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Sequential Decisions and Compensatory Tendencies: Evidence from Camogie

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Abstract: Research on the decision-making of officials in Gaelic Games is sparse and limited to the male game. This paper goes a small way to addressing this gap by examining referee decisions to award frees in the game of camogie, the female version of the game of hurling. It is hypothesised that these decisions are biased toward the team behind on the scoreboard and behind on the cumulative difference in frees awarded. Using data from 136 camogie games across eight seasons, and a series of probit estimations, we find evidence of the presence of such compensatory tendencies. We also find that home bias is not an underlying explanation for the presence of these compensatory tendencies. These findings are consistent with previous research on hurling. This paper advances the analysis by conducting a similar investigation on sideline awards by sideline officials as a benchmark for comparison. These results show no statistical relationship between the award of sidelines and the scoreboard. This comparison strengthens that case that the discretionary nature of the decision to award frees by the referee is the channel through which the compensatory tendencies operate. These decisions are rationalised on the basis that referees in camogie prioritise game-management over accuracy.

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I INTRODUCTION

Twenty-first century literature suggests that there is evidence of bias in the judgements of individuals in financial, legal, health, and sport settings (Kahneman *et al*., 2021). Two of these biases might be termed compensating tendencies. One arises where there is a tendency to compensate for previous decisions in sequential decision-making, e.g. an excessive negative correlation in the judgements of loan officers, asylum judges and sports officials (Chen *et al.*, 2016). The second arises where there is a tendency to compensate the weaker party in a legal or sporting contest. Niblett *et al*. (2010) provide evidence that judges favour the litigants with less financial resources in particular settings. The evidence is more comprehensive using data from sporting contests, including examples from baseball (Moskowitz and Wertheim, 2011), basketball (Price *et al.*, 2012), hurling (Considine *et al.*, 2024), soccer (Butler and Butler, 2017) and water polo (Graham and Mayberry, 2016).[1]

The purpose of this paper is to test if there is a bias in the decisions made by referees in camogie, an Irish team sport played by women.[2] Specifically, the paper examines if there is a tendency for camogie referees to award more frees in favour of the team behind on the scoreboard and behind on the cumulative difference in frees awarded, i.e. the free count. This paper follows the approach used by Considine *et al.* (2024) in their study of hurling referee decisions. However, it extends the analysis in several ways. First, the paper puts forward a novel method of benchmarking the potential compensating tendencies displayed by referees by extending the analysis to the decisions of sideline officials. Sideline officials in camogie (and other Gaelic field sports) award free ground shots against the team that put the ball out of play. The free ground shot is awarded at the point where the ball exited the field of play. Sideline officials therefore make decisions about ball location rather than player behaviour – decisions which are somewhat similar to umpires in baseball or cricket. They have a less complicated task and one that has less discretion than the referee. Differences in the instances of free shots awarded by the referee and sidelines awarded by the sideline official could therefore be considered a measure of discretion, within which we hypothesise the compensating tendency to operate. Put another way, there is less scope for biases to operate from the point of view of sideline officials, and this should be present in the empirical results.

[1] The advantages of using a sports setting are that 'studying sport is a great idea, because people make many decisions that matter enormously to them under standard conditions' (Kahneman, 2008). '..it eliminates any possible scepticism about applying behavioural insights obtained in a laboratory to real-life situations [and] at each point in time, the contestants have complete information about their relative position, which is useful in case of strategic allocation of efforts' (Bar-Eli e*t al.*, 2020).

[2] Camogie is almost identical to its male counterpart – hurling – being played on the same field with equivalent equipment and under the same basic set of playing rules. See https://camogie.ie/.

Second, it is the first paper to test for compensating tendencies in female Gaelic Games using a unique dataset on decisions by officials in the sport. Moreover, to the authors' knowledge, this is the first paper to test for compensating tendencies in any female sport. Given the substantial increase in attendance, viewership, and commercial interest in recent years, research on any aspect of female sports can be said to be justified. Another justification is to examine potential gender differences in the decisions by officials in male and female sports, based on the view that males tend to be more competitive while females are more cooperative. But there is limited research on whether this affects officials' judgements in sporting contests. Sandberg (2018) is one exception. This paper uses data from equestrian dressage where males and females compete on an equal basis. The author finds that the judges were not biased based on gender, but rather on nationality, which included both their own and other judges in the competition. Further research to complement and extend this study is warranted, with a focus in this paper on the presence of compensating tendencies (which Sandberg, 2018, did not examine *per se*) in the female game of camogie, which can then be compared with the presence of compensating tendencies in the male game, based on previous research.

Finally, Considine *et al.* (2024) examined whether the hypothesised compensating tendencies reflect an underlying home team bias, but this was based on a subset of just 39 hurling games played on a home and away basis. This study provides a more comprehensive examination of this hypothesis using a bigger sample of 99 camogie games. Home team advantage is a well-researched topic (see Dohmen and Sauermann, 2016 and Leitner *et al.*, 2023 for reviews; and Dagaev *et al.*, 2024 for a recent application), with most research suggesting that referee biases are one of the reasons why home advantage occurs (Boyko *et al*., 2007; Ponzo and Scoppa, 2018; Dawson *et al.*, 2020). Few studies have in contrast found cognitive biases on the part of the referee to be independent of one of the teams playing at their home venue.

