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.

***QA*1**- Visually (using graphs, charts, etc.), show whether there is an association between the height and heading skills of players. (10%)

Answer: The x-axis is showing the 'Height' data while y-axis is showing the 'Heading Skills'. By seeing the plot, it is clearly seen that as the height of the players increases, the heading skills also increasing. For example, players having the of height above 185 have higher heading skills. Also, players having the of height of above 190 have even higher heading skills starting from 50 and above, which is significant among rest of the height of the players.

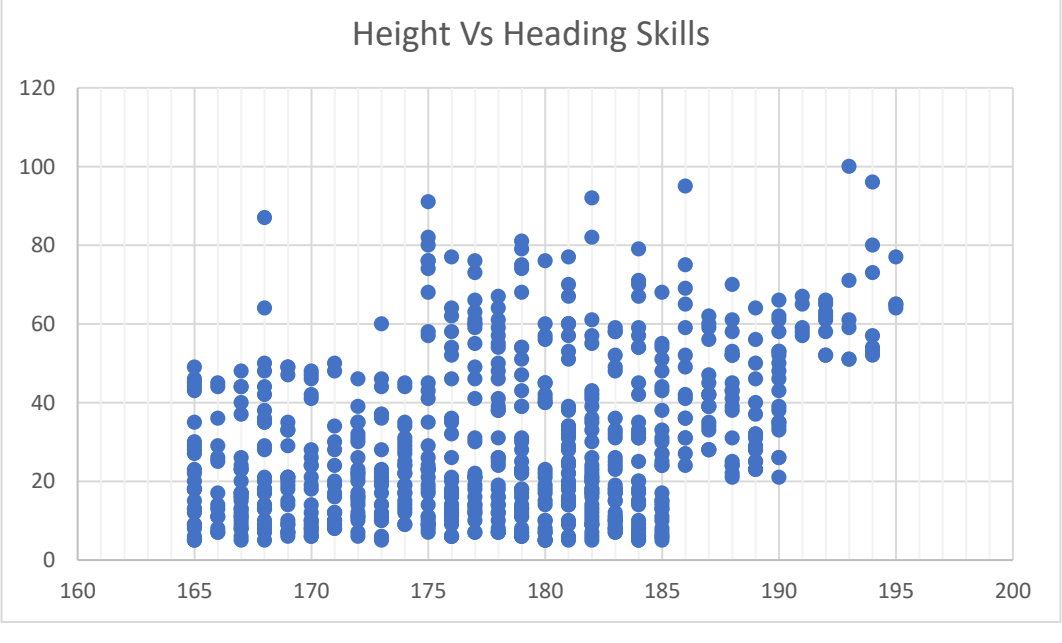

Figure 01: Scatter plot of Height vs Heading Skills

QA2- Basically, people think that taller players have better heading skills. Perform a proper hypothesis test to explore this belief and discuss the results. (10%)

Answer: For this question, performed the t:Test: Two sample Assuming Unequal Variance for 'Height' and 'Heading' skills. We are comparing the (mean) Height with the (mean) Heading.

Ho: (null hypothesis) = u1 – u2 <= 0
H1: (alternative hypothesis) = u1 – u2 > 0

Where u1 and u2 is the taller players having better heading skills and taller players not having better heading skills respectively.

After performing the below t-Test: Two-Sample Assuming Unequal Variances, we have found the p-value is 0. alpha < 0.05, therefore, we reject the null hypothesis.

Table 01: t-Test: Two-Sample Assuming Unequal Variances

	Height	*Heading*
Mean	178.1728571	30.26142857
Variance	55.9829532	405.9816289
Observations	700	700
Hypothesized Mean Difference	0	
df	888	
t Stat	182.073362	
P(T<=t) one-tail	0	
t Critical one-tail	1.646571386	
P(T<=t) two-tail	0	
t Critical two-tail	1.962639044	

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.

***QB*1**- 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%)

Answer: From week 1, it has been observed that all of the 5 players are continuing with their ball passing accuracy. Among themselves, Arian and Luís have the least accuracy, Rüştü has average passing accuracy while Henrik has higher passing accuracy than him. Also, Sunil has shown almost consistent performance with the highest passing accuracy among all the other players.

