How Much of "Home Field Advantage" Comes from the Fans? A Natural Experiment from the COVID-19 Pandemic

Kevin Krieger
Justin L. Davis

Abstract

Home field advantage has been a commonly discussed and researched topic in sports. How much of this advantage is due to the home team's supporters' physical attendance at the game where they might encourage their team, intimidate the opponent, and influence game officials? We utilize the unique natural experiment of the COVID-19 pandemic and consider the case of American professional (NFL) and collegiate (NCAA) football to examine this question. We measure how typical spreads, relative to home teams, changed in the 2020 season compared to their historical levels, and we determine that roughly half of what football fans and analysts consider to be home field advantage emanates from spectators. Generally, the betting market was rather accurate in its predictions of how football game results would change in 2020, during the pandemic. Wagering strategies which were based on possible underappreciation or overcorrection of home field advantage during limited-attendance football games failed.

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Kevin Krieger
University of
West Florida
kevinkrieger@uwf.edu

Justin L. Davis
University of
West Florida
jdavis3@uwf.edu

Introduction

There are advantages to a sports team playing at home (Jamieson, 2010; Gomez, Pollard, & Luis-Pascual, 2011). One advantage is the team's familiarity with the routine of playing a game on its field. Another advantage is the lack of effort, including physical and emotional toll, the home team need expend on traveling to compete. Other advantages come about during the game itself due to the support of the home team's fans. Spectators can encourage some of the players they support, rattle some of the visiting team's players, and even influence some game officials. How much of the "home field advantage" is due to the home team's fans? A small portion? The vast majority? To our knowledge, this is a consideration that has long gone untested empirically. The COVID-19 pandemic has proven to be a global tragedy costing millions of lives and imparting great suffering. The pandemic has also rippled through commerce and impacted supply chains, prices, and human opportunities. However unfortunate, in some cases the pandemic has provided a natural experiment by which to empirically investigate questions that might otherwise prove elusive. Such is the case for the analysis of the true value of home field advantage as it relates to the impact of the home team fans.

Sports leagues and organizations the world over struggled to rebound from the opening, severe portion of the COVID-19 pandemic in 2020. Most leagues pursued initiatives that would enable athletes to compete, while also allowing supporters to enjoy their diversions, and clubs, schools, and leagues to still generate revenue. One mitigation measure to allow the reopening of sports was to conduct games with no, or very few, spectators physically present.

This unexpected dynamic has allowed us to consider how large the spectator contribution to "home field advantage" is, perhaps for the first time, in American football. Our results indicate that roughly half of home field advantage emanates from the spectators' physical presence at contests, leaving the remaining half of the advantage, holistically, to factors like familiarity and travel challenges, etc. Furthermore, we document how successful betting markets were, in American football, at factoring in this home field advantage reduction 'on the fly' in 2020. Generally speaking, the betting markets were quite efficient in recognizing how the traditional home field advantage would be reduced.

Background and Literature Review

Research in the area of sports betting market efficiency has provided a significant amount of evidence suggesting these markets are efficient forecasts of outcomes (Sauer, 1998). A commonly discussed topic in sports wagering markets by bettors has been the idea of home field advantage—the notion that playing at home provides a benefit to the home team. While some findings have been mixed in this line of research (e.g. Gandar, Zuber & Lamb, 2001), the vast majority of research on this topic has confirmed the presence of this advantage. However, to our knowledge studies to date have failed to parse out the underlying causes of this advantage.

Past researchers have drawn general conclusions about the impact of home field advantage, with some researchers identifying simple betting strategies based on this advantage to be effective. For example, researchers have found some successes in strategies such as betting on home team underdogs (Golec and Tamarkin, 1991), betting on home teams in prime time games (Vergin and Sosik, 1999), or betting on home teams when the weather difference between the home team, versus that typically experienced by visiting teams, is vast (Borghesi, 2007). Joly and Dik (2021) examined whether NFL teams located in cold weather environments have an advantage over their opponents during the colder months of the year. And found that this home weather differential did play a significant role in determining game outcomes.

However, each of these studies rests on the general assumption that home field advantage is a simple binary factor (home vs. away). This assumption fails to recognize the distinction between the physical factors contributing to this home field advantage (i.e.

weather, location familiarity, lack of travel, etc.) vs. the influence of intangible factors (i.e. impact of fan participation, crowd noise, nostalgia and/or intimidation of location history or performance, etc.). In addition, the impact of home field advantage has been found to differ based on other factors such as type of sport and/or tier of competition (e.g. Elaad, 2020). In other words, home advantage is comprised of multiple sources and contexts and more nuanced research is necessary to provide more detailed explanations of the advantage's components.