The next section presents an overview of the literature on compensating tendencies by sports officials. This is followed by sections on data, methods and results. The paper finishes with a discussion of the results and a rationalisation of the compensating tendencies.

II LITERATURE ON COMPENSATING TENDENCIES IN SPORTS OFFICIATING

A compensating tendency is a bias where there is a systematic deviation in the errors of those making a judgement. Establishing a compensating tendency requires measurement of the error. The organisation of the material in this section reflects the fact that the measurement and classification of decisions by sports officials is heavily influenced by the rules of the particular sport and the extent to which the organisation monitors and evaluates the decisions of its sports officials. The rules

of some team sports produce natural field experimental settings where it is easier to identify potential compensating tendencies in the decisions of officials. Baseball and cricket are exemplars because most of the decisions are about the position or trajectory of the ball, where player behaviour is almost entirely absent. For somewhat related reasons, baseball and cricket are also exemplars for the way the decisions of their sports officials are evaluated. Both sports have introduced ball-tracking technology that has made it possible to evaluate every decision directly.

2.1 Compensating Tendencies in Human Judgement of Ball Location

Compensating tendencies have been found in both of these sports. Moskowitz and Wertheim (2011) examine how 1.15 million Major League Baseball pitches were called. Using ball tracking technology, they establish the validity of every decision. The base error rate was 14.4 per cent. They then show a range of systematic statistical deviations from this error rate, including two compensating tendencies of interest in this paper. One compensating tendency arises where they find that the errors made by umpires favour the player behind in the count. The second compensating tendency is where umpires are more likely to make errors in favour of a team that had a number of recent calls go against them. This second compensating tendency is similar to a decision-making pattern known as the Gambler's Fallacy where decision-makers make errors that are negatively correlated with previous outcomes. Chen *et al.* (2016) also find evidence for the Gambler's Fallacy in the decisions of baseball umpires, in addition to the decisions of asylum judges and loan officers.

Technology was introduced in baseball as a method of monitoring umpire decisions. It was not introduced as a method of overruling umpire decisions. Cricket is different. While there are limits on the use of technology in cricket, it is used to confirm or overturn on-field decisions. Umpire errors in cricket can be immediately evaluated by a match referee who has the aid of technology. However, there are more complications in evaluating these decisions than the baseball ball/strike decision. This is because the ball is allowed to hit the ground on its way to the wicket target and may have 'nicked' the bat or batter on the way to the gloves of a defender. Adie *et al.* (2020) find that cricket umpires err towards not ending a player's time at the crease in Leg-Before-Wicket (LBW) calls. This type of error is similar to baseball umpires erring in favour of the player behind in the count. Improving accuracy by the introduction of technology should reduce compensating tendencies. This seems to be confirmed by Shivakumar (2018) who finds that the introduction of technology to cricket has diminished the traditional benefit of the doubt given to batsmen.[3]

[3] Shivakumar's finding is similar to Dawson *et al.* (2020) for the introduction of Television Match Officials in Rugby Union. They find that technology has increased the number of yellow cards given to away teams. They suggest that the finding might be explained as a previous tendency by on-field referees to compensate for potential home bias.

The neatness of the baseball[4] and cricket settings suggests that the default hypothesis for other games should be that compensating tendencies exist and that they can be attributed to the officials. This is an important point because the task of identifying compensating tendencies in other sports is more complicated. Baseball and cricket facilitate the identification of errors by sports officials by the nature of the rules and the methods by which decisions are monitored and evaluated. The discrete nature of each decision on ball location and use of technology distinguishes these games from many others. In addition, the nature of the competitive interaction in baseball and cricket tends to be limited to two players from opposing teams in a relatively small geographic location. In many other popular team sports, ball location decisions are of secondary importance as compared to contact between players. These decisions are not articulated in the way that a baseball pitch is declared a ball or a strike. The default decision is a non-call that is more continuous rather than discrete. These complications mean that it can be more difficult for the sports official to arrive at their decisions, and it can be more difficult for sporting organisation (or researcher) to evaluate the correctness of the decision. These difficulties partly explain the more limited use of technology for monitoring, evaluating and overturning decisions in other sports.

2.2 Errors in Rule Application as Identified by Governing Body Experts

The United States National Basketball Association (NBA) provides post-game analysis of the calls of the officials. Published from 2015, these Last Two-Minute (L2M) reports are limited to the last two minutes of a game. Using recorded footage of each game, these reports cast an expert opinion on every call, and many non-calls.[5] Using these L2M reports, Gong (2022) examines four different types of foul call and non-calls. The purpose of distinguishing between personal, shooting, offensive fouls, and loose ball fouls is that there is a different level of referee discretion attached to each call. Contrary to previous studies, they find only partial evidence of home team bias with referees more likely to miss just one type of call (loose ball fouls) on home teams than away teams. In addition to this, they find some evidence to suggest that there is a relationship between the level of officiating and the score differential, with a reduced likelihood of missed shooting foul calls as the home team lead increases.

