Paper: Soccer

Game Theoretic Approach to Analyze Japan's "Keep Rolling the Ball" Tactic Used in the 2018 FIFA World Cup Group Stage Final Matches in Russia

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During the last 10 minutes of the Group H final match of the 2018 FIFA World Cup, Japan was one goal behind Poland. At the same time, Senegal was also one goal behind its opponent. If both teams were defeated by one goal, Japan would qualify to move forward based on fair play points. However, a second goal by Poland would eliminate Japan in the group stage. Therefore, for these 10 minutes, Japan kept rolling the ball between their defense and midfield. In this study, we analyze this incident from the standpoint of game theory to quantitatively evaluate the quality of Japan's tactical decision to keep rolling the ball. We model this situation by estimating the scoring rate based on the number of goals scored in the group stage, and calculate the probability of qualifying. We assume that Japan and Poland can choose their tactics, "attack" or "keep rolling the ball," and compare their expected results. According to our calculation, the scoring rate was estimated to be 0.0307 goals per minute. If Japan chose to "attack," the probability of qualifying would be 0.676. However, if Japan chose to "keep rolling the ball," the probability would increase. Therefore, Japan's choice to "keep rolling the ball" during the last 10 minutes appeared to increase their probability of qualifying; thus, Japan made a rational decision in this situation.

Keywords: FIFA World Cup, game theory, keep rolling the ball, tacticc

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1. Introduction

The FIFA World Cup Group Stage Final Matches in Russia were held between June 14 and July 15, 2018. Japan once had a lead of 2 points against Belgium in the 1st match of the final stage; however, Japan was surpassed by Belgium by one point in the last half and lost the game 3-2. Although Japan lost the game, it was significant in that it showed the team's potential to make its first advance into the quarterfinals. Japan played against Poland in the final game of the primary league for the right to advance into the finals and lost 0-1. Senegal lost to Colombia 0-1 in the same group. As a result, Japan and Senegal showed equal results in wins and losses, total score, and the results of their head-to-head record; however, Japan won against Senegal in the fair play point[*1] related to the number of yellow and red cards received, which allowed Japan to advance from the group stage.

In the final game against Poland, Japan retained possession of the ball in its territory by passing the ball between team members for approximately 10 minutes to run out the clock. There are many pros and cons to this tactic. Some see it as against the principle of football and others consider it a rational tactical decision by the coach (BBC Sport 2018 FIFA World Cup, 2018; Reuters, 2018; Sankeisyo, 2018). Analysis applying game theory to data allowed us to quantitatively examine how the breakthrough probability to the group stage changed with this tactic.

Game theory is mathematical theory related to game tactics. As an academic field, it focuses on the clarification of rational behavior considering tactics as a game (Davis, 1983; Owen, 1995). A pioneering book written by John von Neumann and Oskar Morgenstern (1944) introduced the theory as an aid to decision making in markets, and it has since found broad application in a wide range of fields. It is also applied in sports, and academics study it as a target of research. Kira et al. (2015) developed the Markov game as a model of optimum tactics in baseball, tactics such as sacrifice bunts and base stealing, to calculate the increase

in the probability of wins for opposing teams employing tactics at the best timing. Using the game theory model, Hirotsu et al. (2010) and Li (2014) analyzed tactics for attacking and blocking in volleyball while Worker and Wooders (2001) analyzed the tactics for serving and receiving in tennis. Deck et al. (2014) examined pitting tactics employed at National Association for Stock Car Auto Racing (NASCAR) cups. Thus, the application of game theory to sports enables the quantification and analysis of situations in which tactics are employed.

Regarding football, Chiappori et al. (2002) developed a game tactics model for penalty kicks between kickers and goal keepers and analyzed how each tactic uses three options: left, right and middle. Hirotsu and Wright (2006) attempted to model tactical changes of formations as a zero-sum game, and Hirotsu et al. (2009) attempted. this as a non-zero-sum game.

In this study, we analyze data focusing on situations in which Japan decided to pass the ball between team members during the final game against Poland in Group H of the FIFA World Cup Group Stage Final Matches in Russia. We estimated the rate of scoring goals of each team and calculated the expected payoff to quantify the individual situations in which tactics were employed, and then suggested a new method of analyzing game tactics from the standpoint of game theory. Then, we examined the rationality of passing the ball between team members. Specifically, we estimated the changes in the probability of advancing from the Group Stage when Japan changed tactics from attacking to passing the ball between team members. Furthermore, considering the game tactics against Poland, we calculate the changes in payoff by both Japan and Poland and examine the rationality of the tactics.

In Section 2, we describe situations of the final game in Group H in the Group Stage; and in Section 3, we estimate rate of scoring goals and final scores based on the results of the Group Stage. In Section 4, we show the results of analysis from the standpoint of game theory, and we provide our conclusions in Section 5.

2. Final Games of Group H of the FIFA World Cup Group Stage Final Matches in Russia

The Group Stage of the World Cup applies the game system*2 of classifying 32 teams into eight groups, A to H, each of which having four teams, and uses a round-robin tournament in each group. The top two teams from each group advance into the Final Stage. The final games in Group H were Japan-Poland and Senegal-Colombia. The ranking of Group H before the games is as shown in **Table 1**. Because Japan won against Colombia in the first game, both Japan and Senegal had 1 win, 1 tie and were ranked second place. The results of the final games would determine which teams would advance from the Group Stage.