Generally, past research has recognized four factors contributing to home field advantage: crowd, learning, travel, and rule factors. Of these, the crowd factor has been found to be the most dominant and influential factor contributing to home field advantage (Nevill & Holder, 1999). In their study, Nevill and Holder examined provided a review of research examining home field advantage in a variety of settings (regular season, championship games, unbalanced competition, etc.) and concluded that crowd density was a major factor in contributing to home field advantage in the team sports setting. The influence of the crowd density has been attributed to two factors, including their ability to raise the performance of home team players via psychological support, and their ability to influence the decision-making of officials to subconsciously favor the home team (Nevill, Balmer, & Williams, 2002; Balmer, Nevill, Lane, & Ward, 2007). In fact, one study concluded that the impact of the crowd on biasing officials accounts for approximately 40% of the home advantage (Wright & House, 1989).

The dynamic sports climate resulting from the COVID-19 pandemic eliminated (or nearly so) the "crowd" aspect of home field advantage as fans were completely (or in some cases, mostly) removed from live sports contests. The impact of the pandemic was quickly examined in relation to European football (soccer) and baseball (Losak & Sobel, 2021). For example, two studies examining the impact of the elimination of fans at soccer matches in Germany during the pandemic revealed that bookmakers were mispricing games by not fully reflecting the impact of the loss of home crowds, resulting in profitable betting opportunities when wagering on away teams (Deutscher & Winkelmann, 2021; Fischer & Haucap, 2021; Fischer & Haucap, 2020). With similar findings, Meier, Flepp and Franck (2020) found that bookmakers were mispricing home team odds during the first period of host games, providing a short-term profitable betting approach. A separate study examined the impact of empty stadiums on referee decision-making and concluded that removing fans significantly aided the visiting team in European football matches, represented by a significant reduction in the number of yellow cards issued to those visitors (Bryson, Dolton, Schreyer, & Singleton, 2021). By contrast, a study by Hegarty (2021) finds a more efficient market for soccer match wagering amongst a broader study of European leagues.

Data and Methodology

We gather NFL opening and closing line data,[1] along with game scores from thefootballlines.com for the 2007–2020 NFL seasons. We gather NCAA football (Division I-FBS) opening and closing line data, along with game scores from sportsinsights.com for the 2007–2012 NCAA seasons[2] and hand collect such data for the 2013–2020 seasons from covers.com. Our data includes game dates as well as the corresponding "week of season" identifier within each season. We hand collect stadium capacity and attendance data of each game for the 2020 (COVID-19) season for both NFL and NCAA American football contests from the "Gamecast" area of game summaries on espn.com. This approach finds

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[1]"Opening" lines are the initial point spreads bookmakers make available for bettors to use in wagering on a contest. Notably, high competition amongst proficient bettors can make it difficult for most participants to wager at these values. Over time (typically 3–6 days for American football games) betting volume can shift spreads as bookmakers generally seek to move lines so that roughly 50% of wagered funds are on each side of a contest in order to ensure a riskless profit via commission (commonly referred to as "juice" or "vigorish"). Immediately preceding a game the betting line rests at its final, 'closing' value at which presumably any interested bettor could make a wager.

[2]http://www.sportsinsights.com discontinued selling retroactive spread data in Excel format after the 2012 season.

attendance data for all NFL games and approximately 82% of NCAA games. Internet searches for remaining NCAA games in the 2020 season uncovers attendance data for an additional 10% more games. We consider only regular season contests[3] and omit neutral site games from our analysis.[4]

Our initial analysis considers whether the typical spread (or "line") of American football games shifted in 2020 when in-person spectator attendance dramatically fell due to restrictions necessitated by the COVID-19 pandemic.[5] In doing so, we seek to take advantage of a natural experiment to consider how much of a host's traditional "home field advantage" is holistically due to familiarity with the actual field and contest routine relative to the challenges of an opponent's travel, and how much of 'home field advantage' is holistically due to the impact of supportive crowds in encouraging the home team, impacting their opponent, and influencing game officials.[6]

Next, we consider whether the changes seen in betting lines, relative to the home/visiting team in the COVID-19 season were "efficient" (i.e. did the shift in lines by bookmakers, as influenced by bettor perceptions, correctly forecast any reduced home field advantage in the COVID-19 season?). To answer this question, we must consider whether home teams "covered" spreads at the typical rate (approximately 50%) when the handicapping irregularity of the COVID-19 pandemic was thrust upon bookmakers and bettors.

