



Fantasy  
Premier  
League

# A Case Study on Optimization

BC2410 | Seminar 1 | Group 2

Tan Jun Hong  
Goh Jia Rui, Bryna  
Evelynn Tan Yee Lin  
Yap Teng Suan

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01

# About the FPL

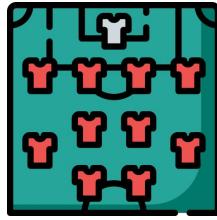


# What is the Fantasy Premier League?

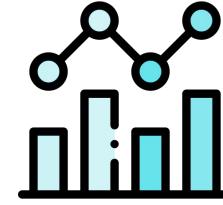
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Take on the role of a manager



Select 15 players to form a squad



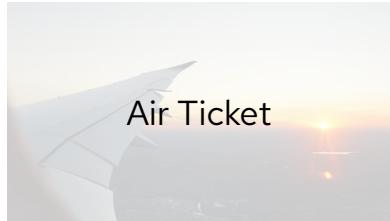
Earn points based on player performances



# Prizes for Winning

## Overall Prizes

- Fantasy Premier League Champion
- Runner Up
- 3rd Place
- FPL Cup Winner



Air Ticket



Holiday in the UK



Visit Tourist Attractions

## Monthly Prizes:

- Manager of the Month
- Top 10



VIP @ Premier League Matches



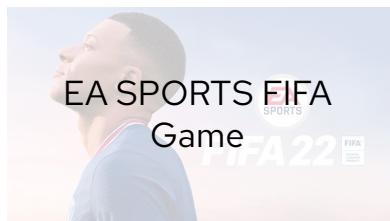
Hublot Watch



Tablet

## Weekly Prizes:

- Manager of the Week
- Top 20



EA SPORTS FIFA  
Game  
FIFA 22



Bluetooth Speaker



Nike Manager Jacket



02

# The Problem



# Understanding The Rules

Excited



## > Selecting Your Initial Squad

### Squad Size: 15 Players

- 2 Goalkeepers
- 5 Defenders
- 5 Midfielders
- 3 Forwards

### Budget: £100 million

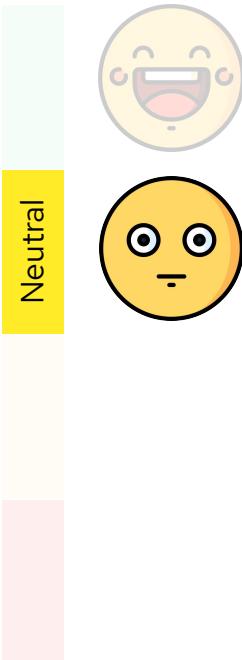
The total value of your initial squad must not exceed £100 million.

### Players Per Team: Up to 3

You can select up to 3 players from a single Premier League team.



# Understanding The Rules



## > Managing Your Squad

### Choose Your Starting 11:

- At least 1 Goalkeeper
- At least 3 Defenders
- At least 1 Forward

### Select a Captain and a Vice-Captain

The captain's score will be doubled.

If the captain plays 0 minutes in the Gameweek, the captain will be changed to the vice-captain.

### Prioritise Your Bench For Automatic Substitutions

Assign priorities to bench players to substitute players in Starting 11 who do not play in the Gameweek.



# Understanding The Rules



Confused



## > Transfers

**Unlimited transfers before your first deadline**

**After your first deadline:**

You will receive 1 free transfer each Gameweek.

Every additional transfer will deduct 4 points from your total score.

## > Chips

**Chips can be used to potentially enhance your team's performance.**

**Bench Boost:** Includes points of bench players in your total score.

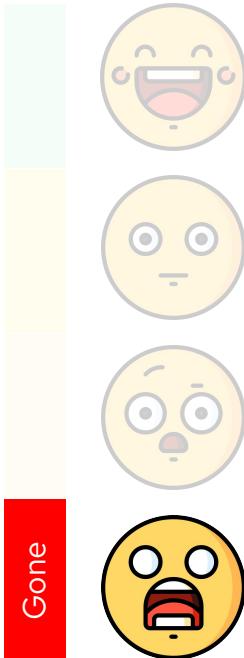
**Free Hit:** Make unlimited free transfers for a single Gameweek.

