In [1]:
```
import pandas as pd
import numpy as np
from tqdm import tqdm
```

In [2]:
```
history_frame = pd.read_csv('race_2008_2015_v2.csv', encoding='cp932')
history_frame.head()
```

Out[2]:

	raceinfo_id	hold_date	place_num	place_code	raceno	distance	situation	raceclass_code	weather_name3	popular	...	p2_Other_90_All_Here_n
0	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
1	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
2	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
3	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
4	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	

5 rows × 364 columns

In [3]:
```
predict_frame = pd.read_csv('predict_v2.csv')
predict_frame.head()
```

Out[3]:

	raceinfo_id	place_num	place_code	raceno	distance	situation	raceclass_code	weather_name3	popular	roadtemp	...	p2_Other_90_All_Here_n
0	52674	2	kawaguchi	1	3100	good	3	sunny	2	14	...	
1	52674	2	kawaguchi	1	3100	good	3	sunny	2	14	...	
2	52674	2	kawaguchi	1	3100	good	3	sunny	2	14	...	
3	52674	2	kawaguchi	1	3100	good	3	sunny	2	14	...	
4	52674	2	kawaguchi	1	3100	good	3	sunny	2	14	...	

5 rows × 358 columns

In [4]:
```
history_frame.columns.values
```

Out[4]:
```
array(['raceinfo_id', 'hold_date', 'place_num', 'place_code', 'raceno',
       'distance', 'situation', 'raceclass_code', 'weather_name3',
       'popular', 'roadtemp', 'temp', 'humid', 'motorbikeno',
       'player_code', 'all_refund', 'all_race_order', 'xorder',
       'racetime', 'all_racetime', 'handicap', 'traialtime', 'home',
       'hensa', 'shisou_hensa', 'soutei_time', 'age', 'graduation',
       'rank_now', 'rank_last', 'point', 'last10_num1th', 'last10_num2th',
       'last10_num3th', 'last10_numother', 'last10_rate2th',
       'last10_rate3th', 'last10_trialave', 'last10_raceave',
       'last10_racehigh', 'last90_numall', 'last90_numwin',
       'last90_numwinwin', 'last90_hightime', 'last90_highplace',
       'last90_highplace_home', 'last90_stave', 'last180_rate0_rate2th',
       'last180_rate0_numall', 'last180_rate0_num2th',
       'last180_rate1_rate2th', 'last180_rate1_numall',
       'last180_rate1_num2th', 'last5_times1_home', 'last5_times1_race',
       'last5_times1_handi', 'last5_times1_order',
       'last5_times1_racetime', 'last5_times1_trialtime',
       'last5_times1_sttime', 'last5_times2_home', 'last5_times2_race',
       'last5_times2_handi', 'last5_times2_order',
```

In [5]:
```
# check which racer included in predict but exluded from history
predict_frame['player_code'].loc[~predict_frame['player_code'].isin(history_frame['player_code'])].nunique()
```

Out[5]: 20

In [6]:
```
predict_frame['player_code'].nunique()
```

Out[6]: 416

Replace symbols

In [7]:
```
history_frame['situation'].unique()
```

Out[7]: array(['good', 'rough', 'wind', 'wet', 'rash', 'oil'], dtype=object)

In [8]:
```
predict_frame['situation'].unique()
```

Out[8]: array(['good', 'rash', 'wet', 'wind', 'oil', 'rough'], dtype=object)

In [9]:
```
situation_dict = {'良走路': 'good', '荒': 'rash', '風': 'wind',
                  '湿走路': 'wet', '斑走路': 'spots', 'オイル': 'oil'}
```

In [10]:
```
history_frame['situation'].replace(situation_dict, inplace=True)
```

In [11]:
```
history_frame['weather_name3'].unique()
```

Out[11]:
```
array(['sunny', 'cloud', 'rain', 'lightrain', 'lightsnow', 'snow', nan],
      dtype=object)
```

In [12]:
```
predict_frame['weather_name3'].unique()
```

Out[12]:
```
array(['sunny', 'cloud', 'lightrain', 'rain', 'lightsnow', 'snow'],
      dtype=object)
```

In [13]:
```
weather_dict = {'晴': 'sunny', '曇': 'cloud', '雨': 'rain',
                '小雨': 'lightrain', '小雪': 'lightsnow', '雪': 'snow'}
```

In [14]:
```
history_frame['weather_name3'].replace(weather_dict, inplace=True)
```

In [15]:
```
# another symbol columns
object_columns = history_frame.select_dtypes('object').columns
```

In [16]:
```
history_frame[object_columns].sample(5)
```

Out[16]:

	hold_date	place_code	situation	weather_name3	all_refund	all_race_order	rank_now	rank_last	l
72037	2009/11/15 0:00	isesaki	wind	sunny	820:100_100_150:0:220:140_250_300:440:470:1540	1_4_2_3_6_5_7_8	B-95	B-120	
300091	2015-12-05 00:00:00	iizuka	rash	sunny	110:100_100_160:0:420:350_300_1060:490:600:1490	8_4_5_2_7_1_3_6	A-267	B-61	
228362	2014/4/14 0:00	isesaki	good	sunny	170:100_100_100:0:480:130_200_110:580:440:1400	4_5_8_3_6_7_2_1	B-74	B-45	
129820	2011/7/27 0:00	hamamatsu	rash	lightrain	100:100_110_150:0:260:200_700_370:760:1140:3400	1_7_2_5_3_4_8_6	B-39	B-24	
275078	2015-05-15 00:00:00	kawaguchi	good	sunny	200:100_100_200:0:190:120_370_300:440:500:1550	3_8_6_1_7_2_5_4	A-92	A-102	

In [17]:
```
history_frame['last90_highplace'].unique()
```

Out[17]:
```
array(['kawaguchi', 'funabashi', 'sanyou', 'hamamatsu', 'iizuka',
       'isesaki', nan], dtype=object)
```

In [18]:
```
predict_frame['last90_highplace'].unique()
```

Out[18]:
```
array(['kawaguchi', 'iizuka', 'hamamatsu', 'sanyou', 'isesaki', nan],
      dtype=object)
```

In [19]:
```
last90_highplace_dict = {'川': 'kawaguchi', '船': 'funabashi', '山': 'sanyou',
                         '浜': 'hamamatsu', '飯': 'iizuka', '伊': 'isesaki'}
```

In [20]:
```
history_frame['last90_highplace'].replace(last90_highplace_dict, inplace=True)
```

show one sample

In [21]:
```
d = dict(history_frame.iloc[0])
```

In [22]:
```
d
```

Out[22]:
```
{'raceinfo_id': 7321,
 'hold_date': '2008/1/2 0:00',
 'place_num': 2,
 'place_code': 'kawaguchi',
 'raceno': 1,
 'distance': 3100,
 'situation': 'good',
 'raceclass_code': 1,
 'weather_name3': 'sunny',
 'popular': 4,
 'roadtemp': 19.0,
 'temp': 9,
 'humid': 42,
 'motorbikeno': 1,
 'player_code': 602,
 'all_refund': '900:110_100_100:0:740:250_220_120:2310:320:3940',
 'all_race_order': '7_2_1_8_4_3_6_5',
 'xorder': 3,
 'racetime': 3.409,
```

In [23]:
```
history_frame['player_code'].nunique() # number of racers
```

Out[23]:
```
554
```

In [24]:
```
history_frame['raceinfo_id'].nunique() # number of races
```

Out[24]: 37945

In [25]:
```
# dropped columns from predict_frame
set(history_frame.columns) - set(predict_frame.columns)
```

Out[25]:
```
{'all_race_order',
 'all_racetime',
 'all_refund',
 'hold_date',
 'racetime',
 'xorder'}
```

Make interaction table

In [26]:
```
hist_interactions = pd.get_dummies(history_frame['player_code'])
#hist_interactions.index = history_frame['raceinfo_id']
hist_interactions.shape
```

Out[26]: (303149, 554)

In [27]:
```
hist_interactions.head(2)
```

Out[27]:

	103	111	208	210	407	408	409	410	411	415	...	8030	8031	8032	9001	9002	9003	9004	9005	9006	9007
0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

2 rows × 554 columns

In [28]:
```
pred_interactions = pd.get_dummies(predict_frame['player_code'])
#pred_interactions.index = predict_frame['raceinfo_id']
pred_interactions = pred_interactions * 0 # clear all marks
pred_interactions.head(2)
```

Out[28]:

	103	208	210	408	502	706	807	813	818	912	...	9005	9006	9007	9008	9009	9010	9011	9012	9013	9014
0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

2 rows × 416 columns

In [29]:
```
pred_interactions.tail()
```

Out[29]:

	103	208	210	408	502	706	807	813	818	912	...	9005	9006	9007	9008	9009	9010	9011	9012	9013	9014
40357	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
40358	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
40359	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
40360	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
40361	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

5 rows × 416 columns

In [30]:
```
# we will concat two interactions matrix later

#interactions = pd.concat([hist_interactions, pred_interactions])
#interactions.fillna(0, inplace=True)
#interactions.shape
```

In [31]:
```
hist_interactions['xorder'] = history_frame['xorder']
one_hot_cols = hist_interactions.columns.drop('xorder')
```

In [32]:
```
%%time
hist_interactions[one_hot_cols] = hist_interactions[one_hot_cols].multiply(hist_interactions['xorder'], axis="index"
```

```
Wall time: 22.3 s
```

In [33]:
```
hist_interactions.head()
```

Out[33]:

	103	111	208	210	407	408	409	410	411	415	...	8031	8032	9001	9002	9003	9004	9005	9006	9007	xorder
0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	3
1	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	2
2	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	6
3	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	5
4	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	8

5 rows × 555 columns

In [34]:
```
hist_interactions.drop('xorder', axis=1, inplace=True)
hist_interactions['raceinfo_id'] = history_frame['raceinfo_id']
hist_interactions = hist_interactions.groupby('raceinfo_id').sum()
```

In [35]:
```
hist_interactions.shape # unique races * unique racers
```

Out[35]:
```
(37945, 554)
```

In [36]:
```
1 hist_interactions.head(3)
```

Out[36]:

raceinfo_id	103	111	208	210	407	408	409	410	411	415	...	8030	8031	8032	9001	9002	9003	9004	9005	9006	9007
7321	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
7322	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
7323	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

3 rows × 554 columns

In [37]:
```
1 # invert range point >> less place number - more points
2 range_dict = {k:v for k,v in zip(range(1, 10), range(9, 0, -1))}
3 hist_interactions.replace(range_dict, inplace=True)
```

In [38]:
```
1 # lets check order in first race
2 history_frame.iloc[0]['raceinfo_id']
```

Out[38]: 7321

In [39]:
```
1 history_frame.loc[history_frame['raceinfo_id']==7321][['xorder', 'player_code']].sort_values(by='xorder', ascending=
```

Out[39]:

	xorder	player_code
6	1	1312
1	2	2620
0	3	602
7	4	1108
3	5	2625
2	6	2425
5	7	2321
4	8	2912

