# fpl_sasoptpy

September 23, 2022

## 1 FPL Squad Selection Optimization Probelm

**credit to and modified from AlpsCode https://youtu.be/DFXCXoR6Dvw**

### 1.0.1 Summary

- Data
  - List of players with their BCV, Position, Price and Team
- Decision
  - Choose a player to sign for each position
- Constraints
  - Total signining cost should not exceed 100 million
  - Can pick a total of 15 players, which should have 2 goalkeepers, 5 defenders, 5 midfielders and 3 forwards
  - Out of these 15, you have to select 11 players to play in a certain gameweek. This 11 should contain 1 goalkeeper, at least 3 defenders, at least 2 midfielders and at least 1 forward.
  - Only a maximum of 3 players can be selected in the squad from a single team

[2]:
```
import pandas as pd
import sasoptpy as so
import requests
import os
import time
import numpy as np
import warnings
import os

pd.set_option('display.max_columns', None)
warnings.filterwarnings('ignore')
```

[3]:
```
url = 'https://fantasy.premierleague.com/api/bootstrap-static/'

r = requests.get(url)
json = r.json()
json.keys()
```

[3]:
```
dict_keys(['events', 'game_settings', 'phases', 'teams', 'total_players',
'elements', 'element_stats', 'element_types'])
```

[12]:
```
type_data = pd.DataFrame(json['element_types']).set_index("id")
type_data.head()
```

[12]:

| id | plural_name | plural_name_short | singular_name | singular_name_short | squad_select | squad_min_play | squad_max_play | ui_shirt_specific | sub_positions_locked | element_count |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Goalkeepers | GKP | Goalkeeper | GKP | 2 | 1 | 1 | True | [12] | 64 |
| 2 | Defenders | DEF | Defender | DEF | 5 | 3 | 5 | False | [] | 225 |
| 3 | Midfielders | MID | Midfielder | MID | 5 | 2 | 5 | False | [] | 272 |
| 4 | Forwards | FWD | Forward | FWD | 3 | 1 | 3 | False | [] | 70 |

[13]:
```
positions = {"M":3, "F":4, "D":2, "GK": 1}
```

[21]:
```
bcv_df = pd.read_csv("TransferAlgorithm.csv", encoding='latin-1')
# print(bcv_df.dtypes)
bcv_df = bcv_df.drop(labels='Unnamed: 17', axis=1)
# print(bcv_df.columns)
# bcv_df.head()
```

[22]:
```
#bcv_df = pd.read_csv("TransferAlgorithm.csv", encoding='latin-1')
bcv_df = bcv_df[[' BCV ', 'Position', 'Player', 'Team', ' Price ',
       ' Weighted minutes ', ' Weighted UPPM ', ' PPG - longer term ',\
       'Fixture ratio', '2', '3', '4', '5', '6', '7','8']]
print(bcv_df.columns)

bcv_df = bcv_df[(bcv_df[' BCV ']!= ' (1.00)') & (bcv_df[' BCV ']!= ' (0.03)')\
                & (bcv_df[' BCV '].notna()) ]

cols = []
for var in bcv_df:
    cols.append(var.strip())
```

```
bcv_df.set_axis(cols, axis='columns', inplace=True)

bcv_df['BCV'] = bcv_df['BCV'].str.strip()
bcv_df['BCV'] = bcv_df['BCV'].astype('float')

# print(bcv_df.dtypes)
# for var in bcv_df:
#     print(f"{var}:{bcv_df[var].unique()}\n")

# bcv_df = bcv_df[(bcv_df[' Price ']<20)].reset_index()
# bcv_df.sort_values('3',ascending=False).head(20)
```

```
Index([' BCV ', 'Position', 'Player', 'Team', ' Price ', ' Weighted minutes ',
       ' Weighted UPPM ', ' PPG - longer term ', 'Fixture ratio', '2', '3',
       '4', '5', '6', '7', '8'],
      dtype='object')
```

[25]:
```
bcv_df = bcv_df[['BCV', 'Position', 'Player', 'Team', 'Price']]
#         ' Weighted minutes ', ' Weighted UPPM ', ' PPG - longer term ',\
#         'Fixture ratio', '1', '2', '3', '4', '5', '6', '7',]]
bcv_df = bcv_df[(bcv_df.Player != "0") & (bcv_df['Price'] <30 )].dropna()
bcv_df["id"] = [i for i in range(len(bcv_df))]
bcv_df["Position"] = bcv_df["Position"].map(positions)
bcv_df.set_index("id", inplace=True)
#.sort_values(" BCV ", ascending=False)
```

