Westfälische Wilhelms-Universität Münster

Institut für Organisationsökonomik

Diskussionspapier des
Instituts für Organisationsökonomik

7/2023

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Discussion Paper of the
Institute for Organisational Economics

Diskussionspapier des
Instituts für Organisationsökonomik
7/2023

Juli 2023

ISSN 2750-4476

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Abstract

The COVID-19 pandemic has led to massive restrictions and changes in many areas of life, including professional sports. In football, many games were cancelled and then five instead of three substitutions were allowed with the unchanged maximum of three time-outs. This initially temporary, but now permanent rule change affects the possibilities and thus the decisions of the coaches of the teams. We analyse 836 games with three possible substitutions and 1,000 games with five possible substitutions in the six seasons from 2017/2018 to 2022/2023 of the Bundesliga (first division of German men's football). In addition to team statistics, data on substitutions was collected. The results show that the rule change changed the behaviour of coaches regarding the number of substitutions made and, in some cases, the timing of substitutions. More substitutions generally have a positive effect on the result of the game.

JEL Codes: Z20

Keywords: Bundesliga, Football, Ghost Game, Rule Change, Substitution

Auswirkungen der Regeländerung von drei zu fünf Auswechslungen in der Bundesliga

Zusammenfassung

Die COVID-19-Pandemie hat zu massiven Einschränkungen und Veränderungen in vielen Lebensbereichen geführt, auch im Profisport. Im Fußball wurden viele Spiele abgesagt und danach wurden fünf statt drei Auswechslungen erlaubt bei unverändert maximal drei Auszeiten. Diese zunächst temporäre, nun aber permanente Regeländerung wirkt sich auf die Möglichkeiten und damit auf die Entscheidungen der Trainer der Mannschaften aus. Wir analysieren 836 Spiele mit drei möglichen Auswechslungen und 1.000 Spiele mit fünf möglichen Auswechslungen in den sechs Spielzeiten von 2017/2018 bis 2022/2023 der Bundesliga (erste Liga des deutschen Männerfußballs). Es wurden neben Teamstatistiken vor allem Werte zu den Auswechslungen erfasst. Die Ergebnisse zeigen, dass die Regeländerung das Verhalten der Trainer hinsichtlich der Anzahl der durchgeführten Wechsel und teils bezüglich der Wechselzeitpunkte verändert hat. Mehr Auswechslungen haben grundsätzlich einen positiven Effekt auf das Spielergebnis.

Im Internet unter:

http://www.wiwi.uni-muenster.de/io/forschen/downloads/DP-IO_07_2023

DOI: 10.17879/50099606262

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Effects of the Rule Change from Three to Five Substitutions in the Bundesliga[1]

1. Introduction

What consequences do rule changes have on the behaviour of actors? This business-related question is not only interesting when legal requirements in countries change, e.g. with regard to labour law or tax law, and companies have to adapt their strategies and business models accordingly, but also in the area of sports economics. In Germany, for example, the change in the points rule had an impact on sporting competitions (Dilger & Geyer 2009). In addition to many negative effects and massive restrictions and changes in many different areas of life, the COVID-19 pandemic has led to temporary changes in sports including the exclusion spectators, which has made it possible to conduct studies on their influence (including Reade & Singleton 2022 and Dilger & Vischer 2022). This was a quasi-experimental design and allowed for many interesting studies in sports economics but also in companies on how they react to the change of rules and conditions. Many analogies have already been drawn from the findings of sports economics to business management issues, and this fits in well with the more interdisciplinary approach of sports economics. In German football, many games were initially cancelled in the spring of 2020, and then when play resumed, more substitutions were possible. This initially temporary but now permanent rule change affects the possibilities and thus the decisions of team coaches.

Until March 2020, games in the Bundesliga, the first division of German men's football, were played with three changes per team. Since the resumption of games, the organising DFL (*Deutsche Fußball Liga* or German Football League) has allowed five substitutions per team in a maximum of three substitution slots. This allows us to analyse 836 games with three substitutions as a control group and 1,000 games with five substitutions as the experimental group in the 2017/2018, 2018/2019, 2019/2020, 2020/2021, 2021/2022 and 2022/2023 seasons. Another interesting aspect of this rule change is that there have long been calls from both practitioners and researchers to increase the number of substitutions in professional games for injury prevention (Mota et al. 2020) and for the attractiveness of the game (Leite & Figueredo 2020). To meet this demand, the DFL needed the exogenous pressure of the

[1] We thank our current and former student assistants for their help in building the dataset, especially Tim Christoph, Vanessa Gathmann, Claas Glindemann, Emely Kutscha, Anna Langner and Rebecca Staubach. We also thank the participants of the 9th Football & Finance Conference at the University of Paderborn on 22 April 2023 for valuable suggestions. Of course, we alone are responsible for any remaining errors.