Before the final games, Poland had been eliminated in the Group Stage and Colombia sought to advance from the Group Stage by a win against Senegal. **Table 1** shows Japan and Senegal ranked evenly at four points each in the group; however, the difference in fair play points (Japan: 3, Senegal: 5) places Japan in the first position.

Table 2 shows predictions for Japan based on the potential results of the final games. If Japan were to achieve a win against Poland or if the game were to end in a draw, Japan would advance from the Group Stage. If Japan were to lose to Poland, it would have four points and the results of the Senegal-Colombia game would determine whether Japan advanced from the Group Stage. If Japan were to lose and Senegal win against Colombia, Japan would advance from the Group Stage. If Japan were to lose and the Senegal and Colombia game were to end in a draw, Japan and Colombia would receive the same number of points, but the goal difference would place Japan behind Senegal and prevent it from advancing from the Group Stage. If both Japan and Senegal were to lose, Colombia would place first in the group and advance from the Group Stage. Japan and Senegal would then compete to advance from the Group Stage in second position.

Under such complicated circumstances, the two

Table 1 Standings of Group H in the group stage before the final match of the group

Position	Team	Played	Won	Tied	Lost	Goal for	Goal against	Goal Diff.	Points
1	Japan	2	1	1	0	4	3	1	4
2	Senegal	2	1	1	0	4	3	1	4
3	Colombia	2	1	0	1	4	2	2	3
4	Poland	2	0	0	2	1	5	-4	0

Table 2 Situation deciding whether Japan was qualified to the final tournament according to the results of the final two matches (Japan-Poland, Senegal-Columbia)

		Senegal		
		Won	Tied	Lost
Japan	Won	Qualified	Qualified	Qualified
	Tied	Qualified	Qualified	Qualified
	Lost	Qualified	Not qualified	Conditional

Note: "Qualified,""Not qualified" or "Conditional"are in terms of Japan. For example, if Japan and Senegal won in these final matches, Japan would be qualified to play in the final tournament.

Table 3 Payoff matrix of Japan and Senegal

		Senegal vs.Colombia					
	Score	2-1	1-1	1-2	0-1	0-2	0-3
Japan	2-1	(1,1)	(1,1)	(1,0)	(1,0)	(1,0)	(1,0)
vs.	1-1	(1,1)	(1,1)	(1,0)	(1,0)	(1,0)	(1,0)
Poland	1-2	(1,1)	(0,1)	(1,0)	(1,0)	(1,0)	(1,0)
	0-1	(1,1)	(0,1)	(0,1)	(1,0)	(1,0)	(1,0)
	0-2	(1,1)	(0,1)	(0,1)	(0,1)	(1,0)	(1,0)
	0-3	(1,1)	(0,1)	(0,1)	(0,1)	(0,1)	(1,0)

Note: "Payoffs of Japan and Senegal are shown in ( ) in the order of Japan and Senegal. Payoffs "1" and "0" correspond to "qualified" and "not qualified" to the final tournament, respectively. For example, if Japan and Senegal won in the score 2-1 in these final matches, Japan and Senegal would be qualified to play in the final tournament.

final games started at the same time on June 28 and the first half of both games ended with a tie score of 0-0. If the games had ended in a draw, Japan would have advanced from the Game Stage. However, Poland scored 11 minutes into the second half, bringing the score to 0-1 (Japan-Poland). If Poland had retained its lead to the end of the second half, then Japan would have been eliminated in the Group Stage. However, Colombia scored in its game against Senegal 29 minutes into the second half, putting Senegal behind by one point. Considering the time remaining, it seemed likely that both Japan and Senegal would lose their respective games and compete for second position based on goal difference and total scores.

Table 3 shows the potential for payoff for both Japan and Senegal. The rows show the possible results of the Japan-Poland game (2-1, 1-1, 1-2, 0-1, 0-2, 0-3) and the columns show the possible results of the Senegal-Colombia game (2-1, 1-1, 1-2, 0-1, 0-2, 0-3). The probability of scoring three or more goals by both teams in the last 10 minutes is not zero, but only about 2%, as described below. Therefore, we show 2-1, 1-1, 1-2, 0-1, 0-2, 0-3 because they are likely to occur. The figures 1 and 0 in ( ) show the payoff of Japan and Senegal depending on the scores. If the team advances from the Group Stage, we assign a score of 1 and if the team loses in the Group Stage, we assign a score of 0. For example, the (1, 0) shown in the intersection of the 0-1 row and 0-1 column means that both games end with a score of 0-1, and that Japan advances from the Group Game and receives 1; and Senegal loses in the Group Game and receives 0. The payoff number is the numerical figure that each team receives based on the results of the games. They are not necessarily set at 1 or 0; however, we set 1 and 0 to match the expected payoff to the probability of advancing from the Group Stage.

