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The effect of rivalry on performance and sabotage: evidence from the national football league

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Abstract

Competitive rivalry is a central driver of behavior and market outcomes, yet its effects on performance and unethical conduct remain insufficiently understood. Drawing on data from the National Football League (2009–2023) and a survey-based measure of rivalry, this study investigates how perceived rivalry in the competition influences performance and sabotage behavior. Using team fixed effects estimations, we find that especially symmetrical rivalry impairs performance, whereas performance improves when the opponent rates the rivalry higher. Moreover, we identify a u-shaped relationship between rivalry intensity and sabotage fouls: sabotage is lowest at moderate rivalry levels but increases under both low and high rivalry. Overall, our findings indicate that contests against direct rivals can undermine performance while simultaneously fostering sabotage at high rivalry intensity. We discuss the implications of these results for tournament and competition design.

Keywords Tournament theory · Rivalry · Performance · Sabotage

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1 Introduction

Competitive situations are common in business. Firms operating in the same market usually compete with each other, e.g., for customers. Even within a firm, individual employees may find themselves in a competitive relationship when a promotion or bonus payment is at stake. Literature reviews show that competition generally has

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a positive effect on performance, but at the same time promotes unethical behavior (Benistant et al. 2022; Worrell et al. 2016).

Within organizations, such competitive incentives are frequently implemented as rank-order tournaments, in which rewards depend on relative rather than absolute performance (Lazear & Rosen 1981). A large body of studies builds on this framework and examines how characteristics of the competitive environment, such as the number or skill level of competitors, influence effort levels (e.g. Boudreau et al. 2016; Gürtler & Harbring 2010). However, while rank-order tournaments explicitly pit actors against specific opponents, little is known about how perceived (and potentially asymmetrical) rivalries between competitors shape behavior in such settings. Addressing this gap is the objective of the present study.

In the tournament theory literature, the terms "rivals" and "competitors" are often used synonymously to refer to actors in the same competition. In this study, however, we define the two terms differently. We define rivalry as "a subjective competitive relationship that one actor has with another actor that involves heightened psychological involvement and perceived competitive stakes for the focal actor, regardless of the objective characteristics of the situation" (Kilduff et al. 2010: 945). Thus, a competitive rival is not just an opponent, but someone to whom the actor feels a stronger emotional connection that goes beyond mere objective competition. Necessary conditions for the development of rivalry are that competitors are neither anonymous nor arbitrarily interchangeable and that the opponent is recognized from previous encounters; otherwise, the interaction would be incidental. In this study, the focus is thus on competitors who are mutually acquainted.

Rivalry is common in business competition and can arise both between organizations or teams and between individuals. At the organizational level, well-known examples include longstanding market rivalries such as Coca-Cola versus Pepsi, Ford versus General Motors, Amazon versus Walmart, or Apple versus Samsung, as well as more personal corporate rivalries such as Elon Musk versus Mark Zuckerberg (Fortune 2013; Berendt et al. 2018; Jindal et al. 2021). Rivalry is also pervasive at the interpersonal level within organizations. Survey evidence indicates that 73% of employees report having a workplace rival, most commonly a colleague (49%), and that perceived rivalry can be intense: 40% of respondents describe their workplace as highly rivalrous, while 46% report having left or considered leaving a job because of a rival (Operti et al. 2021).

Rivalry between two actors often arises when they have a shared history or a high frequency of competitive encounters, when the actors are located close to each other and thus may be more visible and present to each other, and when they have similarities in, e.g., firm structure or performance (Converse & Reinhard 2016; Kilduff et al. 2010; Quintanar et al. 2015). The latter can be explained by social comparison theory, which states that actors tend to evaluate themselves and compare their performance to that of other actors with similar abilities or characteristics (Festinger 1954). Comparing oneself with similar actors can be perceived as a threat to one's status, thus fostering rivalry (Otoiu et al. 2019). In the context of sports, Tyler and Cobbs (2015) define three dimensions that describe the determinants of rivalry for sports teams. The first dimension, conflict, includes frequent competition, memorable incidents, comparable recent and/or historical success, and exceptional individuals. The second

dimension, peer, includes geographic proximity, cultural similarity, and competition for resources. The final dimension, bias, includes cultural differences, relative dominance of a competitor, and perceived unfairness. Ambrose and Schnitzlein (2017) examine the dimensions for individual sports and find that geography and cultural similarity tend to play less of a role, while the first dimension and cultural differences become more important.

This study examines the extent to which perceived rivalry toward a competitor influences one's own performance and sabotage behavior in a rank-order competition. It is of fundamental importance for managers of firms to know how rivalry affects firm and employee performance, especially in direct competition, so that potential participation in competitions can be reconsidered and self-organized competitions can be designed accordingly. These findings are also important for individual employees, e.g., to decide whether it is worth competing against rivals for a promotion. Performance in this context is generally understood as the extent to which individuals or groups contribute to the achievement of their personal or organizational goals (Campbell 1990). Not only performance, but also sabotage in competitions, is an important subject of investigation. Sabotage is defined as intentional and possibly costly actions by an actor that negatively affect another competitor's performance or probability of winning, such as spreading false rumors (Lazear 1989). The literature in this context also refers to unethical behavior that violates generally accepted norms (Treviño et al. 2006). The sabotage literature identifies five main motives for why a person engages in sabotage activities in general (without focusing on tournament type situations): a sense of powerlessness or injustice, frustration, work simplification, and boredom (for a review see Ambrose et al. 2002; Greve et al. 2010, or Kish-Gephart et al. 2010). In a rank-order competitive setting, sabotage occurs because competitors desire a higher position (Charness et al. 2014).

Previous research on rivalry has focused on sports teams, often identifying one main rival of each team and assuming that the relationship between two rivals is symmetrical. Symmetric means that both teams feel and perceive the rivalry to the same degree. As rivalry indicator, studies often use geographical closeness as a proxy for rivalry. Moreover, most of the existing studies on rivalry are cross-sectional. In the present study, we analyze sports teams from the American National Football League (NFL) over 15 seasons. Conceptually, the NFL resembles an organization that organizes rank-order tournaments among its teams. We take the NFL rivalries from a large fan survey that has been active for several years and reflects different facets of rivalry. Our data show that a team usually has several rivals and that a rivalry can be asymmetrical. Using team fixed effects estimations, we show that symmetrical rivalry, in particular, worsens performance and that, in addition, sabotage acts are committed less in mild to medium rivalry games but more in high rivalry games, contradicting most studies in this area.

Chapter 2 contains theoretical considerations regarding the research question. Chapter 3 includes a review of the relevant literature. Chapter 4 covers background information on the NFL. We describe the data and the empirical strategy in Chapter 5 and report the results in Chapter 6. In the final Chapter 7, we provide the conclusion.

2 Theory

2.1 Relation between rivalry and performance

The tournament model of Lazear and Rosen (1981) considers two homogenous employees who compete in a ranked tournament. The person with the higher output receives a predefined winner's prize, such as a bonus payment, while the other person receives a predefined lower loser's prize. The activities of the employees must be similar for the performance result to be comparable. An employee can increase the output by increasing the effort, although random influences can also partially affect the output. The cost of an employee's effort increases with increasing effort. Lazear and Rosen (1981) show that an employee will put more effort into the work if the difference between the winner's and loser's prize increases. In addition, a lower influence of the random component also leads to an employee exerting more effort. The tournament model refers to effort, which is actually not measurable. The model assumes that more effort automatically leads to better performance and thus to higher output.

This tournament model can be transferred to the NFL setting: the tournament conditions such as the prizes are fixed from the start, the probability of winning can be influenced by higher effort, the participating teams are relatively homogeneous and have the same tasks, and there is a random factor due to, e.g., field conditions. It is important to note that we assume in this study that better performance by an individual team member will lead to greater collective performance. The NFL can be viewed as a hierarchical tournament in which a team first plays for a playoff spot and then for the Super Bowl, with the second tournament being a "winner takes it all" tournament since there is an indivisible final prize. However, a single game can also be considered a tournament. It can be a so-called "activating" tournament in which winning is intrinsic or status-oriented, i.e., winning is a reward in itself. But winning also brings an objective reward, namely a higher probability of reaching the playoffs and the Super Bowl. What now changes in the tournament model, however, is the additional factor of rivalry.

When a team plays against a rival instead of a neutral opponent, its perceived tournament prizes change. Defeating a rival is considered more valuable, while losing to one is experienced as more painful. There are various theoretical explanations for it. According to social categorization theory, an extension of social identity theory, persons who are similar to oneself are perceived as belonging to the "ingroup," while those who are different from oneself are perceived as belonging to the "outgroup" (Turner et al. 1987). Ingroup bias occurs when someone favors persons in the own ingroup and discriminates against persons in the outgroup (Tajfel & Turner 1979). Social identity theory and social categorization theory state that overcoming a rival outgroup increases one's self-esteem (Tajfel & Turner 1979). Overpowering a prominent outgroup namely enhances feelings of positive social identity, which in turn boosts self-esteem (Abrams & Hogg 1988). Thus, when an agent competes with a rival perceived as a relevant outgroup, winning is particularly important for boosting self-esteem, while avoiding defeat is crucial to prevent a decline in self-esteem. Hence, a victory over a rival is likely to be perceived as more valuable and a defeat

as more harmful. In addition, Converse and Reinhard (2016) demonstrate through experiments and surveys that individuals are more concerned about their "long-term legacy," i.e., how their current performance will be remembered in the future, when they perceive a rival rather than a non-rival as a competitor. This also likely contributes to a greater tournament prize differential. Furthermore, the concept of "schadenfreude," which refers to the pleasure one takes in the downfall of another (Heider 1958), suggests a higher prize differential in the case of rivalry. A losing rival can induce pleasure, which may even exceed the pleasure derived from one's own victory (Lehr et al. 2019). Using magnetic resonance imaging, Cikara et al. (2011) show that for fans of the two rival American professional baseball teams, the Yankees and the Red Sox, a victory for their favorite team or a defeat for their rival team activates the ventral striatum, which is associated with subjective pleasure. Further studies show that schadenfreude has the same neural correlates as physical pleasure (Lieberman & Eisenberger 2009; Takahashi et al. 2009). The feeling of schadenfreude offers a subjective benefit when winning a tournament against a rival, whereas a loss to a rival may be accompanied by feelings of envy, which could further reduce one's overall well-being.

