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Performing under Pressure: Revisiting Penalty Shootouts

Jan C. van Ours* and Martin A. van Tuijl†

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Abstract

A penalty shootout in professional football is a tie-breaking sequence of penalty kicks. A penalty kick is a shot taken from the penalty mark, at a distance of 11 meters (12 yards) from the goal line. Only the opposing goalkeeper may attempt to prevent a score. Penalty shootouts allow for the study of the relation between performance outcomes and psychological pressure. Psychological pressure may be influenced by whether or not a team starts the sequence and may be present at individual kicks that are potentially decisive on the outcome of the shootout. This paper presents an analysis of penalty shootouts in matches for the Dutch cup competition over a period of 59 seasons. We analyze the outcomes of 291 shootouts and 2,680 individual penalty kicks from 262 of those shootouts. There is evidence of a first-mover advantage but this materializes in the early part of the sample period and not in recent years. Moreover, penalty kicks are more likely to fail under pressure.

Keywords: Performance, pressure, football, penalty kicks, shootouts

JEL-codes: C93, D01, J81, Z20

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Data availability: The data analyzed in this study come from various public sources and will be made publicly available in a single dataset at zenodo.org.

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1 Introduction

The productivity of a worker depends, among other factors, on the ability of a worker, the type of job, and the conditions in the workplace. When a worker is closely monitored, productivity may be affected, due to the psychological pressure the worker experiences. For regular jobs, determining the extent to which psychological pressure influences productivity is difficult. Firstly, measuring both individual productivity and psychological pressure is complicated. Secondly, the assessment of the relation between the two is even more demanding.

To study the relation between psychological pressure and individual worker performance, sports data can be very useful (Palacios-Huerta, 2025). The analysis of penalty kicks in professional football provides a suitable setting, owing to the simplicity of the situation. A penalty kick is taken from the penalty mark, located 11 meters (12 yards) from the goal line. There are two types of penalty kicks. There are penalty kick awarded during play, following a foul by the opposing team. These occur in regular match situations and can influence the scoreline. There are also penalty kicks that are part of a shootout, in which teams take alternating shots at the end of a knockout match to determine the winner.

The current paper focuses on penalty shootouts because, unlike individual in-play penalty kicks, they are always decisive for winning or losing a match. Therefore, psychological pressure is potentially high. Winning a shootout means progressing to the next round of the cup competition or even winning the tournament, which may place additional pressure on performance. Ariely et al. (2009), for example, found experimentally that high rewards can have a detrimental effect on performance.

A penalty shootout is usually organized according to the 5AB-sequence beginning with five players from each team taking one penalty kick. A coin toss determines which team starts or can opt to start first. The teams then take turns. If the score remains tied after five kicks each, the teams continue to take alternate penalties until a winner emerges. The present paper examines several issues through an analysis of penalty shootouts using the 5AB-sequence in Dutch cup matches over a period of fifty-nine seasons.

Our empirical research consists of two parts. The first part focuses on the determinants of winning a penalty shootout. Here, we investigate whether there was a first-mover advantage, whether success was primarily a matter of either luck or skill, and whether it mattered which team scored the equalizing goal in the match preceding the shootout. The second part of the analysis focuses on scoring within a penalty shootout and how this is influenced by psychological pressure. We are able to relate the first-mover advantage to psychological pressure affecting individual shots. This pressure, particularly the threat

of losing the shootout when missing a particular kick, is higher for second-movers, which translates into a first-mover advantage for the overall shootout. Whereas most previous studies have a sample period of at most a few decades, our very long time data period allows us to investigate, for example, the evolution of the first-mover advantage.

The structure of the paper is as follows. Section 2 briefly discusses previous studies on penalty shootouts. Section 3 presents the first part of the empirical analysis focusing on which team won the shootout. Section 4 shows the result of an analysis on the determinants of the success rates of individual penalty kicks. Section 5 concludes.

2 Previous studies on penalty shootouts

To provide a point of reference for our study, we briefly discuss previous studies on penalty shootouts. These studies deal with various potential determinants, the main issues being first-mover advantage, the importance of differences in strength between the two teams, and the effects of psychological pressure.

A *first-mover advantage* is present when the team that kicks first is more likely to win the shootout. A potential explanation for a first-mover advantage is that since most penalty kicks are converted this may choke the opponent whose turn it is to score in order to prevent falling behind. Apesteguia and Palacios-Huerta (2010), analyzing 269 penalty shootouts involving national and club teams, concluded that the team taking the first kick had about a 60% chance of winning the shootout. However, Kocher et al. (2012), extending the analysis to 540 penalty shootouts, found no significant first-mover advantage. Palacios-Huerta (2014) further expanded the sample to 1,001 shootouts confirming the first-mover advantage. Arrondel et al. (2019), analyzing penalty kicks in 239 shootouts in French cup football, found no evidence of a first-mover advantage either. Based on an analysis of 96 penalty shootouts in international tournaments, Kassis et al. (2021) concluded that there was no first-mover advantage. Santos (2023), analyzing 663 penalty shootouts in all major international football competitions since 1970, concluded that there was no first-mover advantage, neither in male nor in female competitions. Pipke (2025) concluded from an analysis of around 7,000 penalty shootouts from various national and international football competitions that there was no evidence of a first-mover advantage. Also Csató and Petróczy (2026), analyzing 268 penalty shootouts in UEFA club competitions, concluded that there was no first-mover advantage.

