03_Modeling

December 11, 2018

```
In [1]: import requests
        from IPython.core.display import HTML
        styles = requests.get("https://raw.githubusercontent.com/Harvard-IACS/2018-CS109A/maste
        HTML(styles)

        import pandas as pd
        import time
        import numpy as np
        from sklearn.decomposition import PCA
        import matplotlib
        import matplotlib.pyplot as plt
        from sklearn.preprocessing import StandardScaler
        from sklearn.preprocessing import MinMaxScaler
        import seaborn as sns
        import scipy.stats as stat
        from sklearn import linear_model
        from sklearn.linear_model import LogisticRegression
        from sklearn.linear_model import LogisticRegressionCV
        from sklearn.feature_selection import chi2
        from sklearn.model_selection import cross_val_score
        from sklearn.utils import resample
        from sklearn.tree import DecisionTreeClassifier
        from sklearn.ensemble import RandomForestClassifier
        from sklearn.ensemble import AdaBoostClassifier
        from sklearn.metrics import accuracy_score
        from sklearn.neighbors import KNeighborsClassifier
        from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
        from sklearn.discriminant_analysis import QuadraticDiscriminantAnalysis
        from sklearn.feature_selection import SelectFromModel
        from bisect import bisect
        from matplotlib.cm import get_cmap
        from matplotlib.colors import PowerNorm
        from matplotlib.colors import LinearSegmentedColormap
        from matplotlib.colors import Normalize
        import warnings
```

Load data
We start from loading the dataset after data imputation:

```
In [2]: #load data
        house_df = pd.read_csv('data/house_mean_imputation.csv')
        #house_df = pd.read_csv('data/house_model_imputation.csv')
        house_df = house_df.drop_duplicates(['year', 'state', 'district', 'name'])
        display(house_df.shape)
        display(house_df.head())
        display(house_df.describe())
```

```
(9974, 20)
```

```
     district  is_incumbent          name party  percent    state    votes  \
0  District 1           0.0  Ratliff Boon     D     42.1  Indiana   4281.0
1  District 1           1.0  Ratliff Boon     D     42.8  Indiana   5202.0
2  District 1           1.0  Ratliff Boon     D     52.2  Indiana   7272.0
3  District 1           0.0      John Law     D     49.1  Indiana  10868.0
4  District 1           1.0  Ratliff Boon     D     50.9  Indiana  11280.0

   won  year  first_time_elected  count_victories  unemployement_rate  \
0    1  1824              1824.0                0            5.790196
1    1  1826              1824.0                1            5.790196
2    1  1828              1824.0                2            5.790196
3    0  1830              1860.0                0            5.790196
4    1  1830              1824.0                3            5.790196

   is_presidential_year  president_can_be_re_elected president_party  \
0                   0.0                          1.0               0
1                   0.0                          1.0               0
2                   0.0                          1.0               0
3                   0.0                          1.0               0
4                   0.0                          1.0               0

   president_overall_avg_job_approval  last_D_house_seats  last_R_house_seats  \
0                            0.525667          200.179856          182.503597
1                            0.525667          200.179856          182.503597
2                            0.525667          200.179856          182.503597
3                            0.525667          200.179856          182.503597
4                            0.525667          200.179856          182.503597

  last_house_majority  fundraising
0                   D  552917.8375
1                   D  552917.8375
2                   D  552917.8375
3                   D  552917.8375
4                   D  552917.8375


       is_incumbent      percent          votes          won          year  \
```

count	9974.000000	9974.000000	9974.000000	9974.000000	9974.000000
mean	0.444456	50.968786	101123.196765	0.528474	1991.993884
std	0.496930	19.917918	55100.387633	0.499214	31.278231
min	0.000000	0.000000	0.000000	0.000000	1824.000000
25%	0.000000	36.160000	59347.250000	0.000000	1982.000000
50%	0.000000	50.235000	94682.000000	1.000000	2004.000000
75%	1.000000	64.300000	136625.250000	1.000000	2012.000000
max	1.000000	100.000000	322514.000000	1.000000	2018.000000

	first_time_elected	count_victories	unemployement_rate \
count	9974.000000	9974.000000	9974.000000
mean	1102.728093	0.963305	6.176784
std	987.884433	1.826929	2.060743
min	0.000000	0.000000	2.700000
25%	0.000000	0.000000	4.600000
50%	1938.000000	0.000000	5.790931
75%	2002.000000	1.000000	7.000000
max	2018.000000	17.000000	19.000000