While Colombia scored a goal with slightly more than ten minutes remaining until the end of the game, in this study, we use 10 minutes for convenience. From the score of 0-1 in the last 10 minutes of both games, the probability of changing scores varies depending on the tactics that each team employs. We apply game theory to such changes to formulate the progress of each game from the above-mentioned scores in and after the next section.

3. Estimation of Rate of Scoring and Final Scores Using Group Stage Game Data

3.1 Estimation of Rate of Scoring Goals

Table 4 shows the results of all games played in FIFA World Cup Russia 2018. **Figure 1** shows the distribution of scores in all games of the Group Stage. In general, it is known that the scores of each team in football follow the Poisson distribution (Maher, 1982; Lee, 1997). All games in the Group Stage totaled 122 points, and the playtime totaled 4,320 minutes (48 games × 90 min.).

Table 4 Number of goals scored before 80 minutes and after 80 minutes in each match of the group stage

			Before 80min.			After 80min.		
Group	Team A	Team B	G_A	G_B	Time	G_A	G_B	Time
A	Russia	Saudi Arabia	3	0	80	2	0	10
A	Egypt	Uruguay	0	0	80	0	1	10
A	Russia	Egypt	3	1	80	0	0	10
A	Uruguay	Saudi Arabia	1	0	80	0	0	10
A	Uruguay	Russia	2	0	80	1	0	10
A	Saudi Arabia	Egypt	1	1	80	1	0	10
B	Morocco	IR Iran	0	0	80	0	1	10
B	Portugal	Spain	2	3	80	1	0	10
…	…	…	…	…	…	…	…	…
F	Germany	Sweden	1	1	80	1	0	10
F	Korea Republic	Germany	0	0	80	2	0	10
F	Mexico	Sweden	0	3	80	0	0	10
G	Belgium	Panama	3	0	80	0	0	10
G	Tunisia	England	1	1	80	0	1	10
G	Belgium	Tunisia	4	1	80	1	1	10
G	England	Panama	6	1	80	0	0	10
G	England	Belgium	0	1	80	0	0	10
G	Panama	Tunisia	1	2	80	0	0	10
H	Colombia	Japan	1	2	80	0	0	10
H	Poland	Senegal	0	2	80	1	0	10
H	Japan	Senegal	2	2	80	0	0	10
H	Poland	Colombia	0	3	80	0	0	10
H	Japan	Poland	0	1	80	0	0	10
H	Senegal	Colombia	0	1	80	0	0	10
	Total	Time 4320	47	48	3840	17	10	480
		Goals 122		95			27	
<Except underlined data>								
	Total	Time 4120	46	45	3680	17	10	440
		Goals 118		91			27	

Note: "Underlined data was unknown at the time 80 minutes had elapsed in the final games of Group H (Japan-Poland and Senegal–Colombia).

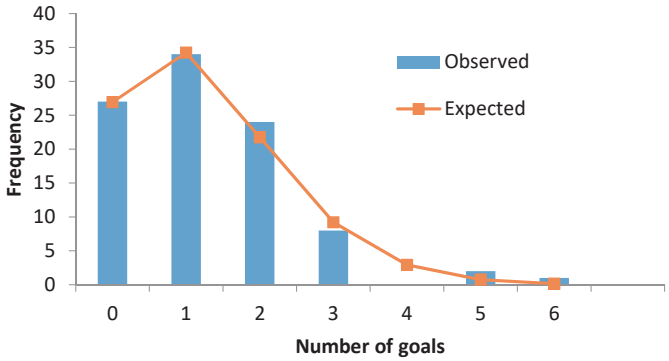

Figure 1 Observed and expected number of goals scored in the group stage

One game is 90 minutes and points are scored by two teams. Therefore, total playtime for each team is double the 4,320 minutes. The number of scores per minute (rate of scoring goals) of a team can be calculated as follows:

122 points/ (2×4,320 min.) = 1.27 points/ 90 min.
= 0.0141 points/ min.

The results of the calculation of scores in the Group Stage using this rate of scoring goals following the Poisson distribution are shown in the line graph of the **Figure 1**. These are very similar to the values shown in the bar graph in **Figure 1**.

To analyze data it is necessary to predict final scores in the last 10 minutes of the final games in Group H. Therefore, excluding the remaining playtime of the two relevant games, and the other two games in Group G played after these, we estimated the rate of scoring goals using the results of games in the Group Stage completed at the time, and then predicted the final points that would be scored in the remaining 10 minutes. The total number of goals in the Group Stage up to the last 10 minutes in the final games of Group H was 118. In addition, **Table 4** gives a breakdown of the number of goals divided into two sections, the first 80 minutes and the last 10 minutes of game time. During the first 80 minutes, 91 goals were scored in 46 games (46 × 80 min. = 3,680 min.); and during the last 10 minutes, 27 goals were scored in 44 games (44 × 10 min. = 440 min.). In **Table 4**, the goals and times during the last 10 minutes of the final games in Group H are underlined. The rate of scoring goals during the first 80 minutes and the last 10 minutes are shown below:

Rate of scoring goals during the first 80 minutes:
91 points/ (2×3,680 min.) = 0.0143 points/ min.

Rate of scoring goals during the last 10 minutes:
27 points/ (2×440 min.) = 0.0307 points/ min.