As a brief example to explain the above considerations, take a hypothetical game in which the Chicago Bears host the Minnesota Vikings. In this case, we would first like to understand whether the spread in such a game would be lower without the supposed advantage that Chicago Bears fans in attendance would provide to their team, and if such a spread is lower, by how much? Comparing typical spread levels from pre-pandemic seasons to the 2020 season should help answer this question. Whether any market adjustment in the line due to the lack of fans was of the "correct" or efficient amount requires also considering teams' actual performances relative to the spread. If, for example, the Bears were 3.5-point favorites in a game and won the game by four points or more, Chicago "covered" this spread. If the Bears were to lose such a game, tie it, or win by three or fewer points, then Minnesota would have "covered."[7] Did the rate of covering spreads by home/visiting teams differ from the historical, approximately 50% level during the COVID-19 season?

We conclude our analysis by considering the subsample of NFL games in which intra-divisional opponents play one game at each other's home venue per season. In this analysis we measure the total "gap" of point spreads (both at the opening and closing lines) when each of the two intra-divisional opponents hosts same-season NFL regular season games. For example, if the Buffalo Bills host the New York Jets in one game and the Bills are a 5-point favorite, and later in the same regular season the Jets host the Bills and the Jets are a 1.5-point favorite, then the "Home-Road" gap in the game is 6.5 points. By isolating this subsample of games in which the same opponents compete in the same series of contests each season, we can consider whether the home field "gap" in betting lines is reduced in the COVID-impacted NFL season of 2020 as we might expect if fan attendance is a substantial driver of homefield advantage.

Results and Discussion

Do spectators affect betting lines?

Our initial analysis considers whether NFL point spreads markedly differ when spectator attendance at games is eliminated or limited. Comparing opening and closing lines

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[3]No preseason/exhibition or playoff NFL games are included. No bowl or playoff NCAA games are included.

[4]e.g. NFL games played in London or NCAA games not hosted by either school participating.

[5]We also separately consider games with zero spectators versus those with limited capacity.

[6]Furthermore, at the kind suggestion of an anonymous reviewer we consider whether the distribution of team quality might have differed in the COVID-19 season of 2020 such that clustered team quality might drive lower spreads in games. Standard deviations of team win totals and final season point differentials were no lower, however, in 2020 than in the control seasons of 2007–2019.

[7]When calculating the success of home or visiting teams covering point spreads we omit games that "push" (end in a tie wager) from consideration.

of typical NFL seasons (2007–2019) to the COVID-19 season (2020) provides a natural experiment disentangling the degree to which home field advantage is based on the impact of fans. Table 1 present the results.

Table 1
This table details the typical level of betting spreads (lines), relative to home teams in NFL games. A line of -4, e.g. denotes a home team favored (projected to win) by 4 points in a contest. Data are taken from the 2007–2020 seasons for the purpose of comparing typical home field advantages in NFL games (2007–2019) to the corresponding advantage in the COVID-19 impacted NFL season of 2020 in which spectator attendance was limited or disallowed. We consider results based on both closing (immediately before game) and opening (initial) spreads. Only regular season games played at the home team's standard field are considered in the analysis. Game results and spread data are from http://www. thefootballlines.com. Attendance data from the 2020 season are from http://www.espn.com.

Season	Mean Close	Median Close	StDev Close	Mean Open	Median Open	StDev Open	Shift Home to Visitor
2007	−2.41	−3.00	6.89	−2.51	−3.00	7.09	0.10
2008	−2.75	−3.00	6.20	−2.77	−3.00	6.54	0.02
2009	−2.67	−3.00	7.35	−2.84	−3.00	7.54	0.17
2010	−2.44	−3.00	5.58	−2.62	−3.00	5.73	0.18
2011	−2.42	−3.00	6.28	−2.60	−3.00	6.30	0.18
2012	−2.30	−3.00	5.62	−2.52	−3.00	5.63	0.22
2013	−2.46	−3.00	6.05	−2.57	−3.00	6.07	0.11
2014	−2.33	−3.00	5.70	−2.54	−3.00	5.40	0.21
2015	−2.18	−3.00	5.36	−2.20	−3.00	5.19	0.02
2016	−2.15	−3.00	4.93	−2.28	−3.00	4.84	0.13
2017	−1.96	−2.50	6.03	−2.21	−2.50	6.00	0.25
2018	−2.35	−3.00	6.11	−2.44	−3.00	5.83	0.09
2019	−1.74	−3.00	6.70	−2.19	−3.00	6.34	0.45
2007–2019 Avg	−2.32	−2.96	6.06	−2.48	−2.96	6.04	0.16
2020 (COVID-19)	−0.99	−1.50	6.47	−1.84	−2.50	5.14	0.85
2020 empty (*n* = 145)	−0.86	−1.50	6.44	−1.71	−2.00	4.97	0.85
2020 limited (*n* = 111)	−1.16	−1.50	6.53	−2.00	−2.50	5.38	0.84

