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On Probabilistic Excitement of Sports Games

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Abstract

In this paper we introduce a quantitative measure of the excitement of sports games. This measure can be thought of as the variability of the expectancy of winning as a game progresses. We illustrate the concept of excitement at soccer games for which the theoretical win expectancy can be well approximated from a Poisson model of scoring. We show that in the Poisson model, higher scoring rates lead to increased expected excitement. Given a particular strength of a team, the most exciting games are expected with opponents who are slightly stronger. We apply this theory to the FIFA World Cup 2006 games, where the winning expectancy was independently estimated by betting markets. Thus, it was possible to compute the expected and the realized excitement of each given game from the trading data.

KEYWORDS: excitement, win expectancy, Markov model of scoring, intensity of scoring

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1 Introduction

In this paper we propose a novel measure of the excitement of a game that depends on the predictability of the outcome of the game. Knowing the outcome of a game upfront does not change the winning expectancy during the game, thus making it less exciting. On the other hand, if the winner is undetermined up until the last moment with many swings in the score throughout the game, this constitutes a highly exciting situation. Thus it makes sense to associate the excitement of the game with the variability of the win expectancy. The greater the variability, the more exciting is the game. In order to distinguish from other possible measures of excitement, we call the variability of win expectancy *probabilistic excitement.*

One can think of other measures of excitement, such as the number of viewers, or measures which depend on the athletic performance of the players. Unfortunately, the number of viewers does not necessarily reflect the quality or excitement of the game, but rather it is more associated with the importance of the game. The final game of a championship typically has the largest number of viewers, but it often does not turn out to be the most exciting game of the season. Similarly, it is hard to quantify events such as a great shot or a great hit during the game, that are often associated with game excitement.

Measuring excitement has potentially important consequences. One can argue that more exciting games will be able to attract larger audiences, and thus create more commercial opportunities for advertisement or the promotion of the sport itself. Also within the game itself, some events are more exciting than others, for instance a game-winning point at the last minute of a match has a larger impact on excitement than a game-winning point that happens in the beginning of the match. Although it is not possible to say how exciting a game will be beforehand, one can determine the expected excitement before the game begins. Usually games with closely matched teams with high scoring intensities (expected number of points scored during the game) tend to have higher expected excitement levels.

Our approach to quantitatively measure the excitement via variability of the win expectancy described in this paper is novel and it could be applied to all sports played with two competing teams. There are already some cases of sports specific attempts to measure excitement. The problem is that for many sports, it is not entirely clear how to determine the win expectancy during the course of the game. The evolution of the game can be modeled with rather simplifying assumptions for only a small number of sports. The simplest and analytically tractable models assume no memory during the game which suggests the use of Markov models. Sports whose evolution could be approximated well by Markov models include baseball, tennis, soccer, or hockey.

Win expectancy in baseball has been extensively studied and is computed for instance in Tango et. al. [7]. Using data from real games, the website fangraphs.com lists statistics of the variability of the winning chances, calling it Win Probability Added (WPA). This concept fits our definition of the probabilistic excitement of the game. However, research on baseball win expectancies uses the rather simplifying assumption that the play is between two teams with equal strengths.

Variability of win expectancy has been studied less for other sports, but there are several papers which determine the win expectancy itself during the game. For instance, tennis win expectancy was determined in the paper of Newton et. al. [2]. Win expectancy in soccer games can be calculated from the theoretical Poisson model of scoring which assumes the memoryless property. As we show in this article, the assumption of no memory in the soccer game is reasonable and leads to results consistent with game data. It is also supported by other works. See for instance Wesson [9]. Hockey is very similar to soccer in terms of scoring (each goal counts as one point), and it can be also well approximated by the Poisson model as shown in Taylor [8]. Other sports are typically less tractable in terms of win expectancy analysis, for instance football games have typically strong memory, and thus the corresponding models of score evolution require more complexity.

Win expectancy can be also obtained from betting markets such as Betfair or Tradesports. It is possible to buy or sell a futures contract on the winning or losing of a particular team, and the price of this contract can serve as an independent estimate of the win expectancy. In this article we illustrate the concept of probabilistic excitement for soccer. We use data from games in FIFA World Cup Soccer 2006, where we can estimate the win expectancies both from the Poisson model, and by using the data obtained from betting markets (tradesports.com).

The paper is structured as follows. In Section 2, we define the concept of the probabilistic excitement of the game. Section 3 applies this methodology to the specific case of Poisson scoring, which could be applied to both soccer and hockey. We show that higher scoring rates of two teams with the same strength lead to higher probabilistic excitement. Given the total scoring rate of two teams, the closer they are, the more exciting the game is expected to be. If a given team has a fixed scoring rate, the most exciting game will be with a slightly better team. Our results support findings from the literature on competitive balance in sports. It has been documented for instance in the papers of Sanderson et. al. [4], Schmidt et. al. [5], or Szymanski [6], that competition among uneven teams may lead to a reduced interest from viewers, partly because of a smaller expected excitement. Section 4 compares the theoretical predictions of the Poisson model with data from the FIFA World Cup Soccer 2006.

2 Probabilistic Excitement of the Game

If we knew which team would win, the outcome of the game would be predetermined, and thus not exciting. On the other hand, when the two teams are competing for the win to the last minute, that makes the game very exciting. Thus we propose the following measure for excitement:

$$\text{Excitement} = \text{Variability of the Winning Expectancy.} \tag{1}$$

Variability can be measured as the Total Variation (TV):

$$TV(f) = \lim_{\max |t_{i+1}-t_i| \to 0} \sum |f(t_{i+1}) - f(t_i)|, \tag{2}$$

where $0 = t_0 < t_1 < \cdots < t_n = T$ is a partition of the interval $[0, T]$. Total variation can be viewed as the vertical component of the arc-length of the graph of a given function f. The longer the path of win expectancy for a given team, the more swings there are in the game, and thus the game is more exciting. Formally, we can define

Definition 2.1

(3) *Excitement = TV(Probability of Team 1 Wins) + TV(Probability of Team 2 Wins).*

This definition makes sense if a draw is not an option, such as in the elimination round games. If a draw is possible, we can use a modified version:

Definition 2.2

(4) *Excitement = TV(Probability that Team 1 Wins)*
+ TV(Probability of Draw) + TV(Probability that Team 2 Wins).

Notice that since

(5) Probability Team 1 Wins = 1 - Probability Team 2 Wins,

we have

(6) TV(Probability of Team 1 Wins) = TV(Probability of Team 2 Wins),

in Definition 2.1.

In general, the total variation of winning expectancy is mostly changed if there is a game deciding event close to the end of the game, if there are a number of events where the game lead is changed, or if the weaker team unexpectedly wins or draws the game. On the other hand, only small changes in the total variation of winning probabilities occur when the game is one sided, with an early lead from the favorite team.

There are several other possible numerical statistics which could be regarded as measures of excitement, including the total number of goals, or the number of changes in which team is leading during the game. However, a large number of goals does not guarantee a good quality match if the game is one sided. Similarly, a change in who is in the lead becomes more exciting as the game gets closer to the end, and thus a measure which puts more weight on the final deciding moments of the game is more appropriate. The variability of win expectancy indeed has this property.

Note that the variance of win expectancy is not a particularly good measure of the excitement. Although the outcome of the game is random, the corresponding probability of winning could be deterministic, having zero variance. Thus the displacement of the winning probabilities as measured by the total variation is a more appropriate measure.

3 Poisson Model of Scoring and Probabilistic Excitement

In this section we assume that the scores of the two teams evolve as independent Poisson processes. In particular, if $X_T : Y_T$ denotes the final score of the game, we have

$$\mathbb{P}(X_T = X_t + k) = \exp[-\lambda(T-t)]\frac{[\lambda(T-t)]^k}{k!},$$

and

$$\mathbb{P}(Y_T = Y_t + k) = \exp[-\mu(T-t)]\frac{[\mu(T-t)]^k}{k!},$$

where $X_t : Y_t$ is the current score at time t in the game. Variable T is the end time of the game, and it is assumed to be fixed. Parameters λ and μ are called the scoring intensities of the two teams. They are related to the expected score by the following relationship:

$$\mathbb{E}[X_T - X_t|X_t] = \lambda(T-t), \qquad \mathbb{E}[Y_T - Y_t|Y_t] = \mu(T-t).$$

Thus one should expect to see on average $\lambda(T-t)$ and $\mu(T-t)$ goals for the two teams in the remaining $T-t$ time of the game.

