



## ***Help the unconventional coach!***

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*H. Abouee Mehrizi wrote this case solely to provide material for the course. The author has disguised certain names as well as other identifying information and mocked datasets to protect confidentiality. This publication may not be transmitted, photocopied, digitized, or otherwise reproduced in any form or by any means without the permission of the copyright holder.*

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### **1- Overview**

The final whistle and another 0-0 result in the last game of the season was enough for Mr. Murray, the manager of the football (soccer) team “FC B”, to decide to replace the current coach of the club. Although the final rank of 17 among 20 teams of the league guaranteed that the team is not going to be relegated to the lower division, it was unprecedented for “FC B” to end up the season as a team on the verge of relegation. The current coach’s justification of *“Well, I did my job and fortunately the team stays in the first division”* was out of the frying pan, into the fire for him. He was sacked from his job the next day with a record of 8 wins, 15 draws, 15 losses, and only 25 scored goals during the whole season and no scored goals in the last 6 matches. Meanwhile, Mr. Murray had to decide who to sign as the coach for the new season. His first option, as always, was Bill, a senior coach but not an old-fashioned one, who spent the last two years relaxing in Béziers, Southern France. This time, Mr. Murray, more determined than ever and regardless of the previous failed attempts, made Bill an offer he could not refuse. Besides the tempting offer, Mr. Murray guaranteed that for the next season, Bill can sign any players, even the most expensive ones at the top of the transfer market. The news came as a bombshell such that the headline of “S.S”, the most prestigious sport newspaper of the country, was indicating this story: *“The great Bill is back!”*

Bill, who recently participated in a conference on *“Sports Analytics”* is not coming alone to the club. He is bringing Aaron, who is a Sports Analytics specialist and met Bill during the conference, as his assistant.

Bill is famous in the football world. He is known for his attacking and pressing tactics. From the very first moment of his first meeting with Mr. Murray, he clarified what his strategy would be:



*"25 goals in 38 matches? Unbelievable! My teams attack, they play beautiful football or as Brazilian say, they perform "jogo bonito". The forwards of my team show no mercy to the opponent defenders and keepers, your current squad lacks good forwards, aye, that's what you need! We need to replace the current players, and sign new forwards based on my attacking tactics!"*

Although Mr. Murray had already showed his support and gave his consent to allocate enough budget for Bill to sign a contract with most valuable players in the current transfer market, Bill believed that they do not need players who are under the spotlight:

*"I don't want to spend the club's resources on names, most of these big names are overrated, I prefer three competent undervalued players who could be adapted on my tactics instead of one overrated super star."*

## **2- Football<sup>1</sup>**

Football, also called association football or soccer, is a game in which two teams of 11 players, using any part of their bodies except their hands and arms, try to maneuver the ball into the opposing team's goal. Only the goalkeeper is permitted to handle the ball and may do so only within the penalty area surrounding the goal. The team that scores more goals wins.

Football is the world's most popular ball game in numbers of participants and spectators. Simple in its principal rules and essential equipment, the sport can be played almost anywhere, from official football playing fields (pitches) to gymnasiums, streets, school playgrounds, parks, or beaches. Football's governing body, the Fédération Internationale de Football Association (FIFA), estimated that at the turn of the 21st century there were approximately 250 million football players and over 1.3 billion people "interested" in football; in 2010 a combined television audience of more than 26 billion watched football's premier tournament, the quadrennial month-long World Cup finals.

Tactics reflect the importance of planning for matches. Tactics create a playing system that links a team's formation to a particular style of play (such as attacking or counterattacking, slow or

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<sup>1</sup> <https://www.britannica.com/sports/football-soccer>

quick tempo, short or long passing, teamwork or individualistic play). Team formations do not count the goalkeeper and enumerate the deployment of players by position, listing defenders first, then midfielders, and finally attackers (for example, 4-3-3 or 5-3-2).

Promotion and relegation is a process where teams are transferred between multiple divisions based on their performance for the completed season. The best-ranked team(s) in the lower division are promoted to the higher division for the next season, and the worst-ranked team(s) in the higher division are relegated to the lower division for the next season. In the league format, teams obtain 3 points for a win, 1 point for a draw, and no points for a loss.



Figure 1- A 4-3-3 formation example with players 7,9, and 11 as attackers (forwards)

### 3- Bill's attacking strategy

Aaron, a young, talented data analytics specialist, is now a key asset for the club to find the best forward players based on Bill's measures. Bill believes that what club needs is talented players who are more competent than what their current market value suggest. *"The feeling that one haven't got what he deserved, is the combustion engine of progress in this sport!"*. Moreover, he believes that generally, the value of the players in the transfer market is determined based on



measures which are not meaningful for the playing strategy that his teams have. Now, this is Aaron's responsibility to find out the real values of the players based on Bill's measures. But what are Bill's measures?