Overall, the perceived winner's prize will be higher and the loser's prize will be lower for the team playing against a rival, causing the tournament prize difference to increase. It can be expected that the spread between the winning and losing prizes increases as the rivalry increases. According to tournament theory, a higher spread leads to greater effort and performance. Kräkel (2008a, 2008b) extends tournament theory by integrating possible positive emotions when winning a tournament and negative emotions when losing. This is similar to rivalry emotions. He also shows that in equilibrium, an agent's effort increases in the own emotions. Malhotra (2010) further demonstrates that in auctions with a rival bidder, a bidder tends to offer more than the item's subjective value, suggesting that rivalry may even lead to overexertion.

Competing against a rival could not only affect the benefits of winning the tournament, but also competitors' effort costs. Rivalry is associated with increased psychological pressure and cognitive interference (Converse & Reinhard 2016). The special situation of competing against a rival can cause attention to be diverted from the task at hand, focusing instead on irrelevant aspects, such as concerns about the competition. As a result, behavior is controlled less by automatic processes and more by controlled, conscious thought processes, making it more difficult and exhausting to perform the tasks (Kali et al. 2017). Moreover, rivalry leads to a kind of tunnel vision (Kilduff et al. 2016). This may narrow the focus to such an extent that the otherwise efficient performance becomes a resource-intensive, conscious effort. Also, a rivalry situation, e.g. triggered by status threats, leads to an adrenaline-charged emotional state, namely competitive arousal (Scheepers 2009). According to the Yerkes-Dodson theorem (1908), high arousal is ultimately detrimental to good performance. Overall, the costs of effort may be higher when a team plays against a rival team. According to the tournament model, higher (marginal) effort costs lead the agent to exert less effort.

Depending on whether the additional incentive effect due to the higher price spread or the additional cost effect predominates, the effort and hence the measurable

performance against a rival may increase or decrease. Thus, we do not formulate an a priori hypothesis.

2.2 Relation between rivalry and sabotage

An agent can also decide to use the efforts for sabotage activities against the opponent. The result of sabotage by one agent is that the output of the other agent is reduced. The agent thus reduces the opponent's chances of winning, possibly incurring sanctions in return. According to tournament theory, the smaller the difference in tournament prizes, the less sabotage an agent will engage in (Lazear 1989). This has been confirmed by experimental studies (e.g. Harbring & Irlenbusch 2011). So when a team plays against a rival, it may be more willing to engage in sabotage in the form of foul play.

The aforementioned activation of the ventral striatum upon encountering a rival correlates in the sports context with a fan's self-reported likelihood to behave aggressively toward a rival fan (Cikara et al. 2011). Sports games between rivals are generally more violent than neutral games (Raney & Kinnally 2009). An increased sense of competition also leads to market attacks between competing firms (Chen et al. 2007). One reason for more aggressive and possibly more severe sabotaging behavior toward a rival may be testosterone. Testosterone increases in response to a particularly competitive situation. For instance, in soccer games between strong rather than moderate rivals, players' testosterone levels increase due to the strong rivalry (Neave & Wolfson 2003). Higher testosterone levels ultimately increase aggressive behavior (Delville et al. 1996). The aforementioned arousal when competing a rival leads to aggressive decisions without considering the costs and benefits of it (Loewenstein et al. 1997). Although sabotage may not be beneficial for the team in the end because of the high risk of detection and punishment by the referee, team members may still sabotage rivals to a greater extent for the above reasons, especially given that people in rivalry situations tend to make spontaneous rather than considered decisions (Converse & Reinhard 2016).

On the other hand, competitors may be careful not to engage in sabotage when competing with rivals in order to avoid sanctions that would reduce their own chances of winning. Furthermore, sabotage activities against rivals could be very damaging to a competitor's reputation, which is why the competitor may choose to reduce such activities. Again, we do not formulate an a priori hypothesis, since the effect is theoretically ambiguous.

3 State of literature

3.1 Rivalry and performance

A positive relationship between rivalry and performance was found in several studies. Kilduff et al. (2010) studied the U.S. college basketball league in the 2005/2006 season and surveyed 362 student sports journalists about the rivalry between the teams. The journalists were asked to rate on a scale of 0 to 10 how much each team

perceived the other teams as a rival. Player and coach opinions were also used for verification. The researchers found that rivalry, which was mostly symmetric, was negatively correlated with the number of points scored per 100 possessions and positively correlated with the number of shots blocked by the opposing team. This indicates better defensive performance. In addition, the shooting percentage decreased in a rivalry game, indicating a worse offensive performance. In another study, Kilduff et al. (2018) examined 34 seasons of U.S. playoff college basketball, using the same rivalry data as in the previous study by Kilduff et al. (2010). Using panel estimations, the researchers demonstrated that a further advancement of the rival in the playoffs leads to the considered team also progressing further in the playoffs in the following season. The researchers replicated the result for the four largest U.S. sports leagues, assigning each team a main rival based on an online search. In another study, Kilduff (2014) analyzed 184 U.S. running club distance races between 2004 and 2009, finding that participants ran a few seconds per kilometer faster when at least one of their rivals was in the race. The first three years of running data were used to determine a runner's rivals based on similar running times. It should be noted that rivalry may also measure a running buddy who intentionally boosts performance. A meta-analysis by Milstein et al. (2022) examined a total of 18 papers, including the studies by Kilduff et al. (2010) and Kilduff (2014), and found a significant positive relationship between rivalry, defined as similar, equivalent competitors with a shared history, and performance, particularly for individual rivalries. One reason for this may be that competitive social comparisons are more pronounced in rivalries, and tournament prize differentials increase, leading to higher motivation and performance (Garcia et al. 2013).

On the other hand, some studies showed a negative relationship between rivalry and performance. Researchers have shown that internal rivalry teams of top managers within a firm can have a negative impact on firm performance (Hambrick 1995) and that intra-firm rivalry is detrimental to employee performance (Newton et al. 2000). In the context of sports, professional golf tournaments have been studied to show that rivalry leads to underperformance, which has been explained with "choking under pressure" (Kali et al. 2017). In addition, researchers measured that persons who saw the logo of their favorite sports team were more likely to hit a target with a ball than in a situation where they saw the logo of the rival team (Yoon et al. 2019).

3.2 Rivalry and sabotage

All existing studies suggest a positive relation between rivalry and the level of sabotage behavior. A higher salience of self-esteem in a competition with a rival leads to an increase in unethical behavior; e.g., dishonesty in the academic field increases (Niiya et al. 2008). Kilduff and Galinsky (2017) showed that the thought of competing against a rival rather than a neutral competitor lead to more unethical behavior, namely falsely inflating one's own performance in an experiment. Participants namely reported a larger number of correctly solved tasks than possible, since some tasks were unsolvable. Other laboratory and field studies have shown that rivalry supports unethical behavior (Kistruck et al. 2016). Using soccer data from the Italian professional league Serie A from 2002 to 2009, Kilduff et al. (2016) conducted

Poisson estimations with and without team fixed effects and showed that rivalry is associated with more yellow and red cards in a game. These team warnings can be considered as sabotage. The analyses were repeated at the player level with the same result. However, only symmetrical rivalry was assumed when two teams were based in the same city. In further studies, in which Kilduff et al. (2016) used an experiment and online surveys, they showed that the use of deception as well as the willingness to use unethical negotiation tactics is higher when someone is playing against a rival instead of a neutral person.

4 The NFL as a research object

4.1 Sports data

We use data from the NFL to address our research question. In general, sports data are often useful for studying economic issues, such as influences on performance or sabotage. The business and sports contexts are very similar, as both settings typically involve hierarchies, teamwork, the pursuit of common goals, and strategic decision making (Kilduff et al. 2010; Wolfe et al. 2005). Statistics from sports games provide comparable data on performance and sabotage, such as fouls, as they are collected in a controlled environment with consistent rules across all games. In addition, the sports context is very useful for studying rivalries. Examples of well-known sports rivalries include those between track and field athletes Usain Bolt and Justin Gatlin (The Guardian 2017), darts players Gerwyn Price and Gary Anderson (BBC 2021), or tennis players Novak Djokovic and Rafael Nadal (Eurosport 2022). At the team level, examples include the New York Yankees and Boston Red Sox baseball teams or the FC Barcelona and Real Madrid soccer teams. Findings from sports can then be transferred to the business context. In order to understand our analyses, the next section provides an insight into the NFL league and the sports rules.

4.2 NFL

The NFL is the professional football league in the U.S., consisting of 32 teams. They are divided into the National Football Conference (NFC) and the American Football Conference (AFC), with each conference consisting of 4 divisions of 4 teams each. In the regular season, which runs from September to December, each team plays 17 games during an 18-week period. Each team's opponents are determined by a special formula.[1] Beginning in 2020, 14 teams (12 teams in previous seasons) play in the playoffs for the Super Bowl title at the end of the regular season.[2] The team that wins the Super Bowl receives the Vince Lombardi Trophy, custom rings, and financial

[1] Each team plays 6 games within its division, 8 games against two predetermined divisions (one per conference), and 3 games against opponents from other divisions with similar prior-season records, rotating on a fixed cycle.

[2] The 4 division winners and 3 wild-card teams per conference advance. The top seed receives a bye; the remaining 6 teams compete in a seeded knockout bracket to determine each conference champion, who then meets in the Super Bowl.

rewards. Each NFL team consists of 53 active players, with 11 per side on the field at any time.

During a game, each team operates in three phases: offense (the team controls the ball), defense (the opponent controls the ball), and special teams (the ball is kicked or punted), each with specialized players and coaches. The main goal is to score touchdowns (6 points) by advancing the ball into the opposing end zone via passing or running. The quarterback typically passes to an eligible receiver, hands the ball to a runner, or runs himself. The offense has 4 attempts (downs) to gain 10 yards and maintain possession; if all 4 are unsuccessful, possession transfers to the opponent. Before the fourth down, the team may instead turn to special teams: either punting to the opponent or attempting a field goal—a kick through the upright posts at the end of the opposing end zone—for 3 points. After a touchdown, teams may add 1 extra point via a kick through the posts, or attempt to advance the ball into the end zone from the 2-yard line for 2 points. The defense can also score by intercepting the ball and reaching the end zone (6 points) or tackling the ball carrier in his own end zone (2 points). A game consists of 4 15-min quarters; in the regular season, ties may stand after up to 10 minutes of overtime, whereas playoff overtime continues until a winner is determined.