The Poisson model of scoring could be used for modeling the evolution of scoring in soccer or hockey games. The memoryless property implies that the time between the goals is exponentially distributed with parameters λ and μ respectively. In this model we can get explicit formulas for the win expectancy of each team, and the expectancy of a draw. If the current time is $t \in [0,T]$, and the current score is $X_t : Y_t$, we have

$$(7) \quad \mathbb{P}(\text{Team 1 Will Win}) = \mathbb{P}(X_T > Y_T) = \\ = \sum_{k=0}^{\infty} \mathbb{P}(X_T = k - X_t, Y_T < k - X_t) = \sum_{k=0}^{\infty} \left[e^{-\lambda_t} \frac{\lambda_t^k}{k!} \cdot \sum_{i=0}^{k+X_t-Y_t-1} e^{-\mu_t} \frac{\mu_t^i}{i!} \right]$$

$$(8) \quad \mathbb{P}(\text{Draw}) = \mathbb{P}(X_T = Y_T) = \\ = \sum_{k=0}^{\infty} \left[e^{-(\lambda_t+\mu_t)} \cdot \frac{\lambda_t^{(k+\max(X_t+Y_t)-X_t)}}{(k+\max(X_t+Y_t)-X_t)!} \cdot \frac{\mu_t^{(k+\max(X_t+Y_t)-Y_t)}}{(k+\max(X_t+Y_t)-Y_t)!} \right]$$

$$(9) \quad \mathbb{P}(\text{Team 2 Will Win}) = \mathbb{P}(Y_T > X_T) = \\ = \sum_{k=0}^{\infty} \mathbb{P}(Y_T = k - Y_t, X_T < k - Y_t) = \sum_{k=0}^{\infty} \left[e^{-\mu_t} \frac{\mu_t^k}{k!} \cdot \sum_{i=0}^{k-X_t+Y_t-1} e^{-\lambda_t} \frac{\lambda_t^i}{i!} \right]$$

Here, $\lambda_t = \lambda(T-t)$ and $\mu_t = \mu(T-t)$ are the expected number of goals of the two teams in the remaining $T-t$ time of the match. We are assuming that the game ends in the regulation time T, and the game is also over in the case of a draw. This is the case for soccer game played in regular season games (leagues, or group stages of the tournaments), but not in elimination rounds. It also applies to hockey games if a draw at the regulation time finishes the game.

We are also making an implicit simplifying assumption that the win expectancy is determined only by the current score using a time homogenous Poisson model, and that changes are possible only due to a goal, or by flow of time (win expectancy decreases with time if there is no scoring). However, we neglect changes due to other effects, most notably to red cards in soccer (playing shorthanded), injuries or substitutions of players, or by having an advantageous scoring opportunity (penalty shot), etc. Scoring rates may change as well during the game due to changes in strategy. The next section uses real win expectancy data which include all the mentioned effects, and thus can serve as a comparison to the Poisson model. From data on soccer matches, it seems that current score indeed has a major influence on win expectancy. The second non-negligent effect comes from playing shorthanded.

Using the assumption that win expectancy depends only on the current score, we can compute the expected excitement of a game as a function of the initial scoring intensity as seen in Figure 1. This computation can be done only numerically, but the evidence suggests that it is more exciting to have higher scoring intensity if there are two facing equal teams as seen in Figure 2. However, it may not be desirable to increase the intensity by changing the rules (like making the distance between goalposts be larger) since this would lead to decreased excitement per goal. Figure 3 shows the graphs of the expected excitement if the sum of the scoring intensities is a fixed number. The expected excitement becomes larger if the two teams gets closer in strength.

Another interesting question is given a fixed strength λ of a team, what intensity of the opponent's team would make the game most exciting in expectation? It turns out that the most exciting games are expected for slightly stronger opponents. Figure 4 show how much larger the intensity of the opponent's team should be in order to maximize the expected excitement. We should point out that a given team does not have a fixed intensity, it is more a pairwise relationship between the two teams, reflecting their relative attacking and defensive abilities. Nevertheless, for a given team it is always desirable to face a slightly stronger opponent if maximization of the excitement is the objective.

4 Application on FIFA World Cup 2006

We can further illustrate the probabilistic excitement of a soccer game by giving the excitement density for particular combinations of scoring intensities. These excitement densities reflect the state of knowledge prior to the games. We give three typical examples: a heavily favored team against an underdog team, a moderately favored team against a slightly weaker team, and two comparable teams.

Consider first a one-sided game with a heavily favored team, for instance the Togo - France game played in the FIFA World Cup 2006. The betting market estimated the scoring intensities to be 0.37 for Togo and 2.65 for France. The expected excitement was 1.28, the lowest for all the games played in that championship. Figure 5 shows the density of the excitement for that particular game. Figure 6 illustrates the individual contributions from different scores to the excitement. Since France was expected to score multiple goals and Togo almost none, the major source of uncertainty in the excitement distribution came from the possibility of a 0:0 draw or a French win. It was considered unlikely that Togo would score. If France were to score the first goal, their win would be expected with large probability. Note that additional goals from France would not increase the excitement, although they would increase the win expectation for France, and lower the draw and loss expectations. However, the win expectancy would be already heading to 1 even with one goal, and draw and loss expectancies would be heading to zero. The only increase in the excitement would come with Togo scoring.

The lowest excitement values would come from the first French goal, which has an exponential distribution. The graph follows the exponential distribution on the left side – the game would get more exciting the later in the game the first French goal was scored. The peak in the density slightly below 2 comes from the event of a 0:0 draw. Higher values of the excitement would come with the rather unlikely event that Togo managed to score a goal. France won the game 2:0, but with a relatively late first score at the 55th minute. That represents a 1.34 excitement value from the Poisson model, slightly above the expected excitement of 1.28. See Figure 7 for evolution of probabilities of a draw, a win of Togo, and a win of France during the game.

The Holland - Argentina match-up represents the game with scoring intensities above 1, but still with a slight favorite. The scoring intensity for Holland was estimated at 1.05, and for Argentina at 1.57. The least exciting game would be the one with an early lead for Argentina and no goal from Holland (the first scoring follows an exponential distribution, see Figures 8 and 9). The later the first goal of Argentina, the more exciting the game would be. This is visible on the left side of the distribution. The density has a peak at 1.50, the case representing a 0:0 draw. A slightly more exciting game would come from a Dutch win with no score from Argentina, which again appears with an exponential distribution shape slightly above the 1.50 level. It is also quite possible to have a multiple scoring game from both teams, leading to even higher values of excitement. The expected excitement was 2.48, the actual result was 0:0, representing a 1.50 value of excitement. See Figure 10 for evolution of probabilities of a draw, a win of Holland, and a win of Argentina during the game.

The Ghana - United States match-up represents the game with scoring intensities above 1, but with teams more close in strength. The scoring intensity for Ghana was estimated at 1.37, and for the United States at 1.16. The expected excitement was 2.55, the highest expectation among all the games in the championship. The least exciting games would be those with an early decisive lead from either team, following the exponential scoring distribution, see Figures 11 and 12. The two exponential distributions have a strong overlap since the two teams were close in strength. A draw 0:0 would also be not so exciting, peaking at the lowest values of the density. Multiple scoring games were also quite possible, leading to higher excitement values. The actual result was 2:1, with the model realized excitement value 2.94, slightly above the expected value of 2.55. See Figure 13 for evolution of probabilities of a draw, a win of Ghana, and a win of United States during the game.

There were 64 games played during the FIFA World Cup 2006, 48 group games, and 16 elimination games. Table 1 orders the group games according to the realized level of excitement, where we used the estimates of the probability of team 1 or 2 winning and the probability of draw by the quotes given by the betting market. Parameters λ_1 and λ_2 are the estimates of scoring intensities for the two teams from the betting market, "Score" marks the result of the game. The "Win" column is the total variation of the Probability that Team 1 wins, the "Loss" column is the total variation of the Probability that Team 2 wins, the "Draw" column is the total variation of the Probability of a draw. The "Total" column is the realized excitement of the game, the "Model" column computes total variation of each particular game from the Poisson model rather than from the market data. The "Exp" column is the expected excitement of the game.