Differences in strength between the two teams in the shootout may influence the outcome but the evidence is not clear. Arrondel et al. (2019) found skill differences to be important: a higher-level team had a higher probability of winning the shootout. Krumer (2020) investigated 586 penalty shootouts in cup competitions in the top five European

football countries finding that teams from higher divisions were more likely to win a penalty shootout. Wunderlich and Memmert (2020) analyzed 1,067 penalty shootouts from 14 cup competitions, finding that team strength affected the conversion rates of penalty kicks positively. Wunderlich et al. (2020) analyzed 1,067 shootouts from various European, non-European, and UEFA cup competitions, concluding that success rates were not affected by differences in strength between teams. Van Hemert and Van der Kamp (2026) analyzed 409 shootouts from club and national team competitions, concluding that differences in team strength mattered for the outcome. Csató and Petróczy (2026) found no effect on the outcome of shootouts of differences in strength between the two teams.

Psychological pressure is likely highest when a penalty kick is potentially decisive, because it may result in either a win or a loss. Scoring in that situation may generate positive stress, since the expected benefits of scoring are substantially larger than the expected costs of missing, as the shootout would continue. Conversely, if missing the kick implies losing the shootout, this may generate negative stress, because the expected costs of missing are much higher than the expected benefits of scoring, while the shootout would continue if the kick is missed. Apesteguia and Palacios-Huerta (2010) labeled these two effects the potential winner penalty kick and the potential loser penalty kick. They found no significant effect of either variable on the scoring rate. However, Savage and Torgler (2012), in an analysis of 325 individual shots in penalty shootouts in international cup competitions, found that scoring rates were positively affected by positive stress and negatively affected by negative stress. Arrondel et al. (2019) further distinguished, for each penalty kick, between stakes and the risk of losing, and found that both had significant negative effects on the penalty scoring rate.

All in all, it is difficult to draw firm conclusions from previous studies, as they vary in their results with respect to first-mover advantage, the importance of differences in strength, and the relevance of psychological pressure.

3 Winning a Penalty Shootout

3.1 Data

We collected data on shootouts in Dutch cup matches over a period of 59 seasons; from season 1968 to 2026.¹ All shootouts are based on the 5AB-system that started with five penalty-kicks per team that were taken alternating. If after five penalty-kicks no decision

¹Seasons are labeled by the second year. So 1968 to 2026 implies seasons 1967/68 to 2025/26. Appendix A provides a brief history of Dutch cup football. Appendix B gives more details on our data.

was reached teams took additional penalty in an alternating order until a decision was reached. Over the sample period, there were 339 shootouts based on the 5AB-system. Of 291 shootouts we were able to find out which team took the first penalty kick.

In the first part of the analysis in which we focus on who won the shootout, in addition to using information about which team was first-mover we take into account the difference in strength between the two teams competing. For the difference in strength we use the difference in league-level as a rough indicator. The level ranges from low to high from 1 to 7. Furthermore, we investigated the relevance of which team scored the last goal preceding the shootout. The team that did may have had a psychological advantage of enjoying being in the shootout rather than losing the match.

Table 1: **Descriptives Penalty Shootouts**

	1968-2026		1968-2007		2008-2026	
	(1)		(2)		(3)	
Home win	0.47	(0.03)	0.45	(0.04)	0.48	(0.04)
First-mover home	0.44	(0.03)*	0.48	(0.04)	0.41	(0.04)*
First-mover wins	0.58	(0.03)**	0.63	(0.04)***	0.53	(0.04)
Δ Level	-0.20	(0.06)***	-0.17	(0.07)**	-0.23	(0.09)**
Home team last goal	0.42	(0.03)**	0.39	(0.04)**	0.44	(0.04)
Away team last goal	0.41	(0.03)**	0.43	(0.04)**	0.40	(0.04)**
Observations	291		143		148	
All shootouts	339		181		158	
Represented (%)	86		79		94	

Note: Δ level reference value is 0; other variables: reference value is 0.5; in parentheses standard errors; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 1 provides summary statistics of the dataset used in the analysis of penalty shootouts. The average probability that a home team wins is slightly below 50%, so other than in regular football matches in penalty shootouts there is no home advantage. The probability that the home team was the first-mover in the penalty shootout is also slightly below 50%. On average, the probability that the first-mover won a shootout was 58%, significantly higher than 50%. All penalty shootouts occur after the regular match – including extra time – ended in a draw. The probability that a home team scored the last goal during the match was 42% while the probability of an away team scoring was 41%. The remaining 17% refers to matches where no goal was scored. The difference in level of the league between the home team and the away team was -0.20 which is small compared to the range of -4 to +3 but still significantly below 0.²

²On average home teams were from a lower league than the away teams. For 50% of the shootouts the difference in level was 0 while for 18% of the shootouts the difference in level was positive and for 32% of the shootouts the difference in level was negative.