	is_presidential_year	president_can_be_re_elected \
count	9974.000000	9974.000000
mean	0.481251	0.604071
std	0.499673	0.489074
min	0.000000	0.000000
25%	0.000000	0.000000
50%	0.000000	1.000000
75%	1.000000	1.000000
max	1.000000	1.000000

	president_overall_avg_job_approval	last_D_house_seats \
count	9974.000000	9974.000000
mean	0.493377	219.603971
std	0.062378	36.152015
min	0.395000	38.000000
25%	0.480000	194.000000
50%	0.490000	205.000000
75%	0.528000	248.000000
max	0.701000	334.000000

	last_R_house_seats	fundraising
count	9974.000000	9.974000e+03
mean	210.664830	1.014975e+06
std	34.645436	9.782140e+05
min	86.000000	-3.469651e+04
25%	180.000000	5.015548e+05
50%	225.000000	8.306668e+05
75%	241.000000	1.329461e+06
max	303.000000	3.410465e+07

We have some data where the president party is not defined: typically they're data from non-election years. Let's drop them.

```
In [3]: #drop observations where president party is not defined
        house_df=house_df.drop(house_df.loc[house_df['president_party']=="0"].index)
```

Baseline model

We define our baseline model simply taking the party, per each district, with the highest winning rate.

Here we have defined `winnerFilter_` and `baselineTrain_`. The only difference with the `winnerFilter` and `baselineTrain` defined in 02-EDA phase is that here we refer to parties as 1 and 0, instead than as 'R' and 'D'

We prepare a dictionary `results` containing the winner parties of each year, grouped by state and district

Also, we define `districtPredictions` and `districtAccuracy` that merge predictions with actual districts, so that accuracy is calculated on all existing districts, rather than only on the ones for which we have a predicted winner.

In fact: - based on the training set we might not have a prediction for all districts. As districts are redistributed through the years, one that is in the test set might not exist in the training set, so we have no prediction for it. - we might have ex aequo winning predictions among candidates of opponent party, which do not lead to a winner prediction

```
In [4]: #baseline model
        def winnerFilter_(df):
            return df[df['won']==1][['state','district','party']].replace(['D', 'R'], [0, 1])

        def baselineTrain_(df):
            df_grouped=df[(df['won']==1)].groupby(['state', 'district'])['party'].sum().reset_i
            df_grouped['R_occurence']=df_grouped['party'].str.count('R')/df_grouped['party'].s
            df_grouped['party']=(df_grouped['R_occurence']>0.5).astype(int)
            df_grouped['proba']=(1-df_grouped['party']-df_grouped['R_occurence']).abs()
            return df_grouped[['state', 'district','party', 'proba']]

        #prepare dataset indexed by state and district, with all results
        results=dict()
        for year in house_df['year'].unique():
            results[year]=house_df[house_df['year']==year].groupby(['state', 'district']).coun
            results[year]=results[year].drop(columns = list(results[year]))
            results[year]['partyWon']=winnerFilter_(house_df[house_df['year']==year]).set_inde
        def districtPredictions(y_pred, year, partyWonCol='party', set_index=1):
            if set_index:
                df=results[year].join(y_pred.set_index(['state', 'district'])).sort_index().fi
            else:
                df=results[year].join(y_pred).fillna(-1)
            return df
        def districtAccuracy(y_pred, year, partyWonCol='party', set_index=1):
```

```
        df=districtPredictions(y_pred, year, partyWonCol, set_index)
        return sum(df['partyWon']==df[partyWonCol])/len(df)
```

Using the above functions, we calculate the accuracy of the baseline model over the 2018 test set:

```
In [5]: y_pred=baselineTrain_(house_df[house_df['year']!=2018]) #train simple average model, r
        baseline_accuracy=districtAccuracy(y_pred, 2018)
        print('Baseline 2018 test accuracy: \t{:.2%}'.format(baseline_accuracy))
```

```
Baseline 2018 test accuracy:        76.78%
```