COVID-19 pandemic and the increased risk of injury after a longer interruption. This increased possibilities for substitutions actually received a mainly positive response and exists now on a permanent basis. This emphasises the relevance of the strength of the substitutes as well as the coach's ability to have the right feeling for the timing and number of substitutions. The coach can be seen as a leader who has to decide whether to continue with the existing team or whether adjustments are necessary for the team's success. Substitutions are his only possibility to make personnel changes during the game. Compared to business, the objective in sport is clear for every game. Regardless of how good a team is, it has the goal of winning or at least not losing any game and thus performance can be clearly measured by the result of the game. More beautiful play or the like are of secondary importance, so that this setting can be understood as an experiment for teams and their fluctuation in companies and whether more possibilities for personnel influence during an ongoing process improve its performance.

This leads to the question of whether and what influence this rule change has on the substitution behaviour in the Bundesliga. Although there have been many studies on transfer behaviour in general in recent years, which we will report on in Section 2, to the best of our knowledge there has been little research on the specific rule change with the exception of Meyer & Klatt (2023). We would like to close this gap in research with a more in-depth analysis of this rule change in the Bundesliga. This is not only interesting for sports economics, but hopefully also offers additional insights in the effects of rule changes for the economy as a whole.

2. Theoretical Background

The literature on changes of the number of substitutions can be divided in three sub-areas. First, there are studies of the effects of substitutes on the game in general. Second, researchers try to find the best possible substitutes and change times for coaches. Third, there are studies that called for an increase in the existing substitution quota before the actual rule change. In this order, we review the existing literature.

First, the reasons for the type and timing of substitutions are generally considered to be the score at the time of the substitution as well as the threat of the substituted player receiving a yellow-red card (Geyer 2008). Furthermore, teams have an increased tendency to score after a certain period of time following the first and second substitutions. This is especially true if the team is behind at the time of the substitution. The time taken could indicate a need for the

substituted player to acclimatise (Amez et al. 2021). Hills et al. (2020) focus on the perceptions of professional players in this area and emphasise the importance of substitutions for both physical and tactical effects. In addition, a preparation strategy for the substituted player is considered important. Furthermore, Boyle et al. (2020) find a higher relative total distance, a higher distance at high speed and more sprints per minute for substitutes compared to players in the starting line-up. Their top speed, however, appears to be lower. Similar results regarding top speed and the higher intensity in the running performances of substitutes are also found by Liu et al. (2020) studying substitutions at the 2018 World Cup. Bradley et al. (2014) find that the higher intensity in running performance is mainly due to substitute strikers. Conversely, Carling et al. (2010) locate the higher intensity in midfield substitutes and suggest that strikers may not be playing to their full physical potential. Padrón-Cabo (2018) also demonstrates the effects of higher intensity for players, primarily offensive players, who do not play the full match time but are substituted at a certain point. Garcia et al. (2023) examine substitutions in the course of the rule change due to the COVID-19 pandemic and confirm the findings of older studies and also refer to a reduction in the risk of injury. Overall, several research studies have concluded that substitutions in games have an effect on the performance data of the individual players and thus also the team and potentially the final result of the game.

Second, there is research that can be used as a decision-making tool for coaches to determine the type and timing of substitutions. An example of this is Gomez et al. (2016), who provide coaches with information on substitutions and extract it through the impact of substitutions in terms of possession, shots on goal and ball wins. Hills et al. (2018) look at the emotional experiences of substitutes in this context with current preparation strategies alongside performance indicators and explore the potential for optimisation in terms of emotional response performance. Hirotsu & Wright (2002) describe the modelling of a football game as a four-state Markov process, using a log-linear model and real data to estimate the transition probabilities to calculate the probability distributions of goals scored and the expected number of league points won for any given game situation to determine the optimal time for tactical changes in the game. Kröckel (2017) also tries to develop an analysis tool to support coaches in their substitution decisions. Myers (2011) uses decision trees to develop a decision rule to inform football coaches when they should make their three substitutions during a game. This is based on over 1,200 observations from the world's leading professional leagues and competitions. Silva & Swartz (2016) disagree in that the substitution guidelines recommended by Myers do not provide any identifiable advantages at specific times in the second half. Alterna-