In [40]:
```
1 hist_interactions.iloc[0].sort_values(ascending=False)[:8]
```

Out[40]:
```
1312    9
2620    8
602     7
1108    6
2625    5
2425    4
2321    3
2912    2
Name: 7321, dtype: int64
```

In [41]:
```
1 hist_interactions.columns[-5:]
```

Out[41]:
```
Index([9003, 9004, 9005, 9006, 9007], dtype='object')
```

track features and racer features

In [42]:
```
# select track features and racer features
history_frame.columns.values
```

Out[42]:
```
array(['raceinfo_id', 'hold_date', 'place_num', 'place_code', 'raceno',
       'distance', 'situation', 'raceclass_code', 'weather_name3',
       'popular', 'roadtemp', 'temp', 'humid', 'motorbikeno',
       'player_code', 'all_refund', 'all_race_order', 'xorder',
       'racetime', 'all_racetime', 'handicap', 'traialtime', 'home',
       'hensa', 'shisou_hensa', 'soutei_time', 'age', 'graduation',
       'rank_now', 'rank_last', 'point', 'last10_num1th', 'last10_num2th',
       'last10_num3th', 'last10_numother', 'last10_rate2th',
       'last10_rate3th', 'last10_trialave', 'last10_raceave',
       'last10_racehigh', 'last90_numall', 'last90_numwin',
       'last90_numwinwin', 'last90_hightime', 'last90_highplace',
       'last90_highplace_home', 'last90_stave', 'last180_rate0_rate2th',
       'last180_rate0_numall', 'last180_rate0_num2th',
       'last180_rate1_rate2th', 'last180_rate1_numall',
       'last180_rate1_num2th', 'last5_times1_home', 'last5_times1_race',
       'last5_times1_handi', 'last5_times1_order',
       'last5_times1_racetime', 'last5_times1_trialtime',
       'last5_times1_sttime', 'last5_times2_home', 'last5_times2_race',
       'last5_times2_handi', 'last5_times2_order',
```

In [43]:
```
1 history_frame.head()
```

Out[43]:

	raceinfo_id	hold_date	place_num	place_code	raceno	distance	situation	raceclass_code	weather_name3	popular	...	p2_Other_90_All_Here_n
0	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
1	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
2	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
3	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	
4	7321	2008/1/2 0:00	2	kawaguchi	1	3100	good	1	sunny	4	...	

5 rows × 364 columns

In [44]:
```
1 # win columns has been dropped from second version of dataset
2 # need to add win column from first version
3 first_version = pd.read_csv('2008_2016.csv', encoding='cp932', usecols=['raceinfo_id', 'player_code', 'win'])
4 first_version.head()
```

Out[44]:

	win	raceinfo_id	player_code
0	0	7321	602
1	0	7321	2620
2	0	7321	2425
3	0	7321	2625
4	0	7321	2912

In [45]:
```
1 first_version.shape, history_frame.shape
```

Out[45]: ((344177, 3), (303149, 364))

In [46]:
```
history_frame = history_frame.merge(first_version, on=['raceinfo_id', 'player_code'], how='left')
```

In [47]:
```
history_frame['win'].unique()
```

Out[47]:
```
array([0, 1], dtype=int64)
```

In [48]:
```
history_frame[history_frame['win']==1]['xorder']
```

Out[48]:
```
6         1
9         1
17        1
27        1
33        1
         ..
303116    1
303123    1
303126    1
303135    1
303143    1
Name: xorder, Length: 37945, dtype: int64
```

Wins history on tracks

In [49]:
```
wins = history_frame[['player_code', 'raceinfo_id','hold_date', 'place_code', 'win']].loc[history_frame['win']==1]
wins.head()
```

Out[49]:

	player_code	raceinfo_id	hold_date	place_code	win
6	1312	7321	2008/1/2 0:00	kawaguchi	1
9	2107	7322	2008/1/2 0:00	kawaguchi	1
17	2918	7323	2008/1/2 0:00	kawaguchi	1
27	2506	7324	2008/1/2 0:00	kawaguchi	1
33	2314	7325	2008/1/2 0:00	kawaguchi	1

In [50]:
```
%%time
wins['hold_date'] = wins['hold_date'].apply(pd.to_datetime)
```

```
Wall time: 2.21 s
```

In [51]:
```
wins.head(2)
```

Out[51]:

	player_code	raceinfo_id	hold_date	place_code	win
6	1312	7321	2008-01-02	kawaguchi	1
9	2107	7322	2008-01-02	kawaguchi	1

In [52]:
```
wins = wins.merge(wins[['player_code', 'place_code', 'hold_date', 'win']],
                  on=['player_code', 'place_code'], how='left', suffixes=('', '_agg'))
wins.head(2)
```

Out[52]:

	player_code	raceinfo_id	hold_date	place_code	win	hold_date_agg	win_agg
0	1312	7321	2008-01-02	kawaguchi	1	2008-01-02	1
1	1312	7321	2008-01-02	kawaguchi	1	2008-01-03	1

In [53]:
```
wins = wins.loc[wins['hold_date'] > wins['hold_date_agg']]
wins.head(2)
```

Out[53]:

	player_code	raceinfo_id	hold_date	place_code	win	hold_date_agg	win_agg
2267	1902	7361	2008-01-03	kawaguchi	1	2008-01-02	1
2278	1312	7362	2008-01-03	kawaguchi	1	2008-01-02	1

In [54]:
```
wins.sort_values(by='hold_date', ascending=False, inplace=True)
wins.head(2)
```

Out[54]:

	player_code	raceinfo_id	hold_date	place_code	win	hold_date_agg	win_agg
1701827	3101	52397	2015-12-31	kawaguchi	1	2015-12-27	1
1701460	2123	52390	2015-12-31	kawaguchi	1	2013-07-16	1

In [55]:
```
wins = wins.groupby(['player_code', 'place_code', 'hold_date'])['win_agg'].sum().reset_index()
wins.sort_values('hold_date', ascending=False, inplace=True)
wins.drop_duplicates(subset=['player_code', 'place_code'], keep='first', inplace=True)
wins.head(2)
```

Out[55]:

	player_code	place_code	hold_date	win_agg
35268	9007	kawaguchi	2015-12-31	48
14943	2407	kawaguchi	2015-12-31	10

In [56]:
```
wins = wins.pivot_table(index='player_code', columns='place_code')
wins = wins['win_agg']
wins.fillna(0, inplace=True)
wins.head(2)
```

Out[56]:

place_code	funabashi	hamamatsu	iizuka	isesaki	kawaguchi	sanyou
player_code						
103	1.0	15.0	0.0	0.0	2.0	0.0
111	0.0	3.0	0.0	0.0	0.0	4.0

In [57]:
```
wins.shape, history_frame['player_code'].nunique()
```

Out[57]: ((512, 6), 554)

In [58]:
```
1 wins.head()
```

Out[58]:

place_code	funabashi	hamamatsu	iizuka	isesaki	kawaguchi	sanyou
player_code						
103	1.0	15.0	0.0	0.0	2.0	0.0
111	0.0	3.0	0.0	0.0	0.0	4.0
208	7.0	44.0	0.0	3.0	10.0	0.0
210	2.0	14.0	0.0	1.0	3.0	0.0
407	0.0	0.0	0.0	0.0	38.0	0.0

In [59]:
```
1 # переименовать
2 toAddNumbers = history_frame['player_code'].loc[~history_frame['player_code'].isin(wins.index)].unique()
```

In [60]:
```
1 toAddFrame = pd.DataFrame(np.zeros((toAddNumbers.shape[0], wins.shape[1])),
2                           index=toAddNumbers, columns=wins.columns)
3 toAddFrame.sort_index(inplace=True)
4 toAddFrame.head()
```

Out[60]:

place_code	funabashi	hamamatsu	iizuka	isesaki	kawaguchi	sanyou
410	0.0	0.0	0.0	0.0	0.0	0.0
411	0.0	0.0	0.0	0.0	0.0	0.0
1124	0.0	0.0	0.0	0.0	0.0	0.0
1221	0.0	0.0	0.0	0.0	0.0	0.0
1306	0.0	0.0	0.0	0.0	0.0	0.0

In [61]:
```
wins = wins.append(toAddFrame)
wins.shape
```

Out[61]: (554, 6)

In [62]:
```
wins.columns.name = 'player_code'
wins.head()
```

Out[62]:

player_code	funabashi	hamamatsu	iizuka	isesaki	kawaguchi	sanyou
103	1.0	15.0	0.0	0.0	2.0	0.0
111	0.0	3.0	0.0	0.0	0.0	4.0
208	7.0	44.0	0.0	3.0	10.0	0.0
210	2.0	14.0	0.0	1.0	3.0	0.0
407	0.0	0.0	0.0	0.0	38.0	0.0

In [63]:
```
mean_wins = wins.mean(axis=1)
sum_wins = wins.sum(axis=1)
max_wins = wins.max(axis=1)
```

track features and racer features

In [64]:
```
track_features = ['raceinfo_id', 'distance', 'situation',
                  'raceclass_code', 'weather_name3', 'roadtemp',
                  'temp', 'humid', 'place_code', 'raceno']

racer_features = ['player_code', 'popular', 'motorbikeno',
                  'handicap', 'home', 'age', #'bike_class', - dropped
                  'graduation', 'rank_now', 'rank_last',
                  'point']
```

In [65]:
```
lasts_features = [i for i in history_frame.columns if (i.startswith('last') and '_' in i)]
p2_features = [i for i in history_frame.columns if i.startswith('p2_')]
```

In [66]:
```
racer_features = racer_features + lasts_features + p2_features + ['hold_date']
racer_features[:20]
```

Out[66]:
```
['player_code',
 'popular',
 'motorbikeno',
 'handicap',
 'home',
 'age',
 'graduation',
 'rank_now',
 'rank_last',
 'point',
 'last10_num1th',
 'last10_num2th',
 'last10_num3th',
 'last10_numother',
 'last10_rate2th',
 'last10_rate3th',
 'last10_trialave',
 'last10_raceave',
 'last10_racehigh',
 'last90_numall']
```

In [67]:
```
track_frame = history_frame[track_features].copy()
track_frame.drop_duplicates(inplace=True)
track_frame.head(3)
```

Out[67]:

	raceinfo_id	distance	situation	raceclass_code	weather_name3	roadtemp	temp	humid	place_code	raceno
0	7321	3100	good	1	sunny	19.0	9	42	kawaguchi	1
8	7322	3100	good	1	sunny	20.0	9	38	kawaguchi	2
16	7323	3100	good	1	sunny	21.0	10	36	kawaguchi	3

In [68]:
```
track_frame['raceinfo_id'].duplicated().sum()
```

Out[68]:
```
0
```

In [69]:
```
1 track_frame.shape
```

Out[69]: (37945, 10)