NFL data are particularly well-suited to answer our research question for several reasons. The NFL resembles a firm organizing rank-order contests: teams are largely homogeneous due to the draft system, a comparable strength of schedule, and a salary cap that each team must utilize by at least 89%. Forbes (2024) rates NFL team values similarly, further supporting this comparability. The league is also the highest-revenue sports league globally, generating more than USD 23 billion in the 2024 season, compared with roughly USD 8 billion for the English Premier League (Sportico 2025), and attracts a wide variety of audiences—fans, media, bookmakers, managers etc. –providing rich and diverse data on the same games. Multiple referees and instant replay officials minimize the risk of incorrect calls, enhancing data reliability. The NFL's scheduling structure causes teams to face certain opponents more frequently than others, naturally producing rivalries of varying intensity—from individual rivalries like Tom Brady vs. Peyton Manning to division- or conference-level team rivalries—making it an ideal setting to study rivalry effects. Finally, NFL teams mirror business teams because they are goal-oriented units with specialized sub-units (offense, defense, special teams), internal hierarchies, continuous information flow to decision-makers, and operate in a high-stakes, multibillion-dollar environment, facilitating the transferability of our findings to a business context.

5 Method

5.1 Data

Our analyses are based on the NFL seasons from 2009 to 2023, which corresponds to 4,060 games. An observation unit represents a game respectively the corresponding game statistics of a team. Thus, we obtain 8,120 observations. We use game statistics, player information, and team information from "Pro Football Reference." Betting

odds are taken from "Fantasy Football," whereby we complete some missing information with data from "Sportsbook Reviews." One game statistic, namely passer rating, is used from "Fantasy Football." Specific information on fouls in games are taken from "NFL Penalties."[3] Here, information is only available from 2009 onwards.

Data on rivalries in the NFL were provided in April 2024 by the researchers David Tyler and Joe Cobbs from their "knowrivalry project" (https://knowrivalry.com). Here, 4,197 adults voluntarily took part in an online survey since 2015. They were first asked to name their favorite NFL football team and then to distribute exactly 100 rivalry points across the other NFL football teams. 1 to 10 other teams could be specified and only integer values could be assigned. In the end, for each NFL team it is indicated how many rivalry points the surveyed fans of this team gave to the other teams on average. The maximum rivalry score of a team toward another team is 100, which would mean that every surveyed fan exclusively indicated this other team as their own team's rival with 100 points.[4]

The survey participants are mainly from North America and well educated. On average, the participants are 28.54 years old with a standard deviation of 11.09, based on available information on 2,900 persons. 2,713 persons are male, 163 are female, and the rest did not specify a gender. On average, 3.98 rivals are named with a standard deviation of 1.75. 218 persons name exactly 1 rival and 106 persons name exactly 10 rivals. The first rival is given an average of 55.86 points with a standard deviation of 20.15. The rivalry scores that arise depend on the number of rivals specified. To establish comparability, we therefore calculate the $RelativeRivalryScore_{i,j}$ for team toward another team j:

$$RelativeRivalryScore_{i,j} = \frac{RivalryScore_{i,j}}{MaximumRivalryScoreAwardedbyi} * 100$$

In this way, the strongest perceived rival of each team is weighted with 100 points, or 100%. In the following, we will only use this relative rivalry score, but for simplicity, we will refer to it as the rivalry score.[5] Table 9 shows the top 3 rivals for each team. Only the Jaguars are not listed as a top 3 rival by any team. It can be seen that teams in the same division often have rivalries with each other. However, there are also strong rivalries between teams that are not in the same division, e.g. the Colts see the Patriots as their main rival. The Texans consider the Cowboys their third strongest rival, even though the teams are not in the same division or conference. There are

[3] The platforms are accessible via https://www.pro-football-reference.com, https://fantasydata.com, https://www.sportsbookreviewsonline.com, https://www.nflpenalties.com.

[4] Example: Laura's favorite team is the Seattle Seahawks, she chooses to allocate 60 points to the San Francisco 49ers, whom she considers to be the Seahawks' strongest rival, and 40 points to the Los Angeles Rams, another opposing team she considers to be a rival of the Seahawks. Nils is another Seahawks fan, and he chooses to allocate 100 points to the Rams, the only team he considers to be a rival. The rivalry score of the Seahawks for the Rams would be 70 (average of Laura's 40 points and Nils' 100 points). The rivalry score of the Seahawks for the 49ers would be 30 (average of Laura's 60 points and Nils' 0 points).

[5] All results remain similar when we use the absolute rivalry score (available from the authors upon request).

seven intense rivalries between two teams where both teams consider each other their main rival, such as the Patriots and Jets. But rivalries are often asymmetrical. For instance, the Lions see the Packers as their biggest rival, while the Packers, with a rivalry score of 18.94, see little rivalry. The same holds for the Bengals and Steelers or the Colts and Patriots, e.g.[6]

5.2 Variables

5.2.1 Independent and dependent variables

The independent variable is the team's rivalry perception toward its opponent, namely the rivalry score. In our estimations, we use the standardized value to improve interpretation. As alternative, we also use a binary variable that indicates whether the team plays against its main rival (1= yes, 0 = no).

The effort used to achieve a desired performance goal is usually not measurable. This could be, e.g., an NFL player's effort to achieve a faster start or sprint during a play. The performance, which is assumed to result from the effort, describes the behavior of an actor that serves to achieve the performance goals. The performance outcome is the result of that behavior. For an NFL team, the goal is usually to win the game and ultimately secure a playoff spot and win the Super Bowl. The performance outcome would be whether the team scored more points than the opponent. In our study, we focus on team behavior during a whole game, thus on the measurable performance.

In this study, we focus on the offensive performance for several reasons. First, it is more difficult to evaluate the performance of the defense, as it has different tasks; for instance, the defense should allow few points and try to get the opponent out of the field as quickly as possible, but at the same time, it should also try to win the ball and score points itself. Second, the gameplay of the defense is generally more complex. While the offense can rehearse plays, the defense has to react to unexpected situations created by the opposing offense, which makes it more difficult to compare the defensive play of different games. Finally, we would like to focus on the offense and the performance of the quarterback, because the quarterback is the most important player and the face of the franchise, which is why there is a high probability that the he will adopt the fans' rivalry as his own.

As dependent variables describing the offensive performance of a team in a game, we use the total yards gained by the team's offense, the points scored by the offense, and the passer rating. The total yards consist of the net rushing yards and the net

[6] While the rivalry survey does not go back to 2009, which is our starting observation point, rivalry has been shown to be stable over time (Kilduff et al. 2010). Moreover, fans' opinions do not necessarily correspond to players' opinions. Fans could form opinions about rivalries through media coverage, e.g., (Havard et al. 2019), whereas players have internal insights. In addition, players may identify less with a team than fans and perceive rivalries as less important. When a player identifies less with the club, he is less likely to take aggressive action against the rival (Havard & Reams 2018). However, it is expected that a player will be aware of fan rivalries and that, because his self-representation includes collective identities, he will perceive the competitions and relationships of his group as his own (Tajfel 1982; Turner et al. 1994). We will discuss this potential issue again later on.

passing yards, where possible sacks, i.e. the quarterback being tackled behind the line of scrimmage, are subtracted with the corresponding yard loss. The passer rating is a statistic that describes the performance of the passing player, usually the quarterback.[7] The main goal of the offense is to score touchdowns to win the game. However, another important goal is to maintain possession on offense for as long as possible, steadily gaining yards to secure good field position, potentially also for field goals, and limit the opposing offense's time on the field. Therefore, we consider not only points scored but also the yards gained by the offense. In addition, we investigate the quality of the passing game. In general, the quarterback is the most important player in a team, as his passing is the main factor in determining whether his teammates are able to score or move the ball forward. His passing performance is captured in the passer rating.

Finally, we use the number of committed sabotage fouls as dependent variable to describe a team's sabotage behavior in a game. In the NFL, not every foul is necessarily intentional, thus we define three categories: unintentional fouls, strategic fouls, and intentional fouls with disruptive intention. The last category comes closest to the definition of sabotage. An explanation of all possible fouls can be found in Table 10. Typically, all rule violations are identified and penalized by (video) referees, which is why the focus here is on sabotage that entails own negative consequences.

It should be noted that all foul statistics do not include fouls that were officially called by the referee but were disallowed by the opposing team due to good field position. They also do not include fouls that were nullified by a simultaneous foul by the opponent. It is important to note that plays involving fouls during the play are not included in the performance statistics. Only if the penalty is given in addition to the play result or if the penalty is rejected is it included in the performance statistics. In this respect, possible rivalry effects on performance are not due to a possible change in the teams' foul behavior.

5.2.2 Control variables

We control for several factors that could influence rivalry as well as competitive behavior: the number of previous encounters between the two opposing teams, the absolute difference between the two teams' total head-to-head winning percentage before the game in percentage points, the probability of the focal team winning the game in % calculated based on the betting odds, the binary information whether the opponent is in the same division (1 = yes, 0 = no), the binary information whether the opponent is in the same conference (1 = yes, 0 = no). If there is only a small

[7] First, 4 individual scores are calculated, whereby the minimum value is set to 0 and the maximum value is set to 2.375: percentage of completed passes $\left(\frac{CompletedPasses}{PassAttempts} * 100 - 30\right) * \frac{1}{20}$, yardage gained per pass attempt $\left(\frac{Yards}{PassAttempts} - 3\right) * \frac{1}{4}$, scored touchdowns per pass attempt $\frac{Touchdowns}{PassAttempts} * 20$, thrown interceptions per pass attempt$2.375 - \frac{Interceptions}{PassAttempts} * 25$. The four individual scores are added and then divided by 6 and multiplied with 100. The maximum passer rating is hence 158.3 and the minimum passer rating is 0.

difference in the strength of the teams, as indicated by the second and third control variables, the game is likely to be intense regardless of the rivalry. Also, the strength of the opponent could influence a team's performance metrics. It could also be that a team is more likely to feel a rivalry if the opponent is stronger than the team itself (Kilduff et al. 2010; Quintanar et al. 2015). Therefore, it is important to control for team strength to avoid biased results. The same is true for being in the same division and conference, which favors rivalry and is also important in determining playoff eligibility.

We also control for several factors that may influence the dependent variables. We control for daytime (1 = evening, 0 = afternoon), playoff game (1 = yes, 0 = no), home game (1 = yes, 0 = no), weather influences (1 = outdoors, 0 = indoors), field condition (1 = turf, 0 = grass), overtime (1 = yes, 0 = no), number of stadium visitors in 1,000, stadium (there are 47 different stadiums in total), whether the opponent is the reigning Super Bowl champion (1 = yes, 0 = no), whether the quarterback is in his first year (1 = yes, 0 = no), whether there was a change in the starting quarterback position compared to the last game (1 = yes, 0 = no), who the team's head coach is (there are 116 different coaches in total), and who the main referee is (there are 53 different referees in total). To control for team experience, we use the average season experience of the players in the starting lineup up to the current season in years. To control for team quality, we use the number of players in the starting lineup who were selected to the Pro Bowl last season. The Pro Bowl takes place one week before the Super Bowl. It is an all-star game that pits the season's best players against each other in an exhibition game. Players are selected through a combination of votes from fans, coaches, and football players. Some players selected for the Pro Bowl choose not to participate due to injury or because they are still playing in the Super Bowl. We still consider them Pro Bowlers. Substitutes are named for these players, and we consider them Pro Bowlers as well. When we examine the offensive performance metrics, the Pro Bowl players and average player experience refer explicitly to the starting offense lineup.