tively, they propose a decision aid using Bayesian logistic regression. Rey et al. (2017) show that coaches tend to make substitutions later when their team is leading and earlier when it is either tied or trailing while the probability of offensive tactical substitutions increases when the team is trailing. Wittkugel et al. (2022) examine the substitution behaviour of football coaches and show that offensive substitutions are preferred, although neutral substitutions are most common in general, while defensive substitutions are most common when the team is leading and offensive substitutions are most common when the team is trailing.

Third, Meyer & Klatt (2021) note that additional substitutions in football could enable a considerable reduction in stress and increase the tactical possibilities for the coach to influence the game. As a result, more young players could be used. Krutsch et al. (2022) find a reduced risk of injury after the resumption of play in the wake of the COVID-19 pandemic with more substitutions. They attribute this primarily to a longer opportunity for physical recovery and individual fitness training. Another possibility would be the reduced strain due to more opportunities for substitutions as well as injury prevention during the game, when injured players can be substituted more often than having to play through. According to Werlayne & Figueredo (2020), an increase in the number of substitutions could make football more dynamic and attractive for the spectators. Lorenzo-Martinez (2022) analyses the development of football, physiological aspects, injury frequency, media relations and economic conditions and argues that more substitutions in modern professional football games could increase the dynamics and attractiveness of the sport. Overall, the main arguments for more substitutions are reducing the risk of injury and increasing the attractiveness of the game.

3. Hypotheses

To answer the question whether and what influence the rule change from three to five allowed substitutions has in the Bundesliga, we formulate three hypotheses that we empirically examine thereafter. The first point to be examined is whether the increase in substitution possibilities due to the rule change has led to an actual increase in substitutions. Several studies find that substitutes have higher performance values in relation to players who play the whole game, so that more substitutions are advantageous and we expect them to take place:

H1: Coaches substitute more players with the rule change.

Another hypothesis is that coaches do not only change the number of substitutions but also their timing. Analogous to the research that attempts to develop decision-making tools for

coaches regarding their substitution behaviour, there are differing views on the appropriate timing of substitution windows. In general, we would assume a longer period between the first and the last substitution with increased substitution possibilities in order to have more influence on the game by the coach over the entire duration of the game, despite the fact that there are still only three substitution slots. This means that the first change is made earlier and especially that the last change is made later:

H2: Coaches hold back the last substitution slot longer after the rule change.

Substitutes have a higher performance potential and therefore substitute players should improve the game. In addition, the coaches in the Bundesliga are just as professional as the players and it can therefore be assumed that their personnel decisions during the game have a positive effect on the game. In sports the better team in a specific game is primarily defined by the fact that it wins the game. Other performance indicators such as the running performance of the entire team, possession, shots on goal or goals are secondary or only relevant as far as they increase the probability of winning. More substitutions should increase this probability:

H3: More substitutions by a coach are positively reflected in the results.

4. Data

To examine our hypotheses and to answer the research question behind them, we look at the Bundesliga seasons from 2017/2018 to 2022/2023 with a total of 1,836 games in these six seasons. In the second half of the 2019/2020 season, the COVID-19 pandemic interruption took place. Therefore, 836 games with three substitutions are distributed as the control group before the COVID-19 pandemic-related interruption and 1,000 games with five substitutions as the experimental group after the interruption.

The data records of www.football-data.co.uk were used for the game pairings as well as the results and team statistics. The substitutions made were collected manually from www.dfb.de and then randomly checked.

Table 1 shows the relevant data collected from the data sets just described, differentiated by the number of substitutions allowed. This includes classic performance data from the teams, such as home and away team shots, home and away team shots on target, home and away team corners and data on their respective penalties and the fouls whistled for them. In particular, these are the fouls committed by the home and away team, their yellow and red cards.