In [70]:
```
1 track_frame.set_index('raceinfo_id', inplace=True)
```

In [71]:
```
1 track_frame.head(3)
```

Out[71]:

raceinfo_id	distance	situation	raceclass_code	weather_name3	roadtemp	temp	humid	place_code	raceno
7321	3100	good	1	sunny	19.0	9	42	kawaguchi	1
7322	3100	good	1	sunny	20.0	9	38	kawaguchi	2
7323	3100	good	1	sunny	21.0	10	36	kawaguchi	3

track features engineering

In [72]:
```
1 track_frame.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 37945 entries, 7321 to 52397
Data columns (total 9 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   distance        37945 non-null  int64  
 1   situation       37945 non-null  object 
 2   raceclass_code  37945 non-null  int64  
 3   weather_name3   37944 non-null  object 
 4   roadtemp        37945 non-null  float64
 5   temp            37945 non-null  int64  
 6   humid           37945 non-null  int64  
 7   place_code      37945 non-null  object 
 8   raceno          37945 non-null  int64  
dtypes: float64(1), int64(5), object(3)
memory usage: 2.9+ MB
```

In [73]:
```
1 track_frame['situation'].unique()
```

Out[73]:
```
array(['good', 'rough', 'wind', 'wet', 'rash', 'oil'], dtype=object)
```

In [74]:
```
1 situation = pd.get_dummies(track_frame['situation'], prefix='situation')
2 situation.head()
```

Out[74]:

raceinfo_id	situation_good	situation_oil	situation_rash	situation_rough	situation_wet	situation_wind
7321	1	0	0	0	0	0
7322	1	0	0	0	0	0
7323	1	0	0	0	0	0
7324	1	0	0	0	0	0
7325	1	0	0	0	0	0

In [75]:
```
track_frame['weather_name3'].unique()
```

Out[75]:
```
array(['sunny', 'cloud', 'rain', 'lightrain', 'lightsnow', 'snow', nan],
      dtype=object)
```

In [76]:
```
weather = pd.get_dummies(track_frame['weather_name3'], prefix='weather')
weather.head()
```

Out[76]:

raceinfo_id	weather_cloud	weather_lightrain	weather_lightsnow	weather_rain	weather_snow	weather_sunny
7321	0	0	0	0	0	1
7322	0	0	0	0	0	1
7323	0	0	0	0	0	1
7324	0	0	0	0	0	1
7325	0	0	0	0	0	1

In [77]:
```
track_frame['place_code'].unique()
```

Out[77]:
```
array(['kawaguchi', 'hamamatsu', 'iizuka', 'isesaki', 'funabashi',
       'sanyou'], dtype=object)
```

In [78]:
```
place = pd.get_dummies(track_frame['place_code'], prefix='place_is')
place.head()
```

Out[78]:

raceinfo_id	place_is_funabashi	place_is_hamamatsu	place_is_iizuka	place_is_isesaki	place_is_kawaguchi	place_is_sanyou
7321	0	0	0	0	1	0
7322	0	0	0	0	1	0
7323	0	0	0	0	1	0
7324	0	0	0	0	1	0
7325	0	0	0	0	1	0

In [79]:
```
1 track_frame.head(3)
```

Out[79]:

raceinfo_id	distance	situation	raceclass_code	weather_name3	roadtemp	temp	humid	place_code	raceno
7321	3100	good	1	sunny	19.0	9	42	kawaguchi	1
7322	3100	good	1	sunny	20.0	9	38	kawaguchi	2
7323	3100	good	1	sunny	21.0	10	36	kawaguchi	3

In [80]:
```
1 track_frame.drop(columns=['situation', 'weather_name3', 'place_code'], inplace=True)
```

In [81]:
```
1 track_frame = pd.concat([track_frame, situation, weather, place], axis=1)
2 track_frame.head(3)
```

Out[81]:

raceinfo_id	distance	raceclass_code	roadtemp	temp	humid	raceno	situation_good	situation_oil	situation_rash	situation_rough	...	weather_ligh
7321	3100	1	19.0	9	42	1	1	0	0	0	...	
7322	3100	1	20.0	9	38	2	1	0	0	0	...	
7323	3100	1	21.0	10	36	3	1	0	0	0	...	

3 rows × 24 columns

racer features engineering

In [82]:
```
racer_frame = history_frame[racer_features].copy()
racer_frame.head()
```

Out[82]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	rank_now	rank_last	point	...	p2_Other_90_All_Here_rate1th	p2_Other_9
0	602	4	1	30	1	59	6	A-37	S-38	81.724	...	0.0	
1	2620	4	2	30	1	32	26	S-52	S-50	89.141	...	0.0	
2	2425	4	3	20	1	35	24	A-90	A-72	75.002	...	0.0	
3	2625	4	4	20	1	33	26	A-18	A-87	84.382	...	0.0	
4	2912	4	5	10	1	29	29	A-172	B-1	64.817	...	0.0	

5 rows × 340 columns

In [83]:
```
racer_frame.shape
```

Out[83]: (303149, 340)

In [84]:
```
racer_frame.sort_values(by='hold_date', ascending=True, inplace=True)
```

In [85]:
```
racer_frame.drop_duplicates(subset=['player_code'], keep='last', inplace=True)
```

In [86]:
```
racer_frame.shape
```

Out[86]: (554, 340)

In [87]:
```
racer_frame.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 554 entries, 38842 to 303148
Columns: 340 entries, player_code to hold_date
dtypes: float64(201), int64(135), object(4)
memory usage: 1.4+ MB
```

In [88]:
```
obj_racer_cols = racer_frame.select_dtypes('object').columns
racer_frame[obj_racer_cols].head(3)
```

Out[88]:

	rank_now	rank_last	last90_highplace	hold_date
38842	B-20	A-177	hamamatsu	2009/1/4 0:00
46459	B-200	B-196	sanyou	2009/3/15 0:00
47423	B-201	B-201	isesaki	2009/3/27 0:00

In [89]:
```
racer_frame.drop('hold_date', axis=1, inplace=True)
```

In [90]:
```
obj_racer_cols = obj_racer_cols[:-1]
obj_racer_cols
```

Out[90]:
```
Index(['rank_now', 'rank_last', 'last90_highplace'], dtype='object')
```

In [91]:
```
#racer_frame.set_index('player_code', inplace=True)
racer_frame.head(3)
```

Out[91]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	rank_now	rank_last	point	...	p2_Other_90_All_Here_numwinwin	p2
38842	1901	2	3	70	1	46	19	B-20	A-177	60.547	...	0	
46459	2513	2	4	0	1	33	25	B-200	B-196	35.859	...	0	
47423	2211	3	8	0	1	41	22	B-201	B-201	35.028	...	0	

3 rows × 339 columns

In [92]:
```
racer_frame['rank_last_symbol'] = racer_frame['rank_last'].apply(lambda x: x[0] if type(x)==str else 'O')
racer_frame['rank_last_symbol'].unique()
```

Out[92]:
```
array(['A', 'B', 'O', 'S'], dtype=object)
```

In [93]:
```
racer_frame['rank_now_symbol'] = racer_frame['rank_now'].apply(lambda x: x[0] if type(x)==str else 'O')
racer_frame['rank_now_symbol'].unique()
```

Out[93]:
```
array(['B', 'A', 'S'], dtype=object)
```

In [94]:
```
symbols = pd.get_dummies(racer_frame[['rank_last_symbol', 'rank_now_symbol']])
```

In [95]:
```
last90_highplace_dummy = pd.get_dummies(racer_frame['last90_highplace'])
```

In [96]:
```
obj_racer_cols = racer_frame.select_dtypes('object').columns
obj_racer_cols
```

Out[96]:
```
Index(['rank_now', 'rank_last', 'last90_highplace', 'rank_last_symbol',
       'rank_now_symbol'],
      dtype='object')
```

In [97]:
```
racer_frame.drop(columns=obj_racer_cols, inplace=True)
```

In [98]:
```
racer_frame = pd.concat([racer_frame, symbols, last90_highplace_dummy], axis=1)
racer_frame.shape
```

Out[98]: (554, 349)

In [99]:
```
racer_frame.head(3)
```

Out[99]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	rank_last_symbol_S	rank_r
38842	1901	2	3	70	1	46	19	60.547	1	0	...	0	
46459	2513	2	4	0	1	33	25	35.859	0	0	...	0	
47423	2211	3	8	0	1	41	22	35.028	0	0	...	0	

3 rows × 349 columns

In [100]:
```
racer_frame.sort_index(inplace=True)
```

In [101]:
```
racer_frame.head(2)
```

Out[101]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	rank_last_symbol_S	rank_r
38842	1901	2	3	70	1	46	19	60.547	1	0	...	0	
44806	415	5	7	20	1	64	4	42.900	1	2	...	0	

2 rows × 349 columns

In [102]:
```
racer_frame.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 554 entries, 38842 to 303148
Columns: 349 entries, player_code to sanyou
dtypes: float64(201), int64(135), uint8(13)
memory usage: 1.4 MB
```

In [103]:
```
uint8_cols = racer_frame.select_dtypes('uint8').columns
```

In [104]:
```
racer_frame[uint8_cols] = racer_frame[uint8_cols].astype(np.int32)
```

In [105]:
```
racer_frame.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 554 entries, 38842 to 303148
Columns: 349 entries, player_code to sanyou
dtypes: float64(201), int32(13), int64(135)
memory usage: 1.5 MB
```

split on train and test

In [106]:
```
train_races = history_frame['raceinfo_id'].drop_duplicates()[:-5000] # train
valid_races = history_frame['raceinfo_id'].drop_duplicates()[-5000:] # validation
```

In [107]:
```
train_set = history_frame.loc[history_frame['raceinfo_id'].isin(train_races)][['raceinfo_id', 'all_race_order',
                                                                               'player_code', 'xorder']]

valid_set = history_frame.loc[history_frame['raceinfo_id'].isin(valid_races)][['raceinfo_id', 'all_race_order',
                                                                               'player_code', 'xorder']]
train_set.head(2)
```

Out[107]:

	raceinfo_id	all_race_order	player_code	xorder
0	7321	7_2_1_8_4_3_6_5	602	3
1	7321	7_2_1_8_4_3_6_5	2620	2

In [108]:
```
1 valid_set.head(2)
```

Out[108]:

	raceinfo_id	all_race_order	player_code	xorder
263155	47316	7_6_4_5_8_3_2_1	2904	8
263156	47316	7_6_4_5_8_3_2_1	1005	7

In [109]:
```
1 hist_interactions.head(2)
```

Out[109]:

raceinfo_id	103	111	208	210	407	408	409	410	411	415	...	8030	8031	8032	9001	9002	9003	9004	9005	9006	9007
7321	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
7322	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

2 rows × 554 columns

In [110]:
```
1 train_interactions = hist_interactions.loc[train_races]
2 valid_interactions = hist_interactions.loc[valid_races]
3 track_frame.head(2)
```

Out[110]:

raceinfo_id	distance	raceclass_code	roadtemp	temp	humid	raceno	situation_good	situation_oil	situation_rash	situation_rough	...	weather_ligh
7321	3100	1	19.0	9	42	1	1	0	0	0	...	
7322	3100	1	20.0	9	38	2	1	0	0	0	...	