[26]:
```
budget=100
```

[29]:
```
def optimise_fpl(bcv_df, type_data, budget):

    model = so.Model(name='single_period');

    players = bcv_df.index.to_list()
    element_types = bcv_df.Position.unique().tolist()
    teams = bcv_df.Team.unique().tolist()

    element_types = bcv_df.Position.unique().tolist()
    element_types

    squad = model.add_variables(players, name='squad', vartype=so.binary)
    lineup = model.add_variables(players, name='lineup', vartype=so.binary)
    captain = model.add_variables(players, name='captain', vartype=so.binary)
    vicecap = model.add_variables(players, name='vicecap', vartype=so.binary)

    squad_count = so.expr_sum(squad[p] for p in players)
```

```
  model.add_constraint(squad_count == 15, name='squad_count');
  model.add_constraint(so.expr_sum(lineup[p] for p in players) == 11,␣
↪name='lineup_count');
  model.add_constraint(so.expr_sum(captain[p] for p in players) == 1,␣
↪name='captain_count')
  model.add_constraint(so.expr_sum(vicecap[p] for p in players) == 1,␣
↪name='vicecap_count');

  model.add_constraints((lineup[p] <= squad[p] for p in players),␣
↪name='lineup_squad_rel')
  model.add_constraints((captain[p] <= lineup[p] for p in players),␣
↪name='captain_lineup_rel')
  model.add_constraints((vicecap[p] <= lineup[p] for p in players),␣
↪name='vicecap_lineup_rel')
  model.add_constraints((captain[p] + vicecap[p] <= 1 for p in players),␣
↪name='cap_vc_rel');

  lineup_type_count = {t: so.expr_sum(lineup[p] for p in players if bcv_df.
↪loc[p, 'Position'] == t) \
                       for t in element_types}

  squad_type_count = {t: so.expr_sum(squad[p] for p in players if bcv_df.
↪loc[p, 'Position'] == t)
                      for t in element_types}

  model.add_constraints((lineup_type_count[t] == [type_data.loc[t,␣
↪'squad_min_play'], \
                                                  type_data.loc[t,␣
↪'squad_max_play']] \
                         for t in element_types), name='valid_formation');
  model.add_constraints((squad_type_count[t] == type_data.loc[t,␣
↪'squad_select']\
                         for t in element_types), name='valid_squad');
  price = so.expr_sum(bcv_df.loc[p, 'Price'] * squad[p] for p in players)


  model.add_constraint(price <= budget, name='budget_limit');
  model.add_constraints((so.expr_sum(squad[p] for p in players if bcv_df.
↪loc[p, 'Team'] == t) <= 3\
                         for t in teams), name='team_limit');


  total_points = so.expr_sum(bcv_df.loc[p, 'BCV'] * (lineup[p] + captain[p] +␣
↪\
                                                      0.1 *␣
↪vicecap[p]) for p in players)
```

```
    model.set_objective(-total_points, sense='N', name='total_xp');
    model.export_mps('single_period.mps')

    command = 'cbc single_period.mps solve solu solution_sp.txt >/dev/null 2>&1'
    #!{command}
    os.system(command)

    for v in model.get_variables():
        v.set_value(0)

    with open('solution_sp.txt', 'r') as f:
        for line in f:
            if 'objective value' in line:
                continue
            words = line.split()
            print(words)
            var = model.get_variable(words[1])
            var.set_value(float(words[2]))

    picks = []
    for p in players:
        if squad[p].get_value() > 0.5:
            lp = bcv_df.loc[p]
            is_captain = 1 if captain[p].get_value() > 0.5 else 0
            is_lineup = 1 if lineup[p].get_value() > 0.5 else 0
            is_vice = 1 if vicecap[p].get_value() > 0.5 else 0
            position = type_data.loc[lp['Position'], 'singular_name_short']
            picks.append([
                lp['Player'], position, lp['Position'], lp['Team'], \
                lp['Price'], lp["BCV"], is_lineup, is_captain, is_vice
            ])

    picks_df = pd.DataFrame(picks, columns=['name', 'pos', 'type', 'team',␣
↪'price',\
                                            'xP', 'lineup', 'captain',␣
↪'vicecaptain']).sort_values(by=['lineup', 'type', 'xP'], ascending=[False,␣
↪True, True])


    print(f"Cost: {picks_df['price'].sum()} \nBCV: {picks_df['xP'].sum()}")
    return picks_df
```