The rate of scoring goals during the last 10 minutes doubled that during the first 80 minutes. This is thought to be because of the additional time in the last 10 minutes would increase the number of goals.

Previous studies have employed log-linear models to estimate rate of scoring goals taking account of the level of team skills (Maher, 1982; Lee, 1997; Hirotsu and Wright, 2003). This study also applied a log-linear model to estimate rate of scoring goals.

We define the scores of Team A and B in an individual game as G_A and G_B, and time as T. As shown in **Table 4**, scores and times are divided into two sections, the first 80 minutes and the last 10 minutes. The difference in rate of scoring goals during the last 10 minutes from the rate of scoring goals during the first 80 minutes is defined as β_{last}, the strength (tendency) of A regarding scores is defined as β_{score} (A), and the strength of A regarding points lost as $\beta_{concede}$ (A). We also defined the strength (tendency) of B regarding scores as β_{score} (B), and the strength of B regarding points lost as $\beta_{concede}$ (B). In this study, we gradually applied more complicated models. Model 1 explains the rate of scoring goals G_A/T and G_B/T of each team in each game utilizing the same parameter, β. Model 2 takes account of the difference between the first 80 minutes and the last 10 minutes utilizing β and β_{last}. Taking account of the difference between the two teams, Model 3 explains the rate of scoring goals utilizing the β_{score} of each team, Model 4 explains the rate of conceding goals utilizing $\beta_{concede}$, of each team, and Model 5 explains rate of scoring goals and rate of conceding goals utilizing β_{score} and $\beta_{concede}$ of each team to find a model whose Akaike's Information Criterion (AIC) (Sakamoto, 1986), a quality standard, becomes the minimum for use as the optimum model. We used the glm function (R i386.3.3.2) to estimate parameters and calculate AIC.

These models are shown in **Table 5**. Estimating β in Model 1 with a logarithm produces a rate of scoring goals of e^{β}. Model 1 estimates the rate of scoring goals of each game using β only, making the number of

Table 5 Log-linear models for estimation of goal rate

No.	Model	Degrees of Freedom	Number of Parameters	logL*	AIC
Model 1	$\log \frac{G_A}{T} = \beta$ $\log \frac{G_B}{T} = \beta$	179	1	-189.0	380.0
Model 2	$\log \frac{G_A}{T} = \beta + \beta_{last}$ $\log \frac{G_B}{T} = \beta + \beta_{last}$	178	2	-181.8	367.6
Model 3	$\log \frac{G_A}{T} = \beta + \beta_{last} + \beta_{score}(A)$ $\log \frac{G_B}{T} = \beta + \beta_{last} + \beta_{score}(B)$	147	33	-162.6	391.2
Model 4	$\log \frac{G_B}{T} = \beta + \beta_{last} + \beta_{concede}(A)$ $\log \frac{G_A}{T} = \beta + \beta_{last} + \beta_{concede}(B)$	147	33	-159.6	385.1
Model 5	$\log \frac{G_A}{T} = \beta + \beta_{last} + \beta_{score}(A) + \beta_{concede}(B)$ $\log \frac{G_B}{T} = \beta + \beta_{last} + \beta_{score}(B) + \beta_{concede}(A)$	124	56	-150.7	413.4

Remarks: G_A and G_B are the number of goals scored in the relevant game by team A and B, respectively, in the first 80 minutes or after 80 minutes in the game. T is 80 minutes or 10 minutes. β is intercept. β_{late} represents an effect of difference of goal rates between the first 80 minutes and the last 10 minutes. β_{score} (A) and $\beta_{concede}$ (A) are the offensive strength of team A in scoring goals and the defensive strength against conceding goals, respectively. β_{score} (B) and $\beta_{concede}$ (B) are those of team B.

parameters 1. Model 2 implements not only β, but also β_{last}, which shows the difference between the first 80 minutes and the last 10 minutes, making the number of parameters 2. Model 3 takes account of the difference in strength of each team regarding scores, and β_{score} varies by team; thus, bringing the number of parameters to 33 (=31+2). (One out of 32 teams is used as the baseline and set as 0 so that the number of parameters by individual teams becomes 31.) $\beta_{concede}$ for Model 4 varies by team, bringing the number of parameters to 33. Both β_{score} and $\beta_{concede}$ for Model 5 vary by team; however, the number of parameters becomes 56 (=2+31+31-8) due to the limitation that the total scores and points lost are the same for all eight groups. Maximum log likelihood (Log L*), which expresses the relative quality of a statistical model for a given set of data, and AIC, which indicates the quality of the model, are also shown. AIC takes account of the complexity of the model and the relative quality of the statistical model for a given set of data. It is calculated with the formula (AIC = -2 {maximum log likelihood – the number of parameters obtained through maximum likelihood estimation}. The AIC of Model 1 is 380.0 (=-2×{-189.0-1}). The smaller the AIC is, the better the model is. Although not shown in **Table 5**, the AIC value in the model taking account of the interactions that change the strength of the team before and after passing the 80 minutes becomes larger.