**Triple Captain:** Captain's points are tripled instead of doubled for the week.

**Wildcard:** All transfers in the Gameweek are free of charge.



# Understanding The Rules



Gone

## > Scoring

Action	Points
For playing up to 60 minutes	1
For playing 60 minutes or more (excl. stoppage time)	2
For each goal scored by a goalkeeper or defender	6
For each goal scored by a midfielder	5
For each goal scored by a forward	4



# Understanding The Rules

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Which players should I select?

"

Why is this player so expensive?

## It's a challenge!



Will this player even play this week?

"

How many points will this player get me?

Is this player worth the transfer?



# The Problem

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How can we help a new manager unfamiliar with the rules of the game come up with a lineup that **satisfies the basic rules** and **maximises the points earned?**



03

# User Personas



# Type 1: Hands-off Passive Manager



## Register to Play Fantasy Premier League

With over 8 million players, Fantasy Premier League is the biggest Fantasy Football game in the world. It's FREE to play and you can win great prizes!

### Creating a new account

#### Your Personal Details

Name:

BC2410 Student

Expected playing frequency:

Once a month

Occupation:

Student

Reason for playing:

Join friends who are playing this game

Goal:

Have fun and hopefully win a prize

Sign up now



**BC2410  
Student**

### Player Breakdown

Management Style	<b>Passive</b>
Playing Style	<b>Set &amp; Forget</b>
Type of Fan	<b>New/Casual</b>



User Personas

# Type 2: Hands-on Active Manager



## Register to Play Fantasy Premier League

With over 8 million players, Fantasy Premier League is the biggest Fantasy Football game in the world. It's FREE to play and you can win great prizes!

### Creating a new account

#### Your Personal Details

Name:

Soccer Fan

Expected playing frequency:

Twice a week

Occupation:

Self-Employed

Reason for playing:

Compete with other like-minded soccer fans

Goal:

Get the best score & win the prize

Sign up now



## Soccer Fan

### Player Breakdown

Management Style	Active
Playing Style	Hands-On
Type of Fan	Soccer Enthusiast



04

# Passive Manager

Modelling, Implementation & Results



# Binary Optimization - Selecting the Initial Squad

Objective: Maximise the points our team can earn

<b>Data</b>	<p>Let <math>X_i</math> be the total points scored by player <math>i</math> in previous seasons (<math>i=1,2,3\dots 382</math>)</p> <p>Let <math>P_i</math> be the cost of player <math>i</math></p> <p>Let <math>M</math> be a <math>i \times 4</math> matrix, where each row represents if player <math>i</math> holds the position of DEF, FWD, GK, or MID respectively</p> <p>Let <math>T_{ik}</math> be the binary data indicating whether player <math>i</math> is in team <math>k</math>, <math>k = 1, 2, \dots, 20</math></p>
<b>Decision Variables</b>	<p>Let <math>Y_i</math> be the binary variable that indicates whether player <math>i</math> is selected for our team</p>



# Binary Optimization - Selecting the Initial Squad

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Assumptions:

- A player's **historical performance is a good indicator** of their overall performance
- Player **costs remain the same** from week to week
- Each player can only hold **one position** throughout the season
- Each player remains in the **same team** throughout the entire season
- Our Passive Player **will not perform any player transfers** throughout the entire season



# Binary Optimization - Selecting the Initial Squad

	Description	Formulation
<b>Objective Function</b>	Maximise the points earned by the squad	$\text{Max } \sum Y_i(X_i)$
<b>Constraint 1</b>	Budget must not exceed \$100million	$0 \leq \sum P_i(Y_i) \leq 100,000,000$
<b>Constraint 2</b>	Up to 15 players in the team	$\sum Y_i \leq 15$
<b>Constraint 3</b>	<u>Position Requirements</u> 5 Defenders, 3 Forwards, 2 Goalkeepers, 5 Midfielders,	$Y_i M_{ip} = (5, 3, 2, 5), p = (1, 2, 3, 4)$
<b>Constraint 4</b>	Select up to only 3 from a single premier league team	$\sum (Y_i * T_{ik}) \leq 3$
<b>Constraint 5</b>	Binary Variable	$Y_i \text{ Binary}$