[30]:
```
optimise_fpl(bcv_df, type_data, 98)
```

```
NOTE: Initialized model single_period.
['5', 'squad[5]', '1', '0']
['51', 'squad[51]', '1', '0']
['84', 'squad[84]', '1', '0']
['98', 'squad[98]', '1', '0']
['148', 'squad[148]', '1', '0']
['173', 'squad[173]', '1', '0']
['186', 'squad[186]', '1', '0']
['196', 'squad[196]', '1', '0']
['213', 'squad[213]', '1', '0']
['215', 'squad[215]', '1', '0']
['216', 'squad[216]', '1', '0']
['218', 'squad[218]', '1', '0']
['222', 'squad[222]', '1', '0']
['322', 'squad[322]', '1', '0']
['329', 'squad[329]', '1', '0']
['339', 'lineup[5]', '1', '-0.53']
['432', 'lineup[98]', '1', '-0.64']
['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
['549', 'lineup[215]', '1', '-0.6']
['550', 'lineup[216]', '1', '-0.56']
['552', 'lineup[218]', '1', '-0.62']
['556', 'lineup[222]', '1', '-0.63']
['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 97.8
BCV: 7.54
```

[30]:

| | name | pos | type | team | price | xP | lineup | captain |
|---|---|---|---|---|---|---|---|---|
| 13 | Sanchez | GKP | 1 | BRI | 4.5 | 0.60 | 1 | 0 |
| 10 | Robertson | DEF | 2 | LIV | 7.0 | 0.56 | 1 | 0 |
| 9 | James | DEF | 2 | CHE | 6.0 | 0.60 | 1 | 0 |
| 11 | Dias | DEF | 2 | MCI | 6.0 | 0.62 | 1 | 0 |
| 8 | Alexander-Arnold | DEF | 2 | LIV | 7.5 | 0.63 | 1 | 0 |
| 12 | Walker | DEF | 2 | MCI | 5.0 | 0.63 | 1 | 0 |
| 0 | Gabriel Martinelli | MID | 3 | ARS | 6.1 | 0.53 | 1 | 0 |
| 3 | Salah | MID | 3 | LIV | 13.0 | 0.64 | 1 | 0 |
| 5 | Toney | FWD | 4 | BRE | 7.0 | 0.55 | 1 | 0 |
| 6 | Mitrovic | FWD | 4 | FUL | 6.6 | 0.57 | 1 | 0 |
| 7 | Haaland | FWD | 4 | MCI | 11.6 | 0.67 | 1 | 1 |
| 14 | Ward | GKP | 1 | LEI | 4.0 | 0.58 | 0 | 0 |
| 1 | Milivojevic | MID | 3 | CPL | 4.5 | 0.12 | 0 | 0 |
| 2 | Soumaré | MID | 3 | LEI | 4.5 | 0.12 | 0 | 0 |

```
4               Downes  MID     3  WHM    4.5  0.12       0        0

    vicecaptain
13            0
10            0
9             0
11            0
8             0
12            0
0             0
3             1
5             0
6             0
7             0
14            0
1             0
2             0
4             0
```