Variables	5 Substitutions	N	Mean	SD	SE
Goals (H)	0	836	1.709	1.398	0.048
	1	1,000	1.737	1.428	0.045
Goals (A)	0	836	1.348	1.240	0.043
	1	1,000	1.370	1.243	0.039
Shots (H)	0	836	14.385	5.042	0.174
	1	1,000	13,664	5.060	0.160
Shots (A)	0	836	11.900	4.747	0.164
	1	1,000	11.556	4.925	0.156
Shots on Target (H)	0	836	5.126	2.652	0.092
	1	1,000	5.182	2.770	0.088
Shots on Target (A)	0	836	4.322	2.439	0.084
	1	1,000	4.260	2.499	0.079
Corners (H)	0	836	5.359	2.991	0.103
	1	1,000	5.049	2.784	0.088
Corners (A)	0	836	4.517	2.552	0.088
	1	1,000	4.490	2.609	0.083
Fouls (H)	0	836	11.725	3.930	0.136
	1	1,000	11.897	3.689	0.117
Fouls (A)	0	836	12.323	4.070	0.141
	1	1,000	12.241	3.752	0.119
Yellow Cards (H)	0	836	1.611	1.278	0.044
	1	1,000	1.802	1.297	0.041
Yellow Cards (A)	0	836	1.951	1.298	0.045
	1	1,000	1.989	1.346	0.043
Red Cards (H)	0	836	0.060	0.247	0.009
	1	1,000	0.046	0.210	0.007
Red Cards (A)	0	836	0.091	0.296	0.010
	1	1,000	0.069	0.261	0.008
Substitutions (H)	0	836	2.854	0.407	0.014
	1	1,000	4.320	0.880	0.028
Unused Substitutions (H)	0	836	0.146	0.407	0.014
	1	1,000	0.680	0.880	0.028
First Substitution (H)	0	836	57.781	15.081	0.522
	1	1,000	57.292	14.664	0.464
Last Substitution (H)	0	836	81.157	9.107	0.315
	1	1,000	82.709	8.530	0.270
Substitutions (A)	0	836	2.874	0.397	0.014
	1	1,000	4.253	0.970	0.031
Unused Substitutions (A)	0	836	0.126	0.397	0.014
	1	1,000	0.747	0.970	0.031
First Substitution (A)	0	836	55.708	15.366	0.531
	1	1,000	55.621	15.481	0.490
Last Substitution (A)	0	836	80.403	9.952	0.344
	1	1,000	81.667	11.113	0.351
Difference Substitutions (H-A)	0	836	-0.020	0.514	0.018
	1	1,000	0.067	1.161	0.037
Betting Odds Home Win	0	836	2.579	1.732	0.059
	1	1,000	2.637	1.611	0.050
Betting Odds Draw	0	836	4.096	1.277	0.044
	1	1,000	4.145	1.216	0.038
Betting Odds Away Win	0	836	3.722	2.492	0.086
	1	1,000	3.586	2.452	0.077
Spectators	0	836	43,109.639	17,220.942	595.599
	1	1,000	19,729.401	22,350.880	707.151
Stadium Utilisation	0	836	90.215 %	12.729	0.440
	1	1,000	43.994 %	42.561	1.345

5 Substitutions (no = 0/yes = 1), N = Sample Size, SD = Standard Deviation, SE = Standard Error, (H) = Home Team, (A) = Away Team.

Table 1: Descriptive Statistics for All Variables

In addition, we collected the number of substitutions, calculated the number of unused substitutions and the difference between the substitutions by the home and the away team. We also document the minute of the first and last substitution made by the home and away team, counting substitutions in the overtime periods as happening in the last minute of the respective half.

Furthermore, we collected the respective spectator numbers for the games and put these in relation to the stadium sizes. With an average of 43,109 spectators during games with three changes and 19,729 spectators during games with five changes, which is of course due to ghost games, there is a large variance in the data. This leads to a stadium occupancy of 90.22 % before the season break in early 2020 and 43.99 % after the season break and we need a test to control for this variance. Furthermore, we have collected the betting odds for a home win, draw and away win for each game from one of the leading betting providers bwin (https://sports.bwin.de/de/sports) to be able to control for the performance of the teams in our subsequent analyses. Betting odds have the advantage that they include a lot of information on the current form of the teams and players and thus offer a better pre-game forecasting model than the more past-oriented standings or the market value of the respective teams. Moreover, they are standardised and can be compared in a uniform way. Higher odds mean that an event is less likely and one can win more money when a bet on the event is successful.

5. Empirical Results

To further test our hypotheses, we use tests for statistical significance. We first perform t-tests for independent samples and use the permitted option of three or five substitutions as the separating value for the two samples. With these tests we want to determine whether the means of both groups deviate from each other. In the following, we report only those variables with significant differences or that relate directly to our hypotheses. In the case of the performance variables relating to the teams, only the reduction in home corners is statistically significant.