Functions definitions

We define a function `splitDf` for splitting the dataset: - test set on data belonging to a specified input `year` - training set on data from remaining years - store `state`, `district` and `party` information using the same original index as the main data - drop response features like `percent` and `votes`, plus `state`, `district` and `name` - split into `x_train` and `y_train`, `x_test` and `y_test`, using `won` as response feature - return `x_train`, `y_train`, `x_test`, `y_test`, `indexed_districts` and `indexed_party`

```
In [6]: def splitDf(df, year):
            dfcopy=df.dropna().copy()
            indexed_districts=dfcopy[['state','district']]
            indexed_party=dfcopy[['party']].replace(['D', 'R'], [0, 1])
            dfcopy=dfcopy.drop(columns=['state', 'district', 'name', 'percent', 'votes'])
            data_train, data_test=dfcopy[dfcopy['year']!=year], dfcopy[dfcopy['year']==year]
            #data_train, data_test=dfcopy[dfcopy['year']<year], dfcopy[dfcopy['year']==year]

            x_train, y_train=data_train.drop('won', axis=1), data_train['won']
            x_test, y_test=data_test.drop('won', axis=1), data_test['won']
            return x_train, y_train, x_test, y_test, indexed_districts, indexed_party
```

Plots

Here we define several plotting functions which will be used afterwards:

```
In [7]: #plot cross validation scores of decision trees
        def plotCVscores(depths, scores_train, scores_train_CV, scores_train_CVstd, title, xlal
            fig, ax = plt.subplots(1, 1, figsize=(15, 5))
            fig.suptitle(title, fontsize=24, y=1.0)
            ax.plot(depths, scores_train, label = 'Full training set')
            ax.plot(depths, scores_train_CV, label = 'Cross validation means')
            upper=np.array(scores_train_CV)+2*np.array(scores_train_CVstd)
            lower=np.array(scores_train_CV)-2*np.array(scores_train_CVstd)
            ax.fill_between(depths, lower, upper, color='chocolate', alpha='0.1')
            ax.axhline(y=1, c='g', label='100% accuracy')
            ax.set_xlabel(xlabel)
            ax.set_ylabel('Score')
            #ax.set(ylim=([0.95*min(lower),1.05*max(upper)])) #I guess this is the meaning of
```

```python
    ax.set_xticks(depths)
    ax.legend();
#plot scores of a model through years
def plotYearscores(years, scores_train, scores_train_CV, scores_CV_mutExcl, Accu_val_2_
    fig, ax = plt.subplots(1, 1, figsize=(15, 5))
    fig.suptitle(title, fontsize=24, y=1.0)
    ax.plot(years, scores_train, label = 'training set')
    ax.plot(years, scores_train_CV, label = 'validation score')
    ax.plot(years, scores_CV_mutExcl, label = 'validation mutually exclusive score')
    ax.plot(years, Accu_val_2_byDistrict, label = 'validation mutually exclusive score
    ax.set_xlabel(xlabel)
    ax.set_ylabel('Score')
    ax.set_xticks(years)
    ax.legend();
#bar plot with model scores
def barplotScores(models_names, scores_train, scores_val, scores_val_mut_escl, scores_
    #plot
    from matplotlib.ticker import PercentFormatter

    fontsize=13
    current_palette = sns.color_palette()
    fig, ax = plt.subplots(1, 1, figsize=(15, 2*len(models_names)))
    fig.suptitle('Scores of all fitted models on training vs cross-validation means', 
    w=0.2
    a=np.arange(len(models_names))
    ax.barh(a+1.5*w, scores_train, height=w,align='center', color=current_palette[0], a
    ax.barh(a+0.5*w, scores_val, height=w,align='center', color=current_palette[1], al
    ax.barh(a-0.5*w, scores_val_mut_escl, height=w,align='center', color=current_palet
    ax.barh(a-1.5*w, scores_val_mut_escl_byDistrict, height=w,align='center', color=cu

    for i, v in enumerate(scores_train):
        ax.text(v-0.02, i+1.5*w, '{:>.2%}'.format(v), color='white', fontsize=fontsize
        ax.text(scores_val[i]-0.02, i+0.5*w, '{:>.2%}'.format(scores_val[i]), color='wh
        ax.text(scores_val_mut_escl[i]-0.02, i-0.5*w, '{:>.2%}'.format(scores_val_mut_e