In the Group Stage, 32 teams compete in eight groups, A to H; therefore, there are only 48 games, which is less than the total number of games in general annual leagues. For this reason, Model 2, which takes account of the difference between before and after 80 minutes, was determined to be the best model because it yielded the lowest AIC, not a model containing a parameter that expresses the strength regarding scored points and lost points. For analysis, we decided, therefore, to use Model 2, which does not take account of the difference in strength regarding scores and points lost by teams. However, we also decided to show the results of Model 5, which estimated rate of scoring goals for each team, for reference.

Parameters obtained through maximum likelihood

estimation for Model 2 are -4.39 (β) and 0.909 (β_{last}). The rate of scoring goals during the last 10 minutes was estimated to be $e^{-4.39+0.909}$ = 0.0307 scores / min., which was the same as the rate of scoring goals during the last 10 minutes, as described above.

3.2 Prediction of Final Scores

Assuming the scores during the last 10 minutes follow the Poisson distribution, the probability distribution of scores during the last 10 minutes using the rate of scoring goals is as shown in **Table 6**. For example, the probability of scoring one point during the last 10 minutes would be 0.226 as a result of $e^{-0.0307\times10}$ (0.0307×10), and the probability of scoring two points would be 0.035 as a result of $e^{-0.0307\times10}$ $(0.0307\times10)^2/2!$. This rate of scoring goals was obtained through maximum likelihood estimation setting the time until the end of games at 10 minutes for all games without considering the length of additional time in each game using score data for the last 10 minutes. Because additional time was not included in the calculation, rate of scoring goals during the last 10 minutes would be evaluated relatively higher than it is. However, we also use 10 minutes for all games to multiply by the rate of scoring goals without taking account of additional time, we deemed this calculation the estimation of scores during the last 10 minutes. **Table 6** shows the probability distribution of scores during the last 10 minutes, which can be used to predict final scores.

Table 7 shows the possible final scores and their probabilities when the score is 0-1 at the end of the first 80 minutes of games played by Team A and B using the probability distribution of scores. It is possible to finish with a score of 0-1 in **Table 7** when neither team scores during the last 10 minutes to yield a probability of 0.541 (=0.736×0.736) for the case that both teams score 0 points, as shown in **Table 6**. The probability of games resulting in a score of 1-1 is 0.166 (=0.226×0.736), which means Team A scores 1 point and Team B scores 0 points. The possible scores when both teams score two or fewer points during the last 10 minutes are 2-1, 1-1, 1-2, 0-1, 0-2, and 0-3, and the total of their probabilities is 0.976, which shows that the probability of scoring three or more is only about 2%.

4. Analysis from the Perspective of Game Theory

In this section, we analyze data from the perspective of game theory utilizing the final score probabilities from the previous section. In 4.1, focusing on the selection of tactics by Japan, we explain how the Japan team can maximize expected payoff by selecting either attacking or passing as a single-player game. In 4.2, we explain this for both teams taking account of the selection of tactics by both Japan and Poland as a two-player game. In 4.3, we show the rate of scoring goals and expected payoff when applying passing and in 4.4, we show the results when taking account of the difference in strength of teams.

4.1 Considering Payoff for Japan Only

Table 8 shows the possible scores for the Japan-Poland and Senegal-Colombia games (2-1, 1-1, 1-2, 0-1, 0-2, 0-3), their payoff, probability, and expected payoff. Japan's payoff is 1 or 0 depending on game results, as shown in **Table 3**. The probability is a product obtained by multiplying the possible scores of the Japan-

Table 6 Probability distribution of the number of goals to be scored in the last 10 minutes

Number of goals	Probability
0	0.736
1	0.226
2	0.035
3	0.004
4	0.000

Table 7 Final scores reached from the score 0-1 at the time of 80 minutes had elapsed in the match between team A and B with probabilities in parenthesis

2-1 (0.0255)	2-2 (0.01)	2-3 (0.001)
1-1 (0.1661)	1-2 (0.05)	1-3 (0.008)
0-1 (0.5414)	0-2 (0.17)	0-3 (0.025)

Poland and Senegal-Colombia games. For example, the probability of a Japan-Poland game score of 0-1 is 0.541, as shown in **Table 7**, and the probability of a Senegal-Colombia game score of 0-1 is also 0.541. Therefore, the multiplying the two (0.293) yields the probability of both games finishing with a score of 0-1.

If we know the probability associated with this payoff, we can calculate the expected payoff for Japan. **Table 8**, for example, shows that the expected payoff in the case of both games ending with a score of 0-1 is 0.293 (=1×0.293). Other scores are similarly calculated. In the case of a Japan-Poland score of 0-1, the total expected payoff for each Japan score is 0.411 corresponding to different scores. The total expected payoff for each Japan scores in the Japan-Poland game is the expected payoff after taking account of the possible scores of both games (2-1, 1-1, 1-2, 0-1, 0-2, 0-3) at 0.676.

The payoff for Japan is set at 1 if Japan advances from the Group Stage and 0 if Japan loses in the Group Stage. The probability of Japan's advancing from the Group Stage is 0.676 because both games are 0-1 before the last 10 minutes of play.

