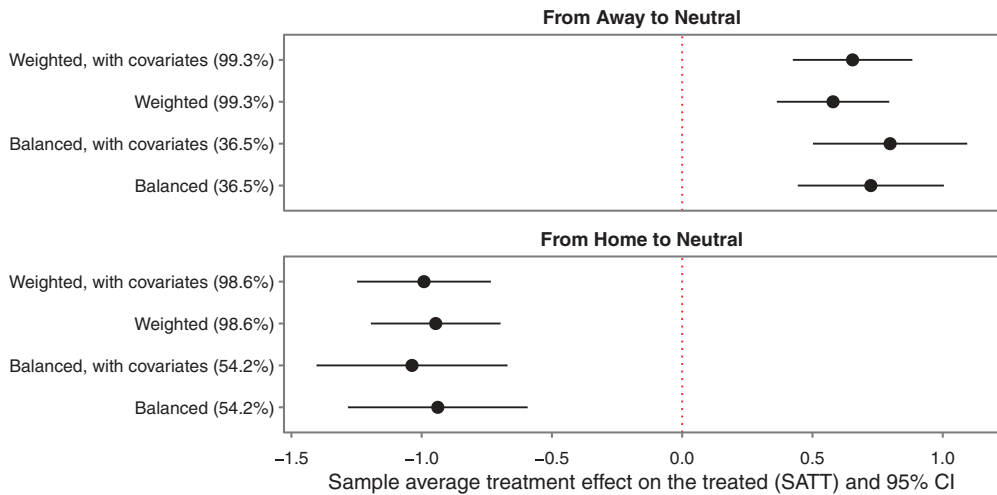
Figure 3. Sample average treatment effect on the treated (SATT) based on coarsened exact matching.
Note: The top panel shows that SATT based on the treatment of moving from "Away" to a "Neutral venue", the lower panel shows the SATT of moving from "Home" to "Neutral". In contrast to the balanced models, the weighted regressions do not have the same number of observations in the treatment and control group. The covariates are Sport, Competition, and the Elo difference (log). The numbers in brackets beside the on the vertical axis show the percentage of observations that remain in the dataset after applying the respective matching procedure.

(*Sport, Competition, Elo Difference (log)*) to the matches samples does not change the conclusions. In Gaelic football and hurling matches, neutral venues decrease the probability that the favourite team wins.

6. Discussion

Having analysed over 3,500 hurling and Gaelic football matches, we found strong support for our expectation that neutral venues decrease the chances of the favourite team winning. This paper provides a number of contributions to the home advantage literature, especially in illustrating the utility of neutral venues. First, we find that a clear home advantage exists in Gaelic Games in Ireland. This is important to consider given that certain common explanations of the home advantage in the literature, such as the effects of long travel distances and jet lag (Goumas, 2014; Nichols, 2014) are not generally applicable to the Irish case. Similarly, differences in weather conditions and/or variation in the use of natural versus artificial turf are also not contributory factors in the case of Gaelic Games, as there is little or no variation in the local climates in competing counties and only natural turf is used for competitive matches. While travel times, local climates, and differences in playing surface may be important in explaining home advantage elsewhere, they do not appear to matter in this context. By comparing to games played at neutral venues, the findings of this study tend to suggest that home advantage in Irish field sports is likely to be driven by other factors, such as the crowd effect on players, familiarity with a venue and established prematch routines, or the influence of home fans on referees' decisions. This pattern corresponds with previous studies regarding

the likelihood of larger home advantage effects in amateur sports: players and referees are not necessarily trained to deal with the effects of hostile home crowds and other contributing factors in the way that professional teams are (Almeida & Volossovitch, 2017).

Second, we observe highly robust effects of playing matches at neutral venues. Neutral venues decrease the probability of the stronger team winning compared to when they play at home. The conclusion does not change even after controlling for the favourite team in our models (estimated as the logged difference in Elo rankings between both teams). The matching analysis offers further support for this conclusion. After coarsening similar observations (based on teams and relative team strength) we observe a strong and significant impact of neutral venues. Neutral venues in Gaelic Games do not tend to systematically differ in their geographic or cultural distance to the competing counties and teams do not have access to these venues on a regular basis to develop familiarity with the dimensions and facilities. Therefore, at least in this context, neutral venues provide a useful means of fostering more competitive and unpredictable games. However, it should be noted that this is not necessarily directly applicable in other countries and across other sporting codes where the selection and use of neutral grounds may not approximate these conditions.