# Model Results - Selecting the Initial Squad



César  
Azpilicueta



Andrew  
Robertson



Virgil  
Van Dijk



Lucas  
Digne



Matt  
Doherty

DF



Bamidele  
Alli



James  
Maddison



Ayoze  
Pérez



João  
Moutinho



Joshua King

MF



Raúl  
Jiménez



Mohamed  
Salah



Raheem  
Sterling

FW



Dean  
Henderson



Kasper  
Schmeichel

GK

Total:

£99,800,000

2348.75 points



Passive Player

# Binary Optimization - Starting 11 & Captain

Objective: Maximise the points our Starting 11 can earn

<b>Data</b>	Let $X_i$ be the total points scored by player $i$ in last season ( $i=1,2,3,\dots,15$ ) Let $G_i, D_i, F_i$ be the binary data indicating a player's position (GK, DEF, FWD)
<b>Decision Variables</b>	Let $Y_i$ be the binary variable that indicates whether player $i$ is selected as part of the Starting 11 Let $Z_i$ be the binary variable that indicates whether player $i$ is selected as the Captain



# Binary Optimization - Starting 11 & Captain

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Assumptions:

- A player's **historical performance is a good indicator** of their overall performance
- Player **costs remain the same** from week to week
- Each player can only hold **one position** throughout the season
- Each player remains in the **same team** throughout the entire season
- Our Passive Player **will not perform any player transfers** throughout the entire season
- **All players will play more than 0 minutes** during the gameweek so that there will be **no automatic substitutions** required



Passive Player

# Binary Optimization - Starting 11 & Captain

	Description	Formulation
<b>Objective Function</b>	Maximise the points earned by Starting 11	$\text{Max } \sum X_i(Y_i + Z_i), i = 1, 2, \dots, 15$
<b>Constraint 1</b>	Select 11 players	$\sum Y_i = 11$
<b>Constraint 2</b>	<u>Position Requirements</u> 1 Goalkeepers, at least 3 Defenders, at least 1 Forward	$\sum G_i Y_i = 1$ , $G_i$ indicates goalkeeper status $\sum D_i Y_i \geq 3$ , $D_i$ indicates defender status $\sum F_i Y_i \geq 1$ , $F_i$ indicates forward status
<b>Constraint 3</b>	There can only be 1 Captain	$\sum Z_i = 1$
<b>Constraint 4</b>	Binary Variables	$Y_i$ Binary $Z_i$ Binary



# Model Results - Starting 11 & Captain

 <p>César Azpilicueta 147.625 Points</p>	 <p>Andrew Robertson 166.75 Points</p>	 <p>Virgil Van Dijk 160.125 Points</p>	 <p>Lucas Digne 139 Points</p>	 <p>Matt Doherty 155.5 Points</p>	DF
 <p>Bamidele Alli 132 Points</p>	 <p>James Maddison 131 Points</p>	MF			
 <p>Raúl Jiménez 187.5 Points</p>	 <p>Mohamed Salah 257 Points</p>	c	 <p>Raheem Sterling 207.75 Points</p>	FW	
 <p>Dean Henderson 160 Points</p>	GK				

Total:  
2101.25 points



Passive Player

05

# Active Manager

Modelling, Implementation & Results



# Binary Optimization (Active Manager)

Objective: Maximise the points our team can earn

<b>Data</b>	<p>Let <math>X_{ij}</math> be the total points scored by player <math>i</math> in <u>week <math>j</math></u> (all previous data (90%) + this week's (10%)), <math>j = 1, 2, \dots, 38</math></p> <p>Let <math>P_i</math> be the cost of player <math>i</math> in any week, <math>i = 1, 2, \dots, 712</math></p> <p>Let <math>M</math> be a <math>712 \times 4</math> matrix, where each row represents if player <math>i</math> holds the position of DEF, FWD, GK, or MID respectively</p> <p>Let <math>T_{ik}</math> be the binary data indicating whether player <math>i</math> is in team <math>k</math>, <math>k = 1, 2, \dots, 20</math></p>
<b>Decision Variables</b>	<p>Let <math>Y_{ij}</math> be the binary variable that indicates whether player <math>i</math> is selected in <u>week <math>j</math></u></p> <p>Let <math>C_{ij}</math> be the binary variable that indicates whether player <math>i</math> was transferred in <u>week <math>j</math></u></p> <p>Let <math>Z_{ij}</math> be the derived decision variable representing the transfer penalties</p>