Last Two-Minute reports provide a type of evaluation not available in most sports. The reports are issued by the governing body based on expert evaluation of decisions. The reports identify errors in non-calls, i.e. situations where officials should have penalised competitors for a breach of rule but did not do so. Prior to

[4] Although the complicated in-field fly rule in baseball has sparked some discussion by legal scholars, e.g. Wasserman (2018).

[5] Unlike baseball and cricket, there are many non-calls in other sports. The difficulty in classifying these non-calls is explained by Pelechrinis (2023) when they say '[i]n theory, every second in the game with no violation is a CNC [correct non-call]'.

the availability of Last Two-Minute reports, biases in the decisions of basketball officials were inferred from differences in the pattern of fouls called (no data are available on non-calls). Using data from college basketball, Noecker and Roback (2012) distinguish between three types of fouls, i.e. offensive, personal, and shooting.[6] They argue that offensive fouls are hardest to call and therefore allow the referee greater discretion. Their results are similar to the baseball results reported earlier. The rate at which fouls are called, on the away team, diminishes as the lead of the home team increases and there is a tendency to compensate for teams that are behind in the foul count. Similar findings are found in Price *et al.* (2012) based on foul calls in play-by-play data for full games from five seasons of NBA. Rather than compare between different foul types, they compare the rate at which the referee decides the ball must be turned over (mainly traveling violations and offensive fouls) with the rate of turnover by players (mainly bad passes and lost balls). They find that NBA referees favoured the team behind on the scoreboard. They also find a compensating tendency in favour of the team behind in a playoff series. They group all these biases under the term pro-league bias and attribute them to the officials rather than changes in player behaviour.

2.3 Compensating Tendencies as Identified by Differences in Statistical Distributions

The ball location errors in bat and ball sports, plus the errors in rule application identified in Last Two-Minute reports, are done on a case-by-case basis. Each decision is evaluated on its own merits. Bias is then determined by correlation between these errors and non-rule factors such as the location of the contest, i.e. home bias. The identification of errors in individual decisions is the exception rather than the norm. The more usual situation is to compare two statistical distributions.

The most widely cited paper on compensating tendencies in soccer compares decisions to award a given number of penalties in a game with an expected (Poisson) statistical distribution, rather than from a distribution of other decisions from the data (Schwarz, 2011). Using every penalty award from over four decades of Bundesliga games, Schwarz (2011) presents evidence that referees are more likely to give the same number of penalties to both sides than would occur by chance. In addition to showing evidence of compensating tendencies in soccer referees, Schwarz made explicit the assumption that fouls in the penalty area tend to be random events. Departure from this naturally occurring sequence of events is treated as evidence of bias. By contrast, Plessner and Betsch (2001) experimented with the natural sequence of decisions in Bundesliga penalty awards to test if there is sequential bias in decision-making. Participants were presented with different sequences of the same recorded incidents from soccer games. The authors found

[6] Noecker and Roback (2012) used two seasons of data from college basketball. One of these seasons had been the subject of analysis by Anderson and Pierce (2009) who did not distinguish between foul types.

evidence of negative correlation in the sequence of decisions where it seems that participants compensate for earlier decisions. In a subsequent comment on the paper in the same journal, Mascarenhas *et al.* (2002) complained about the artificial lab-based setting of Plessner and Betsch (2001).[7] One could argue that these methodological complaints are addressed by Schwarz (2011) based on four decades of Bundesliga penalty awards that supported the findings in Plessner and Betsch (2001). This underlines the argument that compensating tendencies exist both in the lab and on the field.

Evidence of compensating tendencies has also been found in Gaelic Games. Using data on 1,883 free shot awards by referees across all 75 senior inter-county hurling championship games between 2016 and 2018, Considine *et al.* (2024) find that the team behind on the scoreboard is more likely to be awarded the next free shot and that the likelihood increases the bigger the score margin at the time. They also find that a team that is behind in the free count is likely to be awarded the next free. This was the first dynamic analysis of in-game decisions by referees in hurling where the state of the scoreboard and the free count is examined at the time that the free shot was awarded by the referee. Game level, rather than in-game, analysis is conducted in O'Brien *et al.* (2021). The authors examine game outcomes for a different, but overlapping, three-year period to Considine *et al.* (2024), based on 68 games in the years 2018 to 2020. They find that teams that are behind on the scoreboard at the end of the game (losers) foul less often than winners. This is not inconsistent with Considine *et al.* (2024).

O'Brien *et al.* (2021) are primarily concerned with team and player performance outcomes, for example shooting efficiency. As a result, the referees' decisions to award free shots is presumed to be a true reflection of the decisions of the players. Referee discretion is assumed not to exist. Considine and Eakins (2024) argue that such an assumption is more appropriate to the decisions of sideline officials rather than referees in hurling. However, they do not test for differences in statistical significance in the decisions of referees and sideline officials. This paper tests this hypothesis using camogie data.