[31]:
```
for i in np.arange(96,104.5, 0.5):
    optimise_fpl(bcv_df, type_data, i)
```

```
NOTE: Initialized model single_period.
['5', 'squad[5]', '1', '0']
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['98', 'squad[98]', '1', '0']
['148', 'squad[148]', '1', '0']
['173', 'squad[173]', '1', '0']
['186', 'squad[186]', '1', '0']
['196', 'squad[196]', '1', '0']
['213', 'squad[213]', '1', '0']
['215', 'squad[215]', '1', '0']
['218', 'squad[218]', '1', '0']
['222', 'squad[222]', '1', '0']
['225', 'squad[225]', '1', '0']
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['329', 'squad[329]', '1', '0']
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['432', 'lineup[98]', '1', '-0.64']
['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
['549', 'lineup[215]', '1', '-0.6']
['552', 'lineup[218]', '1', '-0.62']
['556', 'lineup[222]', '1', '-0.63']
```

```
['559', 'lineup[225]', '1', '-0.54']
['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 95.8
BCV: 7.5200000000000005
NOTE: Initialized model single_period.
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['98', 'squad[98]', '1', '0']
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['218', 'squad[218]', '1', '0']
['222', 'squad[222]', '1', '0']
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['432', 'lineup[98]', '1', '-0.64']
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['215', 'squad[215]', '1', '0']
```

```
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BCV: 7.5200000000000005
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['507', 'lineup[173]', '1', '-0.55']
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['864', 'captain[196]', '1', '-0.67']
```

```
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 95.8
BCV: 7.5200000000000005
NOTE: Initialized model single_period.
['5', 'squad[5]', '1', '0']
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['550', 'lineup[216]', '1', '-0.56']
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['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 97.8
BCV: 7.54
NOTE: Initialized model single_period.
['5', 'squad[5]', '1', '0']
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['222', 'squad[222]', '1', '0']
```

```
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['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
['549', 'lineup[215]', '1', '-0.6']
['550', 'lineup[216]', '1', '-0.56']
['552', 'lineup[218]', '1', '-0.62']
['556', 'lineup[222]', '1', '-0.63']
['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 98.3
BCV: 7.5200000000000005
NOTE: Initialized model single_period.
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['98', 'squad[98]', '1', '0']
['148', 'squad[148]', '1', '0']
['173', 'squad[173]', '1', '0']
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['432', 'lineup[98]', '1', '-0.64']
['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
['549', 'lineup[215]', '1', '-0.6']
['550', 'lineup[216]', '1', '-0.56']
['552', 'lineup[218]', '1', '-0.62']
['556', 'lineup[222]', '1', '-0.63']
['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 98.3
BCV: 7.5200000000000005
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```
NOTE: Initialized model single_period.
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['98', 'squad[98]', '1', '0']
['148', 'squad[148]', '1', '0']
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['173', 'squad[173]', '1', '0']
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['216', 'squad[216]', '1', '0']
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['222', 'squad[222]', '1', '0']
['322', 'squad[322]', '1', '0']
['327', 'squad[327]', '1', '0']
['339', 'lineup[5]', '1', '-0.53']
['432', 'lineup[98]', '1', '-0.64']
['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
['549', 'lineup[215]', '1', '-0.6']
['550', 'lineup[216]', '1', '-0.56']
['552', 'lineup[218]', '1', '-0.62']
['556', 'lineup[222]', '1', '-0.63']
['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 99.3
BCV: 7.79
NOTE: Initialized model single_period.
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['148', 'squad[148]', '1', '0']
['151', 'squad[151]', '1', '0']
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['196', 'squad[196]', '1', '0']
['213', 'squad[213]', '1', '0']
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['218', 'squad[218]', '1', '0']
['222', 'squad[222]', '1', '0']
['322', 'squad[322]', '1', '0']
['327', 'squad[327]', '1', '0']
['339', 'lineup[5]', '1', '-0.53']
```

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['432', 'lineup[98]', '1', '-0.64']
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['547', 'lineup[213]', '1', '-0.63']
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['550', 'lineup[216]', '1', '-0.56']
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['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 99.8
BCV: 7.93
NOTE: Initialized model single_period.
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['550', 'lineup[216]', '1', '-0.56']
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['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 99.8
BCV: 7.93
NOTE: Initialized model single_period.
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['432', 'lineup[98]', '1', '-0.64']
['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
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['656', 'lineup[322]', '1', '-0.6']
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['1100', 'vicecap[98]', '1', '-0.064']
Cost: 100.8
BCV: 8.06
NOTE: Initialized model single_period.
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['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
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Cost: 100.3
BCV: 7.92
NOTE: Initialized model single_period.
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Cost: 100.3
BCV: 7.92
NOTE: Initialized model single_period.
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['432', 'lineup[98]', '1', '-0.64']
['507', 'lineup[173]', '1', '-0.55']
['520', 'lineup[186]', '1', '-0.57']
['530', 'lineup[196]', '1', '-0.67']
['547', 'lineup[213]', '1', '-0.63']
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Cost: 100.3
BCV: 7.92
NOTE: Initialized model single_period.
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['549', 'lineup[215]', '1', '-0.6']
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['1100', 'vicecap[98]', '1', '-0.064']
Cost: 100.3
BCV: 7.92
NOTE: Initialized model single_period.
['5', 'squad[5]', '1', '0']
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['520', 'lineup[186]', '1', '-0.57']
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['552', 'lineup[218]', '1', '-0.62']
['556', 'lineup[222]', '1', '-0.63']
['656', 'lineup[322]', '1', '-0.6']
['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 100.3
BCV: 7.92
NOTE: Initialized model single_period.
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['196', 'squad[196]', '1', '0']
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['864', 'captain[196]', '1', '-0.67']
['1100', 'vicecap[98]', '1', '-0.064']
Cost: 103.8
BCV: 8.28
```

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