Table 1 also shows the descriptives for two periods, 1968-2007 and 2008-2026. The most striking difference is on the probability that the first mover wins. In the first part of the sample period this was 63% and significantly different from 50% while in the second part of the sample period the probability of the first-mover winning was 53%, not significantly different from 50%.

The bottom rows of Table 1 show the numbers of shootouts over the sample periods. Overall, our data cover 86% of all shootouts. In the first part of the sample period this is 79% while in the second part this is 94%.

3.2 Empirical analysis

Winning a penalty shootout is the result of several separate penalty kicks where the winning team is successful in scoring at least one more penalty than the losing team. From an empirical point of view there is a trade-off in available information and the detail of that information. In quite a few cases happening several decades ago there is information about which team won a penalty shootout but not which team was the first-mover, what the final score was in the shootout or the order in which teams scored the goals.

To investigate the determinants of the probability to win a shootout we estimate a logit model with several explanatory variables:

$$\log\left(\frac{\Pi_{ijt}}{1 - \Pi_{ijt}}\right) = \alpha + \beta_1 F_{ijt} + \beta_2 \Delta L_{ijt} + \beta_3 G_{ijt}^H + \beta_4 G_{ijt}^A + \varepsilon_{ijt} \quad (1)$$

where Π_{ijt} indicates whether or not home team i won the penalty shootout against team j in season t and F_{ijt} indicates whether or not the home team was the first mover. ΔL represents the difference in league level between the two teams. Furthermore, G^H and G^A indicate whether the home team or the away team scored the last and equalizing goal during the match. Finally, α is a constant (not reported), the β 's are parameters and ε is the error term.

The parameter estimates are transformed into average marginal effects and presented in Table 2. The first column of panel a shows that over the full sample period being the first-mover had a significant positive effect of about 18%. The difference in league level has no significant effect on the probability of winning. The second column of panel a shows that it does not matter which team scored the last equalizing goal during the match. Panel b shows the parameter estimates if the difference in league level is excluded from the analysis. The parameter estimates are very much the same in panels a and b.

Columns (3) and (4) of Table 2 show the parameter estimates for the first part of

the sample period, from 1968 to 2007. The main difference compared to the estimates in the first two columns is that the first-mover effect is larger, approximately 23-24%. In columns (5) and (6), with estimates over the period 2008 to 2026, the first-mover advantage is substantially smaller and no longer significantly different from zero.

Table 2: **Parameter Estimates Home Team Wins**

	1968-2026		1968-2007		2008-2026	
	(1)	(2)	(3)	(4)	(5)	(6)
a. Including Δ level						
First-mover home	0.179** (0.054)	0.182*** (0.054)	0.227** (0.071)	0.228** (0.071)	0.118 (0.080)	0.138 (0.081)
Δ Level	-0.033 (0.030)	-0.033 (0.031)	0.084 (0.049)	0.081 (0.049)	-0.098** (0.037)	-0.088* (0.038)
Home team last goal		0.042 (0.084)		0.046 (0.113)		0.022 (0.119)
Away team last goal		0.073 (0.083)		-0.052 (0.112)		0.159 (0.118)
b. Excluding Δ level						
First-mover home	0.173** (0.054)	0.176** (0.054)	0.243*** (0.070)	0.242*** (0.070)	0.103 (0.081)	0.121 (0.082)
Home last last goal		0.029 (0.083)		0.064 (0.113)		-0.023 (0.118)
Away team last goal		0.070 (0.083)		-0.041 (0.113)		0.155 (0.119)
Observations	291	291	143	143	148	148

Note: Δ level: level home minus away team. Home (away) team last goal: last goal scored during match time. Parameter estimates based on logit models; average marginal effects are presented; in parentheses standard errors; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Two conclusions emerge from Table 2. First, first-movers are on average more likely to win the penalty shootout but over time the effect became smaller such that in the second part of the sample period the effect is no longer significantly different from zero. Second, other potential determinants of the outcome of penalty shootouts are irrelevant. Differences in the strength of teams do not matter nor does it matter which team scored the last equalizing goal in the match preceding the penalty shootout.