- **Shooting, Pressing and Heading:** *"My favorite formation is playing with 3 forwards as a 4-3-3. We need to put the opponent defenders under pressure to force them make mistakes. I need a player with good pressing skill for this purpose. As soon as we get the ball, I want the players to pass the ball to sides and then cross the ball for the center forward. The center forward needs to have good heading skill. While the defenders are trying to control the center forward and there is a good empty space in front of them, the other alternative is long distance shots. I want the third forward to have good shooting skills. The average of these skills must be a measure of the value of players in the market."*
- **Substitute players:** *"It is important that the players had enough on-field experience."*
- **Age:** *"The age of the players is a significant factor of their value in the market. However, sometimes a 33-year-old player is better than a 28-year-old one."* Bill is also unsatisfied with the youth talent identification and recruitment policy of the club. He believes that for the upcoming years, the club should maintain a consistent talent scouting policy so that all potential rising stars would be on the club's radar screen.
- **Division:** *"Some of the second-division players are undervalued. There are many talents who are not in the spotlight for their skills."*

At the end of each season, "Goal", a very prestigious football magazine, assign skill scores to the players based on the performance of them during the season. Aaron collected the last season's data for 700 forward players who played in the first and second division leagues of the country and two other European football leagues. He is hopeful that by taking advantage of the data, and his data analytics skills, he will be able to provide helpful insights and analyses for Bill and the club.



## 4- Questions

### Part A: Height and the heading skill

As soon as Bill mentioned the need of the club to recruit a tall forward for his good heading skills, Richard, a senior member of the club's board of directors, opposed Bill by stating that *"Heading skills has nothing to do with the height of the player, sir! We had players in the club, Doran for example, who used to fly like a helicopter! his headers were killers for any goalkeeper!"* Bill, so wise not to come into a direct conflict with an influential member of the board, ignored Richard at that moment and was thinking to prove what he believes using facts and evidences in their next meeting. He asked Aaron to prove his idea. Aaron collected the data of 700 forward players provided in "ForwardPlayers" sheet. The height as well as the heading skill of the players' last season performance are recorded.

*Q<sub>A1</sub>*- Visually (using graphs, charts, etc.), show whether there is an association between the height and heading skills of players. (10%)

*Q<sub>A2</sub>*- Basically, people think that taller players have better heading skills. Perform a proper hypothesis test to explore this belief and discuss the results. (10%)

### Part B: Midfielders and the out list

The team's previous 4-5-1 formation for the last season was highly dependent on the performance of the 5 midfielders. These formation needs the midfielders to flow the ball between themselves with high accuracy to create an empty area for the only striker and the attacking midfielder. In Bill's opinion, the issue is that these 5 midfielders are not synchronized enough to circulate the ball and therefore, the team had difficulties in their attacking strategy. Usually, at the beginning of the season, since the team is not harmonized yet, the pass accuracy of the midfielders is not high enough. Furthermore, it is believed that when we get closer to the end of the season, because of the high pressure the players experience during the season, again we would observe a worse performance from the players. Bill's decision is clear: "I want two of these players out!". These 5 players were fixed players in most of the games and only missed some games because of injuries. Aaron believes that using the data collected about the pass



accuracy of each player in the last season's 38 games, (provided in "PassAccuracy" worksheet), he would be able to provide useful insights so that Bill makes a better decision.

**$Q_{B1}$** - Using the time series concepts discussed in the course, first show how the performance of players (pass accuracy) changed during the season. Determine, approximately, how many weeks it takes for players to find their bearings and be synchronized with other team members. Approximately, after how many weeks does the pass accuracy of players start to drop again? Address these questions based on what you observe in the time series plot(s). (10%)

**$Q_{B2}$** - Can you observe a special change in the pass accuracy of players who start to play after a period of injury? Among the five midfielders, which two players do you think should be replaced? (10%)

### Part C: Youth players scouting

As mentioned before, Bill is really worried about the youth talent identification and recruitment policy of the club. He believes that identification and recruitments of such talents will eventually create a great economic opportunity for the club as these players will be considered valuable assets in the transfer market. Bill has recruited three scouts to monitor all youth forwards of the league as well as two other prestigious European leagues. During all these years, Bill was preoccupied with this question: How to allocate different players to different scouts? It is widely believed that when scouts monitor players who have many aspects in common, they would be able to better compare the players, and suggest the ones that perfectly meet the needs of the club. By leveraging the available data (provided in "ForwardPlayers" worksheet) Aaron is willing to suggest an appropriate assignment of youth players to 3 scouts.