*avg = 16.5% capacity

Immediately, unique results from the COVID-19 season generate a first impression that a lack of spectators at contests indeed reduces the market's value placed on home field advantage.[8] The mean closing line in the COVID-19 season shows home teams favored by about only one point (0.99) as opposed to the 2007–2019 average of 2.32 points. Thus, based on closing lines, we might roughly claim about 57% of the bookmaker's perception of the NFL's home field advantage appears due to spectator influence, while, presumably, the remaining 43% of home field advantage comes from the familiarity of the home team with its surroundings and/or the relative difficulties of the visiting team traveling to the game. The median home field advantage, almost exactly three points over the 2007–2019 era, is halved without home fans in attendance.

Results based on opening lines are also noticeably different in the COVID-19 season, though to less of an extreme. Mean opening lines in 2020 (2007–2019) had home teams favored by 1.84 points (2.48 points) denoting around 26% of the anticipated home field advantage generating from fans.[9] Median opening lines in 2020 (2007–2019) had

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[8]P-value < 0.001 for difference of closing line mean in 2007–2019 vs. 2020.
[9]P-value < 0.10 for difference of opening line mean in 2007–2019 vs. 2020.

home teams favored by 2.50 points (2.96 points), suggesting that only around 16% of the anticipated home field advantage is due to spectators.[10]

One quite noteworthy discrepancy between the 2020 season compared to previous seasons (2007–2019), foreshadowed by the gap between our closing and opening line results, is how differently lines *shifted* between their opening issuance by bookmakers and the closing of betting markets immediately before game kickoffs. On average, from 2007–2019, lines shifted gradually away from home teams and towards visiting teams by a slight 0.16 points. This shift more than quadrupled in the 2020 season to 0.85 points of movement toward the game's visiting team, on average.[11] This extreme change indicates that bettors likely found opening line, home field advantage perceptions in the COVID-19 season to be much too strong. Thus, the market was forced to adjust much more strongly than it historically had in order to reach the notably lower closing lines described above. This would seem to indicate that bookmakers might have been slow to appreciate the impact of missing NFL fans on home field advantage when issuing opening lines, and thus bettors shepherded lines notably away from home teams to a much greater degree in 2020.[12] We caution, as explained by Levitt (2004), that sportsbooks may not necessarily always look to balance the wagering dollars equally on each side of a contest and might instead look to take a positive expected value risk by enticing bettors into poor wagers. Thus, we cannot be completely confident of the meanings behind shifts in betting spreads. Additionally, we note that the actual shifts are not huge, and the number of observations provided by our natural experiment of the COVID-19 season is limited, substantially changing lines, from opening to closing, need not necessarily play out in realized betting opportunities at the opening line.[13] We also note that the 2020 football season offered the additional complication of individual players, including some very important players, having many updates on potential playing status in an upcoming game based on their exposure to, or recovery from, COVID-19. Therefore line movement in general might be more common in the 2020 football season, though we expect no particular impact from this concern on the question of the degree of home advantage (as both home and visiting teams could have players under observation of their COVID status preceding a game).

In general, results across the pre COVID-19 2007–2019 NFL seasons are somewhat stable such that the NFL COVID-19 season of 2020 was noticeably and significantly lower in the degree of home field advantage that betting lines anticipated for contests. It would be overly ambitious to claim that we can conclusively parse out exactly the degree to which "home field advantage" actually comes from NFL fans. Factors such as how crowd noise impacts play at various stadiums, the ability of perhaps influenceable game officials to correct egregious errors via video replay, etc. are ever-changing and not directly measurable based on the current dataset.

Furthermore, the very circumstances of the COVID-19 pandemic that necessitated lower attendance in 2020 might have had other, dynamic spillover effects (such as on the likelihood of important players missing contests). It is certainly true, as well, that with only one season of the natural experiment of the pandemic limiting fan attendance, that sampling error is a concern. But with all of these qualifiers in place, our initial inspection seems to indicate that spectators matter, perhaps to the tune of around 1-1.5 points per game

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[10]As an additional analysis, we consider whether limited fan attendance at NFL games might restore some of the "missing" home field advantage in the COVID-19 season of 2020. Our results indicate a slightly lower home field advantage (mean of 0.86 points at the closing line, e.g.) in games with no fans as opposed to games with limited capacity (mean of 1.16 points), but this gap is statistically insignificant. This is perhaps unsurprising given that even in "limited capacity" games the average attendance of fans was 16.5% of capacity.