2.4 Potential Motivations for Compensating Tendencies

There is a variety of reasons why officials might exhibit compensating tendencies. A rational choice perspective would suggest that the employee is likely to err in the direction of their employer. Posner (2008) suggests these forces are at play in the legal system. Price *et al*. (2012) called the biases they found in basketball 'pro-league' biases rather than compensating tendencies. A related motivation is one that seeks to minimise the cost of errors when making decisions under uncertainty. This decision theoretic approach was most famously applied to judgements in the antitrust setting by Easterbrook (1984) and has been applied to sport by other legal

[7] Plessner and Betsch (2002) is a response to Mascarenhas *et al.* (2002).

scholars, e.g. Berman (2011). Consider a knockout camogie game in the All-Ireland where time is almost up, there is one point between the teams, and a player on the losing team is possibly being illegally stripped of possession within shooting distance. There are two errors that the referee could make. One involves incorrectly awarding a free. The other involves incorrectly not giving a free. The latter one is likely to cost the losing team the game immediately. The former is unlikely to immediately result in the team ahead losing the game. The idea is best captured in the maxim of the jurist William Blackstone who said it is better to allow nine guilty individuals go free than send one innocent person to the gallows (Blackstone, 1893).

There is also a Rawlsian philosophical motivation for compensating tendencies. The philosopher John Rawls used 'a veil of uncertainty' as a way of thinking about distributive justice. Again, consider the scenario of the decision to be made in the dying moments of a knockout All-Ireland camogie game. In addition, suppose that participants are uncertain as to the team that they would find themselves on in this situation. What type of an error would people wish the referee to make? Rawls suggested that they would prefer the referee to err on the side of the weaker party.

2.5 Compensating Tendencies in Female Sport

As previously mentioned, there is sparse evidence on decision-making in games with female contestants/referees and there is none on compensating tendencies in female sport or by female officials. Sandberg (2018) is one exception. Using data from equestrian dressage where there are both male and female judges as well as male and female competitors, the author examines whether there is an in-group gender bias, that is female judges favouring female competitors and vice versa. The author does not find evidence to support this form of in-group bias and instead finds evidence to suggest favouritism toward a competitor of the same nationality.

Although evidence of referee bias in female sports may be sparse, that is not to say that there is not a perception of referee bias in camogie. Anecdotal evidence comes from All-Ireland medal winner and author Eimear Ryan, who suggests that camogie referees are biased towards favoured teams. In her book *The Grass Ceiling: On being a woman in sport*, Ryan says the following of a game she played in:

> *I remember they got a couple of soft frees in the second half of extra time. Tapped them over. I resented the ref for granting those placed balls to them, the team that were supposed to win. It happens all the time.* (Ryan, 2023: 106).

While this paper does not test for favouritism bias due to lack of data, the suggestion is that referee biases are likely to exist in female games in the same manner as they appear in male games.

III DATA AND METHODS

3.1 Data

The data in this paper are based on information collected by one of the authors in his role as data analyst for a senior inter-county camogie team. Information on free shots awarded and scoreboard at the time, for a total of 136 games across eight seasons between 2014 and 2021, is available. It includes games in the All-Ireland Camogie Senior Championship (81), the National Camogie League Division 1 (43) and the Munster Camogie Senior Championship (12). The sample of 136 games comprises approximately a third of the total number of games played in these three competitions across the 2014 to 2021 seasons.[8] For a subset of the sample of 136 games, 80 in total, the sideline shots awarded by the sideline officials and scoreboard at the time was recorded. This dataset is novel and facilitates a unique examination of compensating tendencies in a new context. Summary statistics for free shot and sideline awards is provided in Table 1.

Of the total of 3,869 free shot awards by referees, 50.4 per cent were awarded to the team behind on the scoreboard when the free was awarded. This is 12.8 per cent larger than the number awarded to the team ahead on the scoreboard at the time the free was awarded. In each of the eight years between 2014 and 2021, the team behind on the scoreboard at the time of the award got more frees than the team ahead. The gap was never less than 10 per cent.

Sideline shots (which comprise a free ground shot at the point where the ball exits the field of play) are awarded against the team that put the ball out of play. The sideline official's decision involves ball placement (i.e. did the ball leave the area of play?) and determination of the team that last touched the ball. There is less discretion in these calls. Not surprisingly, the gap between the award of sideline shots to teams ahead and behind on the scoreboard is much smaller when compared to the award of free shots by the referee. Of the total of 907 sidelines, 46.4 per cent were awarded to the team behind on the scoreboard when the sideline was awarded. This is 4.7 per cent larger than the number awarded to the team ahead on the scoreboard at the time the sideline was awarded. Only in four of the seven years between 2015 and 2021 did the team behind on the scoreboard at the time of the award get more sidelines than the team ahead.

Our dataset includes games officiated by both males and females. However, the vast majority (89.7 per cent) are officiated by a male referee. Moreover, the 10.3 per cent of the games refereed by a female are, in fact, the same female. Thus, an analysis of gender differences based on the official making the judgment (similar to Sandberg, 2018) cannot be carried out, as any estimation could be attributed to the individual rather than to all female referees. We can however compare the results

[8] The county teams involved (and number of games) are as follows: Clare (14), Cork (87), Derry (1), Down (1), Dublin (9), Galway (32), Kilkenny (33), Limerick (21), Meath (1), Offaly (11), Tipperary (24), Waterford (15), Westmeath (3), Wexford (20).