**$Q_{C1}$** - Choose an appropriate method to assign all youth forwards (all players less or equal than 22 years old) to the 3 scouts so that the most similar players are assigned to the same scout. Then, calculate the salary of each staff based on the following table. (15%)



Number of assigned players	Annual fee per player
0-50	\$1200
51-150	\$1000
151-250	\$900
+251	\$870

### Part D: Optimal transfer!

Bill's main concern from the beginning of his work, was to recruit three new forwards who fit best to his attacking strategy. He also believes that the higher market price of one player is not necessarily an evidence of better performance of the player. In his point of view, many of the expensive forwards are overrated, and based on his strategy, he is willing to choose forwards from the most underrated players. Aaron is now responsible to define a measure to identify the underrated players. He is thinking to find a new market value for each player based on Bill's preferred features (provided in "ForwardPlayers" worksheet). A new measure can be defined as:

$$\% \text{ of overrated (underrated) } = \left| \frac{\text{Current Market Value} - \text{New Market Value}}{\text{Current Market Value}} \right|.$$

After finding the most underrated players, he should identify a player for each skill, so that the average skill of the selected players is maximized (e.g. if player 1, player 2, and player 3 are selected for skill A, B, and C, with scores  $z_A$ ,  $z_B$ , and  $z_C$  respectively, the goal is to maximize  $\frac{z_A+z_B+z_C}{3}$ ). However, there are some constraints.

- Bill believes that the average age of chosen players for shooting and pressing must be at most 22 years old.
- Regulations do not allow the club to sign more than one player from the second division.
- The budget of the club for these transfers is at most \$8,500,000.
- Based on an agreement between the top six wealthy clubs of the league including "FC B" in 2017, each team can get at most one player from "Market Category" 1.



Player's market value	Player's Market Category
$\geq \$5,000,000$	1
$\$2,000,000-\$4,999,99$	2
$< \$2000,000$	3

$Q_{D1}$ - Based on the abovementioned discussion, create an optimization model to choose the best 3 forwards among 30 forwards from the “list of players”, which can be created as follows:

- Two most underrated players from the Market Category 1 players.
- Eight most underrated players from the Market Category 2 players.
- Twenty most underrated players from the Market Category 3 players.

Make sure that the “list of players” is arranged as illustrated in the following table. Please define your decision variables clearly and provide a final table indicating the playersID and the skill they are selected for. (25%)

Table 1-"List of players" dataset format

Player Number	PlayerID	%Underrated	Player's Market Category
1	.	Sort Largest to smallest ↓	1
2	.		1
3	.	Sort Largest to smallest ↓	2
4	.		2
5	.		2
6	.		2
7	.		2
8	.		2
9	.		2
10	.		2
11	.	Sort Largest to smallest ↓	3
12	.		3
13	.		3
14	.		3
15	.		3
16	.		3
17	.		3
18	.		3
19	.		3
20	.		3
21	.		3
22	.		3
23	.		3
24	.		3
25	.		3
26	.		3
27	.		3
28	.		3
29	.		3
30	.		3



 **$Q_{D2}$  - “Synergy”**

Certain players in the “list of players”, which you obtained in  $Q_{D1}$ , have the experience of playing together as teammates. Bill believes that this plays a key role in determining the true skills of the players as their previous experience would improve their performance. Using the information provided for  $Q_{D1}$ , create an optimization model to find a player for each skill by considering this effect such that the average skill of the chosen players is maximized ((e.g. if player 1, player 2, and player 3 are selected for skill A, B, and C, with scores  $z_A$ ,  $z_B$ , and  $z_C$  respectively, the goal is to maximize  $\frac{z_A+z_B+z_C}{3}$ ). Please explain the decision variables and the constraints of the problem carefully. Provide a final table indicating the playerID and the skills they are selected for. The following table provides information about the players in “list of players” who have been teammates. The table shows how their previous cooperation is expected to increase their skills’ score if they are chosen together. (20%)

Player Number	The expected improvement in skills if the players are chosen and play together
1&7	The Pressing skill of both players increases by 50% The Shooting skill of both players increases by 20%
2&14	The Pressing skill of both players increases by 10%
3&8	All skills of both players increase by 30%
1&9	The Shooting skill of both players increases by 15%
4&5&17	All skills of three players increase by 10%