Finally, we control for the season to account for temporal trends and to control for rule changes, although no major changes occur during the observation period.

Table 11 presents descriptive statistics of the variables. The average rivalry score is 22.6. A team encounters the main rival in 12% of cases. The average performance variables are slightly lower when only looking at games where the opponent is the main rival.

5.3 Empirical strategy

We apply panel estimations with team fixed effects:

$$Performance_{it}/Sabotage_{it} = RivalryScore(Standardized)_{it} * + x'_{it} * \gamma + a_i + \varepsilon_{it}$$

i = 1, …, 32 represents the NFL teams and t = 1, …, 318 represents the number of game days since the beginning of the 2009 season. $Performance_{it}$ respectively $Sabotage_{it}$ represents the corresponding dependent variable of team on game day t. We include the rivalry score as the independent variable. x is a vector that includes

Table 1 Main results – performance

	(1) Yards	(2) Yards	(3) Offensive points	(4) Offensive points	(5) Passer rating	(6) Passer rating
Rivalry score (standardized)	−2.8290* (1.5166)		−0.3087 (0.1831)		−0.7198* (0.3956)	
Main rival		−9.1286*** (3.1969)		−0.8362** (0.3742)		−1.1910 (0.8667)
# Encounters	0.0170 (0.0281)	0.0212 (0.0268)	0.0043 (0.0042)	0.0046 (0.0040)	0.0101 (0.0102)	0.0099 (0.0101)
Win rate difference	−0.1546*** (0.0439)	−0.1554*** (0.0445)	−0.0036 (0.0053)	−0.0037 (0.0053)	−0.0100 (0.0146)	−0.0101 (0.0146)
Win probability	0.9251*** (0.0679)	0.9251*** (0.0669)	0.1125*** (0.0073)	0.1127*** (0.0071)	0.2680*** (0.0229)	0.2692*** (0.0225)
Same division	−4.1458 (2.9497)	−6.0129** (2.4893)	−0.6922 (0.4784)	−0.9373** (0.3905)	−1.2457 (1.1529)	−2.0138** (0.9844)
Same conference	−0.9144 (2.4277)	−1.1571 (2.4264)	0.0230 (0.3110)	−0.0001 (0.3123)	0.1622 (0.8413)	0.1242 (0.8413)
Super bowl champ	3.3015 (5.0479)	3.2413 (5.0589)	−0.8073* (0.4534)	−0.8161* (0.4511)	−0.1301 (1.1602)	−0.1609 (1.1581)
Playoffs	0.3321 (4.0099)	0.2386 (4.0303)	0.4434 (0.4202)	0.4319 (0.4195)	−0.7860 (1.3870)	−0.8186 (1.3879)
Home	1.3853 (2.2444)	1.3767 (2.2326)	0.6126*** (0.2003)	0.6096*** (0.1997)	0.6297 (0.6777)	0.6133 (0.6789)
Evening	−3.7280 (2.2036)	−3.7111 (2.1893)	−0.4301 (0.2690)	−0.4334 (0.2665)	−0.1968 (0.6564)	−0.2289 (0.6566)
Outdoors	7.9173 (7.6623)	7.6881 (7.6672)	1.7332** (0.6741)	1.7138** (0.6742)	4.0755 (2.4679)	4.0575 (2.4692)
Turf	−6.2143 (7.9765)	−6.2053 (7.9710)	−0.7489 (0.6617)	−0.7482 (0.6613)	−0.2833 (2.4651)	−0.2828 (2.4652)
Attendance	0.2496 (0.2954)	0.2454 (0.2958)	0.0238 (0.0265)	0.0232 (0.0266)	0.0686 (0.0744)	0.0668 (0.0746)
Overtime	47.0367*** (4.9201)	47.0096*** (4.9103)	2.5729*** (0.4159)	2.5674*** (0.4157)	1.6246* (0.8950)	1.5995* (0.8952)
QB rookie	−8.1792*** (2.6916)	−8.1727*** (2.6999)	−0.4390 (0.3299)	−0.4385 (0.3308)	−3.0185*** (1.0411)	−3.0186*** (1.0412)
QB change	−10.7709*** (3.3079)	−10.7380*** (3.3143)	−1.4253*** (0.2973)	−1.4203*** (0.2966)	−4.0643*** (0.8587)	−4.0458*** (0.8554)
# Pro bowlers	1.8250 (1.2185)	1.8209 (1.2158)	0.1538 (0.1290)	0.1531 (0.1286)	−0.1095 (0.2952)	−0.1127 (0.2944)
∅ Experience	1.1234 (1.3772)	1.1389 (1.3781)	0.1168 (0.1417)	0.1175 (0.1410)	0.2315 (0.3926)	0.2280 (0.3923)
Coach dummies	Yes	Yes	Yes	Yes	Yes	Yes
Referee dummies	Yes	Yes	Yes	Yes	Yes	Yes
Stadium dummies	Yes	Yes	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes	Yes	Yes
R^2 within	0.1421	0.1426	0.1417	0.1419	0.1086	0.1085
# Observations	8,120	8,120	8,120	8,120	8,120	8,120

[a] Team fixed effects estimations. Clustered robust standard errors at team level in parentheses. * $p < 0.1$, ** $p < 0.05$,

the control variables, including season, coach, referee, and stadium dummies. The estimates of the coefficients β, γ are based on the within-estimator which uses the ordinary least squares method. a_i represents the unobserved, team-specific, and time-constant heterogeneity, such as fan culture or team philosophy, which could influence rivalry and competitive behavior. ε_{it} describes the error term for all unobserved variables that differ across time and teams.

In all analyses, we use clustered robust standard errors at the team level to account for heteroscedasticity and autocorrelation. There are no problems with multicollinearity. Common method bias is not present in the data, as rivalry data come from a different source than performance and foul data. Fisher-type unit root tests confirm that the time series have no unit roots. The presence of a unit root could lead to biased results. Furthermore, Pesaran's tests for cross-sectional independence show that there are no substantial dependencies. We also checked the quality of the fixed effects models. Robust Hausman tests indicate that the fixed effects model is preferred over the random effects model. In a random effects model, unlike a fixed effects model, it is assumed that a_i is not correlated with the explanatory variables.

We will perform various robustness tests to validate our results. Among other things, we will investigate whether results change depending on the symmetry of rivalry.

6 Results

6.1 Rivalry and performance

Table 1 presents the main results of the influence of rivalry on performance. There is a slight negative general relationship between the rivalry score and offensive performance in models 1, 3, and 5, which is significant at the 10% level with the exception of offensive points. When a team plays against its main rival (models 2, 4, 6), there is a significant and even stronger reduction in yards and points compared to when the team plays against no main rival. In such a situation, the team loses almost 10 yards, 1 point scored, and some passer rating points.

Overall, rivalry has a consistently negative association with performance. One might object that weaker offensive performance in rivalry games simply reflects a stronger opposing defense rather than a true rivalry effect. We address this concern in two ways: first, we already control for opponent strength via betting odds and win rate difference; second, we re-estimate our model using DST points as the dependent variable,[8] and find that defensive performance also deteriorates in rivalry games (models 1 and 2 in Table 2). Additionally, when re-estimating the model using the opponent's rivalry score as the independent variable (models 3 and 4 in Table 2), we

[8] Defense/Special Teams (DST) points are used in Fantasy Football and measure the football performance of a team's defense and special teams. The score is based on defensive actions (sacks (+1), interceptions (+2), fumble recoveries (+2), safeties (+2), defensive or kick and punt return touchdowns (+6), 2-point conversion returns (+2) as well as the number of points allowed by the defense (e.g., + 10 points for a shutout and—4 points for allowing 35 or more points), with better defensive performances receiving higher fantasy point totals.

Table 2 Defensive performance

	(1) DST	(2) DST	(3) DST	(4) DST
Rivalry score (standardized)	−0.3189** (0.1359)			
Main rival		−0.5496* (0.2736)		
Rivalry score of opponent (standardized)			0.1784 (0.1482)	
Opponent sees focal team as main rival (1 = yes, 0 = no)				0.3887 (0.3009)
# Encounters	0.0027 (0.0037)	0.0026 (0.0037)	0.0018 (0.0036)	0.0017 (0.0036)
Win rate difference	0.0054 (0.0036)	0.0053 (0.0035)	0.0051 (0.0035)	0.0053 (0.0036)
Win probability	0.0699*** (0.0048)	0.0704*** (0.0047)	0.0709*** (0.0047)	0.0710*** (0.0047)
Same division	0.8034** (0.3570)	0.4690 (0.3344)	0.0508 (0.3972)	0.2157 (0.3448)
Same conference	−0.1451 (0.1771)	−0.1626 (0.1771)	−0.1586 (0.1760)	−0.1453 (0.1739)
Super bowl champ	0.2122 (0.3787)	0.1986 (0.3811)	0.1863 (0.3860)	0.1900 (0.3851)
Playoffs	−1.0413*** (0.3440)	−1.0556*** (0.3452)	−1.0634*** (0.3457)	−1.0572*** (0.3459)
Home	−0.1314 (0.1424)	−0.1378 (0.1435)	−0.1441 (0.1481)	−0.1453 (0.1477)
Evening	−0.1395 (0.2235)	−0.1534 (0.2226)	−0.1790 (0.2256)	−0.1757 (0.2233)
Outdoors	−0.6796* (0.3641)	−0.6885* (0.3617)	−0.6630* (0.3639)	−0.6613* (0.3652)
Turf	−0.2759 (0.3901)	−0.2753 (0.3903)	−0.2776 (0.3905)	−0.2782 (0.3906)
Attendance	−0.0424*** (0.0154)	−0.0433*** (0.0154)	−0.0436*** (0.0155)	−0.0433*** (0.0156)
Overtime	−0.4006 (0.2461)	−0.4115 (0.2439)	−0.4302* (0.2435)	−0.4263* (0.2425)
# Pro bowlers in defense starting lineup	0.0792 (0.0837)	0.0779 (0.0837)	0.0774 (0.0835)	0.0771 (0.0835)
∅ Experience of starting defense players	0.0183 (0.1127)	0.0196 (0.1129)	0.0165 (0.1132)	0.0159 (0.1133)
Coach dummies	Yes	Yes	Yes	Yes
Referee dummies	Yes	Yes	Yes	Yes
Stadium dummies	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes
R^2 within	0.0933	0.0930	0.0926	0.0926
# Observations	8,120	8,120	8,120	8,120

[a] Team fixed effects estimations. Clustered robust standard errors at team level in parentheses. Mean value of # Pro Bowlers in Defense Starting Lineup: 1.21. Mean value of ∅ Experience of Starting Defense Players: 4.24. Control variables QB Rookie and QB Change are omitted because the quarterback does not play in the defense

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

find no significant relationship with the focal team's defensive performance, suggesting that a rivalry-motivated opponent does not cause the focal team's defense to perform differently. Overall, this supports the interpretation that the negative relationship between rivalry and offensive performance is driven by the focal team's own rivalry perception rather than by a better playing opposing defense.