Table 1: Summary Statistics, Free Shots and Sidelines Awarded in Camogie Games

	All Seasons	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Number of Games	136	13	17	16	13	12	23	21	21
Total Free Shots	3,869	341	506	453	369	337	638	642	583
(Average per game)	(28.4)	(26.2)	(29.8)	(28.3)	(28.4)	(28.1)	(27.7)	(30.6)	(27.8)
To teams when tied	466	50	80	57	34	35	89	62	59
(%)	(12.0%)	(14.7%)	(15.8%)	(12.6%)	(9.2%)	(10.4%)	(13.9%)	(9.7%)	(10.1%)
To team ahead	1,454	127	188	155	144	134	233	255	218
(%)	(37.6%)	(37.2%)	(37.2%)	(34.2%)	(39.0%)	(39.8%)	(36.5%)	(39.7%)	(37.4%)
To team behind	1,949	164	238	241	191	168	316	325	306
(%)	(50.4%)	(48.1%)	(47.0%)	(53.2%)	(51.8%)	(49.9%)	(49.5%)	(50.6%)	(52.5%)
Subset of Games with Sideline Data:									
Number of Games	80	–	12	15	13	9	6	7	18
Total sidelines	907	–	149	170	131	117	63	74	203
(average per game)	(11.3)		(12.4)	(11.3)	(10.1)	(13.0)	(10.5)	(10.6)	(11.3)
To teams when tied	108	–	27	26	8	7	6	16	18
(%)	(11.9%)		(18.1%)	(15.3%)	(6.1%)	(6.0%)	(9.5%)	(21.6%)	(8.9%)
To team ahead	378	–	48	64	68	62	29	24	83
(%)	(41.7%)		(32.2%)	(37.6%)	(51.9%)	(53.0%)	(46.0%)	(32.4%)	(40.9%)
To team behind	421	–	74	80	55	48	28	34	102
(%)	(46.4%)		(49.7%)	(47.1%)	(42.0%)	(41.0%)	(44.4%)	(45.9%)	(50.2%)

Source: Authors' own analysis of dataset.

in this paper with previous research on the male version of the game (Considine *et al.*, 2024) as all the games in that paper were officiated by male referees.

Almost three-quarters of the games (99 out of 136) are played at non-neutral or 'home' venues i.e. a venue which is located in either of the counties playing in the game. Previous research has examined whether games played at non-neutral venues display compensating tendencies in favour of the home team only (Considine *et al.*, 2024) but this was based on a smaller sample size of just 39 games played in the All-Ireland Senior Hurling Championship. Thus, a larger sample can provide more robust evidence for any potential home team bias. Additionally, much of the research on home team bias uses data from games played by males, with games played by females – and the potential for home team bias within – an understudied research area.

3.2 Method

The econometric methodology follows Considine *et al.* (2024) which in turn follows work by Anderson and Pierce (2009) and Noecker and Roback (2012). The unit of observation is instances of a free shot being awarded during a game. Equation 1 shows the basic probit model which relates the probability of one team being awarded a free shot to the score differential at the time.

$$\Pr(FreeTeamA) = \beta_0 + \beta_1 TeamABehind + \gamma \text{Controls} \quad (1)$$

where *FreeTeamA* is a binary indicator variable equal to 1 if Team A is awarded a free shot and 0 if the other team (Team B) is awarded the free shot. The *TeamABehind* variable is also binary variable equal to 1 if Team A is behind on the scoreboard and 0 if they are level or ahead on the scoreboard, at the time the free shot is awarded. Controls, in the form of dummy variables, are added to account for referee effects, venue effects, year effects, team effects and competition effects.[9]

This model therefore captures in-game dynamics, that is how referee decisions (and specifically which team to award the next free to) change as the scoreboard changes. This contrasts with much of the previous research in this area which examines official decisions at an aggregate game level (e.g. Ponzo and Scoppa, 2018; Dawson *et al.*, 2020). Some previous research has examined referee decisions using in-game minute-by-minute data (Buraimo *et al.*, 2010; 2012; Albanese *et al.*, 2020), but minute-by-minute data are not available in our dataset. And similar to previous research (Noecker and Roback, 2012; Price *et al.*, 2012), our data only examine free shots calls made by referees and do not examine free shots non-calls made by referees.

[9] There are 22 different referees, 42 different venues, 8 different years, 14 different county teams and 3 different competitions in the dataset.

In Equation 1 and subsequent models, Team A is determined alphabetically (A–Z). The advantage of such an approach is that the choice of Team A is independent of in-game decisions and overall match outcomes. The robustness of this specification can be examined by estimating all of the models using Team B as the dependent variable of interest i.e. alphabetically but in reverse, Z–A. Previous studies have characterised Team A and Team B on a Home-Away basis (Anderson and Pierce, 2009; Noecker and Roback, 2012; Buraimo *et al.*, 2010; 2012) but a proportion of matches in our dataset are played at neutral venues (although home bias is examined later using a sub-sample of non-neutral games). Other studies have used a measure of team strength (e.g. Elo ratings, see Kneafsey and Müller, 2018) or favouritism status as measured by betting odds (Buraimo *et al.*, 2010) but none of these data are available for camogie. The paucity of data highlights the lack of research on female sports in general. This research paper goes some way to address this and in turn, also acts as a call for more data collection and research on female sports.