Table 2 shows a clear increase in the number of substitutions made by both home and away teams. It is noticeable that the home teams have increased the number of substitutions more than the away teams. Nevertheless, on average the full five substitutions are not used, which leads to an increase in unused or open substitution opportunities at the end of the game. In addition, the last change in the game is carried out later than before the rule change. There are no statistically significant differences in the average time of first substitutions.

Variables	5 Subst.	N	Mean	SD	Sig. (2-tailed)	LV 95 % CI	UV 95 % CI
Substitutions (H)	0	836	2.854	0.407	<0.001***	-1.527	-1.405
	1	1,000	4.320	0.880			
Unused Substitutions (H)	0	836	0.146	0.407	<0.001***	-0.595	-0.473
	1	1,000	0.680	0.880			
First Substitution (H)	0	836	57.781	15.081	0.484	-0.876	1.854
	1	1,000	57.292	14.664			
Last Substitution (H)	0	836	81.157	9.107	<0.001***	-2.366	-0.739
	1	1,000	82.709	8.530			
Substitutions (A)	0	836	2.874	0.397	<0.001***	-1.445	-1.313
	1	1,000	4.253	0.970			
Unused Substitutions (A)	0	836	0.126	0.397	<0.001***	-0.687	-0.555
	1	1,000	0.747	0.970			
First Substitution (A)	0	836	55.708	15.366	0.904	-1.331	1.505
	1	1,000	55.621	15.481			
Last Substitution (A)	0	836	80.403	9.952	0.010**	-2.238	-0.290
	1	1,000	81.667	11.113			
Difference Substitutions (H-A)	0	836	-0.020	0.514	0.032**	-0.167	-0.007
	1	1,000	0.067	1.161			

*5 Subst. = 5 Substitutions (no = 0/yes = 1), N = Sample Size, SD = Standard Deviation, Sig. (2-tailed) = Significance (2-tailed), CI = Confidence Interval, LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, ** p < 0.05, *** p < 0.01.*

Table 2: t-Tests for Variables of Substitutions

In the distribution of the cards received, the increase in the yellow cards received by the home team stands out in Table 3. This is surprising insofar as there is no significant change in the number of fouls counted per game. There are also (weakly) statistically significantly fewer red cards for the away team with five compared to three possible substitutions. With more substitutions a team can risk more yellow cards and lower the risk of a red card because of a second yellow card for the same player.

Variables	5 Subst.	N	Mean	SD	Sig. (2-tailed)	LV 95 % CI	UV 95 % CI
Yellow Cards (H)	0	836	1.611	1.278	0.002***	-0.309	-0.072
	1	1,000	1.802	1.297			
Yellow Cards (A)	0	836	1.951	1.298	0.540	-0.160	0.084
	1	1,000	1.989	1.346			
Red Cards (H)	0	836	0.060	0.247	0.202	-0.007	0.035
	1	1,000	0.046	0.210			
Red Cards (A)	0	836	0.091	0.296	0.092*	-0.004	0.047
	1	1,000	0.069	0.261			

*5 Subst. = 5 Substitutions (no = 0/yes = 1), N = Sample Size, SD = Standard Deviation, Sig. (2-tailed) = Significance (2-tailed), CI = Confidence Interval, LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, * p < 0.10, *** p < 0.01.*

Table 3: t-Tests for Cards

Furthermore, we carried out various regressions to test the influence of the substitutions made on the final result. Because the final result is most relevant in football, we estimated a binary logistic regression with the binary dependent variable whether the home team has won or not. As control variables we included the number of yellow cards per team, since cautions can lead to substitutions to avoid potential red cards. We also included the betting odds described in Section 4. Table 4 shows a statistically significant positive influence of the number of home team substitutions on the probability of a home win. The number of substitutions made by the away team has no significant effect on the probability of a home team win (the sign is negative as expected). An increased number of received yellow cards has a negative impact for the home team on the probability of a home win. The betting odds of home and away wins have a significant impact, showing that they work as a predictive tool and control variable here.