At this point, we consider that Japan can select not only attacking, but also passing as tactics during the last 10 minutes. We set the rate of scoring goals of Japan at 0 if Japan selects passing. If Japan succeeds in keeping Poland's rate of scoring goals at 0, the final Japan-Poland score would be 0-1. Japan's advancement from the Group Stage is dependent on the result of the Senegal-Colombia game. The probability is 0.758, which is the total of probabilities of having the final scores of 2-1, 0-1, 0-2, and 0-3 shown in **Table 7**. In other words, the probability of advancing from the Group Stage increases from 0.676 to 0.758 by using passing, making the choice

Table 8 Relationships between final scores, payoff and expected payoff

Score		Payoff		Probability	Expected payoff		Expected payoff (total)	
Japan-Poland	Senegal-Colombia	Japan	Poland		Japan	Poland	Japan	Poland
2-1	2-1	1	-0.8	0.001	0.001	-0.001	0.025	-0.020
	1-1	1	-0.8	0.004	0.004	-0.003		
	1-2	1	-0.8	0.001	0.001	-0.001		
	0-1	1	-0.8	0.014	0.014	-0.011		
	0-2	1	-0.8	0.004	0.004	-0.003		
	0-3	1	-0.8	0.001	0.001	-0.001		
1-1	2-1	1	-0.5	0.004	0.004	-0.002	0.162	-0.081
	1-1	1	-0.5	0.028	0.028	-0.014		
	1-2	1	-0.5	0.008	0.008	-0.004		
	0-1	1	-0.5	0.090	0.090	-0.045		
	0-2	1	-0.5	0.028	0.028	-0.014		
	0-3	1	-0.5	0.004	0.004	-0.002		
1-2	2-1	1	-0.1	0.001	0.001	0.000	0.041	-0.005
	1-1	0	-0.1	0.008	0.000	-0.001		
	1-2	1	-0.1	0.003	0.003	0.000		
	0-1	1	-0.1	0.028	0.028	-0.003		
	0-2	1	-0.1	0.008	0.008	-0.001		
	0-3	1	-0.1	0.001	0.001	0.000		
0-1	2-1	1	-0.1	0.014	0.014	-0.001	0.411	-0.053
	1-1	0	-0.1	0.090	0.000	-0.009		
	1-2	0	-0.1	0.028	0.000	-0.003		
	0-1	1	-0.1	0.293	0.293	-0.029		
	0-2	1	-0.1	0.090	0.090	-0.009		
	0-3	1	-0.1	0.014	0.014	-0.001		
0-2	2-1	1	-0.02	0.004	0.004	0.000	0.036	-0.003
	1-1	0	-0.02	0.028	0.000	-0.001		
	1-2	0	-0.02	0.008	0.000	0.000		
	0-1	0	-0.02	0.090	0.000	-0.002		
	0-2	1	-0.02	0.028	0.028	-0.001		
	0-3	1	-0.02	0.004	0.004	0.000		
0-3	2-1	1	0	0.001	0.001	0.000	0.001	0.000
	1-1	0	0	0.004	0.000	0.000		
	1-2	0	0	0.001	0.000	0.000		
	0-1	0	0	0.014	0.000	0.000		
	0-2	0	0	0.004	0.000	0.000		
	0-3	1	0	0.001	0.001	0.000		
Total				0.952	0.676	-0.162	0.676	-0.162

a reasonable strategy.

We consider it possible for Poland to score even if Japan applies passing. In this study, considering that the rate of scoring goals when passing is 1/10 of the rate of scoring goals (0.003) when attacking, the expected payoff for Japan was 0.742.

4.2 Considering Game Tactics against Poland

The expected payoff for Japan increased from 0.676 to 0.758 (or 0.742) by employing passing as a strategy. However, Japan competes with Poland; therefore, we examined the outcome of the game tactics against Poland.

Even a win by Poland against Japan would not allow an advance from the Group Stage; therefore, we set the payoff at 0 even if Poland were to win by a score of 0-3. Because winning by 0-2 or 0-1 would not yield as great a payoff as a 0-3 outcome would, it is necessary to set it smaller than 0. Here we set -0.02 and -0.1, respectively. A draw would mean no wins in the Group Stage; therefore, the payoff should be set at -0.5. A loss by Poland in this final game would mean the loss of all games in the Group Stage; therefore, the payoff should be set lower at -0.8. **Table 8** shows the cases for Poland.

If we set the payoff for Poland as described above, we can calculate the expected payoffs for Poland. Regarding **Table 8**, for example, if both games end with a score of 0-1, the payoff for Poland at the end of the first 80 minutes would be -0.029 (-0.1×0.293). We also calculated several other cases of scores. If the Japan-Poland game resulted in a score of 0-1, the total of the expected payoff depending on each potential score for the Senegal-Colombia game would be -0.053. The total of the expected payoff depending on each score for Japan-Poland game is -0.612.

As describe above, calculation of expected payoff allows us not only to examine the selection of tactics by both Japan and Poland, and analyze the tactics of both teams based on the condition that allows both teams to apply not only attacking, but it also allows us to examine the use of passing during the last 10 minutes.