The total variation measure indeed separates the most exciting games which had many turns in them (such as the game between England and Sweden), from games where the winner was a heavy favorite to start with and no surprises happened (such as the game between Saudi Arabia and Spain). Note that the excitement as measured from the market and measured from the Poisson model are close in value with the following notable exceptions.

High scoring games are viewed slightly less exciting from the market perspective if compared to the simple Poisson model. This could be explained by the fact that after initial goals have been scored, additional goals are less likely due to the decrease in scoring rates as illustrated in Garicano et. al. [1]. What happens is that the leading team typically changes the strategy in favor of the defense, thus slightly dropping the scoring intensity.

Several games with small realized excitement values (under 3) have significantly smaller excitement from the market if compared to the model values. These games typically have a strong favorite, such as in Sweden - Paraguay, England - Trinidad, Japan - Brazil, Mexico - Angola, Portugal - Iran, Italy - Ghana, Togo - France, or Saudi Arabia - Spain. This indicates that the market views these games as more predictable than the model would suggest. The stronger team has the ability to increase or decrease the scoring intensity during the game (especially if the score is not in their favor), and the markets views it as such, making the outcome of the match more predictable.

A smaller number of games have a realized excitement that is higher in the market than in the model. However, all these games had at least one player sent off which explains the additional changes in the win expectancies. These games include Italy - United States (3 red cards), Ghana - Czech Republic (1 red card, and missed penalty shot opportunity), and Portugal - Mexico (1 red card, converted penalty opportunity). The effect of the red card on the win expectancy was previously studied by Ridder et. al. [3].

A similar picture is seen from the elimination games. Table 2 orders the games according to the excitement within the regulation plus injury time. The teams were more even than in the group stage, so the consistency between the market and the Poisson model is better. Only the England - Ecuador and Brazil - Ghana game had such an obvious favorite that the excitement from the markets were lower than the excitement as predicted by the Poisson model. On the other hand, the Portugal - Holland game was more exciting than the model due to the expulsion of 4 players.

Excitement of the games in the elimination stage could also be measured by using our alternative Definition 2.1, where the draw is not an option as seen in Table 3. Instead of using the contract on winning the game in the regulation time, we have to use a contract on advancing to the next round. If we use this measure, among the top 5 most interesting games in the elimination round, four of them went into the penalty shootouts (England - Portugal, Italy - France, Switzerland - Ukraine, and Germany - Argentina). Penalty shootouts lead to significant changes of win expectancies. The fifth game was the already mentioned match between Portugal - Holland. On the other hand, the least interesting games were one-sided, with the losing team scoring no goals.

Conclusion

In this paper we introduced a novel concept of measuring the excitement in sports games. We relate the excitement to the variability of the win expectancy. The larger is this variability, the higher is the excitement. The win expectancy varies more if there are number of swings during the game, as opposed to a one-sided game. Win expectancy also changes more the closer to the end of the game a decisive event happens, or the more unexpected is the upset of a favorite team. We illustrated this concept at soccer games for which the theoretical win expectancy can be computed from a Poisson model of scoring.

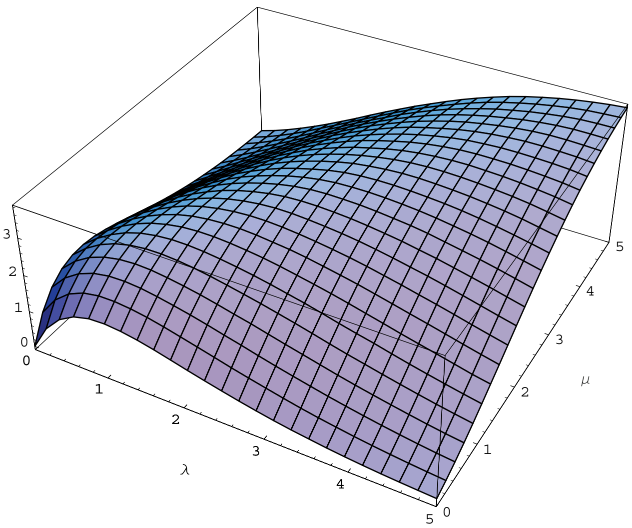

Figure 1: Expected excitement as a function of intensities of scoring.

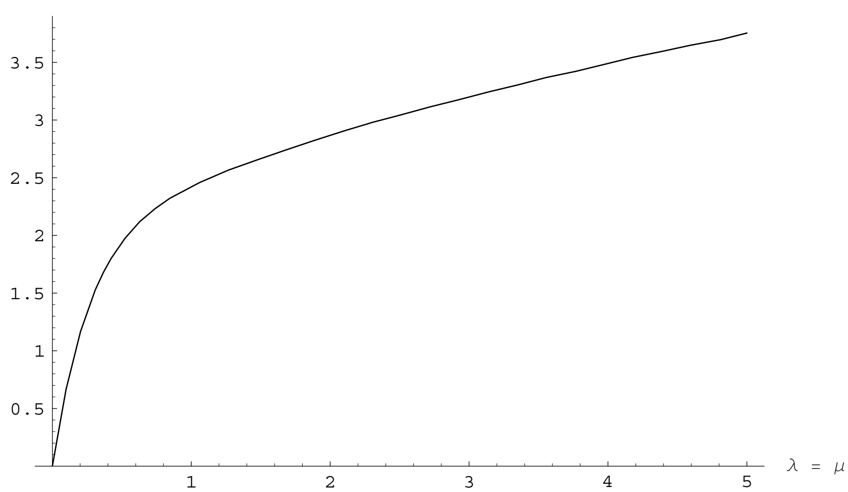

Figure 2: Expected excitement for two equal teams as a function of intensities of scoring.

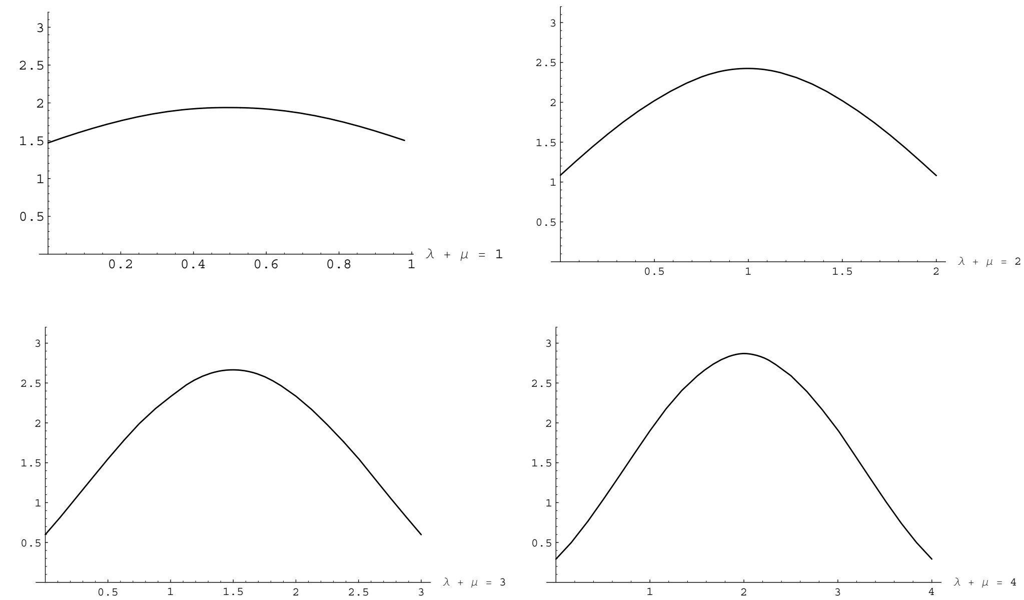

Figure 3: Expected excitement when the sum of the scoring intensities is fixed to be 1, 2, 3, and 4. The expected excitement increases as teams get closer in strength.