4 Scoring within a Penalty Shootout

4.1 Setting the stage

To understand the nature of the first-mover advantage it may be helpful to investigate the success of separate penalty kicks in relation to psychological pressure. We distinguish two possible psychological pressure variables: threat-of-losing and possibly-winning. These

are related to potentially decisive penalty kicks but from a different perspective. If missing a penalty kick would imply losing the shootout, there is a threat of losing. If scoring a penalty kick would imply winning the shootout, there is possibly-winning. The psychological pressure is not exclusively on the penalty taker. He must score with a single kick, while the goalkeeper must try to prevent this.³ The ball typically travels from the penalty mark to the goal line in a split second. Thus, the only interaction between the penalty taker and the goalkeeper occurs in the seconds prior to the shot. It is a simple setup, but one with frequent high stakes. Penalty kicks are often closely followed by large crowds, both in the stadium and via the media. Thus the penalty taker and the goalkeeper experience huge psychological pressure. However, the pressure is generally greater for the taker, who is expected to convert. In contrast, a goalkeeper who fails to stop a penalty kick is less likely to face criticism. Hence, the framing of the psychological pressure variables is from the perspective of the penalty taker.

Table 3: **Descriptives Individual Penalty Shots**

	1968-2026		1968-2007		2008-2026	
	(1)		(2)		(3)	
a. First-movers						
Success rate	0.76	(0.01)***	0.76	(0.01)***	0.76	(0.01)***
Threat-of-losing	0.05	(0.01)***	0.05	(0.01)***	0.04	(0.01)***
Possibly-winning	0.05	(0.01)***	0.06	(0.01)***	0.05	(0.01)***
Observations	1372		657		715	
b. Second-movers						
Success rate	0.73	(0.01)***	0.71	(0.01)***	0.75	(0.01)***
Threat-of-losing	0.18	(0.01)***	0.16	(0.01)***	0.19	(0.01)***
Possibly-winning	0.10	(0.01)***	0.09	(0.01)***	0.11	(0.01)***
Observations	1308		622		686	

Note: In parentheses standard errors; *p< 0.05, **p< 0.01, ***p< 0.001.

Table 3 shows the summary statistics for the dataset used in the analysis of the success rates of the individual penalty kicks. In addition to a distinction by sample period the table shows the descriptives separately for first-movers and second-movers. The difference in success rates of the penalty shots is largest in the first part of the sample period (76% and 71%) while the difference is small in the second sample period (76% and 75%). The indicators for psychological pressure do not vary a lot over the sample periods but are

³Some research focuses on the interaction between penalty taker and goal keeper. An issue here is, for example, whether it is optimal for goal keepers to stay in the center of the goal. It is not clear that it is. Bar-Eli et al. (2007) studying penalty kicks in various professional football leagues worldwide concluded that it is optimal for the goal keeper to stay in the center of the goal. However, Singh and Mukherjee (2026) analyzing penalty kicks taken in World Cup matches found that keepers were not subject to an action bias as they had statistically similar chances of stopping the goal by jumping or staying in the center of the goal.

always more important for the second-movers, in particular in terms of the threat of losing.

Figure 1 provides more information about the separate penalties in the shootouts. Panel a shows the number of penalties taken by penalty order. The number of shootouts that have not yet been concluded drops strongly after the first ten penalty kicks. Of the 262 shootouts in the sample with all information about the sequence of the penalty kicks 195 are decided within the first ten kicks (74%) while within the first 14 kicks 243 (93%) are decided.

Panel b of Figure 1 shows the psychological pressures on first-movers and second-movers. For the first five penalty kicks (three for the first-mover and two for the second-mover) there is no specific pressure. From penalty six onward there may be pressure on the penalty taker. If after five penalty kicks his team has a disadvantage of three goals the sixth player is subject to the threat of losing as he has to score otherwise the shootout is lost. If a team has an advantage of two, the player is subject to possibly winning as he can decide the shootout by scoring. If after ten penalty kicks the score is still even, the players shoot alternating one by one. Then, the kicks of first-mover players are never decisive while there is always a psychological pressure on the second-mover. For the first-movers psychological pressure is limited and present only in the seventh and ninth shot. Of the seventh penalty kick about 11% is subject to the threat of losing or possibly winning; for the ninth penalty kick this is about 24% for the threat of losing and another 28% for the possibly-winning effect. The threat-of-losing is more important than possibly-winning.