We considered the combination of tactics that Japan and Poland could choose under such conditions. The following four combinations of tactics were possible:

(1) Attacking-Attacking: Both Japan and Poland apply attacking.
(2) Passing-Attacking: Japan applies passing, and Poland applies attacking.
(3) Passing-Passing: Japan applies passing, and Poland also applies passing.
(4) Attacking-Passing: Japan applies attacking, and Poland applies passing.

Although in actual practice it does not seem to happen frequently, (3) and (4) above are cases in which Poland applies passing. In regard to these four cases, **Table 9**

Table 9 Scoring rates and expected payoff for the four cases according to the final score of the Japan vs. Poland match

Case	Scoring rate (Goals/min.)		Final score	Expected payoff		Expected payoff (total)	
	Japan	Poland	(Japan-Poland)	Japan	Poland	Japan	Poland
①	0.0307	0.0307	2-1	0.025	-0.020	0.676	-0.162
			1-1	0.162	-0.081		
			1-2	0.041	-0.005		
			0-1	0.411	-0.053		
			0-2	0.036	-0.003		
			0-3	0.001	0.000		
②	0	0.003	0-1	0.736	-0.095	0.742	-0.095
			0-2	0.006	-0.001		
			0-3	0.000	0.000		
③	0	0	0-1	0.758	-0.098	0.758	-0.098
④	0.003	0	2-1	0.000	0.000	0.765	-0.109
			1-1	0.028	-0.014		
			0-1	0.736	-0.095		

Table 10 Payoff matrix of Japan and Poland

		Poland	
		Attack	Keep rolling the ball
Japan	Attack	**(0.676, -0.162)**	**(0.765, -0.109)**
	Keep rolling the ball	**(0.742, -0.095)**	**(0.758, -0.098)**

shows the results of expected payoff calculated using the same method used in **Table 8** described in 4.1 above.

The rate of scoring goals of both teams in the case of (1) is 0.0307, and the expected payoff at the end of the first 80 minutes for Japan is 0.676 and that for Poland is -0.162 as described in 4.1 above.

If Japan applies passing, and Poland applies attacking in the case of (2), we can calculate the expected payoff during the last 10 minutes depending on the final scores. In such case the expected payoff for Japan would be 0.742 and that for Poland would be -0.095.

If both Japan and Poland apply passing in the case of (3), the rate of scoring goals of both teams would be 0, and the game would result in a score of 0-1. Japan's advancement from the Group Stage depends on the results of the Senegal-Colombia game. The expected payoff for Japan would be 0.758 and that for Poland would be -0.098.

Regarding case (4) in which Japan applies attacking and Poland applies passing, the expected payoff for Japan would be 0.765 and that for Poland would be -0.109.

Table 10 shows the summary of the above rate of scoring goals and their expected payoffs.

Table 10 shows that a score of 0-1 at the end of the first 80 minutes is categorized in (1) Attacking-Attacking. Shifting from attacking to passing, Poland could reduce the possibility of Japan adding points, and increase the possibility of winning the game. However, it is hard to conclude that Poland would employ passing before Japan. Shifting from (1) Attacking-Attacking to passing, Japan could reduce the possibility of Poland adding more points, although the tactic may be criticized, for a potential score of 0-1. Doing so would increase the probability of Japan's advancing from the Group Stage from 0.676 to 0.742. Increasing the probability by 6 to 7% would justify the shift of tactics by Japan as a reasonable strategy. In addition, the risk of Poland scoring decreases, and the expected payoff increases from -0.162 to -0.095. This change of tactics by Japan would also be welcomed by Poland. According to **Table 10**, once Japan shifts to passing, the expected payoff for Poland by attacking would be -0.095 and -0.098 by passing, which is not a significant difference. In other words, the incentive for Poland to continue attacking is low. In fact, Poland did not seem to be active in attacking probably because players were already tired at the end of the game. In such case, the expected payoff for Japan increases by 1% to 0.758. Considering the above results, we can conclude that the change of tactics by Japan led the shift of the game state from (1) Attacking-Attacking to (2) Passing-Attacking, and then ending the game in (3) Passing-Passing, and that both teams could gain a higher expected payoff by 6 to 8% than by ending the game in (1) Attacking-Attacking.

In the end, as Japan expected, Senegal lost to Colombia 0-1 and lost in the Group Stage, and Japan could advance the Group Stage helped by the fair play points although Japan lost to Poland by 0-1.

4.3 Relationship between the Rate of Scoring Goals of Poland and Expected Payoff for Japan

Because passing does not eliminate the risk of lost points, rate of scoring goals was set at 0.003 for passing in the previous section. It is difficult to estimate the rate of scoring goals from the data; therefore, we calculated the degree to which the expected payoff for Japan would change under the assumption that the rate of scoring goals for passing would be about half or less (0.016 or less) that for attacking. **Figure 2** shows the results. When the rate of scoring goals of Poland changes from 0 to 0.016, the expected payoff for Japan changes linearly from 0.758 to 0.676. When setting the rate of scoring goals for passing at about a half of that for attacking, the expected payoff for Poland would be 0.676, which is the same as when Japan applies attacking. In other words, if passing can reduce the rate of scoring goals of the opposing team to half or lower, passing would be beneficial. Even if we set the rate of scoring goals at 0.006, which is about one fifth of that for attacking, the expected payoff for Japan would remain at 0.727, which

is an approximately 5% increase from that for attacking (0.676).