A further potential concern is that NFL players may not share the same sense of rivalry as fans, given that players frequently change teams and may lack strong team identification. However, we assume that players are aware of fan rivalries through media coverage and are likely to internalize them, as self-representation tends to encompass collective team identities (Tajfel 1982; Turner et al. 1994). This is particularly plausible for the quarterback—the most important, usually highest-paid player and face of the franchise, who typically remains with a team longer than other players. Since quarterback passer rating deteriorates significantly in rivalry games (see Table 1), we attribute this effect to rivalry rather than confounding factors.

Due to the reasons outlined above, we now refocus on offensive performance. A further concern relates to the direction of causality. While our observational design does not permit definitive causal claims, several features of the study reduce causality and endogeneity concerns. First, reverse causality appears unlikely because rivalry is measured using an independent fan-based assessment from an external source rather than being derived from the focal game outcomes or performance measures used in the analyses. It represents a relatively stable, opponent-specific perception that cannot be mechanically generated by within-game performance fluctuations. Second, the separation of data sources, namely fan evaluations for rivalry and objective game statistics for performance, minimizes common method bias and the risk that the observed relationships are artifacts of a shared measurement process. Third, measurement error is unlikely to drive the results, as performance measures were cross-validated across multiple data sources yielding consistent statistics. Fourth, all models include team fixed effects and extensive controls, for example for season, matchday, referee, coach, and stadium, addressing many potential confounders and omitted variable bias.

Table 3 Propensity score matching

Average treatment effect	(1) Yards	(2) Yards	(3) Offensive points	(4) Offensive points	(5) Passer rating	(6) Passer rating
Rival	−1.7204 (6.1369)		−1.6955** (0.7105)		−4.1435* (2.2153)	
Main rival		−71.8712 (61.1014)		−7.4117* (3.8840)		−17.8579*** (3.9856)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes	Yes	Yes
# Observations	8,120	8,120	8,120	8,120	8,120	8,120

1:2 matching. Abadie-Imbens robust standard errors in parentheses. Coach, referee, and stadium dummies are excluded. Rival = 1: Rivalry Score >= Mean Rivalry Score of focal team. Rival = 0: Rivalry Score < Mean Rivalry Score of focal team

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Nevertheless, we additionally conduct propensity score matching, which yields substantively similar estimates, as shown in Table 3. Furthermore, Oster (2019) coefficient stability tests indicate that unobserved selection would need to be at least as strong as observed selection to eliminate our estimated effects (δ is around 1 for the models 1, 3, 5 in Table 1 and even is 1.4, 2, and 19 for the models 2, 4, 6 in Table 1). Taken together, these analyses substantially strengthen confidence that the reported associations reflect a genuine rivalry effect and that endogeneity does not pose a major concern.

We now conduct various robustness checks to verify the results reported in Table 1. First, we check whether there is a possible quadratic relationship between rivalry and performance. To do this, we look at the models with the rivalry score and add the quadratic term of it as a control. However, no significant quadratic effects are found. We also repeat the results without the 2020 season, as this was partially affected by spectator restrictions and other precautions due to the COVID pandemic. The results remain similar. We also estimate our models as dynamic models to check whether performance values depend on past performance. To do this, we add the lagged dependent variable from the previous game day as a control variable to the models using the Arellano-Bond method. However, it turns out that the dynamics of the process are negligible, as the coefficients of the lagged dependent variables are always insignificant at the 10% level, while the relationships between rivalry and performance remain similar. We also examined whether the results are similar when we use the geographical proximity between the two teams as a proxy for rivalry instead of our rivalry indicator. Here, no significant effects are apparent, which underscores that the mere use of geography may not be a sufficient representation of rivalry.

Finally, we examine whether our findings change in certain situations. In our models, we interact rivalry with home games, playoff games, and a variable that indicates whether the opponent has a similar sense of rivalry. There are no differences between regular season games and playoff games or between home and away games (all robustness results reported up to this point are available from the authors upon request). The results regarding the symmetry of rivalry, where we focus on the rivalry

Table 4 Moderating role of opponent's rivalry perception

	(1) Yards	(2) Offensive points	(3) Passer rating
Rivalry score (standardized)	−4.1164**	−0.3835*	−0.6222
	(1.5871)	(0.2084)	(0.5228)
Rivalry score (standardized) x higher rivalry	2.4406	0.1363	−0.1923
	(2.4281)	(0.2333)	(0.5393)
Rivalry score (standardized) x lower rivalry	7.2073**	1.1219**	0.3636
	(3.4564)	(0.4646)	(1.5799)
Controls	Yes	Yes	Yes
Coach dummies	Yes	Yes	Yes
Referee dummies	Yes	Yes	Yes
Stadium dummies	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes
R^2 Within	0.1424	0.1422	0.1086
# Observations	8,120	8,120	8,120

[a] Team fixed effects estimations. Clustered robust standard errors at team level in parentheses. * p < 0.1, ** p < 0.05

[b] 71.6% of observations belong to the symmetric group and 14.2% to each of the two asymmetrical groups

score, are shown in Table 4. The moderator variable "rival type" indicates whether the opponent has the same sense of rivalry and whether it is therefore a symmetrical rivalry (the difference in rivalry rating between the two teams is less than 10 points), whether the observed team sees a greater rivalry (observed team rates rivalry with at least 10 points more, called "Higher Rivalry") or whether the opponent sees a greater rivalry (opponent rates rivalry at least 10 points higher, called "Lower Rivalry").

In the case of symmetrical rivalry, there is a significant negative rivalry association in terms of yards and offensive points. This improves somewhat, albeit not significantly, when the team feels greater rivalry than its opponent. If there is asymmetric rivalry in the sense that the team perceives less rivalry than the opponent, rivalry is significantly associated with increased yards and points, which ultimately leads to an overall positive relationship between rivalry and performance.

We conclude from our results that there is generally a negative relationship between rivalry and performance. Thus, we align ourselves with the smaller strand of literature that posits a negative relationship between rivalry and (offensive) performance. The negative rivalry-performance-relationis particularly evident in situations where a team is playing against its main rival as well as in symmetrical rivalries. However, one-sided rivalries seem to improve performance again provided that the team feels less rivalry than its opponent.

In order to examine possible reasons for this in more detail, we carry out further estimations. First, we run another estimation with the dependent variable "Team performs worse than expected" (1 = yes, 0 = no).[9] Table 5 shows that a team did not

[9] For each game, "Pro Football Reference" calculates the total expected points for both teams using a formula. Expected points represent the estimated point value at the start of the play based on down, distance, and field position. If a team's offense ends up scoring fewer points on its drive than expected, it performed worse than expected on this drive (and the opposing defense performed better than expected). The offense may also have a negative expected score on its drive, e.g., if the offense starts very close to its own end zone and there is a high risk that the defense will score. A team's total expected points in a game is the sum of its expected points for each drive.

Table 5 Choking under pressure and risk behavior

	(1) Worse than expected	(2) Worse than expected	(3) 4. Down attempt	(4) 4. Down attempt
Rivalry score (standardized)	0.0011 (0.0057)		−0.0007 (0.0087)	
Main rival		0.0040 (0.0119)		−0.0047 (0.0178)
Controls	Yes	Yes	Yes	Yes
Coach dummies	Yes	Yes	Yes	Yes
Referee dummies	Yes	Yes	Yes	Yes
Stadium dummies	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes
R^2 Within	0.0706	0.0707	0.0638	0.0639
# Observations	8,120	8,120	8,120	8,120

[a] Team fixed effects estimations. Clustered robust standard errors at team level in parentheses

[b] In 10.14% of cases, a team is worse than expected. In 62.9% of cases, a team plays a 4. Down

perform significantly worse than expected in rivalry games, so that "choking under pressure" is probably not the reason behind the worse performance (see models 1 and 2). We also used the dependent variables "% of field goals successfully made" and "% of extra points successfully made after touchdowns," which describe the kicker's performance in a game. Here, too, we find no significant relationship with rivalry, which is why an individual player does not appear to be affected by "choking under pressure," as otherwise it would have been expected that the kicker would miss more often (results are available from the authors upon request).

Kilduff et al. (2010) likewise show that "choking under pressure" cannot explain underperformance in basketball. Then, we use the dependent variable "Offense plays a fourth down in the game" (1 = yes, 0 = no). This symbolizes the risk behavior of the offense. An increased willingness to take risks in sports is often inefficient, as Grund et al. (2013) demonstrate with professional basketball data. An NFL team is likely aware that a fourth down attempt often fails and can ultimately result in a favorable field position for the opponent. Normally, the ball is punted on the fourth attempt. But we find no indications that the team acts (see models 3 and 4 in Table 5). There are no significant interactions with home games, playoff games, or feelings of rivalry toward the opponent for the results in Table 5. The results from Table 5 remain the same when we perform probit random effects estimates instead of fixed effects estimates (results are available from the authors upon request).

One possible explanation for our findings is that rivalry games generate psychological pressure and stress due to their emotional and media-driven nature, which may lead to heightened expectations placed on the team. This could reduce the offensive potential. Performance is particularly lower in symmetrical rivalry situations, as perceiving each other as rivals has a reinforcing effect, maximizing psychological pressure on both sides. In asymmetrical situations, the team that is less driven by rivalry is under less pressure and may be able to use the tension caused by the rivalry to create a clear focus and to perform better.