Variables	B	Exp(B)	Sig.	LV 95% CI	UV 95% CI
Substitutions (H)	0.329	1.390	<0.001***	1.230	1.571
Substitutions (A)	-0.070	0.932	0.250	0.828	1.050
Yellow Cards (H)	-0.169	0.844	<0.001***	0.779	0.915
Yellow Cards (A)	-0.005	0.995	0.893	0.921	1.074
Betting Odds Home Win	-0.198	0.820	<0.001***	0.735	0.916
Betting Odds Draw	-0.035	0.966	0.716	.800	1.166
Betting Odds Away Win	0.144	1.155	0.001***	1.059	1.259

*B = Regression Coefficient, Exp(B) = Exponentiation of B, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, *** p < 0.01, Cox & Snell R Square = 0.129, Nagelkerke R Square = 0.172, Chi-square = 253.039 with p < 0.001, 1,836 Observations in the Model.*

Table 4: Binary Logistic Regression of Home Wins

Another, less common indicator to analyse the final result is the scoring of at least one point by the home team. This includes, in addition to the previous analysis, draws and thus any points scored by the home team. In this regression, the same effects are statistically significant and additionally the substitutions of the away team with a negative sign as Table 5 shows.

Variables	B	Exp(B)	Sig.	LV 95% CI	UV 95% CI
Substitutions (H)	0.174	1.191	0.009***	1.044	1.357
Substitutions (A)	-0.201	0.818	0.002***	0.718	0.932
Yellow Cards (H)	-0.119	0.888	0.005***	0.816	0.965
Yellow Cards (A)	0.068	1.071	0.113	0.984	1.165
Betting Odds Home Win	-0.184	0.832	0.001***	0.745	0.929
Betting Odds Draw	-0.002	0.998	0.986	0.810	1.229
Betting Odds Away Win	0.233	1.262	<0.001***	1.133	1.406

*B = Regression Coefficient, Exp(B) = Exponentiation of B, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, *** p < .01, Cox & Snell R Square = 0.133, Nagelkerke R Square = 0.188, Chi-square = 262.111 with p < 0.001, 1,836 Observations in the Model.*

Table 5: Binary Logistic Regression of Home Points

We estimated further regressions to see to what extent the results of Table 4 are robust. We repeated the regression of home wins with the subsamples of three and five permitted substitutions. The effect of substitutions by the home team on home wins also occurs in the subsamples and is even stronger with three permitted substitutions, as Table 6 shows. Table 7 has the results for the subsample with five possible substitutions.

Variables	B	Exp(B)	Sig.	LV 95% CI	UV 95% CI
Substitutions (H)	1.298	3.660	<0.001***	2.237	5.590
Substitutions (A)	-0.082	0.921	0.598	0.613	1.384
Yellow Cards (H)	-0.142	0.868	0.002***	0.768	0.980
Yellow Cards (A)	-0.021	0.979	0.730	0.869	1.102
Betting Odds Home Win	-0.323	0.724	0.208	0.606	0.864
Betting Odds Draw	0.022	1.023	0.060*	0.771	1.356
Betting Odds Away Win	0.078	1.081	0.390	0.954	1.224

*B = Regression Coefficient, Exp(B) = Exponentiation of B, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, * p < 0.10, *** p < 0.01, Cox & Snell R Square = 0.152, Nagelkerke R Square = 0.204, Chi-square = 138.242 with p < 0.001, 836 Observations in the Model.*

Table 6: Binary Logistic Regression of Home Wins with Three Substitutions

Variables	B	Exp(B)	Sig.	LV 95% CI	UV 95% CI
Substitutions (H)	0.470	1.600	<0.001***	1.348	1.900
Substitutions (A)	0.137	1.147	0.072*	0.988	1.332
Yellow Cards (H)	-0.156	0.855	0.005***	0.767	0.055
Yellow Cards (A)	0.004	1.004	0.943	0.905	1.113
Betting Odds Home Win	-0.137	0.872	0.067*	0.753	1.010
Betting Odds Draw	-0.035	0.966	0.793	0.745	1.252
Betting Odds Away Win	0.173	1.189	0.006***	1.050	1.346

*B = Regression Coefficient, Exp(B) = Exponentiation of B, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, * p < 0.10, *** p < 0.01, Cox & Snell R Square = 0.146, Nagelkerke R Square = 0.196, Chi-square = 158.237 with p < 0.001, 1,000 Observations in the Model.*

Table 7: Binary Logistic Regression for Home Wins with Five Substitutions

As a further robustness test, another indicator of the success of the home team is used as dependent variable, namely the goals scored by the home team, see Table 8. The positive effect of the number of substitutions by the home team is confirmed.