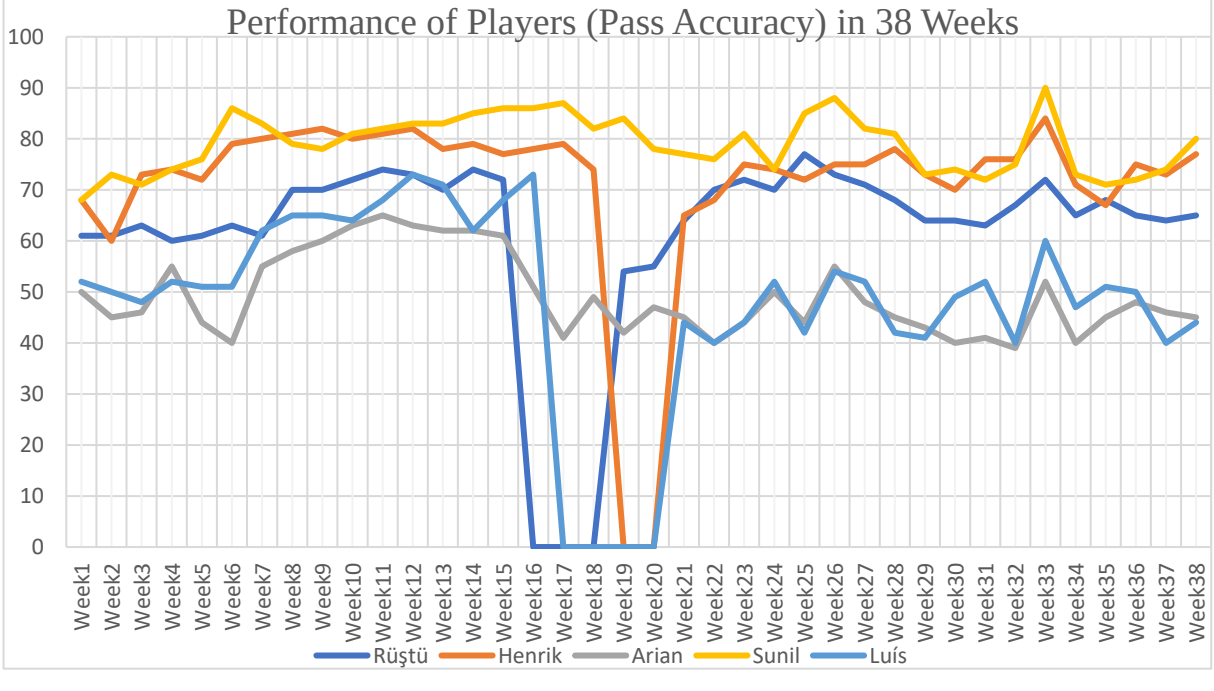

Figure 02: Peformance of Players (Pass Accuracy) Vs Weeks (38 in Total)

From week 1, players find their bearings and have been synchronized with other team members. Approximately, after 15 weeks, the pass accuracy of players starts to drop again due to some players had been suffering from injury.

QB2- 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%)

Answer: After a period of injury, we have observed that Rüştü has higher passing accuracy than before. Luís has passed longer period of injury time and his passing accuracy deteriorates after coming back from the injury. Henrik has passed shorter period of injury time and his passing accuracy has improved a bit after coming back from the injury.

Based on the passing accuracy of these 5 players, it has been observed that Arian and Luís have the least accuracy from week 1 till week 38. Also, their passing accuracy deteriorates after coming back from the injury. Therefore, both of the players need to be replaced.

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.

***QC*1**- 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

Answer: We have created the 'Scout' by taking the average of the 3 skills (Shooting, Heading, Pressing) Then created a pivot table (please refer to the Excel Solution File) thus count the 'Scout'. Filtered the data based on the age of less or equal than 22 years old. Segregating them into 3 scouts so that the most similar players are assigned to the same scout. After that, calculated the salary of each staff based on the mentioned table.

Row Labels	Count of Scout	Salary in $	No of assigned players	Annual Fee per player
1	220	198000	0-50	$1,200
2	103	103000	51-150	$1,000
3	11	13200	151-250	$900
Grand Total	**334**		+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:

$\%\ of\ overrated\ (underrated) = |Current\ Market\ Value - New\ Market\ Value / Current\ Market\ Value|$.

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 zA, zB, and zC respectively, the goal is to maximize $(zA+zB+zC)/3$). 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

***QD*1**- 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%)

Answer: Please refer to the attachment.

Table 1-"List of players" dataset format

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

$QD2$- "Synergy"

Certain players in the "list of players", which you obtained in **$QD1$**, 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 **$QD1$**, 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 zA, zB, and zC respectively, the goal is to maximize $(zA+zB+zC)/3$). Please explain the decision variables and the constraints of the problem carefully. Provide a fin.al 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%

Answer: Please refer to the attachment.