2 rows × 24 columns

In [111]:
```
1 train_track_frame = track_frame.loc[train_races]
2 valid_track_frame = track_frame.loc[valid_races]
```

Make a prediction model

In [112]:
```
from lightfm import LightFM
from lightfm.evaluation import precision_at_k
from lightfm.evaluation import auc_score
```

```
C:\Users\User\Anaconda3\lib\site-packages\lightfm\_lightfm_fast.py:10: UserWarning: LightFM was compiled without OpenMP
support. Only a single thread will be used.
  "LightFM was compiled without OpenMP support. "
```

In [113]:
```
train_interactions.head(3) # n_users * n_items
```

Out[113]:

raceinfo_id	103	111	208	210	407	408	409	410	411	415	...	8030	8031	8032	9001	9002	9003	9004	9005	9006	9007
7321	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
7322	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
7323	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

3 rows × 554 columns

In [114]:
```
train_interactions.shape, valid_interactions.shape
```

Out[114]: ((32945, 554), (5000, 554))

In [115]:
```
train_track_frame.shape, valid_track_frame.shape
```

Out[115]: ((32945, 24), (5000, 24))

In [116]:
```
racer_frame.shape
```

Out[116]: (554, 349)

In [117]:
```
mean_wins.shape, sum_wins.shape, max_wins.shape
```

Out[117]: ((554,), (554,), (554,))

In [118]:
```
racer_frame.shape
```

Out[118]: (554, 349)

In [119]:
```
racer_frame['mean_wins'] = mean_wins
racer_frame['sum_wins'] = sum_wins
racer_frame['max_wins'] = max_wins
racer_frame.fillna(0, inplace=True)
racer_frame.shape
```

Out[119]: (554, 352)

In [ ]:
```

```

In [120]:
```
racer_frame.head()
```

Out[120]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	rank_now_symbol_S	funab
38842	1901	2	3	70	1	46	19	60.547	1	0	...	0	
44806	415	5	7	20	1	64	4	42.900	1	2	...	0	
44958	411	1	7	0	1	64	4	37.859	0	0	...	0	
44959	1404	1	8	0	0	53	14	41.062	2	1	...	0	
44966	1124	1	7	0	1	60	11	39.725	0	0	...	0	

5 rows × 352 columns

In [121]:
```
1 wins.head()
```

Out[121]:

player_code	funabashi	hamamatsu	iizuka	isesaki	kawaguchi	sanyou
103	1.0	15.0	0.0	0.0	2.0	0.0
111	0.0	3.0	0.0	0.0	0.0	4.0
208	7.0	44.0	0.0	3.0	10.0	0.0
210	2.0	14.0	0.0	1.0	3.0	0.0
407	0.0	0.0	0.0	0.0	38.0	0.0

In [122]:
```
1 racer_frame.shape, wins.shape
```

Out[122]: ((554, 352), (554, 6))

In [123]:
```
1 r = racer_frame.merge(wins, left_on='player_code', right_index=True, how='left', suffixes=('', '_wins'))
2 r.head()
```

Out[123]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	sanyou	mean_wins	sum_v
38842	1901	2	3	70	1	46	19	60.547	1	0	...	0	0.0	
44806	415	5	7	20	1	64	4	42.900	1	2	...	0	0.0	
44958	411	1	7	0	1	64	4	37.859	0	0	...	0	0.0	
44959	1404	1	8	0	0	53	14	41.062	2	1	...	0	0.0	
44966	1124	1	7	0	1	60	11	39.725	0	0	...	0	0.0	

5 rows × 358 columns

In [124]:
```
from scipy.sparse import coo_matrix, csr_matrix
model = LightFM() # learning_rate=0.05
model.fit(coo_matrix(train_interactions),
          user_features=csr_matrix(train_track_frame),
          item_features=csr_matrix(racer_frame),
          epochs=20, verbose=True)
```

```
Epoch: 100%|██████████| 20/20 [02:46<00:00,  8.31s/it]
```

Out[124]:
```
<lightfm.lightfm.LightFM at 0x229387d0a90>
```

In [ ]:
```

```

In [125]:
```
train_auc = auc_score(model, coo_matrix(train_interactions),
                      user_features=csr_matrix(train_track_frame),
                      item_features=csr_matrix(racer_frame)).mean()
train_auc # 0.5
```

Out[125]:
```
0.4944716
```

In [126]:
```
test_auc = auc_score(model, coo_matrix(valid_interactions),
                      user_features=csr_matrix(valid_track_frame),
                      item_features=csr_matrix(racer_frame)).mean()
test_auc # 0.5
```

Out[126]:
```
0.50863504
```

In [127]:
```
predicted_rank = model.predict_rank(coo_matrix(valid_interactions),
                                    #train_interactions=coo_matrix(train_interactions),
                                    item_features=csr_matrix(racer_frame),
                                    user_features=csr_matrix(valid_track_frame))
```

In [128]:
```
predicted_rank.shape # 5000 track on 554 racers
```

Out[128]:
```
(5000, 554)
```

convert data to place table

In [129]:
```
y_true = valid_set.pivot_table(index=['raceinfo_id'], columns='xorder')
y_true.shape
```

Out[129]: (5000, 9)

In [130]:
```
y_true.head(3)
```

Out[130]:

	player_code								
xorder	1	2	3	4	5	6	7	8	9
raceinfo_id									
47316	2315.0	2821.0	208.0	810.0	2532.0	2608.0	1005.0	2904.0	NaN
47317	2505.0	3206.0	2930.0	3001.0	2813.0	2402.0	2728.0	2108.0	NaN
47318	2614.0	2914.0	2927.0	2931.0	2415.0	2804.0	1930.0	2911.0	NaN

In [131]:
```
from tqdm import tqdm
pred_dict = {}
for num, row in tqdm(y_true.iterrows()):
    l = row.values
    l = l[~np.isnan(l)]
    l = np.array(l, dtype=np.int)
    pred_dict[num] = list(set(l))
```

```
5000it [00:00, 19393.72it/s]
```

In [132]:
```
1 pred_dict
```

Out[132]:
```
{47316: [2532, 2821, 810, 2315, 1005, 208, 2608, 2904],
 47317: [2402, 3206, 2728, 2505, 2930, 3001, 2108, 2813],
 47318: [2914, 1930, 2415, 2927, 2931, 2804, 2614, 2911],
 47319: [2305, 3109, 2309, 2924, 2701, 502, 602, 2908],
 47320: [2727, 2920, 1932, 1709, 2610, 2901, 2104, 2815],
 47321: [3104, 2209, 2018, 2703, 2929, 2805, 2201, 2938],
 47322: [2816, 2818, 2822, 2406, 3017, 2921, 2619, 2907],
 47323: [2720, 2820, 2215, 3113, 3116, 2004, 2613, 2713],
 47324: [2304, 2624, 2306, 2216, 2409, 2410, 2222, 3004],
 47325: [2305, 2409, 3017, 2318, 2930, 2804, 2904, 2713],
 47326: [3206, 2727, 2508, 2924, 208, 2938, 2619, 2014],
 47327: [2404, 2309, 2822, 2920, 2601, 2321, 2931, 2104],
 47328: [3104, 2532, 1927, 2728, 2415, 2516, 2613, 2907],
 47329: [2721, 2914, 2820, 2410, 810, 2221, 2703, 502],
 47330: [2304, 2402, 3011, 3109, 1930, 2315, 1908, 2805],
 47331: [2528, 2306, 2406, 2423, 2201, 602, 2524, 2815],
 47332: [2720, 2821, 2505, 2921, 1932, 2610, 2902, 3001],
 47333: [2018, 1709, 2701, 2319, 2608, 2612, 2004, 2911],
 47334: [1601, 2209, 2215, 3004, 2123, 818, 2523, 2908],
```

In [133]:
```
1 pred_df = pd.DataFrame(predicted_rank.toarray(),
2                        index=valid_interactions.index, columns=valid_interactions.columns)
3 pred_df.head()
```

Out[133]:

raceinfo_id	103	111	208	210	407	408	409	410	411	415	...	8030	8031	8032	9001	9002	9003	9004	9005	9006	9007
47316	0.0	0.0	496.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47317	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47318	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47319	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47320	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5 rows × 554 columns

In [134]:
```
prediction_table = []
rank_table = []
for k, vlist in tqdm(pred_dict.items()):
    try:
        line = [(i, pred_df.loc[k, i]) for i in vlist]
        line = sorted(line, key=lambda x: x[1], reverse=True)
        prediction_table.append([i[0] for i in line])
        rank_table.append([i[1] for i in line])
    except KeyError:
        prediction_table.append([0 for i in range(len(vlist))])
        rank_table.append([0 for i in range(len(vlist))])
```

```
100%|██████████| 5000/5000 [00:00<00:00, 15553.67it/s]
```

In [135]:
```
rank_table[:2]
```

Out[135]:
```
[[543.0, 527.0, 496.0, 486.0, 305.0, 197.0, 175.0, 49.0],
 [549.0, 434.0, 432.0, 273.0, 263.0, 100.0, 90.0, 61.0]]
```

In [136]:
```
prediction_table = pd.DataFrame(prediction_table, index=valid_interactions.index, columns=range(1, 9))
prediction_table.head()
```

Out[136]:

raceinfo_id	1	2	3	4	5	6	7	8
47316	2821	2608	208	810	2315	1005.0	2904.0	2532.0
47317	2402	2930	2728	2108	2505	3001.0	2813.0	3206.0
47318	2614	2804	1930	2415	2914	2927.0	2911.0	2931.0
47319	3109	2309	2305	2701	602	2908.0	502.0	2924.0
47320	2610	2815	2104	1932	1709	2901.0	2727.0	2920.0

In [137]:
```
rank_table = pd.DataFrame(rank_table, index=valid_interactions.index, columns=range(1, 9))
rank_table.head()
```

Out[137]:

raceinfo_id	1	2	3	4	5	6	7	8
47316	543.0	527.0	496.0	486.0	305.0	197.0	175.0	49.0
47317	549.0	434.0	432.0	273.0	263.0	100.0	90.0	61.0
47318	542.0	426.0	356.0	279.0	103.0	80.0	50.0	46.0
47319	515.0	500.0	428.0	408.0	320.0	254.0	170.0	78.0
47320	342.0	287.0	244.0	173.0	143.0	127.0	19.0	8.0

In [138]:
```
rank_table.max(1)
```

Out[138]:
```
raceinfo_id
47316    543.0
47317    549.0
47318    542.0
47319    515.0
47320    342.0
         ...
52393    546.0
52394    499.0
52395    498.0
52396    527.0
52397    553.0
Length: 5000, dtype: float64
```

In [139]:
```
rank_table_nom = rank_table.copy()
```

In [140]:
```
rank_table = rank_table.divide(rank_table.max(1), axis='index')
rank_table.head(3)
```

Out[140]:

raceinfo_id	1	2	3	4	5	6	7	8
47316	1.0	0.970534	0.913444	0.895028	0.561694	0.362799	0.322284	0.090239
47317	1.0	0.790528	0.786885	0.497268	0.479053	0.182149	0.163934	0.111111
47318	1.0	0.785978	0.656827	0.514760	0.190037	0.147601	0.092251	0.084871

In [141]:
```
deltas = pd.DataFrame()
deltas[1] = rank_table[1] - rank_table[2]
deltas[2] = rank_table[2] - rank_table[3]
deltas[3] = rank_table[3] - rank_table[4]
deltas.head()
```