Equation 1 examines the simple compensating tendency hypothesis that being behind on the scoreboard increases the probability of being awarded the next free. A further hypothesis that could be examined is whether this effect (if present) differs by the actual margin which Team A is behind by. The estimation model in this instance is given below where each variable is a binary variable based on the size of the margin at the time the free is awarded. These values were chosen based on the scoring rules in camogie and particularly the fact that a goal is worth three points. One might expect that a bigger margin will have a greater positive effect on the probability of a team being awarded the next free relative to a smaller margin.

$$\begin{aligned}\Pr(FreeTeamA) = {} & \beta_0 + \beta_1 TeamABehind\_1ptto3pt + \\ & + \beta_2 TeamABehind\_4ptto6pt \\ & + \beta_3 TeamABehind\_7pt + \gamma \text{Controls}\end{aligned} \tag{2}$$

The basic models given in Equations 1 and 2 can be extended to include other variables that capture evidence of additional compensating tendencies. The literature on baseball and basketball cited previously suggests that the cumulative net difference in frees awarded, i.e. the net free count, between the two teams prior to the next free could be a significant explanatory variable (*NetFreesTeamA*). Including this variable can test for whether there is a tendency of referees to compensate on the number of frees awarded over the course of a game, independent of whether the team is behind on the scoreboard or not.

$$\begin{aligned}\Pr(FreeTeamA) = {} & \beta_0 + \beta_1 TeamABehind \\ & + \beta_2 NetFreesTeamA + \gamma \text{Controls}\end{aligned} \tag{3}$$

$$\begin{aligned}\Pr(FreeTeamA) = {} & \beta_0 + \beta_1 TeamABehind\_1ptto3pt \\ & + \beta_2 TeamABehind\_4ptto6pt + \beta_3 TeamABehind\_7pt \\ & + \beta_4 NetFreesTeamA + \gamma \text{Controls}\end{aligned} \tag{4}$$

The results from Equations 1 to 4 cover the primary objective of the paper of identifying the presence of compensatory tendencies in referee decisions in camogie. A second objective is to propose and carry out a test which supports the reasoning that the attribution channel for the compensatory tendencies originates from the referee. The logic for this test follows from previous research using data on officials' decisions in basketball by Noecker and Roback, 2012, Price *et al.*, 2012 and Gong, 2022. In each study, the authors parse the foul data by the extent to which the referees have discretion over a decision. Decisions with more discretion are found to be more likely to be subject to biases, i.e. favouring teams behind on the scoreboard or favouring home teams. In short, the literature suggests that discretion is the channel through which biases occur.

The referee does not specify the type of foul that they are penalising in camogie, so we cannot parse these data. This is a limitation of the study. But as previously described, there are data on the awarding of sidelines by sideline officials when the ball exits the field of play. The gap between the free shots awarded for breaking the rules on foul play (awarded by the referee) and the free ground shots awarded for breaking the rules of fair play (awarded by the sideline official) could be considered a measure of discretion. It is in this gap that this paper hypothesises the compensating tendency to operate. Support for this hypothesis would be found if there were no compensating tendency in the awarding of sidelines relative to the scoreboard.

We examine whether a compensating tendency in the awarding of sidelines relative to the scoreboard by estimating Equations 5 and 6. A test to support our hypothesis would therefore simply be H0: $\beta_1 = 0$.

$$\Pr(SidelineTeamA) = \beta_0 + \beta_1\, TeamABehind + \gamma \text{Controls} \tag{5}$$

$$\Pr(SidelineTeamA) = \beta_0 + \beta_1\, TeamABehind + \beta_2\, NetSidelinesTeamA + \gamma \text{Controls} \tag{6}$$

IV RESULTS

Equations 1 to 6 are estimated using probit models. All the models were estimated using cluster robust standard errors with each match defined as the cluster (Bose *et al.*, 2022). As previously stated, each of the models include sets of dummy variables for the fixed effects of referee, venue, team A, team B, year and competition. Results for these are not reported.

The probit results for referee decisions on free shots are presented in Table 2. The estimates presented are coefficients of the covariates in the probit model linear predictor of F–1(p) where F is the standard normal cumulative distribution function and p is the probability of team A receiving the free shot, when a free shot is awarded by the referee. The results are similar to those for referees in hurling as

presented in Considine *et al.* (2024). In Models 1 and 3, the *TeamABehind* coefficient is positive and significant indicating that when Team A is behind on the scoreboard, the probability of a free awarded to Team A increases. In Models 2 and 4, the probability of a free awarded to Team A increases with the size of the margin between the teams.

Table 2: Econometric Results of Models 1-4: Referee Decisions on Free Shots Awarded

	Model 1	*Model 2*	*Model 3*	*Model 4*
Coefficients:				
TeamABehind	0.398***		0.369***	
TeamABehind_1ptto3pt		0.365***		0.326***
TeamABehind_4ptto6pt		0.403***		0.371***
TeamABehind_7pt+		0.574***		0.596***
NetFreesTeamA			–0.050***	–0.052***
N	3,869	3,869	3,869	3,869
Pseudo R^2	0.0275	0.0280	0.0353	0.0362

Source: Authors' own analysis of dataset.
Notes: ***p-value<0.01, **p-value<0.05, * p-value<0.10. Models also include sets of dummy variables for the fixed effects of referees, venues, years, teams and competitions. Results for these are not reported.