6.2 Rivalry and sabotage

We classified the NFL fouls into three separate categories, which indicate the intention of the foul (see Table 10). We are particularly interested in fouls with a disruptive intent. They are closest to the sabotage definition because they are intentional fouls committed by players to harm the opponent and reduce the opponent's chances of success. In Table 6, it can be seen that there is a significant u-relationship between rivalry and the number of committed intentional fouls with disruptive intent. The minimum number of fouls is reached at 58.5 rivalry points (0.3508/(2*0.1685) = 1.04 standardized rivalry points, which corresponds to 58.5. points). When playing against the main rival, sabotage fouls significantly increase by 0.13.

As discussed above, we do not believe our results are subject to severe endogeneity concerns. Nevertheless, we again conduct propensity score matching and find that games against a (main) rival are associated with a significant negative average treatment effect on sabotage fouls (see Table 7). To additionally validate the u-shaped relationship identified in Table 6, which a binary treatment variable cannot capture, we complement this analysis with a generalized propensity score (GPS) regression

Table 6 Main results – sabotage

	(1)	(2)	(3)
Rivalry score (standardized)	0.0031 (0.0333)	−0.3508*** (0.0977)	
Rivalry Score (Standardized) x Rivalry Score (Standardized)		0.1685*** (0.0468)	
Main rival			0.1307* (0.0757)
# Encounters	0.0014 (0.0011)	0.0015 (0.0011)	0.0012 (0.0011)
Win rate difference	−0.0020* (0.0010)	−0.0021** (0.0010)	−0.0020* (0.0010)
Win probability	0.0015 (0.0014)	0.0012 (0.0014)	0.0016 (0.0014)
Same division	−0.0803 (0.1183)	0.2009 (0.1347)	−0.1096 (0.0957)
Same conference	−0.1395** (0.0584)	−0.1163** (0.0567)	−0.1367** (0.0582)
Super bowl champ	0.0695 (0.1443)	0.0805 (0.1446)	0.0679 (0.1437)
Playoffs	−0.7356*** (0.0975)	−0.7097*** (0.0960)	−0.7364*** (0.0969)
Home	−0.1622*** (0.0414)	−0.1585*** (0.0403)	−0.1637*** (0.0413)
Evening	0.0165 (0.0483)	0.0248 (0.0499)	0.0126 (0.0478)
Outdoors	0.0214 (0.1771)	0.0247 (0.1748)	0.0259 (0.1773)
Turf	0.4323*** (0.1479)	0.4312*** (0.1479)	0.4321*** (0.1481)
Attendance	0.0056 (0.0059)	0.0061 (0.0059)	0.0055 (0.0058)
Overtime	0.5710*** (0.1028)	0.5825*** (0.1021)	0.5691*** (0.1030)
QB rookie	−0.0599 (0.0874)	−0.0604 (0.0870)	−0.0602 (0.0872)
QB change	−0.2250*** (0.0719)	−0.2257*** (0.0721)	−0.2240*** (0.0716)
# Pro bowlers	0.0182 (0.0147)	0.0194 (0.0147)	0.0181 (0.0147)
∅ Experience	−0.0354 (0.0447)	−0.0364 (0.0447)	−0.0369 (0.0448)
Coach dummies	Yes	Yes	Yes
Referee dummies	Yes	Yes	Yes
Stadium dummies	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes
R^2 Within	0.1120	0.1135	0.1123
# Observations	8,120	8,120	8,120

[a] Team fixed effects estimations. Dependent variable = Number of fouls with disruptive intent. Clustered robust standard errors at team level in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01

following Hirano & Imbens (2004), which confirms the significant u-shaped relationship between rivalry intensity and sabotage fouls (see Table 7).

Finally, we again apply the Oster (2019) coefficient stability test. The Oster delta for the models in Table 6 is negative, indicating that selection on observables works in the opposite direction of the estimated effect. This implies that omitted variable bias would need to counteract the observed selection pattern to eliminate the finding, making it unlikely that unobserved confounders drive the result.

We conduct several robustness tests. The results remain the same when we use Poisson team fixed effects instead of linear team fixed effects estimations, when we exclude the 2020 season, and when we use a dynamic model, which again proves to be unsuitable. Incidentally, when we use geographical proximity as an alternative to our rivalry indicator, no significant effects emerge. We also separate the results according to fouls committed by the offense and fouls committed by the defense, with the results remaining similar. There are no significant interactions with playoff games

Table 7 Propensity scores

	Propensity score matching		Generalized propensity score	
	(1)	(2)	(1)	(2)
	# Fouls with disruptive intent	# Fouls with disruptive intent	# Fouls with disruptive intent	# Fouls with disruptive intent
Rival	−0.5820*** (0.1684)			
Main rival		−1.3465*** (0.2803)		
Rivalry score (standardized)			0.0031 (0.0333)	−0.3508*** (0.0977)
Rivalry score (standardized) x rivalry score (standardized)				0.1685*** (0.0468)
Generalized propensity score				−4.7215** (2.0702)
Controls	Yes	Yes	Yes	Yes
Coach dummies	No	No	Yes	Yes
Referee dummies	No	No	Yes	Yes
Stadium Dummies	No	No	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes
R^2 Within			0.1120	0.1135
# Observations	8,120	8,120	8,120	8,120

Regarding models 1 and 2: 1:2 matching. Average treatment effect is shown. Abadie-Imbens robust standard errors in parentheses. Rival = 1: Rivalry Score >= Mean Rivalry Score of focal team. Rival = 0: Rivalry Score < Mean Rivalry Score of focal team

Regarding models 3 and 4: Team fixed effects estimations. Clustered robust standard errors at team level in parentheses

** $p < 0.05$, *** $p < 0.01$

or the (a)symmetry of rivalry.[10] However, slightly different results emerge when we distinguish between home and away games, as shown in Table 8. When a team plays against a rival in its own stadium, sabotage-like fouls are significantly less frequent than in away games. This is probably because reputation is important in home games, so players may be more careful to avoid fouls in order not to upset the fans or because they place more value on fair play in front of their home crowd and do not want a "dirty" victory.

We conclude from these results that, regardless of the reciprocation of rivalry, there is a u-shaped relationship between rivalry and sabotage. Furthermore, we find no significant rivalry effects with regard to classified unintentional fouls, which shows that unnecessary mistakes do not change with rivalry and that "choking under pressure" is therefore not necessarily present. We do not examine strategic fouls because they occur very rarely in a game. However, we examine emotional fouls, namely disqualification, taunting, unsportsmanlike conduct, or unnecessary roughness. With the exception of unnecessary roughness, these fouls can also be called when a player

[10] All results are available upon request from the authors.

Table 8 Sabotage fouls and home game

	(1)	(2)
Home	−0.1607*** (0.0414)	−0.1309*** (0.0393)
Rivalry score (standardized)	0.0443 (0.0380)	
Rivalry score (standardized) x home	−0.0760** (0.0348)	
Main rival		0.2713** (0.1139)
Main rival x home		−0.2647* (0.1306)
Coach dummies	Yes	Yes
Referee dummies	Yes	Yes
Stadium dummies	Yes	Yes
Season dummies	Yes	Yes
R^2 Within	0.1123	0.1127
# Observations	8,120	8,120

[a] Team fixed effects estimations. Dependent variable = Number of fouls with disruptive intent. Clustered robust standard errors at team level in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

is inactive off the court, and theoretically can be called on coaches and team personnel. Taunting, for example, can be compared to workplace bullying, while the other fouls represent more aggressive assaults. There is no significant relationship between rivalry and emotional fouls (all results are available from the authors on request). This suggests that emotions or aggression are no different in rivalry games. Rather, it could be that players behave professionally regardless of rivalry and take care not to make unnecessary mistakes.

The u-shaped relationship between rivalry and sabotage warrants further discussion. One possible explanation for the high level of sabotage in games with little or no perceived rivalry is that these games carry lower reputational stakes, reducing the social and media scrutiny that would otherwise deter misconduct. Players may act more impulsively or carelessly when the game feels less consequential, without fearing the reputational damage that would accompany such behavior in a high-profile rivalry game. As rivalry intensity increases, players may become more cautious and deliberate, suppressing fouls due to heightened awareness of consequences, which results in lower sabotage at moderate rivalry levels. At high rivalry levels, however, sabotage increases again, but for different reasons: here, deliberate and strategic rule violations may be more likely, as players are willing to accept the risk of penalties if it weakens a particularly important opponent. Thus, the u-shape may reflect a transition from impulsive misconduct at low rivalry to strategic misconduct at high rivalry, with a period of cautious restraint in between.

7 Conclusion

Using longitudinal data from the NFL and a survey-based rivalry indicator, we find that a team's offensive performance is significantly worse as the perceived rivalry increases. Performance is particularly poor when rivalry is acknowledged by both sides, and improves for a team in case of asymmetric rivalry where the opponent feels greater rivalry. We attribute the decline in performance to heightened psychological

pressure. In addition, we show a u-shaped relationship between rivalry and sabotage fouls, regardless of whether the rivalry is one-sided or mutual.

When transferring these findings to corporate contexts, it is important to recognize that the NFL represents an exceptionally professionalized and intensely competitive environment. Players and teams operate under constant performance pressure, frequent evaluation, and repeated high-stakes competition, and are accustomed to rivalrous settings. In typical corporate environments, by contrast, employees and teams are often less habituated to persistent head-to-head competition. As a result, perceived rivalry may exert stronger psychological strain and attentional disruption, potentially leading to even larger performance decrements or more pronounced dysfunctional responses than observed in the NFL. In this sense, the effects documented here may constitute a conservative lower bound for many organizational contexts.

Overall, our findings are particularly applicable to corporate settings that resemble rank-order tournaments, such as industries characterized by up-or-out promotion systems, competitive bidding, or relative performance evaluation (e.g., management consulting, investment banking, or sales organizations). In such environments, rewards depend on outperforming specific peer groups, and individuals or teams often compete repeatedly against the same counterparts, allowing rivalries to emerge and persist. For these settings, the results suggest that the presence of a direct rival can impair performance and dysfunctional competitive behavior.

Because organizations often deliberately implement tournament-like incentive structures to stimulate effort, an important managerial question concerns how to mitigate potential downsides of rivalry while preserving its motivational benefits. To counteract negative effects, preventive measures such as workshops, psychological support, and strategic preparation may help employees cope with competitive pressure. Alternatively, organizations might redesign internal tournaments to reduce repeated head-to-head encounters between the same actors or to avoid strongly symmetrical rivalries. Where rivalry cannot be avoided, structuring competition to maintain moderate rather than extreme rivalry intensity may help balance motivational gains against behavioral risks. This is particularly relevant because sabotage typically imposes costs on the organization rather than the rival alone, for example through reduced team performance, cooperation breakdowns, or reputational damage.