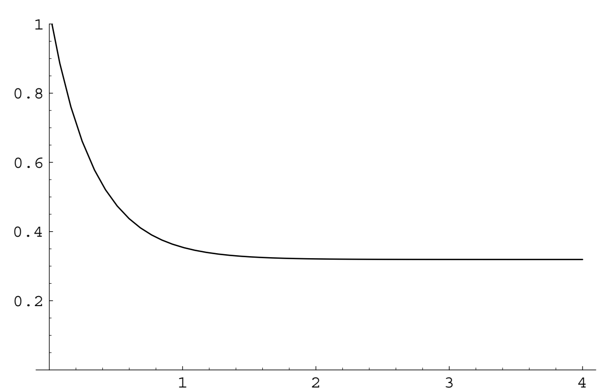

Figure 4: Difference between the scoring intensities of the two teams which makes the game most exciting, assuming fixed scoring intensity for the first team.

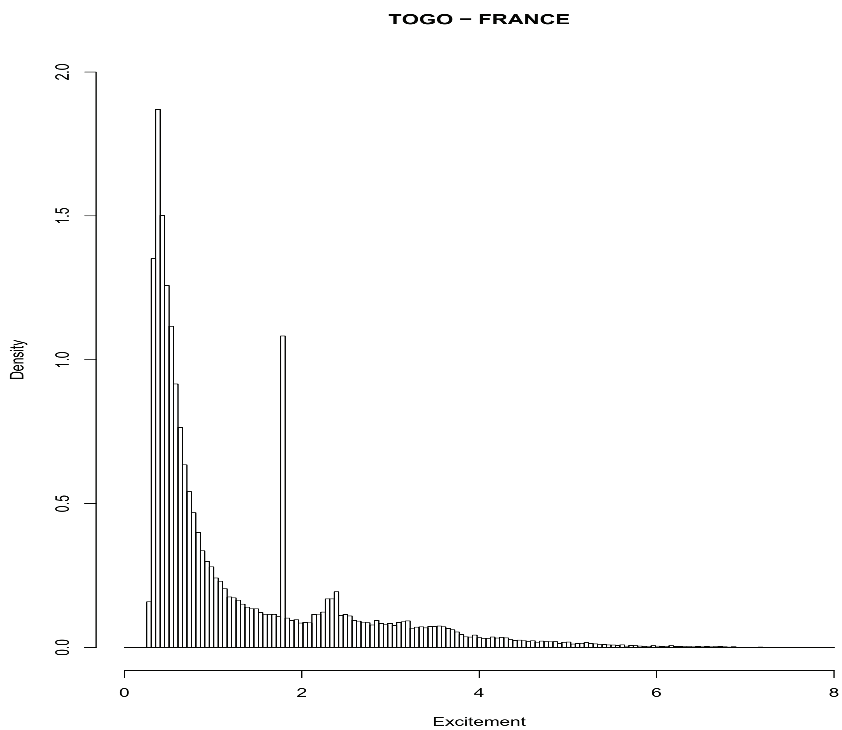

Figure 5: Density of the excitement for the game Togo - France.

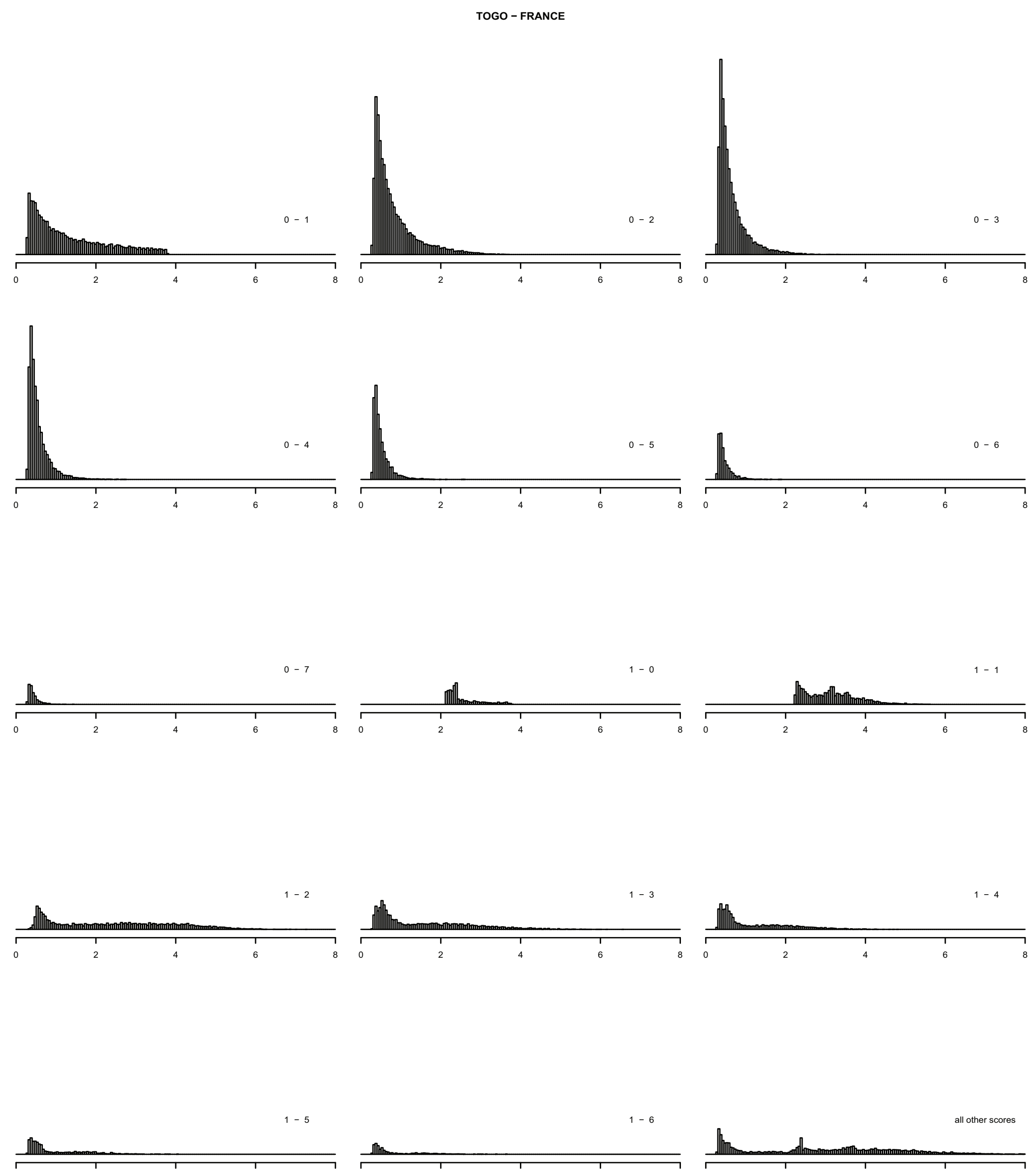

Figure 6: Individual contributions to the excitement from different scores for the game Togo - France.