[11]P-value < 0.001 for difference in shift of the line in 2007–2019 vs. 2020.

[12]We acknowledge the theoretical possibility that team quality ranged to a much smaller degree in the COVID-19 season, thereby correctly driving lower spreads, but our aforementioned results showing typical standard deviations of team win totals and point differentials somewhat rebuts this concern. Further evidence against this concern can be seen in Table 5.

[13]We also note that none of our results, whether in the NFL or NCAA, were driven by the opening weeks of the 2020 season. For example, lines did not shift more in September, 2020, nor did visiting teams cover more spreads (as discussed in detail in Tables 3 and 4) than in December, 2020.

(around 50% of the typical home field advantage) in NFL regular season contests. To more fully measure the impact of fans we must also consider whether the market's expectations of NFL games seen here, after adjusting for a lack of fans, turned out to be *accurate* (see Table 3). If, for example, home teams were to disproportionately cover the generally lower "home field advantage" spreads seen in the 2020 season, then it might be that the market anticipated the lack of fans to be a meaningful, relative factor in 2020, but that was not actually the case.

We next consider similar analysis on the question of betting spread differences in the 2020 season, versus the historical norms established in 2007–2019, for college football games (NCAA, Division I (FBS)). Table 2 presents the results.

Table 2
This table details the typical level of betting spreads (lines), relative to home teams in NCAA Division I (FBS) games. A line of -4, e.g. denotes a home team favored (projected to win) by 4 points in a contest. Data are taken from the 2007–2020 seasons for the purpose of comparing typical home field advantages in NCAA games (2007–2019) to the corresponding advantage in the COVID-19 impacted NCAA season of 2020 in which spectator attendance was limited or disallowed. We consider results based on both closing (immediately before game) and opening (initial) spreads. Only regular season games played at the home team's standard field are considered in the analysis. Game results and spread data are from sportsinsights.com for the 2007–2012 seasons and hand collected from covers.com for the 2013–2020 seasons. Attendance data from the 2020 season are from http://www.espn.com.

Season	Mean Close	Median Close	StDev Close	Mean Open	Median Open	StDev Open	Shift Home to Visitor
2007	−5.24	−4.50	13.09	−4.99	−4.50	13.33	−0.25
2008	−5.06	−4.00	13.26	−4.97	−4.50	13.46	−0.09
2009	−6.21	−6.00	14.45	−5.97	−5.50	14.25	−0.24
2010	−7.50	−6.50	15.52	−7.27	−6.50	15.09	−0.23
2011	−7.67	−7.00	15.54	−7.32	−7.00	15.62	−0.35
2012	−7.21	−6.00	15.97	−6.88	−6.00	15.88	−0.33
2013	−7.62	−6.00	16.77	−7.45	−6.00	16.33	−0.17
2014	−7.65	−6.50	15.45	−7.34	−6.00	15.84	−0.31
2015	−7.26	−6.00	15.58	−6.97	−6.00	15.45	−0.29
2016	−7.50	−6.75	16.77	−7.05	−6.50	16.63	−0.45
2017	−7.20	−6.50	16.17	−6.79	−6.00	16.23	−0.41
2018	−7.90	−6.50	16.67	−7.69	−6.50	16.58	−0.21
2019	−7.77	−6.50	17.59	−7.45	−6.50	17.44	−0.32
2007–2019 Avg	−7.06	−6.06	15.60	−6.78	−5.96	15.55	−0.28
2020 (COVID-19)	−4.62	−3.50	15.27	−4.89	−4.50	14.72	0.27
2020 empty (n = 130)	−2.32	−2.75	13.29	−3.15	−3.50	12.90	0.83
2020 limited (n = 401)	−5.36	−5.00	15.80	−5.43	−4.50	15.22	0.07

*avg = 15.2% capacity

As in the NFL, we see notably reduced spreads favoring home teams in the 2020 NCAA season. The mean closing line in 2020 (2007–2019) NCAA contests had the home team favored by 4.62 points (7.06 points) representing an estimate of about 35% of NCAA home field advantage coming from the team's spectators.[14] The median closing line in 2020 (2007–2019) of 3.50 points (6.06 points) by the home team estimates that about 42% of the home field advantage is based on crowds. In short, initial results are similar, though

[14]P-value < 0.001 for difference of closing line mean in 2007–2019 vs. 2020.

slightly smaller, than those we see in the NFL. As in the NFL analysis of Table 1, we also note that the initial impression of fan influence as part of the home field advantage is weaker when based on opening lines (28% of the advantage based on mean opening lines in 2020 vs. 2007–2019 and 24% of the advantage based on median opening lines in 2020 vs. 2007–2019). We reiterate, however, that anecdotal understanding of betting market mechanics, as well as traditional market efficiency theory (see, e.g. Krieger and Fodor, 2013) hold closing lines to be a more robust measure of the market's impression of a game's accurate spread as it incorporates the most information.