The observed impact of neutral grounds has important implications for structuring competitions without a full set of home-and-away league games. Both in hurling and Gaelic football a handful of inter-county teams have been dominating the championship in the past decade. Many observers have criticised this dominance by a select few and indeed the GAA, the players' union, and media analysts have all proposed structural reforms to address the imbalance (e.g. GAA, 2016; McGuinness, 2015). Our analysis suggests that hurling and Gaelic football could develop more balanced competition if more important matches are played on neutral grounds. While there is an established tradition of this in Gaelic games, there is significant room to expand the use of neutral venues further. Indeed, recent reforms to the Gaelic football championship designate one-in-three final group-stage games to be played at a neutral venue. This will not eliminate the effects of differences in coaching and player pools or structural imbalances in resources, but may help diminish the compounding effect of home advantage on top of these more systemic issues.

With regard to other countries and codes, single-elimination competitions are ripe for more systematic use of neutral venues to enhance opportunities for underdogs. As a recent cross-national analysis has shown (Pollard, Prieto, & Gómez, 2017), indoor sports are associated with larger home advantages while certain states are outliers in the scale of the home advantage across multiple sports. In contexts with single-game knock-out matches, consideration should be given to a move towards hosting more major games at neutral venues. Overall, our results show that the effects of neutral venues in diminishing the favourite's likelihood of victory are quite robust across distinct sporting codes, levels of competition, associated stakes, incentives, and over a decade of results with no substantively or statistically significant difference year-to-year. In certain contexts, neutral venues appear to be an under-utilised option for those interested in fostering more competitive balance in a given sport.

Notes

1. The best (if still imperfect) analogy here is likely "wildcard" games in American sports.
2. In this case, the most relevant comparison are regional conference games in NFL albeit in most cases the provincial matches in Gaelic Games are typically knockout rather than round-robin with some exceptions.
3. The R statistical software (version 3.5.0) was used for all analyses. For the data analyses, regression models and visualisation we used the following R packages: cem (Iacus, King, & Porro, 2018), dplyr (Wickham et al., 2018), effects (Fox, 2003), ggplot2 (Wickham, 2016), lme4 (Bates et al., 2015) and nnet (Venables & Ripley, 2002).

Disclosure statement

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ORCID

Liam Kneafsey ⬤ http://orcid.org/0000-0002-9259-8542
Stefan Müller ⬤ http://orcid.org/0000-0002-6315-4125

References

Almeida, C. H., & Volossovitch, A. (2017). Home advantage in Portuguese football: Effects of level of competition and mid-term trends. *International Journal of Performance Analysis in Sport*, 17(3), 244–255.

Barnett, V., & Hilditch, S. (1993). The effect of an artificial pitch surface on home team performance in football (soccer). Journal of the Royal Statistical Society. Series A (Statistics in Society), 156(1), 39–50.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1), 1–48.

Brambor, T., Clark, W. R., & Golder, M. (2006). Understanding interaction models: Improving empirical analyses. *Political Analysis*, 14(1), 63–82.

Carroll, R., & Collins, K. (2012). An examination of home-field advantage in Gaelic football 2001–2010. In *Proceedings of the 17th Annual Congress of the European College of Sport Science*, 4–7 July, *Bruges*.

Carron, A. V., Loughead, T. M., & Bray, S. R. (2005). The home advantage in sport competitions: Courneya and Carron's (1992) conceptual framework a decade later. *Journal of Sports Sciences*, 23(4), 395–407.

Caudill, S. B., & Mixon, F. G., Jr. (2007). Stadium size, ticket allotments and home field advantage in college football. *The Social Science Journal*, 44(4), 751–759.

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

CSO (2015). *QNHS sport and physical exercise*. http://www.cso.ie/en/releasesandpublications/er/q-sp/qsp2013q02/.

Da Silva C., D., Braga, C. P., & Pollard, R. (2018). The effect on home advantage when a team changes from grass to artificial turf: A worldwide study in professional football. *International Journal of Performance Analysis in Sport*, *12*(2), 1–8.

Efron, B., & Tibshirani, R. (1986). Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. *Statistical Science*, *1*(1), 54–77.

Elo, A. E. (1978). *The rating of chess players: Past and present*. Arco: Ishi Press.

Fox, J. (2003). Effect displays in R for generalised linear models. *Journal of Statistical Software*, *8*(15), 1–27.

GAA (2016). *Proposal on a Revised Format of the All-Ireland Senior Football Championship: 2018 and Beyond*, Dublin.

Gelman, A., & Hill, J. (2007). *Data analysis using regression and multilevel/hierarchical models*. Cambridge: Cambridge University Press.

Goumas, C. (2013). Modelling home advantage in sport: A new approach. *International Journal of Performance Analysis in Sport*, *13*(2), 428–439.

Goumas, C. (2014). Tyranny of distance: Home advantage and travel in international club football. *International Journal of Performance Analysis in Sport*, *14*(1), 1–13.

Iacus, S. M., King, G., & Porro, G. (2012). Causal inference without balance checking: Coarsened exact matching. *Political Analysis*, *20*(1), 1–24.