Beyond these practical implications, our findings also extend the broader literature on rivalry, competition, and team performance. Prior work has largely highlighted the motivational benefits of rivalry or its contribution to harmful practices; however, our results reveal how rivalry can paradoxically impede performance while exerting a non-linear effect on sabotage. Our approach differs both conceptually and methodologically from previous work. Unlike other studies in this field, we use a suitable rivalry index that can indicate asymmetries. Until now, asymmetries have not been (comprehensively) investigated. In addition, our longitudinal data set and fixed effects estimations allow us to better control for endogeneity, which is not the case in most other studies that use cross-sectional data. We are therefore convinced that our approach better reflects the relationship between rivalry and competitive behavior. Our results prompt a reexamination of established models of rivalry and of how organizations should manage rivalry within teams and across their employees, suggesting

that the interplay between competition, performance, and destructive behavior may be more multifaceted than previously assumed.

By illuminating these unanticipated dynamics, our study encourages scholars and practitioners to reassess assumptions about how rivalry unfolds and to explore novel avenues for mitigating its downside risks while leveraging its possible advantages. Also, gender-specific differences in rivalry dynamics may shape how individuals perceive and respond to competition, underscoring the importance of further research on this topic. Because our data rely on male NFL players and predominantly male participants in the rivalry survey, this study presents a male-focused perspective. Future work could extend these insights by examining (i) rivalry among women, who may prefer more cooperative environments (Kuhn & Villeval 2015), tend to be less competitive in sports (Wozniak 2012), and are less inclined to exhibit aggressive behavior or sabotage (Dato & Nieken 2014), and (ii) cross-gender rivalry, which would broaden the understanding of how gender interacts with rivalry-related behaviors and outcomes.

Appendix A

List of NFL Rivalries
See Table 9

Table 9 Top Rivalries

NFL Team	Conference & Division	Surveyed Fans	1. Rival	2. Rival	3. Rival
Buffalo Bills	AFC East	128	New England Patriots	Miami Dolphins (52.42)	New York Jets (34.81)
Miami Dolphins	AFC East	84	New York Jets	New England Patriots (78.14)	Buffalo Bills (48.05)
New York Jets	AFC East	252	New England Patriots	Miami Dolphins (36.12)	Buffalo Bills (25.9)
New England Patriots	AFC East	174	New York Jets	Buffalo Bills (36.71)	Miami Dolphins (35.78)
Denver Broncos	AFC West	131	Las Vegas Raiders	Kansas City Chiefs (60.95)	New England Patriots (44.04)
Los Angeles Chargers	AFC West	126	Las Vegas Raiders	Denver Broncos (46.04)	Kansas City Chiefs (40.47)
Kansas City Chiefs	AFC West	167	Las Vegas Raiders	Denver Broncos (75.7)	Los Angeles Chargers (25.6)
Las Vegas Raiders	AFC West	97	Denver Broncos	Kansas City Chiefs (94.48)	Los Angeles Chargers (48.98)
Cincinnati Bengals	AFC North	221	Pittsburgh Steelers	Cleveland Browns (28.12)	Baltimore Ravens (20.99)
Cleveland Browns	AFC North	192	Pittsburgh Steelers	Baltimore Ravens (56.72)	Cincinnati Bengals (22.97)
Baltimore Ravens	AFC North	104	Pittsburgh Steelers	New England Patriots (28.52)	Cleveland Browns (12.90)
Pittsburgh Steelers	AFC North	145	Baltimore Ravens	Cleveland Browns (27.34)	Cincinnati Bengals (23.73)

Table 9 Top Rivalries

NFL Team	Conference & Division	Surveyed Fans	1. Rival	2. Rival	3. Rival
Indianapolis Colts	AFC South	169	New England Patriots	Houston Texans (66.99)	Tennessee Titans (61.98)
Jacksonville Jaguars	AFC South	60	Tennessee Titans	Indianapolis Colts (27. 97)	Houston Texans (15.71)
Houston Texans	AFC South	166	Indianapolis Colts	Tennessee Titans(76.17)	Dallas Cowboys (34.46)
Tennessee Titans	AFC South	49	Indianapolis Colts	Houston Texans (54.91)	Baltimore Ravens (47.9)
Washington Commanders	NFC East	75	Dallas Cowboys	Philadelphia Eagles (36.66)	New York Giants (26.82)
Dallas Cowboys	NFC East	134	Philadelphia Eagles	Washington Commanders (61.70)	New York Giants (56.86)
Philadelphia Eagles	NFC East	305	Dallas Cowboys	New York Giants (40.59)	Washington Commanders (20.24)
New York Giants	NFC East	80	Philadelphia Eagles	Dallas Cowboys (95.28)	Washington Commanders (28.59)
San Francisco 49ers	NFC West	90	Seattle Seahawks	Dallas Cowboys (55.74)	Los Angeles Rams (44.21)
Arizona Cardinals	NFC West	73	Seattle Seahawks	San Francisco 49ers (58.76)	Los Angeles Rams (33.67)
Los Angeles Rams	NFC West	43	San Francisco 49ers	Seattle Seahawks (42.72)	Arizona Cardinals (11.81)
Seattle Seahawks	NFC West	86	San Francisco 49ers	Los Angeles Rams (55.76)	Green Bay Packers (41.47)
Chicago Bears	NFC North	154	Green Bay Packers	Minnesota Vikings (13.57)	Detroit Lions (12.55)
Detroit Lions	NFC North	62	Green Bay Packers	Chicago Bears (49.17)	Minnesota Vikings (30.29)
Green Bay Packers	NFC North	157	Chicago Bears	Minnesota Vikings (53.56)	Detroit Lions (18.94)
Minnesota Vikings	NFC North	146	Green Bay Packers	New Orleans Saints (30.95)	Chicago Bears (22.33)
Tampa Bay Buccaneers	NFC South	52	New Orleans Saints	Carolina Panthers (70.15)	Atlanta Falcons (62.98)
Atlanta Falcons	NFC South	193	New Orleans Saints	Carolina Panthers (12.72)	Tampa Bay Buccaneers (7.74)
Carolina Panthers	NFC South	130	New Orleans Saints	Atlanta Falcons (91.55)	Tampa Bay Buccaneers (33.84)
New Orleans Saints	NFC South	152	Atlanta Falcons	Carolina Panthers (14.98)	Tampa Bay Buccaneers (8.24)

[a] Three strongest rivals of each team are shown. In the last two columns, the rivalry score of the team named in the first column towards the team named in the last two columns is shown in parentheses. In the column "1. Rival", the rivalry score is 100 in each case

Appendix B

NFL Foul Explanation

See Table 10

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Chop block	An attempt by an offensive player to cut block a defensive player who is being blocked by another offensive player below the thigh. It is legal if it takes place along the line of scrimmage, within three yards behind it, or within a four-yard width extending in either direction from the spot where the ball is snapped	15 yards			x
Clipping	Making contact with an opponent who is not carrying the ball from behind, at, or below the waist	15 yards			x
Defensive delay of game	A defensive player obstructing the offense from quickly executing the next snap	5 yards	x		
Defensive holding	A defensive player illegally restraining an offensive player who does not have possession of the ball	5 yards and automatic first down			x
Defensive offside	A defensive player is positioned on the wrong side of the line of scrimmage at the snap. If a defender crosses the line but returns before the snap, no foul occurs. When a foul is committed, the play continues, and the foul is announced after the play concludes	5 yards	x		
Defensive pass interference	A defensive player deliberately makes physical contact with an intended receiver after the ball has been thrown but before it is touched by another player, aiming to hinder or prevent the reception of a forward pass	The ball is placed at the spot of the foul (or on 1 yard line if the foul occurred in the end zone) and automatic first down			x
Defensive too many men on field	Having twelve or more defensive players on the field at the time of the snap. Before the 2018 season, this penalty was known as "Defensive 12 On-Field"	5 yards	x		
Delay of game	Failing to snap the ball before the play clock expires. This penalty may also be called when a player intentionally spikes the ball on non-touchdown plays	5 yards	x		
Delay of kickoff	If the kicking team fails to execute the kickoff before the play clock expires, a delay of kickoff penalty will be assessed	5 yards	x		

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Disqualification	A player is ejected from the game for committing a flagrant foul, such as throwing punches or making contact with officials. The player must then proceed to the locker room	15 yards and disqualification of the player			x
Encroachment	Before the snap, a defensive player illegally crosses the line of scrimmage, making contact with an opponent or gaining a clear path to the quarterback	5 yards	x		
Face mask	Grasping another player's face mask and pulling or twisting it while attempting to block or tackle him	15 yards, additionally automatic first down if committed by defense			x
Fair catch interference	An opponent player may not interfere with a punt returner's ability to catch the football after the returner has signaled for a fair catch	15 yards or safety and touchback when it happened in the receiver's end zone			x
False start	A false start occurs when, after the ball is ready for play, an offensive player in a set position moves or simulates the start of the play, or if a player in motion suddenly moves toward the line of scrimmage. Any abrupt movement that mimics the start of the snap is a false start, except for a player under the center turning the head or shoulders, unless it is an obvious attempt to draw an opponent offside	5 yards	x		
Horse collar tackle	Tackling an opponent by grabbing the inside of his shoulder pads or jersey from behind and immediately pulling him down. It is legal inside the tackle box. It is legal to grab the pads or jersey, as long as the player is not yanked down immediately in one motion	15 yards			x
Illegal bat	Advancing a live ball by intentionally batting it up the field. For example, if an offensive lineman sees a scramble forming on a fumbled ball, instead of recovering it, he kicks the ball down the field to another teammate or to gain yards	10 yards		x	

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Illegal blindside block	A block made from outside an opponent's field of vision or in a manner that makes it difficult for the opponent to defend himself	15 yards			x
Illegal block above the waist	A blocker making contact with a non-ball-carrying member of the opposing team from behind and above the waist. It is also sometimes called "Illegal Block in the Back"	10 yards			x
Illegal contact	A defensive player makes significant contact with a receiver after the receiver has advanced five yards beyond the line of scrimmage. It is called only if the quarterback is still in the pocket and has the ball in his hands	5 yards and automatic first down			x
Illegal crackback	A block delivered below the opponent's waist by an offensive player who had either exited the close line play area and returned, or was not within it at the time of the snap	15 yards			x
Illegal cut	A player deliberately hits an opponent below the waist in an unsafe manner, such as from behind, outside the tackle box, or after the ball has been released	15 yards, additionally automatic first down if committed by defense			x
Illegal double-team block / illegal wedge	A double team block is defined as two or more players making contact with an opponent simultaneously. It is allowed only by players who were initially lined up in the setup zone at the time of the kick A wedge block is prohibited at all times. A wedge block occurs when two or more players align shoulder-to-shoulder within two yards of each other and move forward together. Contact with an opponent is not necessary for calling the penalty	15 yards			x
Illegal formation	Fewer than seven players line up on the line of scrimmage, or eligible receivers do not line up as the leftmost and rightmost players on the line, or five properly numbered ineligible players fail to line up on the line	5 yards	x		
Illegal forward handoff	A forward handoff occurs when the ball is handed to a player who is positioned ahead of a teammate from whom he takes or receives it, regardless of the direction the ball is moved	5 yards and loss of down	x		