As in Table 1 with our NFL results, we note a striking difference in how college football lines moved in the COVID-19 NCAA season of 2020 as compared to the traditional 2007–2019 seasons. Unlike in the NFL, NCAA lines have actually historically shifted toward home teams between their issuance and the line's closing. The average shift toward home teams was 0.28 points from 2007–2019, and year-by-year results show very little dispersion. In the COVID-19 season this changed dramatically as lines shifted 0.27 points, on average, toward visiting teams. As in the NFL, our conjecture is that bookmakers offered lines, in the COVID-19 season, that were too "traditional" in favoring home teams and had to be adjusted much more strongly than usual by bettors to appreciate the importance of the lack of spectators at contests.

We also note an intuitive, statistically significant result where NCAA games with limited capacity indeed had lines denoting more home field advantage than games with no spectators (5.36 points vs. 2.32 points based on means of closing lines).[15] This finding suggests that the oddsmakers do believe that fans add some amount of value in the form of home advantage, and that they are adjusting the lines consistent with this perspective. As in the NFL case, we must also consider whether these adjustments, by betting markets, to home field advantage's 'price' in spreads were prescient, or whether they might have still understated the advantage's diminishment or, conversely, overcorrected. To do so we consider the performance of home/visiting teams relative to betting lines in Table 4.

We finally note, in order to explain our topline, summary conclusion, that in our NFL data, 145 of 256 games (57%) had no fans in attendance, and this helped lead to the base-line calculation of 57% (coincidentally) of home field advantage generating from home NFL fans. By contrast, only 130 of 531 NCAA games (24%) were empty of fans, and this helped lead to the baseline calculation that 35% of home field advantage is generated by home NCAA fans. Our results, segmented in Tables 1 and 2, respectively, for 'empty' vs. 'limited' attendance describe the specifics. Thus, in short, we are comfortable in roughly describing the importance of American football spectators by saying that the natural experiment provided by the COVID-19 pandemic suggests that the market attributes around half of home advantage to spectator influence.

Are betting market's perceptions of spectator influence correct?

We turn back to the NFL and consider whether the betting market proved accurate when it roughly cut in half its perception of homefield advantage in the 2020, COVID-19 season in which fan attendance at regular season games was eliminated or severely restricted. Table 3 presents the results.

As might be expected in a betting market as widely followed as the NFL's, historically there has been no systematic advantage to simply wagering on home or visiting teams. Given the traditional 10% commission bettors pay on winning wagers, bettors must win 52.4% of uniform wagers simply to break even and success rates of "all home" and "all visitor" strategies both hover closer to 50%. Did this trend change in the COVID-19 season of 2020? Perhaps the irregular season provided an opportunity for savvy bettors to profit if the market over-shifted or under-shifted spreads of games with few fans.

The answer is no. Betting market perceptions of the necessary shift in lines needed to offset the lack of home fans proved to be correct. In fact, remarkably, exactly 50% of home

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[15]P-value < 0.05 for the difference in shift of line in 2020 vs. 2007–2019.

NFL teams covered regular-season spreads in the 2020 season, and even though opening lines adjusted very differently in 2020, as opposed to 2007–2019, per our discussion of Table 1, actual game results did not play out in such a way that even savvy bettors, wagering on visiting teams immediately at opening lines, were able to profit (only 51.6% of such wagers won in 2020). Nor did contrasting regular season games with zero fans, as opposed to limited capacity, uncover any systematic mispricing, even at opening lines.

We conclude by considering the question of the betting market's skill of pricing the importance of spectators via NCAA spreads. Table 4 presents the results.

Table 3

This table details the historical record of NFL home and visiting teams covering betting closing (immediately before game) spreads (shown in Table 1). Data are taken from the 2007–2020 seasons for the purpose of considering whether home teams were any more or less likely to cover betting spreads in the COVID-19 impacted NFL season of 2020 in which spectator attendance was limited or disallowed. For comparison, the analysis of the 2020 season is repeated based on opening (initial) spreads as well. Only regular season games played at the home team's standard field are considered in the analysis. Games resulting in a push (tie) bet, accounting for the spread, are omitted from the analysis. Game results and spread data are from thefootballlines.com. Attendance data from the 2020 season are from http://www.espn.com.