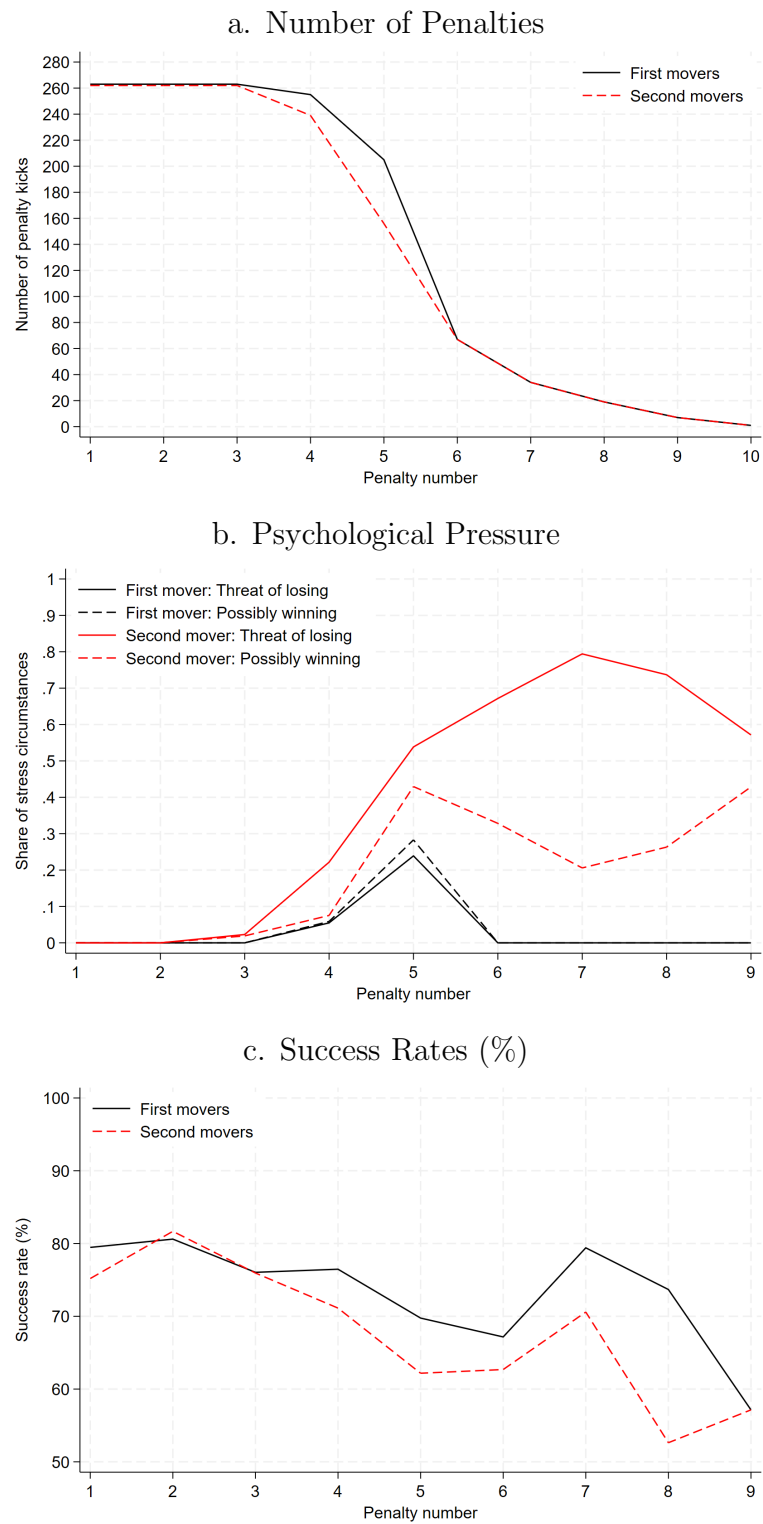
Panel c of Figure 1 shows that over the first six penalty kicks the success rates are very similar, from 75% to 80%. After that, the success rates of first-movers are higher than the success rates of second-movers with the exception of the 17th and 18th shot. Over the sequence of the shootouts the success rates go down. This could be due to the increased psychological pressure, the best penalty takers shooting first (McGarry and Franks, 2000) or a combination of the two.

4.2 Set-up of the analysis

In this part of our empirical analysis, our dependent variable is goal scoring with a value of 1 (scored) or 0 (missed). The success of scoring penalty k within shootout s is modeled as follows:

$$\log\left(\frac{p_{ks}}{1 - p_{ks}}\right) = \alpha_s + \beta^F F_{ks} + \beta^h H_{ks} + \beta^l P_{ks}^l + \beta^w P_{ks}^w + \epsilon_{ks} \quad (2)$$

Figure 1: Number of Penalties, Psychological Pressure and Success Rates by Penalty Number



where p_{ks} is an indicator whether or not penalty $k, k = 1, \dots, N$ leads to a goal (N is the last penalty taken within the shootout). F indicates whether a penalty is taken by a player from the first-mover team. Similarly, H indicates whether a player from the home team took the penalty. Furthermore, P^l is an indicator of the psychological pressure threat-of-losing. It has a value of one if the penalty would imply losing the shootout if it does not turn into a goal. P^w is the second psychological pressure variable, possibly-winning, with a value of one if scoring would imply winning the penalty shootout. The α_s represents shootout-specific fixed effects, the β 's represent parameters and ϵ_{ks} is the error term. The most interesting parameters in this model are β^l and β^w because they indicate how psychological pressure affects performance. Comparing both parameters gives an idea about whether the threat of losing or the possibility of winning has a bigger 'choking' effect on performance.