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Illegal forward pass	A forward pass is illegal if it is thrown from beyond the line of scrimmage, after a change of possession, or if a second forward pass is thrown during the same play	5 yards from the spot of the foul and loss of down	x		
Illegal kick/kicking loose ball	Intentionally kicking a loose ball	10 yards		x	
Illegal Motion	An offensive player in motion is moving forward at the time of the snap	5 yards	x		
Illegal onside kick / illegal touch kick	The ball, after a kick, touches a member of the kicking team before traveling ten yards. This is most commonly seen on an onside kick, where a member of the kicking team makes premature contact with the ball while attempting to recover it	Receiving team gets the ball at the spot of the foul	x		
Illegal peelback	An offensive player blocks a defensive player who is running towards his own end zone from the side or behind	15 yards			x
Illegal receiver pass / ineligible downfield pass	A forward pass is thrown and an ineligible receiver is beyond the line of scrimmage without blocking an opponent at the time of the pass	5 yards	x		
Illegal shift	An offensive player is not set before the snap and is not in motion, or more than one offensive player is in motion at the snap, or all eleven offensive players have not been stationary for one second before the snap	5 yards	x		
Illegal substitution	A team has twelve or more players in the huddle for at least three to five seconds, or a team has twelve or more players in the formation before a play, or a player is attempting to leave the field as the ball is snapped	5 yards	x		
Illegal touch pass	Only eligible receivers are allowed to touch a forward pass before it is touched by another offensive player. It is not a penalty if the ball unintentionally hits an offensive lineman	5 yards	x		
Illegal use of hands	A player uses his hands improperly while attempting to ward off a block, cover a receiver, or tackle a ball carrier	10 yards if committed by offense, 5 yards and automatic first down if committed by defense			x

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Impermissible use of helmet	A player lowers his head and makes forcible contact with his helmet against an opponent, or uses any part of his helmet or facemask to make forcible contact to an opponent's head or neck	15 yards			x
Ineligible downfield kick	On a punt, only the two players on the punting team positioned on the end of the line of scrimmage are allowed to cross the line before the punt	5 yards	x		
Intentional grounding	A forward pass is thrown intentionally incomplete so that the passer avoids loss of yardage or to conserve time. It is not called if the ball is spiked. If the quarterback has moved outside of the area between his offensive tackles, the foul is not called if the quarterback throws the ball past the line of scrimmage	10 yards or spot of the foul (whichever is further away from the original line of scrimmage) and loss of down (if the foul occurs in the end zone, the play is ruled a safety)		x	
Interference with opportunity to catch / kick catch interference	Kick Catch Interference is called if a player of the kicking team contacts the receiver, or causes a passive player of either team to contact the receiver, before or simultaneous as he touches the ball Interference with Opportunity to Catch is called if a player from the kicking team prevents the receiving player from having a fair opportunity to catch the ball, even if no actual contact is made, and regardless of whether any signal was given	15 yards from spot of the foul			x
Invalid fair catch signal	A fair catch signal is valid if it is made while the kick is in flight, with the player fully extending one arm above his helmet and waving it from side to side	5 yards from spot of the signal	x		

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Illegally kicking ball / kickoff out of bounds	Kickoffs cannot go out of bounds between the goal lines	The receiving team may elect to take possession of the ball 25 yards from the spot of the kick (for a kickoff after a safety it is 30 yards), or at the out of bounds spot	x		
Leaping	A defender running forward and leaping in an attempt to block a field goal or point-after-touchdown-try, and then landing on other players from either team. The penalty is not called if the defender was within one yard of the line of scrimmage at the time of the snap	15 yards and automatic first down			x
Leverage	A player jumping or standing on a teammate or an opponent to block or attempt to block an opponent's kick	15 yards and automatic first down			x
Low block	An illegal block below the waist	15 yards			x
Neutral zone infraction	Before the snap, a defensive player jumps into the neutral zone and causes an offensive player to false start	5 yards	x		
Offensive holding	An offensive player keeps a defender from advancing by grasping him with his hands or arms	10 yards			x
Offensive offside	An offensive player is on the wrong side of the line of scrimmage when the ball is snapped	5 yards	x		
Offensive pass interference	Making intentional physical contact with a defender, between the snap and the first touch of a forward pass, in order to hinder or prevent the defender from catching or defending the ball	10 yards			x
Offensive too many men on field	Having twelve or more offensive players on the field at the time of the snap. Before the 2018 season, this penalty was known as "Offensive 12 On-field"	5 yards	x		

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Offside on free kick	A player cannot cross the yard line where the ball is spotted for the kickoff until the ball has been kicked	5 yards	x		
Player out of bounds on kick / player out of bounds on punt	Prior to the ball being touched by the receiving team or prior to the end of the kick, a kicking team player voluntarily goes out of bounds to avoid a block	5 yards		x	
Roughing the kicker	A defender, having missed an attempt to block a kick, tackles the kicker or runs into the kicker in a way that might injure the kicker. This also applies to the holder of a place kick	15 yards and automatic first down			x
Roughing the passer	A defender continues an effort to tackle or hit a passer after the pass is already thrown. A defender is allowed to take one step after the ball is thrown	15 yards and automatic first down			x
Running into the kicker	On a kicking play, a defensive player fails to touch the kicked ball and runs unintentionally into the kicker or punter. If the contact is intentional, it is considered roughing the kicker	5 yards			x
Short free kick	A kickoff must travel at least ten yards if it is not touched by the receiving team	Receiving team gets the ball where it stopped or crossed out of bounds	x		
Taunting	Taunting is the act of mocking or disrespecting an opponent. It also includes any prolonged or premeditated celebrations by players, such as using props like the end zone pylon during a touchdown celebration	15 yards, additionally automatic first down if committed by defense			x
Tripping	A player trips an opponent with the lower leg	15 yards, additionally automatic first down if committed by defense			x

Table 10 Fouls in the NFL (as of Season 2023/2024)

Foul	Explanation	Penalty	Unintentional Foul	Strategic Foul	Intentional Foul with Disruptive Intent
Unnecessary roughness	A conduct or safety-related infraction which includes actions such as hitting a ball carrier after he is out of bounds, piling on a ball carrier who is already down, or making violent contact with an opponent who is away from the play	15 yards, additionally automatic first down if committed by defense			x
Unsportsmanlike conduct	A person acts or speaks in a way that is intentionally harmful or particularly offensive, as determined by the officials or the rules. This is a non-contact foul. Examples include verbally abusing officials or engaging in disrespectful behavior	15 yards, additionally automatic first down if committed by defense			x

Appendix C

Descriptive Statistics
See Table 11

Table 11 Descriptive statistics of variables

	Whole sample (n = 8,120)				Main rival (n = 965)
Variable	Mean/Share	SD	Min	Max	Mean/Share
Independent variables					
Rivalry score (toward opponent)	22.58	34.5	0	100	100
Main rival (rivalry score = 100)	0.12		0	1	1
Dependent variables—performance					
Yards (total net yards gained by offense)	345.3	84.9	47	726	333.70
Offensive points (points scored by offense)	21.50	9.66	0	70	20.16
Passer rating (rating of passing player / quarterback, on a scale from 0 to 158.3)	89.30	26.76	0	158.3	86.83
Dependent variables—sabotage					
# Unintentional fouls (committed against opponent)	2.43	1.65	0	11	2.40
Strategic fouls (committed against opponent, 0 = no, 1 = yes)	0.09		0	1	0.09
# Intentional fouls with disruptive intent (committed against opponent)	3.68	2.07	0	14	3.75
Controls					
# Encounters (# previous games against opponent)	48.53	45.55	1	207	96.98
Win Rate difference (absolute difference between the two teams' head-to-head win percentages, in percentage points)	20.37	18.76	0	100	13.27

Table 11 Descriptive statistics of variables

	Whole sample (n = 8,120)				Main rival (n = 965)
Variable	Mean/Share	SD	Min	Max	Mean/Share
Win probability (probability of winning against opponent by betting odds, in %)	50	19.34	4.29	95.71	46.61
Same division (0 = opponent is in different division, 1 = opponent is in same division)	0.36		0	1	0.99
Same conference (0 = opponent is in different conference, 1 = opponent is in same conference)	0.75		0	1	1
Super bowl champ (0 = opponent is no reigning super bowl champion, 1 = opponent is reigning super bowl champion)	0.03		0	1	0.04
Playoffs (0 = regular season game, 1 = playoff game)	0.04		0	1	0.03
Home (0 = away game, 1 = home game)	0.50		0	1	0.50
Evening (0 = afternoon game, 1 = evening game)	0.20				0.30
Outdoors (0 = indoor game / closed roof, 1 = outdoor game / open roof)	0.73		0	1	0.74
Turf (0 = grass, 1 = turf)	0.43		0	1	0.45
Attendance (in 1,000 persons)	63.9	18	0	105.12	64.91
Overtime (0 = no overtime game, 1 = game with overtime)	0.06		0	1	0.07
QB rookie (0 = starting quarterback is not in his first season, 1 = starting quarterback is in his first season)	0.11		0	1	0.12
QB change (0 = no change in quarterback position, 1 = other starting quarterback compared to last game)	0.09		0	1	0.10
# Pro bowlers (# last season's pro bowlers in starting line-ups of team)	2.65	1.92	0	10	2.61
# Offense pro bowlers (# last season's pro bowlers in starting offense line-up of team)	1.44	1.32	0	7	1.42
# Defense pro bowlers (# last season's pro bowlers in starting defense line-up of team)	1.21	1.16	0	6	1.19
∅ Experience (∅ season experience of starting line-up players in team)	4.19	0.74	1.50	7.27	4.19
∅ Experience offense (∅ season experience of offense starting line-up players in team)	4.15	1	0.82	8	4.15
∅ Experience defense (∅ season experience of defense starting line-up players in team)	4.24	1	0.91	8.45	4.24

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Data availablity The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of Interest The author has no relevant financial or non-financial interests to disclose.

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