# Binary Optimization (Active Manager)

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Assumptions:

- A player's **historical performance is a good indicator** of their overall performance
- Each player can only hold **one position** throughout the season
- Each player remains in the **same team** throughout the entire season



# Binary Optimization (Active Manager)

	Description	Formulation
Objective Function	Maximise the points earned by player	$\text{Max } \sum \sum (Y_{ij}X_{ij}) - \text{Max}(0, 4\sum C_{ij} - 4)$ $\text{Let } Z_{ij} = \text{Max}(0, 4\sum C_{ij} - 4)$ <b>Linearised Objective Function:</b> $\text{Max } \sum \sum Y_{ij}X_{ij} - Z_{ij}$
Constraint 1	From linearisation of $C_{ij}$	$C_{ij} \geq Y_{ij} - Y_{i(j-1)}$ $C_{ij} \geq 0$
Constraint 2	From linearisation of $z$	$Z_{ij} \geq 0$ $Z_{ij} \geq 4\sum C_{ij} - 4$ $C_{ij} = \text{Max}(Y_{ij} - Y_{i(j-1)}, 0)$

```

# GW - penalty if transfer
model.max(y @ x - z)

model.st(y.sum() <= max_players)
model.st(y @ p <= price_budget)
model.st(y @ t <= max_players_per_team)
model.st(y @ pos_matrix == position_req)

if game_week_no != 1:
    # set C[i]=1 if player is transferred in
    # (1-0), for calculation of penalty
    model.st(y - prev_gw_y_result <= c)

# Penalty for transfers: z = max(0, 4 * sum(c) - 4)
model.st(z >= 0, z >= 4 * sum(c) - 4)

```



# Binary Optimization (Active Manager)

	Description	Formulation
<b>Constraint 3</b>	Up to 15 players in team	$\sum Y_{ij} \leq 15$
<b>Constraint 4</b>	Budget must not exceed \$100 million	$0 \leq \sum P_i(Y_{ij}) \leq 100,000,000$
<b>Constraint 5</b>	<u>Position Requirements</u> 5 Defenders 3 Forwards, 2 Goalkeepers 5 Midfielders	$Y_{ij} M_{ip} = (5, 3, 2, 5)$
<b>Constraint 6</b>	Select up to only 3 from each premier league team	$\sum (Y_{ij} * T_{ik}) \leq 3$
<b>Constraint 7</b>	Binary Variable	$Y_{ij}, C_{ij}$ Binary



# Model Results (Total Historical Data, weight = 0.1)

	Fernando Marçal		Gabriel Magalhães		Lucas Digne		Luke Thomas		Timothy Castagne	DF
	Bruno Fernandes		Jack Harrison		Kalvin Phillips		Mateusz Klich		Mohamed Salah	MF
	Callum Wilson		Jamie Vardy		Raúl Jiménez	FW				
	Jordan Pickford		Rui Patrício	GK						

Week 1:  
£100,000,000  
102.38 points



Active Player

# Model Results (Total Historical Data, weight = 0.1)

	Fernando Marçal		Gabriel Magalhães		Lucas Digne		Luke Thomas		Timothy Castagne	DF
	Bruno Fernandes		Jack Harrison		Kalvin Phillips		Mateusz Klich		Mohamed Salah	MF
	Callum Wilson		Jamie Vardy		Raúl Jiménez	FW				
	Mathew Ryan		Rui Patrício	GK						

Week 2:  
£99,600,000  
96.46 points



Active Player

# Model Results (Total Historical Data, weight = 0.1)



Fernando  
Marçal



Gabriel  
Magalhães



Lucas  
Digne



Luke  
Thomas



Timothy  
Castagne

DF



Bruno  
Fernandes



Jack  
Harrison



Kalvin  
Phillips



Mateusz  
Klich



Mohamed  
Salah

MF



Neal  
Maupay



Jamie  
Vardy



Raúl  
Jiménez

FW



Mathew  
Ryan



Rui  
Patrício

GK



Active Player

Week 3:

£99,900,000

94.53 points

# Model Results (Total Historical Data, weight = 0.1)



Fernando  
Marçal



Gabriel  
Magalhães



Lucas  
Digne



Luke  
Thomas



Timothy  
Castagne

DF



Bruno  
Fernandes



Jack  
Harrison



Kalvin  
Phillips



Mateusz  
Klich



Mohamed  
Salah

MF



Neal  
Maupay



Jamie  
Vardy



Callum  
Wilson

FW



Mathew  
Ryan



Rui  
Patrício

GK

Week 4:

£97,900,000

89.79 points



Active Player

# Model Results (Total Historical Data, weight = 0.5)

Gabriel Magalhães	Lucas Digne	Reece James	Romain Saïss	Timothy Castagne	DF
Jeff Hendrick	Jorginho	Mateusz Klich	Mohamed Salah	Willian	MF
Callum Wilson	Jamie Vardy	Raúl Jiménez	FW		
Jordan Pickford	Vicente Guaita	GK			

**Week 1:**  
£97,000,000  
133.02 points



Active Player

# Model Results (Total Historical Data, weight = 0.5)

 Gabriel Magalhães	 Ezri Konsa Ngoyo	 Reece James	 Romain Saïss	 Timothy Castagne	DF
 H. Son	 Hélder Costa	 Mateusz Klich	 Mohamed Salah	 Wilfried Zaha	MF
 Dominic Calvert- Lewin	 Harry Kane	 Raúl Jiménez		FW	
 Jordan Pickford	 Vicente Guaita			GK	

Week 2:  
£100,000,000  
125.69 points



Active Player

# Model Results (Total Historical Data, weight = 0.5)

Gabriel Magalhães	Ezri Konsa Ngoyo	Andrew Robertson	Tyrone Mings	Timothy Castagne	DF
H. Son	Hélder Costa	Mateusz Klich	Jarrod Bowen	Wilfried Zaha	MF
Dominic Calvert-Lewin	Harry Kane	Jamie Vardy	FW		
Jordan Pickford	Vicente Guaita	GK			

**Week 3:**  
£98,700,000  
103.07 points



Active Player

# Model Results (Total Historical Data, weight = 0.5)



Aaron  
Cresswell



Ezri Konsa  
Ngoyo



Benjamin  
Chilwell



Tyrone  
Mings



Timothy  
Castagne

DF



H. Son



Jack  
Grealish



James  
Rodriguez



Jarrod  
Bowen



Pablo  
Fornals

MF



Dominic  
Calvert-  
Lewin



Harry  
Kane



Callum  
Wilson

FW



Jordan  
Pickford



Alex  
McCarthy

GK

Week 4:

£95,900,000

126.03 points



Active Player

06

# Sensitivity Analysis



# Sensitivity Analysis: Passive Manager

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Constraint 1: Budget must not exceed £100 million

$$0 \leq \sum P_i(Y_i) \leq 100,000,000$$

where  $P_i$  : the cost of player i

$Y_i$  : 1 if player i is selected for our team

vary this!