Out[141]:

raceinfo_id	1	2	3
47316	0.029466	0.057090	0.018416
47317	0.209472	0.003643	0.289617
47318	0.214022	0.129151	0.142066
47319	0.029126	0.139806	0.038835
47320	0.160819	0.125731	0.207602

nominal bets

In [142]:
```
1 y_true.head()
```

Out[142]:

	player_code								
xorder	1	2	3	4	5	6	7	8	9
raceinfo_id									
47316	2315.0	2821.0	208.0	810.0	2532.0	2608.0	1005.0	2904.0	NaN
47317	2505.0	3206.0	2930.0	3001.0	2813.0	2402.0	2728.0	2108.0	NaN
47318	2614.0	2914.0	2927.0	2931.0	2415.0	2804.0	1930.0	2911.0	NaN
47319	2305.0	2908.0	2701.0	3109.0	502.0	2309.0	2924.0	602.0	NaN
47320	2727.0	2920.0	2610.0	1932.0	2815.0	2901.0	1709.0	2104.0	NaN

In [143]:
```
1 y_true = pd.DataFrame(y_true.values, index=y_true.index, columns=range(1, 10))
```

In [144]:
```
1 prediction_table.iloc[:,:3].equals(y_true.iloc[:,:3])
```

Out[144]: False

In [145]:
```
1 # quinella - guess one from two first (any places) 100 >> 740,only first column, 1|2
2 # exacta - guess two first (any places) 100 >> 2310, two first columns, 2|3
3 # Trio - guess three first (any places) 100 >> 320, three first columns, 3|4
4 # Trifecta - guess three first with places, 100 >> 3940, three first columns, 3|4
```

In [146]:
```
quinella = []
qlist = []
for ind in tqdm(prediction_table.index):
    equal = prediction_table.loc[ind, :1].isin(y_true.loc[ind, :2]).any()
    quinella.append(equal)
    qlist.append(ind)
refund_first = sum(quinella) # number of refund for first columns
```

```
100%|██████████| 5000/5000 [00:02<00:00, 2307.97it/s]
```

In [147]:
```
quinella = []
qlist = []
for ind in tqdm(prediction_table.index):
    equal = prediction_table.loc[ind, 2:2].isin(y_true.loc[ind, :2]).any()
    quinella.append(equal)
    qlist.append(ind)
refund_second = sum(quinella) # number of refund for second columns
```

```
100%|██████████| 5000/5000 [00:02<00:00, 2324.63it/s]
```

In [148]:
```
# recovery rate for first and second columns in quinella case
(refund_first*740)/100/5000, (refund_second*740)/100/5000
```

Out[148]: (1.8233599999999999, 1.776)

In [149]:
```
exacta = []
for ind in tqdm(prediction_table.index):
    equal = prediction_table.loc[ind, :2].isin(y_true.loc[ind, :2]).all()
    exacta.append(equal)
refund_exacta = sum(exacta)
```

```
100%|██████████| 5000/5000 [00:02<00:00, 2340.10it/s]
```

In [150]:
```
# recovery rate for quinella case
refund_exacta, (refund_exacta*2310) / 100/ 5000
```

Out[150]: (184, 0.85008)

In [151]:
```
trio = []
for ind in tqdm(prediction_table.index):
    equal = prediction_table.loc[ind, :3].isin(y_true.loc[ind, :3]).all()
    trio.append(equal)
refund_trio = sum(trio)
```

```
100%|██████████| 5000/5000 [00:02<00:00, 2318.73it/s]
```

In [152]:
```
# recovery rate for trio case
(refund_trio*320) / 100 / 5000
```

Out[152]: 0.05184

In [153]:
```
trifecta = []
for ind in tqdm(prediction_table.index):
    equal = prediction_table.loc[ind, :3].equals(y_true.loc[ind, :3])
    trifecta.append(equal)
refund_trifecta = sum(trifecta)
```

```
100%|██████████| 5000/5000 [00:01<00:00, 3251.51it/s]
```

In [154]:
```
# recovery rate for trifecta case
(refund_trifecta*3940) / 100/ 5000
```

Out[154]: 0.10244

tuning bets

tune threshold as subtract N column and N+1 (N = number of used columns for each case)

In [155]:
```
deltas.iloc[:, 0].max()
```

Out[155]: 0.8027888446215139

In [156]:
```
np.linspace(0, 1, 101)
```

Out[156]:
```
array([0.  , 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1 ,
       0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19, 0.2 , 0.21,
       0.22, 0.23, 0.24, 0.25, 0.26, 0.27, 0.28, 0.29, 0.3 , 0.31, 0.32,
       0.33, 0.34, 0.35, 0.36, 0.37, 0.38, 0.39, 0.4 , 0.41, 0.42, 0.43,
       0.44, 0.45, 0.46, 0.47, 0.48, 0.49, 0.5 , 0.51, 0.52, 0.53, 0.54,
       0.55, 0.56, 0.57, 0.58, 0.59, 0.6 , 0.61, 0.62, 0.63, 0.64, 0.65,
       0.66, 0.67, 0.68, 0.69, 0.7 , 0.71, 0.72, 0.73, 0.74, 0.75, 0.76,
       0.77, 0.78, 0.79, 0.8 , 0.81, 0.82, 0.83, 0.84, 0.85, 0.86, 0.87,
       0.88, 0.89, 0.9 , 0.91, 0.92, 0.93, 0.94, 0.95, 0.96, 0.97, 0.98,
       0.99, 1.  ])
```

In [157]:
```
# tuning threshold for quinella case | first place
quinella_tune = []
for thresh in tqdm(np.linspace(0, 1, 101)):
    frame = deltas.loc[deltas[1] > thresh]
    incNum = []
    for ind in (frame.index):
        equal = prediction_table.loc[ind, :1].isin(y_true.loc[ind, :2]).any()
        incNum.append(int(equal))
    quinella_tune.append(-100*len(incNum) + 740*sum(incNum))
quinella_tune = np.array(quinella_tune)
```

```
100%|██████████| 101/101 [00:27<00:00,  3.66it/s]
```

In [158]:
```
import matplotlib.pyplot as plt
plt.plot(np.linspace(0, 1, 101), quinella_tune)
```

Out[158]:
```
[<matplotlib.lines.Line2D at 0x22a013261d0>]
```

In [159]:
```
quinella_tune.argmax(), quinella_tune.max(), quinella_tune.max()/100/5000
```

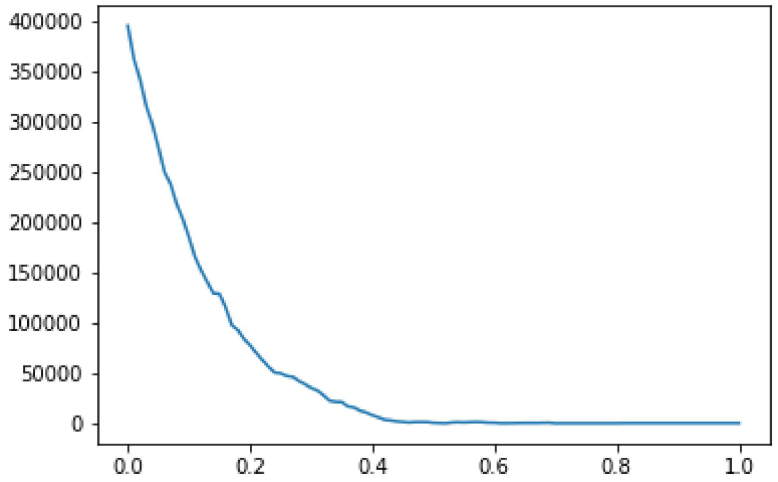
Out[159]:
```
(0, 418680, 0.83736)
```

In [160]:
```
# tuning threshold for quinella case | second place
quinella_tune_2 = []
for thresh in tqdm(np.linspace(0, 1, 101)):
    frame = deltas.loc[deltas[1] > thresh]
    incNum = []
    for ind in (frame.index):
        equal = prediction_table.loc[ind, 2:2].isin(y_true.loc[ind, :2]).any()
        incNum.append(int(equal))
    quinella_tune_2.append(-100*len(incNum) + 740*sum(incNum))
quinella_tune_2 = np.array(quinella_tune_2)
```

```
100%|██████████| 101/101 [00:26<00:00,  3.75it/s]
```

In [161]:
```
import matplotlib.pyplot as plt
plt.plot(np.linspace(0, 1, 101), quinella_tune_2)
```

Out[161]:
```
[<matplotlib.lines.Line2D at 0x22a014ff6d8>]
```



In [162]:
```
quinella_tune_2.argmax(), quinella_tune_2.max(), quinella_tune_2.max() / 100/ 5000
```

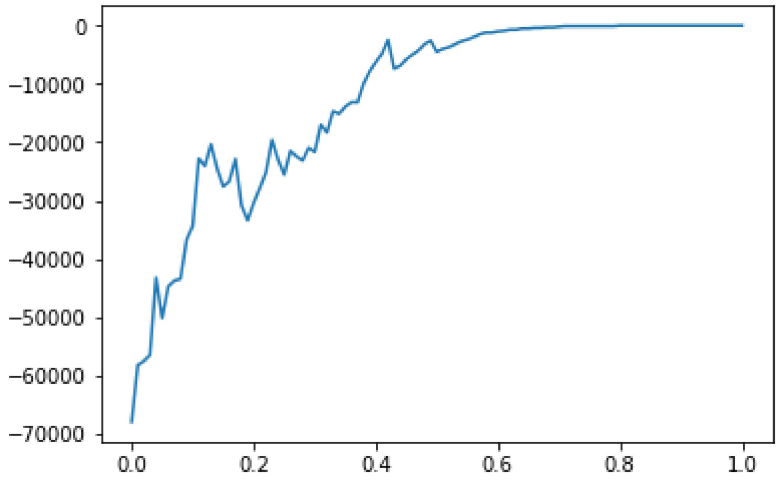
Out[162]:
```
(0, 395000, 0.79)
```

In [163]:
```
# tuning threshold for exacta case
exacta_tune = []
for thresh in tqdm(np.linspace(0, 1., 101)):
    frame = deltas.loc[deltas[2] > thresh]
    incNum = []
    for ind in (frame.index):
        equal = prediction_table.loc[ind, :2].isin(y_true.loc[ind, :2]).all()
        incNum.append(int(equal))
    exacta_tune.append(-100*len(incNum) + 2310*sum(incNum))
exacta_tune = np.array(exacta_tune)
```

```
100%|██████████| 101/101 [00:27<00:00,  3.73it/s]
```

In [164]:
```
plt.plot(np.linspace(0, 1., 101), exacta_tune)
```

Out[164]:
```
[<matplotlib.lines.Line2D at 0x22a01580128>]
```



In [165]:
```
exacta_tune.max(), exacta_tune.argmax(), exacta_tune.max()/100/5000
```