Even when changing the payoff values set for Poland slightly, we obtained similar results.

4.4 Difference among Teams

As shown in **Table 5,** we examined Model 2 with two parameters, β and β_{last}, taking account of the difference between before and after 80 minutes. We also show the results of the calculation using Model 5 taking account of the difference in strength regarding scores and points lost by teams. In Group H before final games, Colombia made four goals and lost only two points, as shown in **Table 1**. Both the offensive and defensive strength of Colombia were highly regarded while the defensive strength of Poland was considered low due to the lost points. Therefore, the rate of scoring goals for Colombia and Japan in the final game was 0.0428 and that for Senegal and Poland was 0.0203. **Table 11** shows the results of payoff calculations based on these rate of scoring goals. According to the data on goal difference in the Group Stage, Colombia's defensive strength was highly regarded while the possibility of Senegal scoring goals against Columbia was considered low. Therefore, Japan's choosing passing as a strategy would increase the possibility of both games ending in a score of 0-1. As a result, it was suggested that passing by Japan would increase the possibility of advancing from the Group Stage from 0.660 by 14 to 16%.

5. Conclusion

This study examined passing as a strategy during the last 10 minutes of the final game of Japan against Poland in the Group Stage of the FIFA World Cup in Russia from the perspective of game theory. Both Japan and Senegal were one point behind from their opponents when they applied passing.

We used the scores before the last 10 minutes in the Group Stage, examined log-linear models to evaluate the strength of teams, and obtained the rate of scoring goals through maximum likelihood estimation. We then calculated final scores from 0-1 at the 80-minute point and probabilities using the probability distribution of scores obtained from the rate of scoring goals, which clarified that choosing not only attacking, but also passing in the last 10 minutes for both teams increased the probability of advancing from the Group Stage by

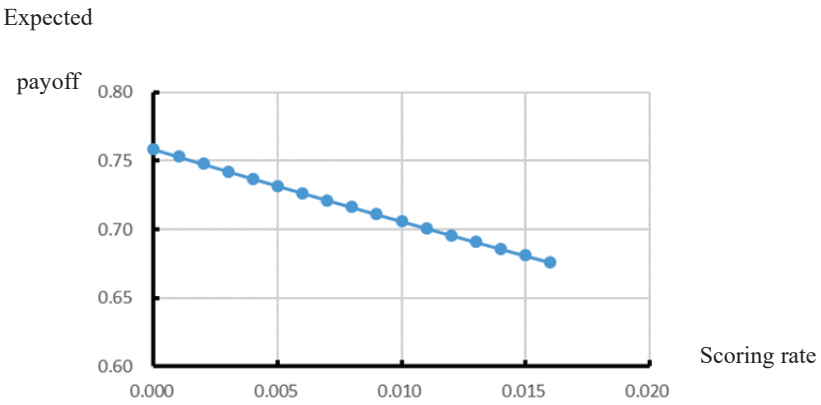

Figure 2 Relationship between the scoring rate of Poland and the expected payoff of Japan in the case that Japan keeps rolling the ball

Table 11 Payoff matrix of Japan and Poland in the case of considering the teams' offensive and defensive strengths

		Poland	
		Attack	Keep rolling the ball
Japan	Attack	**(0.660, -0.122)**	**(0.824, -0.109)**
	Keep rolling the ball	**(0.804, -0.095)**	**(0.819, -0.097)**

6 to 7%; that is, from 0.676 to 0.742. If we consider that this change of tactics by Japan increases the expected payoff for Poland and reduces the incentive for Poland to continue attacking, the expected payoff for Poland increases to 0.758. Considering all these facts and the evaluation of the rate of scoring goals when passing, the probability of Japan’s advancement from the Group Stage increases.

In this study, we calculated rate of scoring goals from gained and lost points using a log-linear model with minimum AIC. The results changed slightly depending on the method of estimating rate of scoring goals, which also changed the probability of advancing from the Group Stage. Here, therefore, we showed examples of rational considerations. In fact, it is not easy to apply such calculations in real time; however, it is not impossible to quantitatively simulate game development by coaches based on scenarios and calculations in advance using methods similar to those applied in this study. We would like to continue our study to provide quantitative analytic methods that help coaches make better decisions during games. We also hope that game analysis for football utilizing game theory will find wider application and that doing so will lead to a greater understanding of the usability and validity of the analysis.

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Notes

1. Fair play points are shown in the total of the lost points for each carded foul: One point for each yellow card; three points for each secondary yellow cards; four points for straight red cards; and five points for a red card after a yellow card. (Regulations, 2018)
2. The ranking of the Group Stage is determined by the total points that each team has in all games of the relevant stage. Three points are given for a win, and one point is given for a draw. If more than one team has the same number of points, the team with the larger goal difference is ranked higher, followed by the team with the greater total score. If more than one team is in the same position, the ranking is determined by the points given, goal difference, scores, and fair play points in the head-to-head game. If more than one team is still in the position, the ranking is determined by lottery. (Regulations, 2018)

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