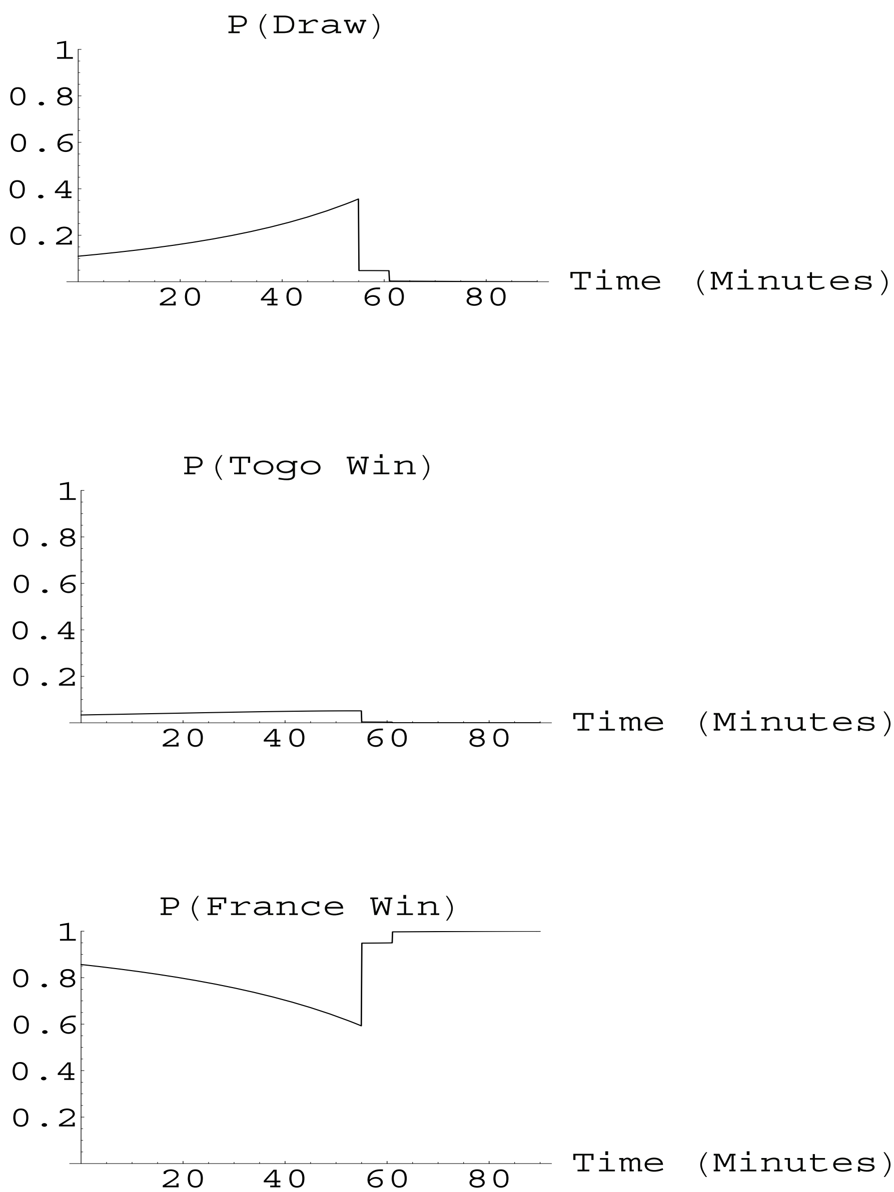

Figure 7: Evolution of probabilities (implied by a Poisson model of scoring) of a draw (top), win of Togo (center) and win of France (bottom) during the Togo - France game. France scored in the 55th and the 61st minute of the match.

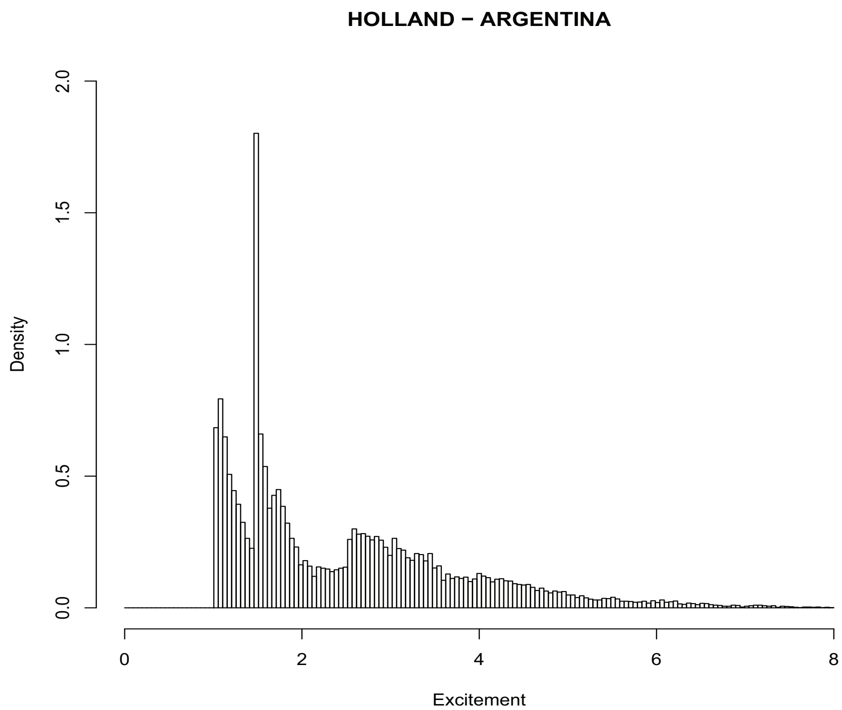

Figure 8: Density of the excitement for the game Holland - Argentina.

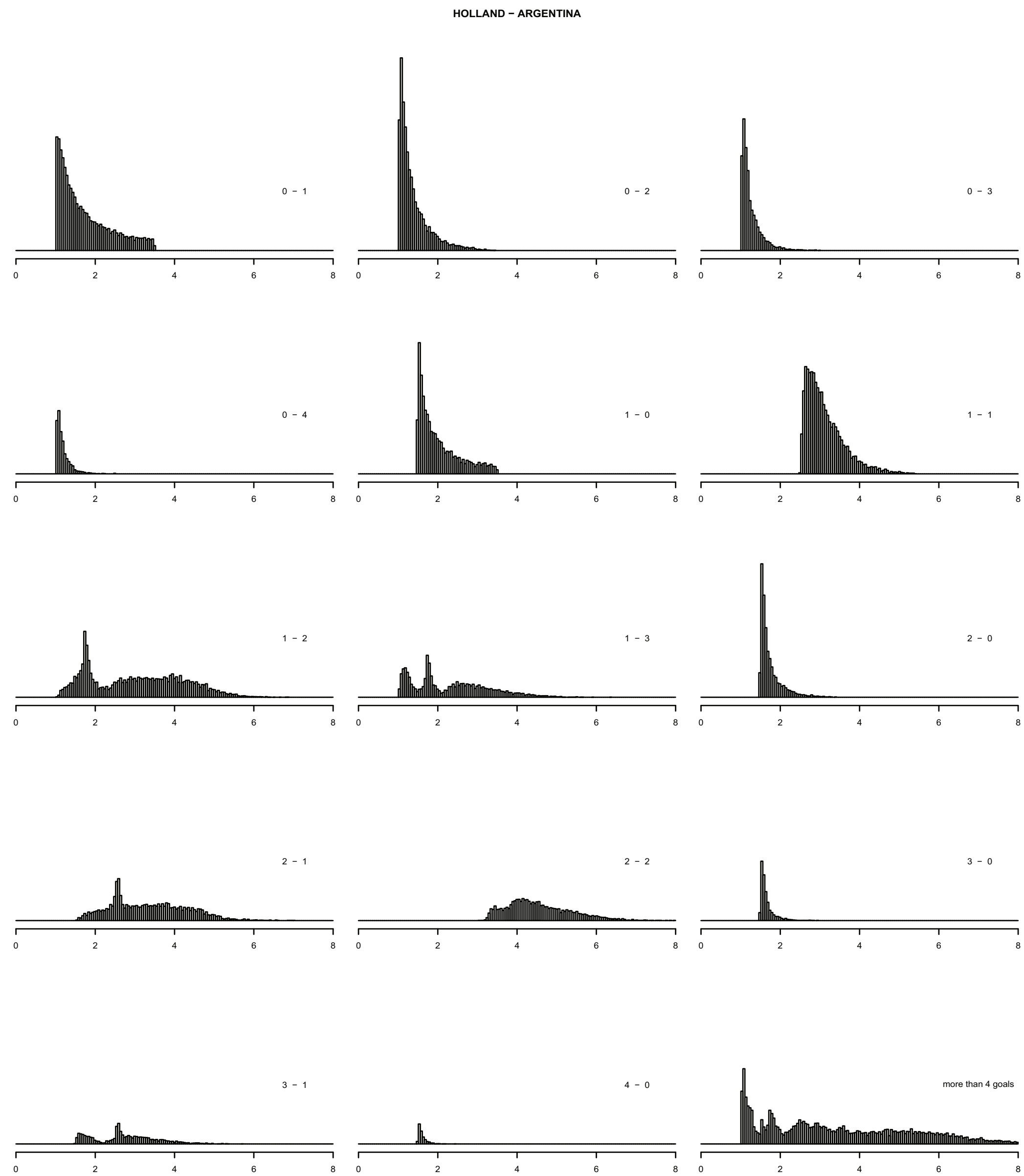

Figure 9: Individual contributions to the excitement from different scores for the game Holland - Argentina.