Equation (2) relates success rates of individual penalty kicks to various types of variables. The kicking order – who shoots first – is randomized by a coin toss but which players take which kick is chosen by the coach or the players themselves. The probability of scoring depends on lagged choices and outcomes. In a shootout it is not only the lagged outcome of the own team but also the lagged outcome of the opponent that may be relevant. These dynamics are partly taken into account by the two psychological pressure variables, threat-of-losing and possibly-winning. Furthermore, unobserved heterogeneity could be important. Because all estimates included shootout-specific fixed effects, unobserved heterogeneity between shootouts is taken into account. Potential unobserved heterogeneity between teams within a shootout is not accounted for.

4.3 Parameter estimates

Table 4 presents the parameter estimates in terms of average marginal effects for the penalty scoring success rates. The first column shows that only the threat-of-losing has a significant effect, which is negative. If a penalty kick is taken under the pressure of failing and losing the shootout this has a negative effect on the scoring rate of about 20%. In the second column the penalty number (1-18) is added. With every additional penalty taken, the success rate drops with 1.9%. Because of the correlation between the psychological pressure variables and the penalty number the effect of the threat-of-losing is approximately halved. A similar situation occurs in the first half of the sample period while in the second half introducing the penalty number removes the significance of the threat-of-losing effect.

All in all, the parameter estimates of Table 4 suggest that there is a significant effect of the threat-of-losing. There is also a negative effect of the penalty number which could be

Table 4: **Parameter Estimates Success Rates Individual Penalties**

	1968-2026		1968-2007		2008-2026	
	(1)	(2)	(3)	(4)	(5)	(6)
First Mover	0.010 (0.023)	0.010 (0.022)	0.036 (0.032)	0.031 (0.031)	-0.017 (0.033)	-0.011 (0.030)
Home team	-0.011 (0.022)	-0.010 (0.021)	-0.015 (0.031)	-0.015 (0.030)	-0.007 (0.031)	-0.005 (0.029)
Threat-of-losing	-0.197*** (0.033)	-0.096** (0.037)	-0.231*** (0.047)	-0.139* (0.055)	-0.170*** (0.046)	-0.064 (0.050)
Possibly-winning	-0.041 (0.042)	0.052 (0.043)	-0.001 (0.062)	0.080 (0.064)	-0.082 (0.058)	0.021 (0.059)
Penalty number		-0.019*** (0.004)		-0.018** (0.006)		-0.019*** (0.005)
Observations	2,680	2,680	1,279	1,279	1,401	1,401
Shootouts	262	262	131	131	131	131

Note: Penalty shootout fixed effects logit models; presented are average marginal effects; in parentheses standard errors; *p< 0.05, **p< 0.01, ***p< 0.001.

caused by teams on average put there best penalty shooters in the start of the shootout. It could also be the psychological pressure increases with the penalty number (as shown in Figure 1b).

5 Conclusions

Whereas often papers with null results find it hard to land in scientific journals this is not the case with papers investigating the existence of a first-mover advantage in football penalty shootouts. On the contrary, papers finding that there is no first-mover advantage outnumber papers who find evidence of a first-mover advantage. The success of publishing null results is at least partly related to shootouts being clear in their set-up and clear in their outcomes. There is also interest in the existence of a first-mover advantage as for fairness reasons there could be incentives to change the set-up of a shootout. A shootout is instrumental to get a decision about who wins a match in case in regular playing time of 90 minutes and an extension of 30 minutes (both including extra time) no decision was reached. The set-up of a shootout is intended to be fair. A first-mover advantage would make a shootout unfair from the perspective of the second mover. Based on this, there have been attempts to create a more fair set-up than the 5AB-system. The ABBA-system could avoid a first-mover advantage but turned out to be too complex to digest and was never introduced as an alternative system.

Studying penalty shootouts in football is interesting beyond the sport itself. Under pressure workers may perform suboptimal and penalty shootouts are an interesting way to

investigate this in more detail. This paper uses observational data on penalty shootouts of fifty-nine seasons in the Dutch cup competition. In the analysis both the outcome of the shootout as well as success rates in individual penalty kicks are analyzed. We find evidence of a first-mover advantage, i.e. first-movers had a higher probability of winning a shootout. Furthermore, under psychological pressure, in particular the fear of losing, penalty attempts were more likely to fail. The first-mover advantage is likely related to differences in the fear of losing which were predominantly present for second-movers. Over time, the first-mover advantage became less important and average over the last two decades it was insignificantly different from zero. We can only speculate about why the first-mover advantage became less important. Perhaps penalty shootouts have been anticipated more in recent decades. With increasing anticipation more may have been invested in practicing and training. Indeed, increased practicing could have caused the psychological disadvantage of second-movers to fade away.