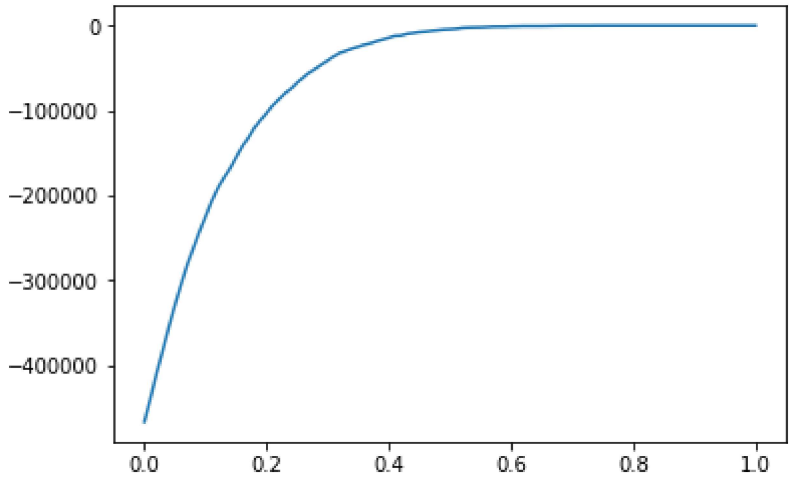
Out[165]:
```
(0, 80, 0.0)
```

In [166]:
```
# tuning threshold for trio case
trio_tune = []
for thresh in tqdm(np.linspace(0, 1., 101)):
    frame = deltas.loc[deltas[3] > thresh]
    incNum = []
    for ind in (frame.index):
        equal = prediction_table.loc[ind, :3].isin(y_true.loc[ind, :3]).all()
        incNum.append(int(equal))
    trio_tune.append(-100*len(incNum) + 320*sum(incNum))
trio_tune = np.array(trio_tune)
```

```
100%|██████████| 101/101 [00:26<00:00,  3.78it/s]
```

In [167]:
```
plt.plot(np.linspace(0, 1., 101), trio_tune)
```

Out[167]:
```
[<matplotlib.lines.Line2D at 0x22a015d0208>]
```



In [168]:
```
trio_tune.max(), trio_tune.argmax(), trio_tune.max()/100/5000
```

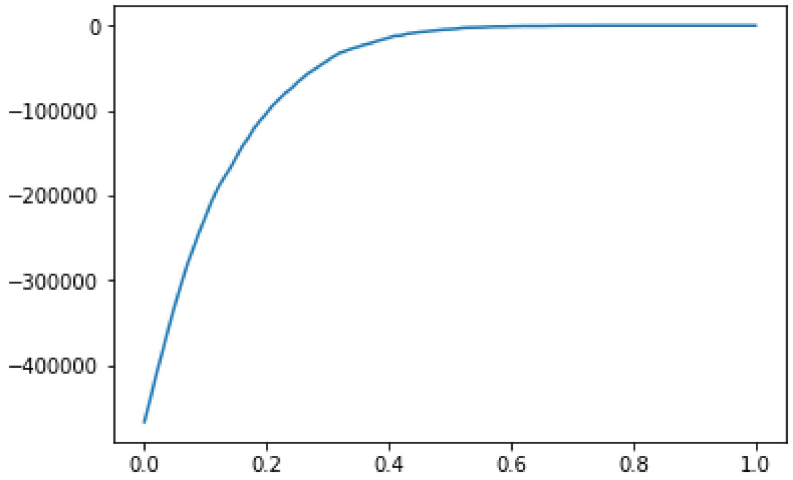
Out[168]:
```
(0, 74, 0.0)
```

In [169]:
```
# tuning threshold for trifecta case
trifecta_tune = []
for thresh in tqdm(np.linspace(0, 1., 101)):
    frame = deltas.loc[deltas[3] > thresh]
    incNum = []
    for ind in (frame.index):
        equal = prediction_table.loc[ind, :3].equals(y_true.loc[ind, :3])
        incNum.append(int(equal))
    trifecta_tune.append(-100*len(incNum) + 3940*sum(incNum))
trifecta_tune = np.array(trio_tune)
```

```
100%|██████████| 101/101 [00:19<00:00,  5.27it/s]
```

In [170]:
```
plt.plot(np.linspace(0, 1., 101), trifecta_tune)
```

Out[170]:
```
[<matplotlib.lines.Line2D at 0x22a0163d208>]
```



In [171]:
```
trifecta_tune.max(), trifecta_tune.argmax(), trifecta_tune.max()/100/5000
```

Out[171]:
```
(0, 74, 0.0)
```

In [172]:
```
# tuning bets
# tune threshold as abs predicted rank
```

In [173]:
```
1 rank_table_nom.head()
```

Out[173]:

raceinfo_id	1	2	3	4	5	6	7	8
47316	543.0	527.0	496.0	486.0	305.0	197.0	175.0	49.0
47317	549.0	434.0	432.0	273.0	263.0	100.0	90.0	61.0
47318	542.0	426.0	356.0	279.0	103.0	80.0	50.0	46.0
47319	515.0	500.0	428.0	408.0	320.0	254.0	170.0	78.0
47320	342.0	287.0	244.0	173.0	143.0	127.0	19.0	8.0

In [174]:
```
1 prediction_table.head()
```

Out[174]:

raceinfo_id	1	2	3	4	5	6	7	8
47316	2821	2608	208	810	2315	1005.0	2904.0	2532.0
47317	2402	2930	2728	2108	2505	3001.0	2813.0	3206.0
47318	2614	2804	1930	2415	2914	2927.0	2911.0	2931.0
47319	3109	2309	2305	2701	602	2908.0	502.0	2924.0
47320	2610	2815	2104	1932	1709	2901.0	2727.0	2920.0

In [175]:
```
1 rank_table_nom[[1, 2]].max(), rank_table_nom[[1, 2]].min()
```

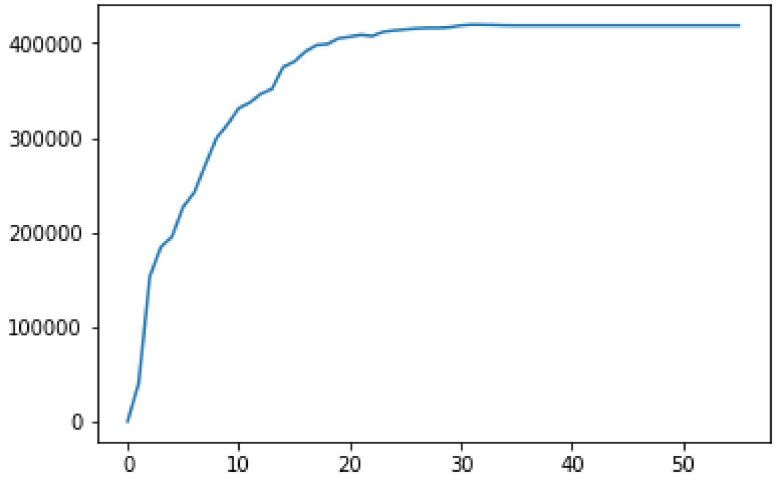
Out[175]:
```
(1    553.0
 2    550.0
 dtype: float64, 1    0.0
 2    0.0
 dtype: float64)
```

In [176]:
```
# quinella case | first place
tune = []

for threshold in tqdm(range(560, 0, -10)):
    frame_rank = rank_table_nom.loc[(rank_table_nom[1] > threshold) |
                                    (rank_table_nom[2] > threshold) ]
    frame_pred = prediction_table.loc[frame_rank.index][[1, 2]]

    incNum = []

    for ind in frame_pred.index:
        equal = frame_pred.loc[ind, :1].isin(y_true.loc[ind, :2]).any()
        incNum.append(int(equal))
    tune.append(-100*len(incNum) + 740*sum(incNum))

```

```
100%|██████████| 56/56 [01:30<00:00,  1.61s/it]
```

In [177]:
```
plt.plot(tune)
```

Out[177]:
```
[<matplotlib.lines.Line2D at 0x22a016ad438>]
```

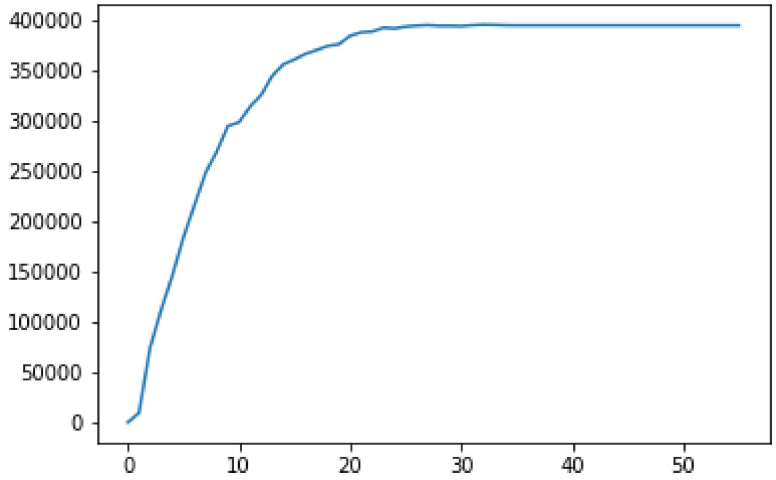


In [178]:
```
# quinella case | second place
tune = []

for threshold in tqdm(range(560, 0, -10)):
    frame_rank = rank_table_nom.loc[(rank_table_nom[1] > threshold) |
                                    (rank_table_nom[2] > threshold) ]
    frame_pred = prediction_table.loc[frame_rank.index][[1, 2]]
    incNum = []
    for ind in frame_pred.index:
        equal = frame_pred.loc[ind, 2:2].isin(y_true.loc[ind, :2]).any()
        incNum.append(int(equal))
    tune.append(-100*len(incNum) + 740*sum(incNum))
```

```
100%|██████████| 56/56 [01:30<00:00,  1.61s/it]
```

In [179]:
```
plt.plot(tune)
```

Out[179]:
```
[<matplotlib.lines.Line2D at 0x22a017090f0>]
```

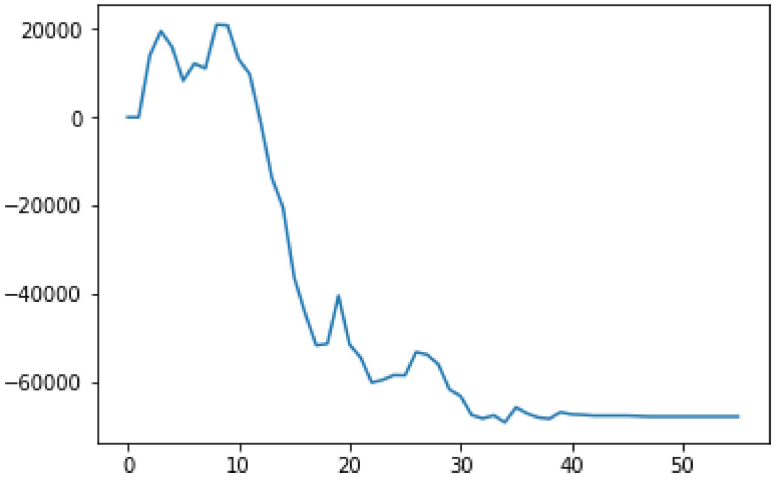


In [180]:
```
# exacta case
tune = []
for threshold in tqdm(range(560, 0, -10)):
    frame_rank = rank_table_nom.loc[(rank_table_nom[1] > threshold) &
                                    (rank_table_nom[2] > threshold) ]
    frame_pred = prediction_table.loc[frame_rank.index][[1, 2]]
    incNum = []
    for ind in frame_pred.index:
        equal = frame_pred.loc[ind, :2].isin(y_true.loc[ind, :2]).all()
        incNum.append(int(equal))
    tune.append(-100*len(incNum) + 2310*sum(incNum))
```

```
100%|██████████| 56/56 [01:18<00:00,  1.40s/it]
```