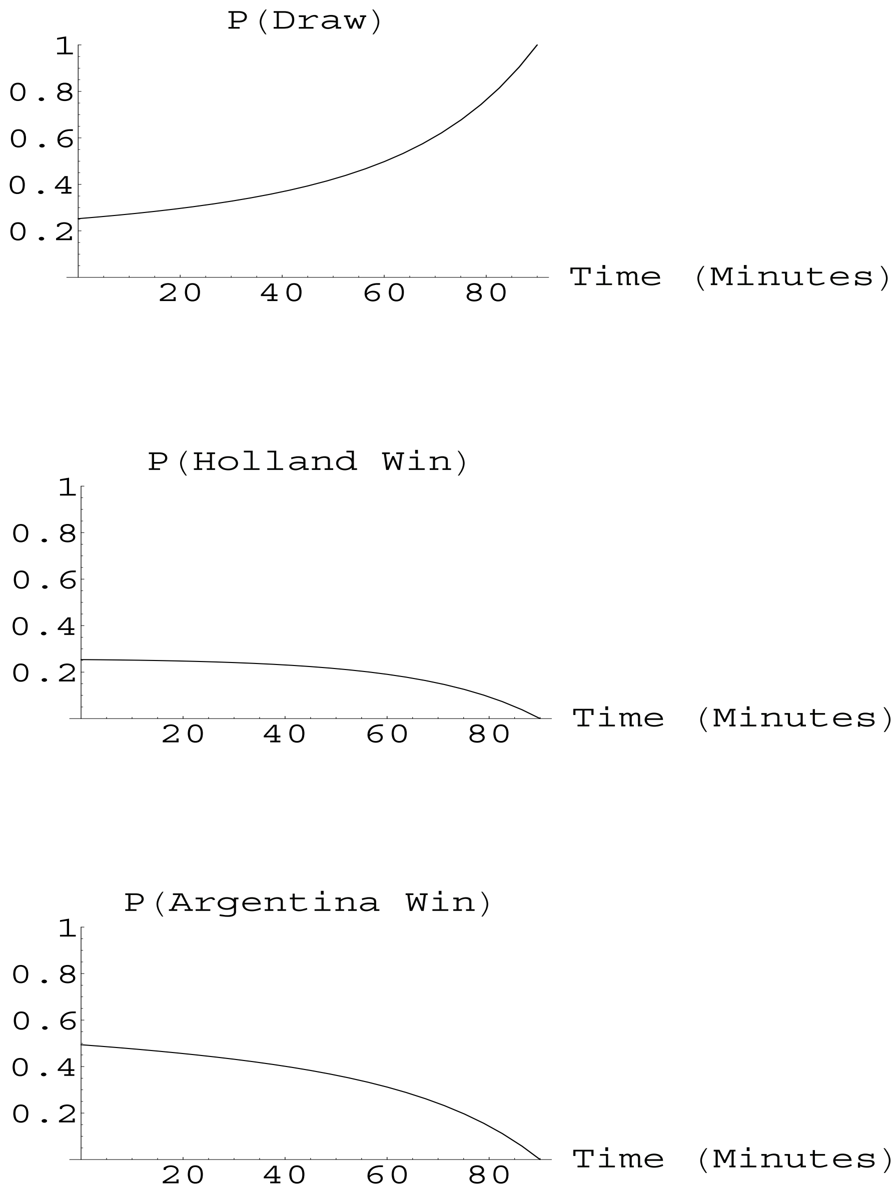

Figure 10: Evolution of probabilities (implied by a Poisson model of scoring) of a draw (top), win of Holland (center) and win of Argentina (bottom) during the Holland - Argentina game. The game ended with a 0:0 draw.

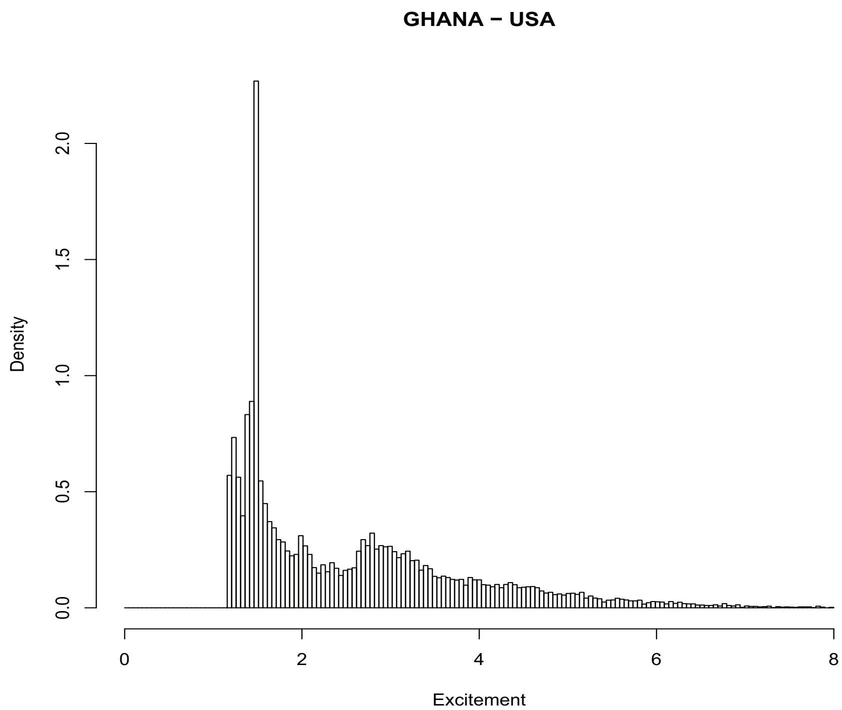

Figure 11: Density of the excitement for the game Ghana - United States.