Generalizing our findings to regular jobs, we conclude that workers under psychological pressure may be less productive than in absence of such pressure. We find that fear of a negative outcome had a negative effect on productivity while the probability of being successful did not seem to be affecting productivity. Apparently, potential negative effects are more important determinants of labor productivity than potential positive effects. It could also be that the negative effects of psychological pressure become less important if workers receive the appropriate training and guidance.

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Appendix A: The penalty shootouts as successor to the coin toss: its very Dutch roots

Until 1970, the toss of a coin often settled matches in UEFA competitions that remained undecided, even after extra time. Obviously, this procedure relied purely on chance. Nevertheless, a coin toss determined the outcome of high-profile European fixtures. For example, on 5 June 1968, when Italy reached the final of the UEFA European Championship after a 0-0 draw at home against the Soviet Union. The West-German referee Tschenscher tossed a coin in his dressing room, in favor of the Italian captain Facchetti. Similarly, in the 1969/70 season of the now defunct UEFA Cup Winners' Cup, AS Roma eliminated PSV Eindhoven in the round of sixteen. Both teams had won their home matches 1-0. The toss of a coin, following extra-time in the return match in Eindhoven, determined that the Italians progressed to the next round. However, later that season, Polish cup-winners Gornik Zabrze advanced to the final at the expense of AS Roma. The toss of a coin, following a 1-1 draw in a play-off match, decided who went to the final in Vienna. The fate of AS Roma once more stresses the randomness of this tie-breaking method. This haphazardness eventually prompted UEFA to introduce a supposedly more skill-based system. Beginning with the 1970/71 season, UEFA officially replaced coin tosses and play-off matches with penalty shootouts as the secondary tie-breaking method, posterior to extra-time in the return match. This decision probably followed from the wish for a supposedly fair, skill-based mechanism to determine who would progress to the next round. Initially, finals were exempt, with replays still functioning as the secondary tie-breaker.

Many commentators consider the introduction of the penalty shootout, in which skill is supposedly more important than luck, in the 1970/71 season as a significant development in European football. Lyttleton (2015) considers three possible candidates for the invention preceding this innovation. Firstly, he mentions the Spanish referee Ballester, whose ideas led to the introduction of the penalty shootout at the Trofeo Ramon de Carranza in Cadiz in 1962. In the final, FC Barcelona beat Real Zaragoza after a penalty shootout. Secondly, he points at the West-German referee Wald, who proposed it on the meeting of the Bavarian Football Federation in 1970. Apparently, Wald had developed the idea in March 1965, after English champions Liverpool FC eliminated the West-German title-holders 1. FC Köln in the quarter-finals of European Champions' Cup via the toss of a coin, after three draws (including a play-off match in Rotterdam). Thirdly, he notes the Israeli referee Dagan, who prompted the introduction of penalty shootouts in the Israeli cup in the 1965/66 season. However, the real roots of the penalty shootout precede even Ballester by approximately three decades. One may trace this back to the

amateur era of Dutch football (which ended in November 1954), viz. in the first decades of the twentieth century.

Indeed, in the amateur era of Dutch football, this method had already been employed for more than three decades prior to the Cadiz tournament. Two major preseason tournaments played a vital role. Firstly, Sparta Rotterdam organized the Zilveren Voetbal Competitie (Silver Football Competition) between 1901 and 1956. Secondly, AFC Amsterdam, distinct from AFC Ajax, organized the AROL-tournament (in memory of their late member Antoine Robert Onslow van Lierop) from 1923 to 1970. In the years before 1929, the toss of a coin functioned as the tie-breaker in these tournaments. In the 1928/29 season, the organizing committee of the Silver Football Competition changed its rules, introducing a (3A/3B) penalty shootout to replace this random mechanism.