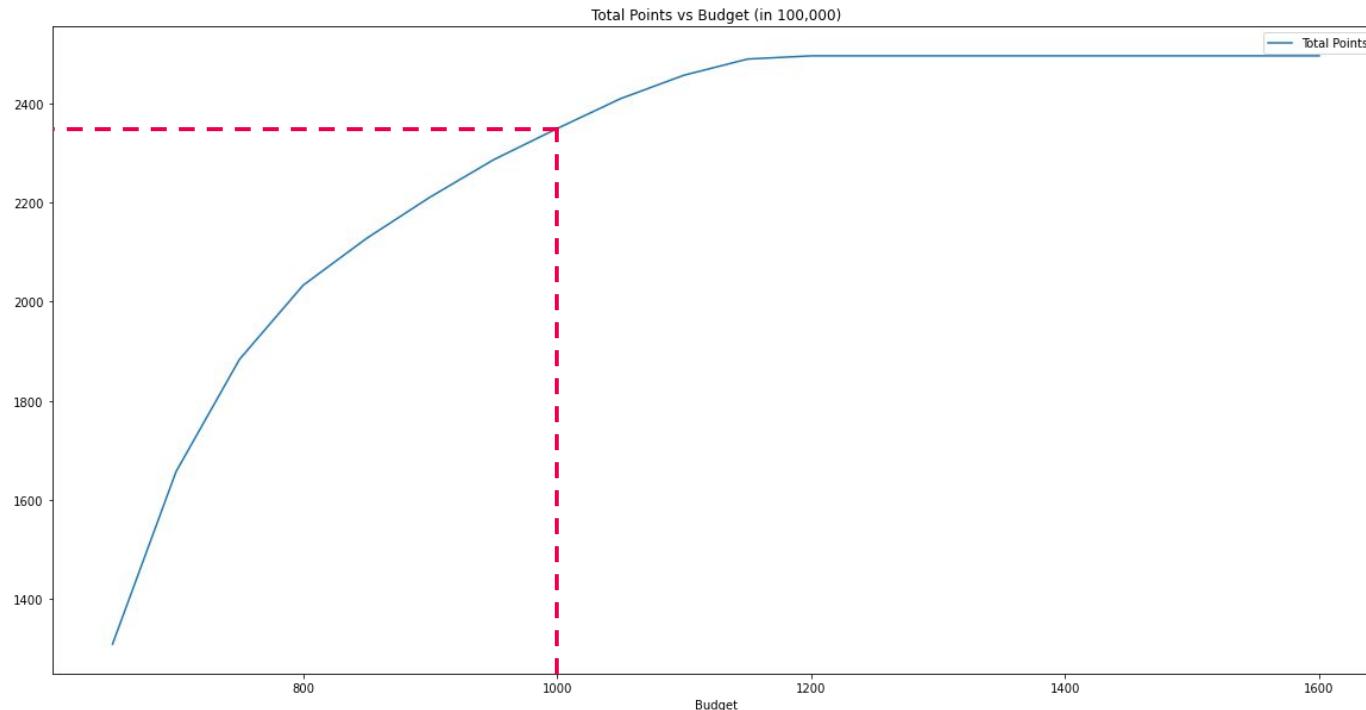


# Sensitivity Analysis: Implementation

How does the **total points** of the lineup chosen by our model **change with the budget constraint?**



# Sensitivity Analysis: Results



Sensitivity  
Analysis

07

# Further Discussion



# Future Model Enhancements

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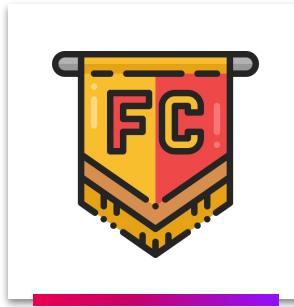


# For The Managers

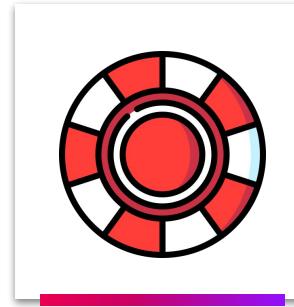
Introducing model interaction to provide customization for managers will **create new constraints** and **new objective functions**.



Selecting an age range  
for team members



Choosing teams to  
select players from

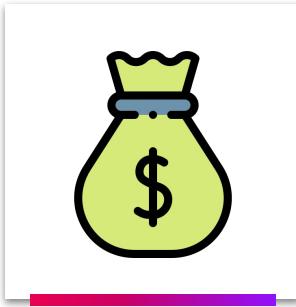


Selecting Chips to use  
for the Gameweek

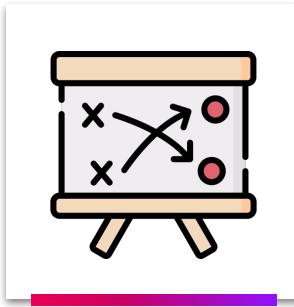


# For The Gamemakers

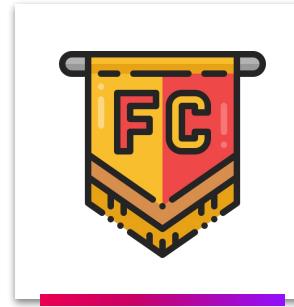
Adjusting game rules as identified through sensitivity analysis can help make the game more **challenging** and **interesting** for the managers playing.



Adjusting budget  
constraints or player prices



Adjusting position  
requirements



Adjusting the number of  
players that can be  
selected from each team



08

# Conclusion



# Conclusion

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## Many things can affect the game

Luck, unforeseen circumstances, etc

Our model cannot guarantee winning of the Fantasy Premier League, but it...

- Caters to **different types of managers**
- Gives managers **suggestions** of the players to pick
- Can aid gamemakers in **deciding game constraints**





**Thank You  
Questions?**