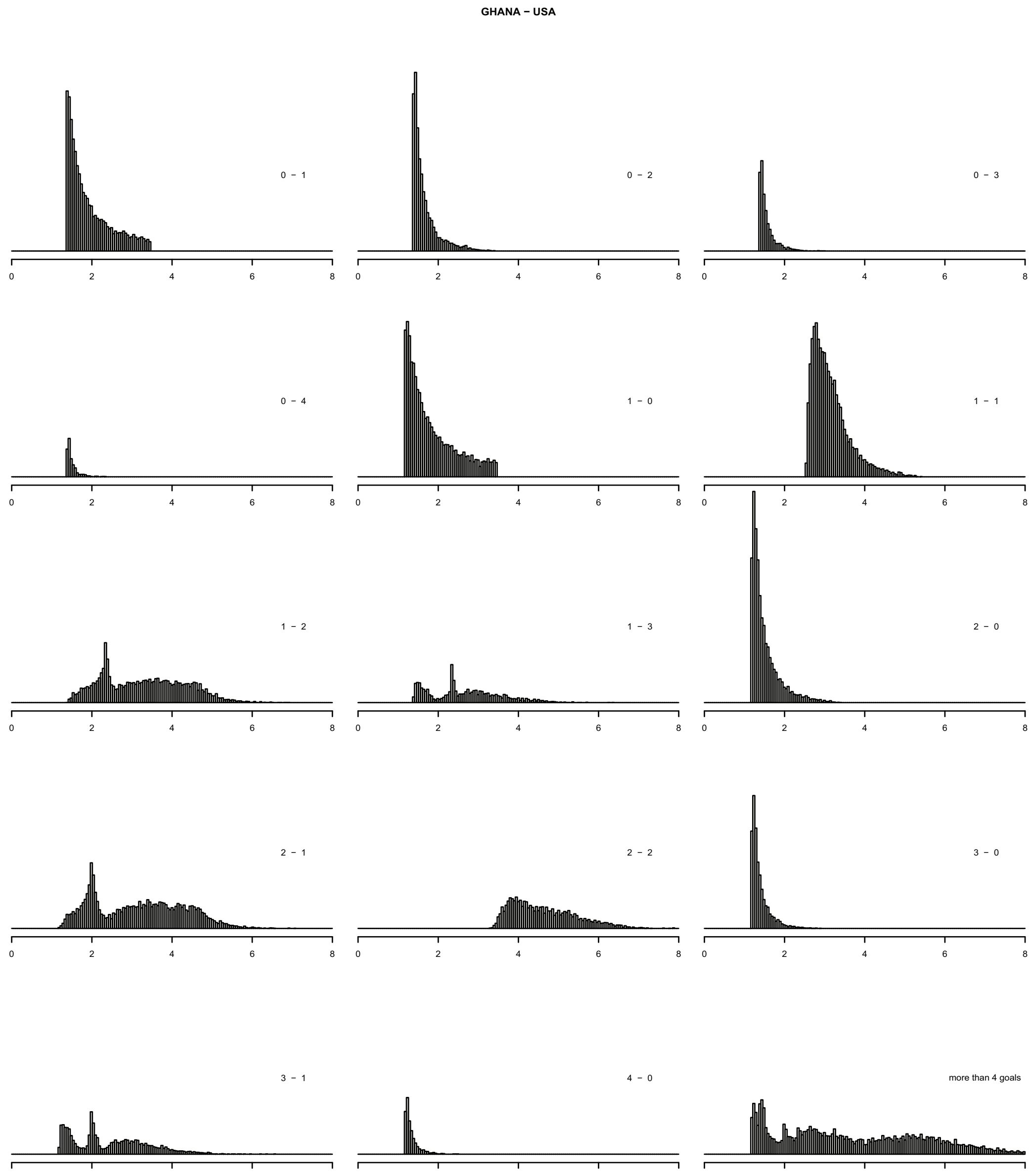

Figure 12: Individual contributions to the excitement from different scores for the game Ghana - United States.

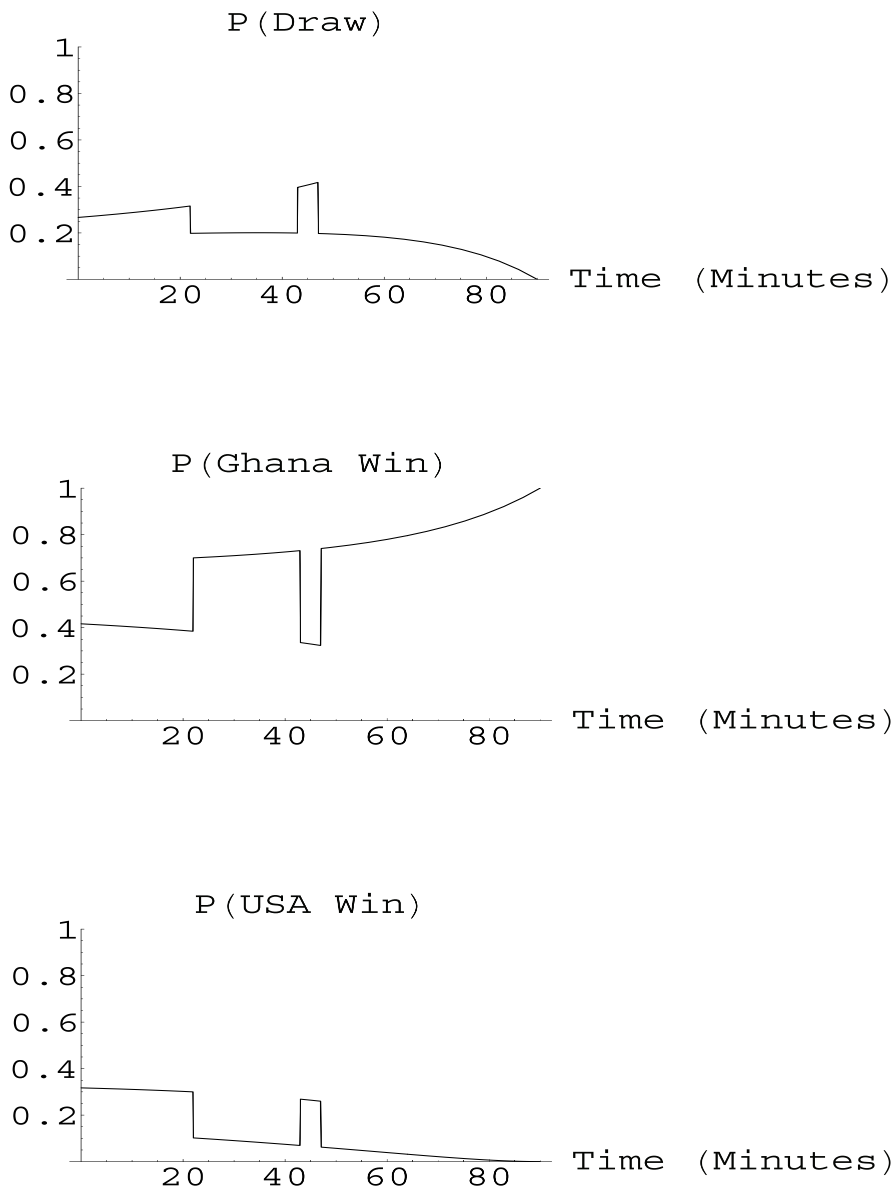

Figure 13: Evolution of probabilities (implied by a Poisson model of scoring) of a draw (top), win of Ghana (center) and win of United States (bottom) during the Ghana - United States game. Ghana scored in the 22nd minute, followed by the goal of United States in the 43rd minute and the second goal of Ghana in the 47th minute.