The first recorded penalty shootout in these tournaments happened on 7 September 1930, when Xerxes (Rotterdam) defeated Quick (The Hague) 3–2 after a 1–1 draw.⁴ A national newspaper, *De Courant/Nieuws van de Dag* (Amsterdam) described it as “infantile” but noted that “the boys in the stands seemed to enjoy it.” The first penalty shootout in the AROL tournament took place on 28 August 1932, when HBS (The Hague) defeated DEC (Amsterdam).⁵ The first penalty shootout in the official cup competition of the KNVB (Dutch Football Association) occurred in the 1948 final, where Wageningen defeated DWV (Amsterdam) 2–1, following a draw.⁶ One year later, Quick Nijmegen captured the trophy by defeating Helmondia ’55 by the same score, at the first use of the alternating (ABAB) format. In the 1958/59 Dutch Cup, the first shootouts of the semi-professional era took place. On New Year’s Day 1959, the amateurs of Oss ’20 eliminated the home team, the semi-professionals of BVV (Den Bosch) via a penalty shootout. On that same festive day, the semi-professionals of DFC (Dordrecht) defeated the home team, the amateurs of RAC (Rijen), also via a penalty shootout. Both shootouts followed the 5A5B schedule. In 1968, the KNVB introduced the alternating ABAB system, starting with five penalty-kicks per team. Disarray occurred every now and then, as illustrated by the 1968/69 Cup match between NOAD (Tilburg) and GVAV (Groningen). The referee had initially used the wrong (5A5B) schedule. KNVB officials corrected it, even after the players had already taken a shower. In the 2018/19 season, the KNVB introduced the ABBA system to lower the supposed first-mover advantage. However, this rule change

⁴Probably, the first mentioned incidental penalty shootout took place as early as on January 17, 1909, during an internal tournament at AFC. The prize was a real trophy, a silver cup donated by Mr. P. Mulder, a local pub-owner. The quarter final between AFC reserves and the fourth team of AFC had ended in a nil-nil draw. However, the AFC reserves won the penalty shootout (2-1) and progressed to the semi-finals. (*Het Nieuws van den Dag: kleine courant*, Amsterdam, January 19, 1909, p. 6).

⁵Consulting of the Dutch tournaments in www.rsssf.org/intclub-friend.html yields a plethora of penalty-shootouts prior to 1954.

⁶See the season’s pages of the KNVB-beker at Wikipedia.

also caused distress, most notably in the match for the 2018 Johan Cruijff Schaal (Dutch Super Cup). PSV and Feyenoord drew 0-0, after regular time. Although PSV had a home advantage, they lost the shootout 5-6. The KNVB put the alternating system back in place the following season.

This historical summary makes clear that the penalty shootout is not a post-war invention, but that it originated in Dutch football during the interwar period. From the Silver Football Competition of 1930 to the KNVB Cup finals of the late 1940s, penalty shootouts functioned as tie-breakers, decades before the formal adoption by UEFA in 1970. Thus, the penalty shootout emerged in the Netherlands, replacing a tie-breaker based on sheer luck by a mechanism where skill might play a crucial role.

Appendix B. Details on Our Data

In the past several set-ups were used for the penalty shootouts in the Dutch cup competition. Over the period 1959-1968 there were 30 shootouts using the 5A5B-system. In the period 2018-2019 there were 8 shootouts according to the ABBA-system. Over the period 1968-2026 there were in total 339 shootouts using the 5AB-system. In our analysis we use data from penalty shootouts in the Dutch cup competition using the 5AB-system from season 1968 to season 2026.

Table B.1: **Observations on Shootouts by Decade**

Seasons	All	Part 1	Part 2
1968-1977	50	49 (98)	44 (88)
1978-1987	38	36 (95)	34 (89)
1988-1997	56	38 (68)	33 (59)
1998-2007	37	20 (54)	20 (54)
Period 1	181	143 (79)	131 (72)
2008-2017	87	77 (89)	64 (74)
2018-2026	71	71 (100)	67 (94)
Period 2	158	148 (94)	131 (83)
Total	339	291 (86)	262 (77)

Note: Part 1: Analysis of winning a shootout; part 2: Analysis of individual success rates; in parentheses percentages of the number in the first column.

The data primarily stem from flashscore.nl, voetbal.com and transfermarkt.com. In addition to this we used information from national, regional and local newspapers available through Delpher.nl and occasional You Tube-videos. Table B.1 gives an overview of the available information by decades. The first column shows the total number of observations; the second column shows how many observations were available to analyze who

won the shootout. The third column shows how many shootouts were available for the analysis of the success rates of the individual penalty kicks. Table B.2 gives an overview of the 262 shootouts for which we have information by individual penalty kicks.

Table B.2: **Success Rates by Penalty Number**

Penalty	Observed	Scored	(%)	Decided	FM win	(%)
1	262	208	79.4			
2	262	197	75.2			
3	262	211	80.5			
4	262	214	81.7			
5	262	199	76.0			
6	262	199	76.0	8	3	37.5
7	254	194	76.4	15	10	66.7
8	239	170	71.1	34	20	58.8
9	205	143	69.8	49	39	79.6
10	156	97	62.2	89	40	44.9
11	67	45	67.2			
12	67	42	62.7	33	18	54.5
13	34	27	79.4			
14	34	24	70.6	15	9	60.0
15	19	14	73.7			
16	19	10	52.6	12	7	58.3
17	7	4	57.1			
18	7	4	57.1	7	3	42.9
Total	2680	2002	74.7	262	149	56.9

Note FM win = First-mover win.