ATS (Closing) Result	Home Cover	%	Visitor Cover	%
2007	124	50.61%	121	49.39%
2008	113	45.38%	136	54.62%
2009	115	46.37%	133	53.63%
2010	122	49.39%	125	50.61%
2011	121	49.59%	123	50.41%
2012	118	47.01%	133	52.99%
2013	134	53.60%	116	46.40%
2014	123	49.20%	127	50.80%
2015	114	45.97%	134	54.03%
2016	123	49.00%	128	51.00%
2017	130	52.42%	118	47.58%
2018	119	48.18%	128	51.82%
2019	106	43.09%	140	56.91%
2007–2019 Avg	120.2	48.47%	127.8	51.53%
At closing line 2020	127	50.00%	127	50.00%
empty ($n = 145$)	74	51.75%	69	48.25%
limited ($n = 111$)	53	47.75%	58	52.25%
At opening line: 2020	121	48.40%	129	51.60%
empty ($n = 145$)	69	47.92%	75	52.08%
limited ($n = 111$)	52	49.06%	54	50.94%

Table 4

This table details the historical record of NCAA Division I (FBS) home and visiting teams covering betting closing (immediately before game) spreads (shown in Table 2). Data are taken from the 2007–2020 seasons for the purpose of considering whether home teams were any more or less likely to cover betting spreads in the COVID-19 impacted NCAA season of 2020 in which spectator attendance was limited or disallowed. For comparison, the analysis of the 2020 season is repeated based on opening (initial) spreads as well. Only regular season games played at the home team's standard field are considered in the analysis. Games resulting in a push (tie) bet, accounting for the spread, are omitted from the analysis. Game results and spread data are from sportsinsights.com for the 2007–2012 seasons and hand collected from covers.com for the 2013-2020 seasons. Attendance data from the 2020 season are from http://www.espn.com.

ATS (Closing) Result	Home Cover	%	Visitor Cover	%
2007	349	49.86%	351	50.14%
2008	355	50.00%	355	50.00%
2009	348	46.52%	400	53.48%
2010	389	48.75%	409	51.25%
2011	406	50.81%	393	49.19%
2012	402	48.85%	421	51.15%
2013	416	49.35%	427	50.65%
2014	403	47.92%	438	52.08%
2015	407	47.71%	446	52.29%
2016	413	48.36%	441	51.64%
2017	391	45.78%	463	54.22%
2018	426	48.80%	447	51.20%
2019	431	49.54%	439	50.46%
2007–2019 Avg	120.2	48.47%	127.8	51.53%
At closing line 2020	260	49.71%	263	50.29%
empty ($n = 130$)	58	45.31%	70	54.69%
limited ($n = 401$)	202	51.14%	193	48.86%
At opening line: 2020	259	48.78%	272	51.22%
empty ($n = 130$)	57	43.85%	73	56.15%
limited ($n = 401$)	202	50.37%	199	49.63%

Similar to our NFL results of Table 3, the general impression provided is that betting markets did an accurate job in appreciating the degree of home field advantage provided by fans. Historically, neither blanket wagering on home or visiting teams has proven profitable for NCAA football, and that continued to be the case in the COVID-19 season. Almost exactly half (263 of 523) of visiting teams covered closing spreads in the 2020 season, and accounting for the use of opening lines did not change the results noticeably.

Moderately more complication exists, however, in analyzing the 2020 NCAA results. Particularly, wagering on visiting teams in empty stadiums proved to be modestly profitable during the COVID-19 season, suggesting that the market did not fully adapt to the importance of completely absent fans. While such a strategy was profitable even at closing lines (winning 54.7% of wagers), such that any bettor might profit, it was even more profitable (56.1% winning wagers) for those bettors able to wager quickly at opening lines.[16]

Finally, in Table 5, we consider whether the "gap" between the spreads of the two games of intra-divisional opponents, who play games at one another's home stadiums each season, is decreased during the COVID-impacted NFL season of 2020.

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[16]In fact, the success of wagering on visiting teams, at opening lines, in empty stadiums, is modestly significantly higher (p-value < 0.10) than the success of such wagers in limited capacity stadiums.