	Unstandardised Coefficients		Standardised Coefficients			95 % CI	
Variables	B	Std. Error	Beta	t	Sig.	LV	UV
Substitutions (H)	0.201	0.037	0.144	5.438	<0.001***	0.128	0.273
Substitutions (A)	-0.048	0.037	-0.035	-1.302	0.193	-0.119	0.024
Yellow Cards (H)	-0.117	0.024	-0.107	-4.839	<0.001***	-0.165	-0.070
Yellow Cards (A)	0.008	0.024	0.008	0.340	0.734	-0.038	0.054
Betting Odds Home Win	-0.122	0.028	-0.181	-4.353	<0.001***	-0.177	-0,067
Betting Odds Draw	0.108	0.055	0.109	1.954	0.051*	0.000	0.216
Betting Odds Away Win	0.065	0.024	0.171	2.727	0.006***	0.018	0.111

*B = Regression Coefficient, Std. Error = Standard Error, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, * p < 0.10, *** p < 0.01, R Square = 0.165, Adjusted R Square = 0.162, F (7, 1828) = 51.523 with p < 0.001, Chi-square = 79.753 with p < 0.001, 1,836 Observations in the Model.*

Table 8: Multiple Linear Regression of Home Goals

Finally, we examine whether the ghost games because of COVID-19 had an influence on the importance of substitutions. For this purpose, we calculated the stadium capacity utilisation by dividing the number of spectators by the stadium capacity. Since in addition to pure ghost games without any spectators there were also many semi-ghost games with only a few hundred spectators, we classified games with a stadium capacity utilisation of less than 10 % as ghost games and games with a higher capacity utilisation as regular games. The atmosphere

created by the spectators at such a low capacity is very different from that in a normally filled stadium, also due to additional distance regulations. A stadium occupancy rate of less than 10 % only occurred due to legal restrictions on spectators in the wake of the COVID-19 pandemic and not due to a lack of interest in the game. The substitutions are significant in the subsample of the regular games (Table 9) and that of the ghost games (Table 10), while only the betting odds of the away wins are significant for the ghost games.

Variables	B	Exp(B)	Sig.	LV 95% CI	UV 95% CI
Substitutions (H)	0.393	1.481	<0.001***	1.271	1.726
Substitutions (A)	-0.117	0.889	0.127	0.765	1.034
Yellow Cards (H)	-0.160	0.852	<0.001***	0.776	0.935
Yellow Cards (A)	0.004	1.004	0.928	0.921	1.094
Betting Odds Home Win	-0.209	0.811	0.001***	0.716	0.919
Betting Odds Draw	0.039	1.040	0.718	0.842	1.285
Betting Odds Away Win	0.115	1.122	0.020**	1.018	1.237

*B = Regression Coefficient, Exp(B) = Exponentiation of B, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, ** p < 0.05, *** p < 0.01, Cox & Snell R Square = 0.125, Nagelkerke R Square = 0.167, Chi-square = 190.325 with p < 0.001, 1,423 Observations in the Model.*

Table 9: Binary Logistic Regression of Home Wins in Regular Games

Variables	B	Exp(B)	Sig.	LV 95% CI	UV 95% CI
Substitutions (H)	0.336	1.399	0.006***	1.101	1.777
Substitutions (A)	0.107	1.113	0.357	0.887	1.396
Yellow Cards (H)	-0.171	0.843	0.046**	0.713	0.997
Yellow Cards (A)	-0.084	0.919	0.353	0.769	1.098
Betting Odds Home Win	-0.109	0.897	0.365	0.709	1.135
Betting Odds Draw	-0.318	0.727	0.136	0.479	1.105
Betting Odds Away Win	0.263	1.301	0.008***	1.070	1.581

*B = Regression Coefficient, Exp(B) = Exponentiation of B, Sig. = Significance, CI = Confidence Interval for Exp(B), LV = Lower Value, UV = Upper Value, (H) = Home Team, (A) = Away Team, ** p < 0.05, *** p < 0.01, Cox & Snell R Square = 0.160, Nagelkerke R Square = 0.216, Chi-square = 71.883 with p = 0.003, 413 Observations in the Model.*

Table 10: Binary Logistic Regression of Home Wins in Ghost Games

6. Discussion

In the following, we first discuss our hypotheses (see Section 3) and then a few more general points.

H1: Coaches substitute more players with the rule change.