In [181]:
```
plt.plot(tune)
```

Out[181]:
```
[<matplotlib.lines.Line2D at 0x22a0176b358>]
```

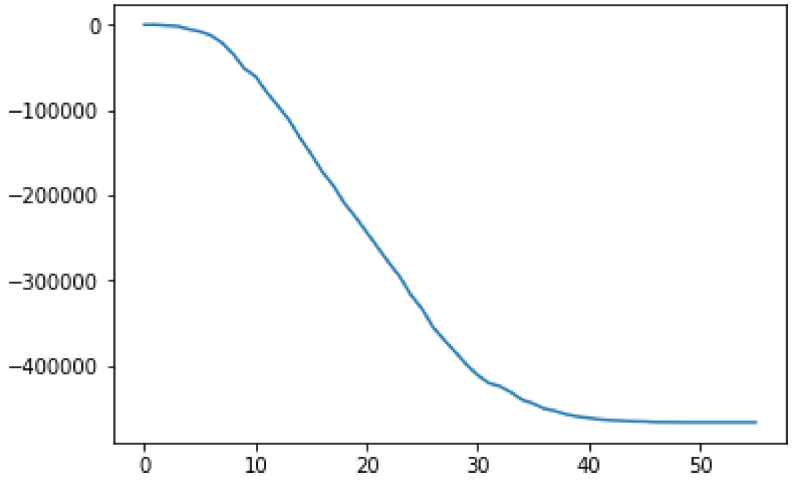


In [182]:
```
# trio case
tune = []
for threshold in tqdm(range(560, 0, -10)):
    frame_rank = rank_table_nom.loc[(rank_table_nom[1] > threshold) &
                                    (rank_table_nom[2] > threshold) &
                                     (rank_table_nom[3] > threshold)]
    frame_pred = prediction_table.loc[frame_rank.index][[1, 2, 3]]
    incNum = []
    for ind in frame_pred.index:
        equal = frame_pred.loc[ind, :3].isin(y_true.loc[ind, :3]).all()
        incNum.append(int(equal))
    tune.append(-100*len(incNum) + 320*sum(incNum))
```

```
100%|██████████| 56/56 [01:06<00:00,  1.18s/it]
```

In [183]:
```
plt.plot(tune)
```

Out[183]:
```
[<matplotlib.lines.Line2D at 0x22a017cd0b8>]
```

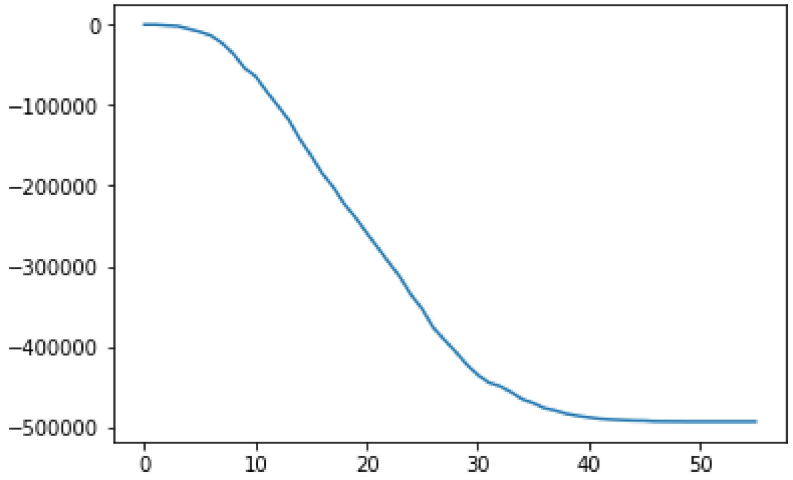


In [184]:
```
# Trifecta case
tune = []
for threshold in tqdm(range(560, 0, -10)):
    frame_rank = rank_table_nom.loc[(rank_table_nom[1] > threshold) &
                                    (rank_table_nom[2] > threshold) &
                                     (rank_table_nom[3] > threshold)]
    frame_pred = prediction_table.loc[frame_rank.index][[1, 2, 3]]
    incNum = []
    for ind in frame_pred.index:
        equal = frame_pred.loc[ind, :3].equals(y_true.loc[ind, :3])
        incNum.append(int(equal))
    tune.append(-100*len(incNum) + 3940*sum(incNum))
```

```
100%|██████████| 56/56 [00:50<00:00,  1.11it/s]
```

In [185]:
```
plt.plot(tune)
```

Out[185]:
```
[<matplotlib.lines.Line2D at 0x22a0181fdd8>]
```



In [186]:
```
# TO BE DETERMINED
```

make predicton for test dataset

repeat preprocessing for interactions

In [187]:
```
# Can't unite train and test interactions matrix
# need set one big interaction matrix
```

In [188]:
```
pred_interactions['raceinfo_id'] = predict_frame['raceinfo_id']
```

In [189]:
```
pred_interactions.drop_duplicates(inplace=True)
pred_interactions.set_index('raceinfo_id', inplace=True)
pred_interactions.shape
```

Out[189]: (5049, 416)

In [190]:
```
interactions = pd.concat([hist_interactions, pred_interactions])
interactions.shape, hist_interactions.shape, pred_interactions.shape
```

Out[190]: ((42994, 574), (37945, 554), (5049, 416))

In [191]:
```
interactions.fillna(0, inplace=True)
interactions.head()
```

Out[191]:

raceinfo_id	103	111	208	210	407	408	409	410	411	415	...	3311	3312	3313	9008	9009	9010	9011	9012	9013	9014
7321	0	0.0	0	0	0.0	0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7322	0	0.0	0	0	0.0	0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7323	0	0.0	0	0	0.0	0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7324	0	0.0	0	0	0.0	0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7325	0	0.0	0	0	0.0	0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5 rows × 574 columns

repeat preprocessing for interactions

In [192]:
```
interactions.shape
```

Out[192]: (42994, 574)

In [193]:
```
track_frame = pd.concat([history_frame[track_features], predict_frame[track_features]])
track_frame.drop_duplicates(inplace=True)
track_frame.head()
```

Out[193]:

	raceinfo_id	distance	situation	raceclass_code	weather_name3	roadtemp	temp	humid	place_code	raceno
0	7321	3100	good	1	sunny	19.0	9	42	kawaguchi	1
8	7322	3100	good	1	sunny	20.0	9	38	kawaguchi	2
16	7323	3100	good	1	sunny	21.0	10	36	kawaguchi	3
24	7324	3100	good	1	sunny	21.0	10	35	kawaguchi	4
32	7325	3100	good	1	sunny	21.0	11	35	kawaguchi	5

In [194]:
```
track_frame.shape # correct shape
```

Out[194]: (42994, 10)

In [195]:
```
situation = pd.get_dummies(track_frame['situation'], prefix='situation')
situation.head(2)
```

Out[195]:

	situation_good	situation_oil	situation_rash	situation_rough	situation_wet	situation_wind
0	1	0	0	0	0	0
8	1	0	0	0	0	0

In [196]:
```
weather = pd.get_dummies(track_frame['weather_name3'], prefix='weather')
weather.head(2)
```

Out[196]:

	weather_cloud	weather_lightrain	weather_lightsnow	weather_rain	weather_snow	weather_sunny
0	0	0	0	0	0	1
8	0	0	0	0	0	1

In [197]:
```
place = pd.get_dummies(track_frame['place_code'], prefix='place_is')
place.head(2)
```

Out[197]:

	place_is_funabashi	place_is_hamamatsu	place_is_iizuka	place_is_isesaki	place_is_kawaguchi	place_is_sanyou
0	0	0	0	0	1	0
8	0	0	0	0	1	0

In [198]:
```
track_frame.drop(columns=['situation', 'weather_name3', 'place_code'], inplace=True)
```

In [199]:
```
track_frame = pd.concat([track_frame, situation, weather, place], axis=1)
track_frame.head(3)
```

Out[199]:

	raceinfo_id	distance	raceclass_code	roadtemp	temp	humid	raceno	situation_good	situation_oil	situation_rash	...	weather_lightsnow	weat
0	7321	3100	1	19.0	9	42	1	1	0	0	...	0	
8	7322	3100	1	20.0	9	38	2	1	0	0	...	0	
16	7323	3100	1	21.0	10	36	3	1	0	0	...	0	

3 rows × 25 columns

In [200]:
```
track_frame = track_frame.set_index('raceinfo_id')
track_frame.head()
```

Out[200]:

raceinfo_id	distance	raceclass_code	roadtemp	temp	humid	raceno	situation_good	situation_oil	situation_rash	situation_rough	...	weather_ligh
7321	3100	1	19.0	9	42	1	1	0	0	0	...	
7322	3100	1	20.0	9	38	2	1	0	0	0	...	
7323	3100	1	21.0	10	36	3	1	0	0	0	...	
7324	3100	1	21.0	10	35	4	1	0	0	0	...	
7325	3100	1	21.0	11	35	5	1	0	0	0	...	