Table 5

This table details the means and medians of the gaps in opening and closing betting spreads (lines), each year, based on the subsample of intra-divisional games where NFL teams played one another two times within the regular season. For example, if the Buffalo Bills host the New York Jets in one game and the Bills are a 5-point favorite, and later in the same regular season the Jets host the Bills and the Jets are a 1.5-point favorite, then the "Home–Road" gap in the game is 6.5 points. We consider results based on both closing (immediately be fore game) and opening (initial) spreads. Data are taken from the 2007– 2020 seasons for the purpose of comparing typical home field advantages in NFL games to the corresponding advantage in the COVID-19 impacted NFL season of 2020 in which spectator attendance was limited or disallowed. Results are shown to provide indications regarding the distribution of team quality throughout the NFL within respective seasons, particularly for comparison with the limited-attendance "COVID" season of 2020.

Season	Mean Gap (Close)	Median Gap (Close)	Mean Gap (Open)	Median Gap (Open)
2007	5.65	5.50	5.71	5.50
2008	5.12	5.00	4.98	5.00
2009	6.01	6.00	5.84	6.00
2010	5.33	5.50	5.63	5.50
2011	5.05	5.00	5.14	5.00
2012	5.33	5.50	5.72	5.50
2013	5.23	5.00	5.02	5.00
2014	5.09	5.00	5.22	5.00
2015	5.77	6.00	5.45	5.50
2016	5.01	5.00	5.31	5.50
2017	5.55	5.50	5.82	6.00
2018	5.72	5.50	5.93	6.00
2019	5.44	5.50	5.35	5.50
2007–2019 Avg	5.41	5.50	5.47	5.50
2020 (COVID)	2.67	2.50	2.44	2.50

*All 2020 "Gaps" are significantly smaller than their respective 2017–2019 averages ($p < 0.001$)

Indeed, as Table 5 details, the change, or gap, in both closing and opening spreads between when "Team X" hosts "Team Y" and "Team Y" hosts 'Team X' when aggregated by the home teams of each contest, is considerably smaller, in fact about half as much in the 2020 NFL season. The means and medians of these gaps are significantly smaller than the average gaps seen in the 2007–2019 seasons (p-value < 0.001).[17]

Future research

Past research has examined the sources and impact of home field advantage in sport. Research in the area of sports market efficiency has also provided numerous studies examining how home field might impact betting markets. However, the current study has begun the discussion of dissecting the idea of home field advantage and more precisely examining the factors contributing to this advantage. By doing so, we have also uncovered several promising future areas of study that could contribute to this line of analysis. For example, if past research in sport psychology and medicine has revealed four factors contributing to home field advantage (i.e. learning, travel, rules, and crowd) and the current study's findings attribute approximately half of the home field advantage in American football point

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[17]We thank an anonymous reviewer for the suggestion to include such analysis.

spreads to the "crowd" factor, then at what level do the other three factors contribute to this advantage? Are they equal, "one-sixth" contributors? Can we better parse out their individual contributions? In our study we consider the COVID-19 pandemic as a natural experiment to examine the role of fans. Can we identify other natural scenarios such as neutral-site sports competitions to conduct other insightful analysis on this topic?

An additional opportunity is the further study of factors influencing home field advantage in American football. In conducting this study, there was a surprisingly small number of other research studies that have examined home field advantage in the American football setting. While the concept has seen much attention in the literature, analysis related to American football made up only a very small percentage of the published research studies that were revealed in our search. Future research can examine how the concept of home field advantage has been studied in other popular sports (e.g. European football) and apply these approaches in the American football setting.

Conclusion

The COVID-19 pandemic provided a hopefully unique "opportunity" to consider the components of what comprises 'home field advantage' in American football by utilizing betting market metrics. We consider both NFL and NCAA spreads and game results and compare the 2020 season to the historical norms seen over the 2007–2019 period. Mean closing regular season game lines, relative to home teams, were reduced around 57% in 2020 for NFL teams and around 35% in 2020 for NCAA teams, but with many more of the NFL observations based on empty stadiums (as opposed to only limited spectators), we roughly put the importance of home crowds to be around half of the home field advantage.

Betting markets proved prescient in how much spreads, relative to home teams, should be reduced with few or no spectators in attendance. In both NFL and NCAA football the shifted lines of 2020 proved rather accurate in forecasting game outcomes such that betting on games in order to profit on the odd setup of the COVID-19 season was not particularly profitable. The primary exception to this finding, based on a rather small sample, indicates that betting on visiting teams in NCAA games with no attendees, particularly if opening lines could be utilized, was modestly profitable.

Even though few betting profitability differences emerged, the shifts of lines in the COVID-19 season were quite different than seen historically. Lines shifted more toward visiting teams in 2020, both in NFL and NCAA markets, than ever before. Most likely, it took the influence of involved sports bettors to move the rather efficient opening lines to their extremely efficient closing values.

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