The results for the cumulative difference between the frees awarded to teams in camogie is also similar to those presented in Considine *et al.* (2024). The negative coefficient on *NetFreesTeamA* suggests that the greater the cumulative difference between fouls awarded to Team A versus Team B, the *less likely* Team A will be awarded the next free. This can potentially be read as a 'balancing' in the awarding of frees on the part of the referee.

Models 1 to 4 were also estimated using Team B as the dependent variable of interest and the results were the same in terms of evidence of the same compensating tendencies. Therefore, the ordering of teams (alphabetically in this case) does not matter in determining the presence of the compensating tendencies.

The fact that the results in this study focusing on a female sport are the same as previous research on the male version of the game suggests that gender is not a factor in determining whether compensating tendencies in refereeing decisions are present or not. This to an extent supports the research by Sandberg (2018). Sandberg (2018) also found no evidence to support a gender bias in the decisions made by equestrian dressage judges and went further to say that a nationalistic bias crowded out any gender bias. We believe a similar result occurs here in that the bias to compensate a team behind on the scoreboard or on the free count appears to play a

more important role than gender in influencing the behaviour of camogie/hurling referees.

The probit results for decisions made by the sideline official on free ground shots when the ball exits the pitch are presented in Table 3. Once again, the estimates presented are for coefficients of covariates in the probit model linear predictor of F–1(p) where p is the probability of team A receiving the free ground shot awarded by the sideline official. As expected, fewer of the coefficients are statistically significant compared to those for referee decisions on free shots awarded. In Models 5 and 6 there is no statistical evidence to suggest that sidelines are awarded to the team behind on the scoreboard. This result would support the contention that the channel through which the compensatory tendency to award frees to the team that is behind on the scoreboard operates through the referee, because the referee has discretion in these decisions. This finding supports previous research cited above that carry out a similar analysis (Noecker and Roback, 2012; Price *et al*., 2012; Gong, 2022).

Table 3: Econometric Results of Models 5-6. Sideline Official Decisions on Free Ground Shots Awarded

	Model 5	*Model 6*
Coefficients:		
TeamABehind	0.233	0.261
NetSidelinesTeamA		–0.147***
N	907	907
Pseudo R^2	0.0457	0.0718

Source: Authors' own analysis of dataset.
Notes: ***p-value<0.01, **p-value<0.05, * p-value<0.10. Models also include sets of dummy variables for the fixed effects of referees, venues, years, teams and competitions. Results for these are not reported.

There is a statistically negative correlation between the award of a sideline and the number of previous sidelines awarded in the game up to that point. On the face of it, this might suggest a compensating tendency in the decisions of sideline officials, that is to 'balance up' the awarding of sidelines. But as little to no discretion is allowed in these decisions, this is not a satisfactory interpretation, and an alternative explanation is required. It is possible that with the natural 'ebb and flow', and frequent changing of possession in the game of camogie (and equally in the male equivalent of hurling), it is perhaps not unusual to see the sequence of sidelines awarded to naturally alternate between the two teams over the course of a game. Interestingly, this raises an issue regarding the interpretation of a compensating tendency for net free shots awarded presented in Table 2 and suggested in previous

research (Anderson and Pierce, 2009; Noecker and Roback, 2012; Considine *et al.*, 2024). Whether this is a compensating tendency that can be attributed to the referee or if it is a characteristic of games where possession changes on a routine basis (such as camogie, hurling or indeed basketball) or a combination of both, is a new question which requires further research.

The final objective of this paper is to investigate whether there is a difference in the discovered compensating tendencies in games played at non-neutral venues. More specifically do 'home' teams receive more favourable compensating tendencies than the 'away' team. To examine this question, Equation 3 is estimated using the sub-sample of games played at non-neutral or 'home' venues only. It is estimated with Team A = 'Home' Team and then re-estimated using Team A = 'Away' Team. If a compensating tendency is present which favours the home team over the away team, the coefficients from the two models should be significantly different from each other. Table 4 presents the results from the 'home' team model and the 'away' team model with chi-square test results for the equality of coefficients in both models.

Table 4: Econometric Results of Model 3 on Games played at Non-Neutral Venues

	Team A = 'Home' Team	*Team A = 'Away' Team*	*Chi-square Test of Equality of Coefficients*[1,2]
Coefficients:			
TeamABehind	0.432***	0.430***	χ^2 (1) = 0.00 (p-value=0.9794)
NetFreesTeamA	–0.085***	–0.084***	χ^2 (1) = 0.35 (p-value = 0.5551)
N	2,831	2,831	
Pseudo R^2	0.0424	0.0434	

Source: Authors' own analysis of dataset.

Notes: ***p-value<0.01, **p-value<0.05, * p-value<0.10. Models also include sets of dummy variables for the fixed effects of referees, venues, years, teams and competitions. Results for these are not reported.

[1] H0: β[*TeamABehind*] in 'Home' Team Model = β[*Team ABehind*] in 'Away' Team Model. $\chi^2(1) = 0.00$ (p-value=0.9794) = > Do Reject H0.