Iacus, S. M., King, G., & Porro, G. (2018). cem: Coarsened exact matching. R package version 1.1. 2019. https://CRAN.R-project.org/package=cem.

Ireland, S. (2015). *Irish sports monitor: 2015 annual report*. Ipsos MRBI.

Leite, W., & Pollard, R. (2018). International comparison of differences in home advantage between level 1 and level 2 of domestic football leagues. *German Journal of Exercise and Sport Research*, *48*(2), 271–277.

Loughead, T. M., Carron, A. V., Bray, S. R., & Kim, A. J. (2003). Facility familiarity and the home advantage in professional sports. *International Journal of Sport and Exercise Psychology*, *1*(3), 264–274.

Mangan, S., & Collins, K. (2016). A rating system for Gaelic football teams: Factors that influence success. *International Journal of Computer Science in Sport*, *15*(2), 78–90.

McGuinness, J. (2015). How I would reinvigorate football championship. *The Irish Times*, Jun 9, 2015. https://www.irishtimes.com/sport/gaelic-games/jim-mcguinness-how-i-would-reinvigorate-football-championship-1.2241993.

Moran, S., 2007. GAA's real genius is in local identity. *The Irish Times*, Oct 3, 2007. https://www.irishtimes.com/sport/gaa-s-real-genius-is-in-local-identity-1.969062.

Neave, N., & Wolfson, S. (2003). Testosterone, territoriality, and the 'home advantage'. *Psychology & Behavior*, *78*(2), 269–275.

Nichols, M. (2014). The impact of visiting team travel on game outcome and biases in NFL betting markets. *Journal of Sports Economics*, *15*(1), 78–96.

Pollard, R. (1986). Home advantage in soccer: A retrospective analysis. *Journal of Sports Sciences*, *4*(3), 237–248.

Pollard, R. (2008). Home advantage in football: A current review of an unsolved puzzle. *The Open Sports Sciences Journal*, *1*(1), 12–14.

Pollard, R., & Armatas, V. (2017). Factors affecting home advantage in football World Cup qualification. *International Journal of Performance Analysis in Sport*, *17*(1–2), 121–135.

Pollard, R., & Pollard, G. (2005). Home advantage in soccer: A review of its existence and causes. *International Journal of Soccer and Science*, *3*(1), 28–44.

Pollard, R., Prieto, J., & Gómez, M. A. (2017). Global difference in home advantage by country, sport and sex. *International Journal of Performance Analysis in Sport*, *17*(4), 586–599.

Pollard, R., Silva, C. D., & Medeiros, N. C. (2008). Home advantage in football in Brazil: Differences between teams and the effects of distance traveled. *Revista Brasileira De Futebol (The Brazilian Journal of Soccer Science)*, *1*(1), 3–10.

Ponzo, M., & Scoppa, V. (2018). Does the home advantage depend on crowd support? evidence from same-stadium derbies. *Journal of Sports Economics*, *19*(4), 562–582.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing: Vienna. https://www.R-project.org/

Reilly, G. (2018a). GAA Elo Ratings – Football. https://goo.gl/KgGpXx

Reilly, G. (2018b). *GAA Elo Ratings – Hurling.* https://goo.gl/MUL9Vi.

Reilly, T., & Collins, K. (2008). Science and the Gaelic sports: Gaelic football and hurling. *European Journal of Sports Science*, *8*(5), 231–240.

Rouse, P. (2016). GAA is a connection to home that spans several centuries. *Irish Examiner*, Aug 3, 2016. https://www.irishexaminer.com/sport/columnists/paul-rouse/gaa-is-a-connection-to-home-that-spans-several-centuries-415467.html.

Staufenbiel, K., Riedl, D., & Strauss, B. (2018). Learning to be advantaged: The development of home advantage in high-level youth soccer. *International Journal of Sport and Exercise Psychology*, *16*(1), 36–50.

Sutter, M., & Kocher, M. G. (2004). Favoritism of agents: The case of referees' home bias. *Journal of Economic Psychology*, *25*(4), 461–469.

Trombley, M. J. (2016). Does artificial grass affect the competitive balance in major league soccer? *Journal of Sports Analytics*, *2*(2), 73–87.

Van de Ven, N. (2011). Supporters are not necessary for the home advantage: Evidence from same-stadium derbies and games without an audience. *Journal of Applied Social Psychology*, *41*(12), 2785–2792.

Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with S.* 4th. New York: Springer.

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis.* New York: Springer.

Wickham, H., François, R., Henry, L., & Müller, K. (2018). dplyr: A grammar of data manipulation. R package version 0.7.6. https://CRAN.R-project.org/package=dplyr.

Wolfson, S., Wakelin, D., & Lewis, M. (2005). Football supporters' perceptions of their role in the home advantages. *Journal of Sports Sciences*, *23*(4), 365–374.