Game	λ_1	λ_2	Score	Win	Loss	Draw	Total	Model	Exp
Tunisia – Saudi Arabia	1.55	0.74	2 - 2	1.14	2.05	2.36	5.55	6.46	2.26
Sweden – England	0.93	1.22	2 - 2	0.52	2.57	2.21	5.30	6.78	2.42
Ivory Coast – Serbia	1.01	1.50	3 - 2	1.82	1.52	1.30	4.65	5.13	2.45
Australia – Japan	1.21	1.04	3 - 1	1.35	1.36	1.65	4.36	5.33	2.50
Croatia – Australia	1.28	1.12	2 - 2	1.79	1.16	1.21	4.16	4.91	2.55
Italy – United States	1.92	0.53	1 - 1	1.96	0.65	1.20	3.81	2.67	1.89
Mexico – Iran	1.72	0.84	3 - 1	1.77	0.65	1.38	3.80	3.75	2.31
Spain – Tunisia	2.26	0.53	3 - 1	1.91	1.01	0.84	3.76	4.16	1.71
Korea – Togo	1.39	0.86	2 - 1	1.52	1.02	0.98	3.52	4.00	2.38
Germany – Poland	2.13	0.77	1 - 0	1.54	0.16	1.62	3.32	3.62	2.08
Iran – Angola	1.20	1.29	1 - 1	0.45	1.41	1.27	3.13	3.68	2.55
Costa Rica – Poland	0.93	1.77	1 - 2	0.83	1.33	0.76	2.93	3.23	2.36
Sweden – Paraguay	1.39	0.88	1 - 0	1.29	0.24	1.32	2.85	3.37	2.40
Ghana – United States	1.37	1.16	2 - 1	1.42	0.82	0.35	2.59	2.94	2.55
Ghana – Czech Republic	0.69	1.77	2 - 0	1.37	0.63	0.58	2.58	1.80	2.12
Portugal – Mexico	1.19	0.97	2 - 1	1.23	0.43	0.84	2.50	2.00	2.45
France – Korea	1.77	0.53	1 - 1	1.11	0.20	1.04	2.35	2.66	1.95
England – Trinidad	2.55	0.29	2 - 0	1.11	0.09	1.04	2.24	3.03	1.22
Ukraine – Tunisia	1.85	0.83	1 - 0	0.92	0.21	0.86	1.99	2.16	2.26
Holland – Ivory Coast	1.63	0.80	2 - 1	0.99	0.39	0.53	1.91	1.87	2.43
Trinidad – Sweden	0.46	2.58	0 - 0	0.11	0.92	0.80	1.83	1.75	1.47
Japan – Brazil	0.56	2.45	1 - 4	0.39	0.86	0.52	1.77	2.65	1.67
Poland – Ecuador	1.36	0.90	0 - 2	0.47	0.84	0.34	1.65	1.65	2.41
Japan – Croatia	0.70	1.70	0 - 0	0.21	0.74	0.70	1.65	1.53	2.17
Czech Republic – Italy	0.89	1.37	0 - 2	0.35	0.71	0.44	1.50	1.29	2.40
Holland – Argentina	1.05	1.57	0 - 0	0.28	0.50	0.69	1.47	1.50	2.48
Germany – Costa Rica	2.31	0.49	4 - 2	0.54	0.19	0.73	1.46	1.55	1.65
Mexico – Angola	1.96	0.62	0 - 0	0.58	0.08	0.70	1.36	1.60	1.97
Argentina – Ivory Coast	1.63	0.80	2 - 1	0.58	0.29	0.45	1.32	1.35	2.26
France – Switzerland	1.59	0.69	0 - 0	0.55	0.10	0.66	1.31	1.50	2.18
Portugal – Iran	2.13	0.51	2 - 0	0.64	0.07	0.60	1.31	1.81	1.77
Brazil – Australia	2.26	0.55	2 - 0	0.55	0.13	0.53	1.21	1.30	1.74
Switzerland – Korea	1.43	0.92	2 - 0	0.57	0.23	0.40	1.20	1.24	2.42
Ecuador – Costa Rica	1.42	0.96	3 - 0	0.57	0.28	0.29	1.14	1.11	2.43
Serbia – Holland	0.83	1.41	0 - 1	0.24	0.50	0.36	1.10	1.14	2.38
Togo – Switzerland	0.50	1.79	0 - 2	0.17	0.49	0.40	1.06	0.82	1.88
Paraguay – Trinidad	1.63	0.85	2 - 0	0.57	0.25	0.24	1.06	1.13	2.32
USA – Czech Republic	0.94	1.47	0 - 3	0.25	0.51	0.28	1.04	1.07	2.43
Brazil – Croatia	2.24	0.67	1 - 0	0.52	0.14	0.32	0.98	1.20	1.91
Italy – Ghana	1.64	0.70	2 - 0	0.46	0.18	0.33	0.97	1.33	2.17
Spain – Ukraine	1.43	0.78	4 - 0	0.48	0.19	0.29	0.96	1.07	2.31
Serbia – Argentina	0.83	1.41	0 - 6	0.12	0.42	0.26	0.79	0.83	2.12
Saudi Arabia – Ukraine	0.66	1.78	0 - 4	0.08	0.39	0.24	0.71	0.78	2.11
Ecuador – Germany	0.76	1.96	0 - 3	0.35	0.12	0.23	0.70	0.77	2.10
Togo – France	0.37	2.65	0 - 2	0.09	0.36	0.21	0.67	1.34	1.28
England – Paraguay	1.70	0.71	1 - 0	0.35	0.12	0.16	0.63	0.80	2.18
Angola – Portugal	0.51	2.22	0 - 1	0.08	0.22	0.17	0.47	0.52	1.70
Saudi Arabia – Spain	0.44	2.69	0 - 1	0.06	0.18	0.13	0.37	0.82	1.37

Table 1: Group games ordered by the excitement level.

Game	λ_1	λ_2	Score	Win	Loss	Draw	Total	Model	Exp
Spain – France	1.16	0.92	1 - 3	1.48	1.16	1.41	4.05	4.53	2.42
Italy – Australia	1.65	0.62	1 - 0	1.57	0.35	1.68	3.60	3.52	2.11
Germany * – Argentina	1.22	1.06	1 - 1	0.62	1.27	1.47	3.36	3.62	2.47
Argentina * – Mexico	2.07	0.57	1 - 1	1.11	0.91	0.78	2.80	2.73	1.87
Italy * – France	0.97	0.82	1 - 1	0.97	0.93	0.87	2.77	2.77	2.36
Portugal – Holland	1.15	0.98	1 - 0	1.06	0.58	0.44	2.08	1.40	2.44
Brazil – France	1.56	0.78	0 - 1	0.57	0.82	0.59	1.98	2.18	2.28
England – Portugal *	0.78	1.22	0 - 0	0.46	0.58	0.61	1.65	1.40	2.33
Germany – Portugal	1.56	0.93	3 - 1	0.72	0.28	0.60	1.60	1.76	2.40
England – Ecuador	1.73	0.64	1 - 0	0.69	0.17	0.64	1.50	1.82	2.08
Portugal – France	0.77	1.13	0 - 1	0.73	0.33	0.42	1.48	1.48	2.34
Switzerland – Ukraine *	0.90	1.20	0 - 0	0.25	0.45	0.68	1.38	1.41	2.43
Germany – Italy *	1.06	0.91	0 - 0	0.66	0.39	0.30	1.35	1.38	2.39
Italy – Ukraine	1.43	0.60	3 - 0	0.44	0.15	0.28	0.86	0.91	2.16
Germany – Sweden	1.72	0.74	2 - 0	0.39	0.15	0.25	0.79	0.83	2.20
Brazil – Ghana	0.50	2.21	3 - 0	0.22	0.07	0.17	0.46	0.57	1.71

Table 2: Elimination round games ordered by the excitement level, regulation time plus injury time. Draw was a possible outcome. Games marked by a star ended up with draw, and went into overtime.

Game	Score	T1 Advance	T2 Advance	Total
England – Portugal *	0 - 0	1.47	1.53	3.00
Portugal – Holland	1 - 0	1.24	1.16	2.40
Italy * – France	1 - 1	1.10	1.16	2.26
Switzerland – Ukraine *	0 - 0	1.14	1.02	2.16
Germany * – Argentina	1 - 1	1.06	1.04	2.10
Spain – France	1 - 3	1.00	0.92	1.92
Italy – Australia	1 - 0	0.74	0.76	1.50
Brazil – France	0 - 1	0.71	0.70	1.41
Argentina – Mexico	2 - 1	0.67	0.55	1.22
Germany – Italy	0 - 2	0.57	0.56	1.13
Germany – Portugal	3 - 1	0.40	0.49	0.89
Portugal – France	0 - 1	0.48	0.40	0.88
England – Ecuador	1 - 0	0.41	0.38	0.79
Italy – Ukraine	3 - 0	0.26	0.26	0.52
Germany – Sweden	2 - 0	0.22	0.20	0.42
Brazil – Ghana	3 - 0	0.11	0.18	0.29

Table 3: Elimination round games ordered by the excitement level, including overtime. Draw was not an option. Games marked by a star went into penalty shootouts.

References

[1] Garicano, L., I. Palacios-Huerta, "Sabotage in Tournaments: Making the Beautiful Game a Bit Less Beautiful". Working Paper, 2005.

[2] Newton, P., K. Aslam, "Monte Carlo Tennis," *SIAM Review*, Vol. 48, No. 4, 722-742, 2006.

[3] Ridder, G., J. S. Cramer, P. Hopstaken, "Down to Ten: Estimating the Effect of a Red Card in Soccer," *JASA,* Vol. 89, No. 427, 1994.

[4] Sanderson, A. R., J. J. Siegfried, "Thinking About Competitive Balance", *Journal of Sports Economics*, No. 4, Vol. 4, 255-279, 2003.

[5] Schmidt, M. B., D. J. Berri, "Competitive Balance and Attendance: The Case of Major League Baseball", *Journal of Sports Economics*, Vol. 2, No. 2, 145-167, 2001.

[6] Szymanski, S., "Income inequality, competitive balance and the attractiveness of team sports: Some evidence and a natural experiment from English soccer", *The Economic Journal*, Vol. 111, F69 - F84, 2001.

[7] Tango, T., M. Lichtman, A. Dolphin, *The Book: Playing Percentages in Baseball*, TMA Press, 2006.

[8] Thomas, A. "The Impact of Puck Possession and Location on Ice Hockey Strategy," *Journal of Quantitative Analysis in Sports* Vol. 2, No. 1, Article 6, 2006.

[9] Wesson, J., *The Science of Soccer,* IoP, 2002.