[2] H0: β[*NetFreesTeamA*] in 'Home' Team Model = β[*NetFreesTeamA*] in 'Away' Team Model. χ^2 (1) = 0.35 (p-value = 0.5551) = > Do Reject H0.

As can be seen based on the test statistics in the table and associated p-values, we cannot reject the null hypothesis in both cases, implying that the coefficients from the 'home' team model are equal to the coefficients from the 'away' team model.

In effect, the 'home' team and 'away' team models are equivalent. In summary, although compensatory tendencies are present, they are equally present for home and away teams. Thus, there is no evidence of favouritism toward home teams or a home team bias in the context of the compensatory tendencies explored in this study. There may be two reasons for this. First, attendances at camogie games are in the main low, thus crowd effects, which are usually the underlying reason for home advantage, may not be present. Second, a team is designated as being at 'Home' if they play in their own county, but this might not necessarily be in a regular 'Home' stadium. Only three teams out of the 14 in the sample played at one stadium for all of their home matches. The rest therefore played at multiple 'Home' stadia.

V CONCLUSIONS

Using data from 136 games across eight seasons of senior inter-county camogie, this paper investigates whether compensating tendencies are present in the awarding of free shots by referees. It is one of the first to test for the presence of compensating tendencies in a female sport. The results display clear evidence of this bias, a finding which is consistent with compensating tendencies found in the literature for other male sports such as baseball, basketball, water polo and hurling. First, teams that are behind on the scoreboard are more likely to be awarded the next free shot by the referee and the probability of this tendency increases the greater score difference between the sides. Second, teams that are behind on the free count are more likely to be awarded the next free. Notably, the presence of these compensating tendencies is not affected by a potential home team bias. That is, in matches where there is a home team and an away team both receive equal treatment in the extent to which the compensating tendencies occur. Small crowd effects and the use of multiple home stadia may be possible reasons for this finding.

It is possible that player behaviour is responsible for the findings because the referee is making decisions about the relationship between player behaviour and the rules. Unfortunately, the GAA does not produce the equivalent of the NBA's Last Two-Minute reports. Nor are there data on the type of fouls a referee is penalising. However, this paper advances the investigation into this issue by examining decisions from other members of the officiating crew in games, i.e. sideline officials. The majority of player behaviour is removed from the decisions of the sideline officials. They decide if the ball crossed a line and the last player to touch the ball before it crossed the line. There is much less discretion in these calls compared to those of the referee and there is very little room for non-calls. Our findings confirm that there is no relationship between the scoreboard and the awarding of sidelines. While this is a different set of officials, it is the same set of players. It could be interpreted as there being no evidence of players changing their behaviour in respect of fouling the ball out of play depending on the scoreboard.

Although this test helped clarify the channel of attribution, it has raised further questions. In one of the sideline models, a significant relationship between the decision to award sidelines and the net cumulative number of sidelines previously awarded was found. This raises doubts about whether the tendency to favour teams behind on the net free count is a 'true' compensating tendency in the same sense as the decision to award a free to the team behind on the scoreboard. The tendency for frees to balance out over the course of the game, just like sidelines, might also be attributed to other factors such as the nature of play and frequent changes of possession with the game of camogie. Additional research is needed to examine this new question, possibly in sports where there are less frequent 'ebbs and flows'.

Our results suggest that the tendency to compensate teams that are behind on the scoreboard and the net free count is independent of whether the players are male or female. The biases on the part of the referee do not appear to be gender specific. It is possible that the consistency is because the referees are predominantly male. As previously mentioned, our dataset does contain a proportion of games which are refereed by a female, although there is not enough variation to merit a thorough analysis. Future research could test for compensating tendencies on the part of a female referee in a female sport. It may take some time for such an analysis within camogie, however. As researchers we were disappointed to find only one female referee in our dataset. Further investigation revealed that the lack of female referees in camogie is not particular to our dataset. For example, in the 50 years before 2004 all but one of the All-Ireland senior camogie finals was refereed by a female, whereas since that year only one female has taken charge of the final. Our dataset ends in 2021. Things have not changed. The one female referee in our dataset was the only female to referee games in the 2024 season. Some would consider that a bigger concern than the presence of any compensating tendency in the decision of referees.

A final question surrounds the rationalisation of the compensating tendencies identified in this study, particularly as the gender of the participants does not appear to matter. Mascarenhas *et al.* (2002) argues that there is a need to understand the rationale for refereeing decisions and suggests that there are times when game-management priorities trump accuracy. Specific examples, with testimony from the individual referees, are provided in MacMahon and Mildenhall (2012) for basketball and in Considine and Eakins (2024) for hurling. In the latter paper, for example, a referee explained not implementing the rules because he feared that it would subsequently result in overly aggressive behaviour by the players on the penalised team. Game-management provides a rationale as to why compensating tendencies might exist in camogie and hurling, that is, a tendency for referees to keep the contest competitive by giving the benefit of the doubt to teams behind on the scoreboard. Further research could examine the presence of compensating tendencies in sports where referees have less game-management discretion and accuracy in the implementation of the rules is of more importance.

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