5 rows × 24 columns

preprocessing for racer features

In [201]:
```
interactions.shape, racer_frame.shape
```

Out[201]: ((42994, 574), (554, 352))

In [202]:
```
add_hist = predict_frame.copy()
add_hist['hold_date'] = '1990'
full_racer_frame = pd.concat([history_frame[racer_features], add_hist[racer_features]])
full_racer_frame.shape
```

Out[202]: (343511, 340)

In [203]:
```
full_racer_frame.sort_values(by='hold_date', ascending=False, inplace=True)
full_racer_frame.drop_duplicates(subset=['player_code'], inplace=True)
full_racer_frame.shape # correct shape
```

Out[203]: (574, 340)

In [204]:
```
full_racer_frame.head(2)
```

Out[204]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	rank_now	rank_last	point	...	p2_Other_90_All_Here_rate1th	p2_Ot
303084	2607	2	8	20	0	39	26	A-53	A-58	80.425	...	0.0	
303105	2204	1	5	10	1	47	22	A-99	A-46	73.885	...	0.0	

2 rows × 340 columns

In [205]:
```
obj_racer_cols = full_racer_frame.select_dtypes('object').columns
full_racer_frame[obj_racer_cols].head(3)
```

Out[205]:

	rank_now	rank_last	last90_highplace	hold_date
303084	A-53	A-58	iizuka	2015-12-31 00:00:00
303105	A-99	A-46	kawaguchi	2015-12-31 00:00:00
303083	A-2	A-142	funabashi	2015-12-31 00:00:00

In [206]:
```
full_racer_frame.drop('hold_date', axis=1, inplace=True)
```

In [207]:
```
obj_racer_cols = obj_racer_cols[:-1]
obj_racer_cols
```

Out[207]: Index(['rank_now', 'rank_last', 'last90_highplace'], dtype='object')

In [208]:
```
full_racer_frame.shape
```

Out[208]:
```
(574, 339)
```

In [209]:
```
full_racer_frame['rank_last_symbol'] = full_racer_frame['rank_last'].apply(lambda x: x[0] if type(x)==str else 'O')
full_racer_frame['rank_last_symbol'].unique()
```

Out[209]:
```
array(['A', 'S', 'B', 'O'], dtype=object)
```

In [210]:
```
full_racer_frame['rank_now_symbol'] = full_racer_frame['rank_now'].apply(lambda x: x[0] if type(x)==str else 'O')
full_racer_frame['rank_now_symbol'].unique()
```

Out[210]:
```
array(['A', 'S', 'B'], dtype=object)
```

In [211]:
```
symbols = pd.get_dummies(full_racer_frame[['rank_last_symbol', 'rank_now_symbol']])
```

In [212]:
```
last90_highplace_dummy = pd.get_dummies(full_racer_frame['last90_highplace'])
```

In [213]:
```
obj_racer_cols = full_racer_frame.select_dtypes('object').columns
obj_racer_cols
```

Out[213]:
```
Index(['rank_now', 'rank_last', 'last90_highplace', 'rank_last_symbol',
       'rank_now_symbol'],
      dtype='object')
```

In [214]:
```
full_racer_frame.drop(columns=obj_racer_cols, inplace=True)
```

In [215]:
```
full_racer_frame = pd.concat([full_racer_frame, symbols, last90_highplace_dummy], axis=1)
full_racer_frame.shape
```

Out[215]:
```
(574, 349)
```

In [216]:
```
1 full_racer_frame.head(3)
```

Out[216]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	rank_last_symbol_S	rank_
303084	2607	2	8	20	0	39	26	80.425	1	2	...	0	
303105	2204	1	5	10	1	47	22	73.885	0	1	...	0	
303083	2808	2	7	20	0	34	28	89.720	0	1	...	0	

3 rows × 349 columns

In [217]:
```
1 full_racer_frame.sort_index(inplace=True)
```

In [218]:
```
1 full_racer_frame.head(2)
```

Out[218]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	rank_last_symbol_S	rank_nc
25230	3313	3	1	0	0	22	33	NaN	0	0	...	0	
25238	3310	2	1	0	0	22	33	NaN	0	0	...	0	

2 rows × 349 columns

In [219]:
```
1 full_racer_frame.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 574 entries, 25230 to 303148
Columns: 349 entries, player_code to sanyou
dtypes: float64(201), int64(135), uint8(13)
memory usage: 1.5 MB
```

In [220]:
```
uint8_cols = full_racer_frame.select_dtypes('uint8').columns
full_racer_frame[uint8_cols] = full_racer_frame[uint8_cols].astype(np.int32)
full_racer_frame.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 574 entries, 25230 to 303148
Columns: 349 entries, player_code to sanyou
dtypes: float64(201), int32(13), int64(135)
memory usage: 1.5 MB
```

In [221]:
```
interactions.shape, track_frame.shape, full_racer_frame.shape
```

Out[221]: ((42994, 574), (42994, 24), (574, 349))

```
#  Add wins count
# we use wins features from train set
```

In [222]:
```
join_wins = pd.DataFrame(pd.concat([mean_wins, sum_wins, max_wins], axis=1))
join_wins.columns = ['mean_wins', 'sum_wins', 'max_wins']
join_wins.shape
```

Out[222]: (554, 3)

In [223]:
```
join_wins.head()
```

Out[223]:

	mean_wins	sum_wins	max_wins
103	3.000000	18.0	15.0
111	1.166667	7.0	4.0
208	10.666667	64.0	44.0
210	3.333333	20.0	14.0
407	6.333333	38.0	38.0

In [224]:
```
full_racer_frame = full_racer_frame.merge(join_wins, left_on='player_code', right_index=True, how='left')
full_racer_frame.fillna(0, inplace=True)
full_racer_frame.head()
```

Out[224]:

	player_code	popular	motorbikeno	handicap	home	age	graduation	point	last10_num1th	last10_num2th	...	rank_now_symbol_S	funaba
25230	3313	3	1	0	0	22	33	0.0	0	0	...	0	
25238	3310	2	1	0	0	22	33	0.0	0	0	...	0	
25246	3309	4	1	0	1	21	33	0.0	0	0	...	0	
25262	3301	2	1	0	1	27	33	0.0	0	0	...	0	
25294	9008	4	1	0	0	21	33	0.0	0	0	...	0	

5 rows × 352 columns

In [225]:
```
interactions.shape, track_frame.shape, full_racer_frame.shape
```

Out[225]:
```
((42994, 574), (42994, 24), (574, 352))
```

make prediction model

In [226]:
```
predict_frame[['raceinfo_id', 'player_code']].head()
```

Out[226]:

	raceinfo_id	player_code
0	52674	1315
1	52674	2119
2	52674	2005
3	52674	1214
4	52674	2514

In [ ]:
```

```

In [227]:
```
# set ones in races to predict
for ind, line in tqdm(predict_frame[['raceinfo_id', 'player_code']].iterrows()):
    racenum, playernum = line
    interactions.loc[racenum, playernum] = 1
```

```
40362it [00:12, 3268.97it/s]
```

In [228]:
```
big_model = LightFM() # learning_rate=0.05
big_model.fit(coo_matrix(interactions),
          user_features=csr_matrix(track_frame),
          item_features=csr_matrix(full_racer_frame),
          epochs=20, verbose=True)
```

```
Epoch: 100%|██████████| 20/20 [03:27<00:00, 10.36s/it]
```

Out[228]:
```
<lightfm.lightfm.LightFM at 0x22a0196a4e0>
```

In [229]:
```
pred_df = big_model.predict_rank(coo_matrix(interactions),
                                 item_features=csr_matrix(full_racer_frame),
                                 user_features=csr_matrix(track_frame))
```

In [230]:
```
df = pd.DataFrame(pred_df.toarray(), index=interactions.index,
                  columns=interactions.columns)
```

In [231]:
```
df.tail()
```

Out[231]:

raceinfo_id	103	111	208	210	407	408	409	410	411	415	...	3311	3312	3313	9008	9009	9010	9011	9012	9013	9014
62788	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62789	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62790	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62791	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62792	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5 rows × 574 columns

In [232]:
```
df.tail().loc[:, df.tail().sum() != 0] # predicted rank
```

Out[232]:

raceinfo_id	2101	2215	2301	2305	2306	2410	2416	2511	2519	2529	...	2928	2934	3017	3101	3102	3115	3206	3215	9002	900
62788	360.0	0.0	297.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	70.0	0.0	0.0	281.0	131.0	0.0	341.0	0.0	0
62789	0.0	0.0	0.0	0.0	0.0	62.0	293.0	529.0	0.0	0.0	...	0.0	0.0	68.0	0.0	0.0	0.0	0.0	0.0	0.0	0
62790	0.0	169.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	550.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
62791	0.0	0.0	0.0	365.0	0.0	0.0	0.0	0.0	0.0	141.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	271.0	123
62792	0.0	0.0	0.0	0.0	471.0	0.0	0.0	0.0	542.0	0.0	...	0.0	0.0	0.0	81.0	0.0	0.0	310.0	0.0	0.0	0

5 rows × 40 columns

Save csv

In [233]:
```
pred_table = []
rank_table = []

for ind, line in tqdm(df.loc[predict_frame['raceinfo_id'].unique()].iterrows()):
    vlist = [(a,b) for a,b in zip(line, interactions.columns)]
    vlist = sorted(vlist, reverse=True)[:10]
    pred_table.append([ind, *(i[1] for i in vlist)])
    rank_table.append([ind, *(i[0] for i in vlist)])
```

```
5049it [00:01, 4970.32it/s]
```

In [234]:
```
# check 9 and 10 columns
rank_table = pd.DataFrame(rank_table)
rank_table.set_index(0, inplace=True)
```

In [235]:
```
rank_table.iloc[:, -2:].sum()
```

Out[235]:
```
9     0.0
10    0.0
dtype: float64
```

In [236]:
```
rank_table.drop(columns=[9, 10], inplace=True)
```

In [237]:
```
pred_table = pd.DataFrame(pred_table)
pred_table.set_index(0, inplace=True)
pred_table.drop(columns=[9, 10], inplace=True)
pred_table.head(3)
```

Out[237]:

0	1	2	3	4	5	6	7	8
52674	1315	2119	1214	1604	2005	2013	2510	2514
52675	1542	2110	2224	3012	1618	3203	1907	1925
52676	1121	1932	2115	3114	2324	2321	1912	2114

In [238]:
```
pred_table['order'] = pred_table.apply(lambda x: '_'.join([str(i) for i in x]), axis=1)
```

In [239]:
```
pred_table.head(2)
```

Out[239]:

0	1	2	3	4	5	6	7	8	order
52674	1315	2119	1214	1604	2005	2013	2510	2514	1315_2119_1214_1604_2005_2013_2510_2514
52675	1542	2110	2224	3012	1618	3203	1907	1925	1542_2110_2224_3012_1618_3203_1907_1925

In [240]:
```
pred_table.reset_index(inplace=True)
pred_table.rename(columns={0: 'raceinfo_id'}, inplace=True)
pred_table.head(3)
```

Out[240]:

	raceinfo_id	1	2	3	4	5	6	7	8	order
0	52674	1315	2119	1214	1604	2005	2013	2510	2514	1315_2119_1214_1604_2005_2013_2510_2514
1	52675	1542	2110	2224	3012	1618	3203	1907	1925	1542_2110_2224_3012_1618_3203_1907_1925
2	52676	1121	1932	2115	3114	2324	2321	1912	2114	1121_1932_2115_3114_2324_2321_1912_2114

In [241]:
```
%%time
pred_table[['raceinfo_id', 'order']].to_csv('predict_hit_rate.csv', index=False)
```

```
Wall time: 11 ms
```

In [242]:
```
# add bets columns for each case
# NO tuning
pred_table['Quinella_(1st_place)'] = 5
pred_table['Quinella_(2nd_place)'] = 5
pred_table['Exacta'] = 0
pred_table['Trio'] = 0
pred_table['Trifecta'] = 0
```

In [243]:
```
%%time
pred_table[['raceinfo_id', 'order', 'Quinella_(1st_place)', 'Quinella_(2nd_place)',
            'Exacta', 'Trio', 'Trifecta']].to_csv('predict_recovery_rate.csv', index=False)
```

```
Wall time: 13 ms
```

to do

```
1. Add ranking model (LightGBM, ListNet, RankNet) and compare metrics
2. Add neural network model with KL divergence loss function and compare
3. Add more track features and racer features and check metrics
```

```
4. Add more threshold tunings on different features
```

```
time spending:
from from 10 May to 14 May, 16 May and 18 May
all days was part-time
```