We can already confirm this hypothesis with our conducted t-tests. Coaches actually substitute more players with the increased substitution options. However, on average, not all of the coaches' substitution options are used, perhaps to hedge against the risk of a serious injury in the remaining playing time, especially of the goal keeper.

H2: Coaches hold back the last substitution slot longer after the rule change.

Another question was whether this change in behaviour also affects the timing of substitutions. We can confirm our hypothesis that, at a statistically significant level, both the home team and the away team substitute later. The first substitution time does not change significantly for either team. Nevertheless, with more substitution options, the coaches try to stretch their influence on the game, be it through time play or a reaction to a certain game trend, over a longer period of time. Sometimes this can result in substitution options not being used.

H3: More substitutions by a coach are positively reflected in the results.

We can also confirm our third hypothesis that more substitutions improve the result, although a few points need to be discussed here. The more often the home coach substitutes, the higher is the probability of a home win. This can also be found for other dependent variables such as points scored, goals scored and goal completions of the home team and passes such a robustness test. It is interesting to note here that the effect is even more pronounced in the subsample with three change options and seems to dilute somewhat with more change options. Basically, the coach's interventions in the personnel structure and presumably the performance of the substitutes have a positive influence on the game, which confirms the literature reviewed in Section 2. This is true even when considering only the performance determinants that could lead to a positive outcome. Nevertheless, it is not possible to draw any compelling conclusions from this analysis as to what is ultimately the cause of this result. It could either be the pure impulse of the coach on the team through a substitution or the increased performance of the substitutes, or both. Not considered here is the possible time play of the leading team through increased substitutions. The time required for substitutions could at least theoretically be added on the end of the game and these substitutions can also have a positive influence on

the game, apart from the time saved. Empirically, it would also be difficult to classify when time play begins and which substitutions primarily serve the purpose of time play and are not intended, for example, to reinforce the offensive or defensive.

Beyond our hypotheses, it is interesting to note that at least according to classical performance variables for teams the game does not become more attractive with more substitutions. Variables such as goal finishes etc. do not differ significantly after the rule change, apart from home corners, so one cannot say that the game has become significantly more offensive (with more goal shots, more goals etc.) and therefore more attractive with more substitutions. This partly contradicts the literature's expectations of increased substitution potential. The running distance and intensity are not considered here and they are usually not indicators of an attractive game. Furthermore, the home team does not seem to produce more fouls than before the rule change but they presumably take more risks in duels, as they receive statistically significantly more yellow cards for fouls committed. However, this may also be due to a change in referee behaviour. The away teams do not get statistically more cards and this difference could be investigated further.

In general, coaches change more often and keep more options open for longer with the increased possibility of personnel modifications. These personnel changes also seem to have a positive effect. However, these personnel changes could only be successful to a limited extent, since the effect is weaker with five substitutions. In addition, the DFL is also meeting a demand from academia here, and this had so far more positive than negative consequences.

However, many different factors can and do influence the result of a game. Although we have controlled for some of these factors or will included more in further analyses, still other factors like the mental state of the players, the injury of a key player during the game or other specific events during a game can significantly influence the result. It is hardly possible to investigate all these factors, some of which are psychological and subjective, with a reasonable amount of effort. In addition, other leagues and sports could be included in the analysis in order to be able to exclude a pure phenomenon of the German Bundesliga.

Some of the variables used by us also have weaknesses. One example is betting odds as a control variable with its own limitations. For example, these odds can be influenced by subjective factors such as public opinion, media coverage or betting trends and betting odds cannot fully capture all aspects of the performance or economic value of teams or players.

7. Conclusion and Outlook

Any rule change has an influence on the behaviour of actors and can change it. This is also true for the increase from three to five allowed substitutions in football. We examine a total of 1,836 games in the German Bundesliga in six seasons. With the opportunity of more substitutions, coaches actually substitute more often and a higher number of substituted players seems to have a positive influence on the game result. In addition, with more options available, coaches try to spread out these options over the game in order to be able to react at any time.

This study is intended to serve as a starting point for further research on rule changes in German football. We are planning an examination of the extent to which the experience of the coaches has an influence on their substitution behaviour and what the substitutions look like in specific game situations. Does a team that is behind tend to substitute offensively and a leading team to substitute more defensively, and what role does the time of the substitution play with regard to the state of the game? We also want to analyse the characteristics of the substituted players. Is there more variance in terms of age, nationality and playing time with more substitutions and does a higher variance of the substituted lead to better results? Finally, the analysis could be extended to other competitions, countries and sports.

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