        ax.text(scores_val_mut_escl_byDistrict[i]-0.02, i-1.5*w, '{:>.2%}'.format(score

    ax.axvline(x=baseline_accuracy, c='g', label='baseline')
    ax.text(baseline_accuracy, -0.8, '{:.2%}'.format(baseline_accuracy), color='green'

    #ax.xaxis.set_major_formatter(PercentFormatter())
    #ax.set_xticklabels(fontsize=fontsize)
    ax.set_xlabel('Score', fontsize=fontsize)
    ax.set_yticklabels(models_names, fontdict=None, minor=False, fontsize=fontsize)
    ax.set_yticks(a, minor=False)
    plt.xlim(baseline_accuracy*0.95,1)
    vals = ax.get_xticks()
    ax.set_xticklabels(['{:,.0%}'.format(x) for x in vals], fontsize=fontsize)
    ax.legend(fontsize=fontsize)
```

```python
    #fig.legend(bbox_to_anchor=(1.45, 0.84), fontsize=fontsize); #put the legend outsi
def plotModelsScores(modelList, baseline_accuracy):
    models_names=[]
    scores_train=[]
    scores_val=[]
    scores_val_mut_escl=[]
    scores_stacking=[]
    scores_val_mut_escl_byDistrict=[]
    for model in modelList:
        models_names.append(model['name'])
        scores_train.append(model['score train'])
        scores_val.append(model['score validation'])
        scores_val_mut_escl.append(model['score val mut exclusive'])
        scores_val_mut_escl_byDistrict.append(model['score val mut exclusive by distric
    barplotScores(models_names, scores_train, scores_val, scores_val_mut_escl, scores_v
def plotDR(df, n_intervals=30, markersize=20, fontsize=12):
    pred2018=df.copy()
    breakpoints=(np.arange(0,1,1/n_intervals)+1/n_intervals).round(5)
    x_cols=(breakpoints-0.5/n_intervals).round(5)
    breakpoints=breakpoints[:-1]

    #function to assign an ID-interval x_cols according to which interval the input va
    def x_prob(proba):
        return x_cols[bisect(breakpoints, proba)]
    #assign a number from 0 to 1 according to the probability of democrat towards prob
    pred2018['DtoRproba']=(1-pred2018['won_pred']-pred2018['rel_won_proba']).abs()
    #use x_prob to assign in which interval each observation lies
    pred2018['x']=pred2018['DtoRproba'].apply(x_prob)
    #assign the y position in the scatterplot for each observation: for each x-positio
    for x_col in x_cols:
        pred2018.loc[pred2018['x']==x_col, 'y']=np.arange(sum(pred2018['x']==x_col))
    #Define color ID: according to prediction probability and correctness of predictio
    midColor=0.5 #color for 50% probability values: 0.0=completely white, 0.5=max
    pred2018['color_strength']=midColor*pred2018['rel_won_proba'].apply(x_prob)+midColo
    pred2018['colorID']=(1-pred2018['won_pred']-pred2018['color_strength']).abs() #con
    pred2018['colorID']=(((~pred2018['correct_pred']).astype(float)-pred2018['colorID']
    #Define colors
    colorsDR=(['#0869ac', '#ffffff', '#d00d0f'])
    #Define linear color space
    line_cmap = LinearSegmentedColormap.from_list('my_cmap', colorsDR)
    line_norm = Normalize(vmin=0,vmax=1)
    #Assign color from color space according to color ID
    pred2018['color']=pred2018['colorID'].apply(line_cmap)
    fig, ax = plt.subplots(1, 1, figsize=(markersize*1.2/2, pred2018['y'].max()*markers
    fig.suptitle('2018 predictions vs actual results', fontsize=24, y=0.95)
    legend_elements = [plt.scatter([x_cols[0]], [0], marker='o', color=colorsDR[0], s=m
                       plt.scatter([x_cols[-1]], [0], marker='o', color=colorsDR[-1], s
    for color in pred2018['color'].unique():
```

```
            x=pred2018.loc[pred2018['color']==color, 'x']
            y=pred2018.loc[pred2018['color']==color, 'y']
            ax.scatter(x, y, color=color, s=markersize)
        ax.set_xlabel('\nD to R prediction probability', fontsize=fontsize)
        ax.set_ylabel('seats', fontsize=fontsize)
        x_ticks=np.arange(0,1.1,0.1)
        ax.set_xticks(x_ticks)
        x_tickslabels=['100% D', '90% D', '80% D', '70% D', '60% D', '50%', '60% R', '70% 
        #ax.set_xticklabels(['{:,.0%}'.format(x) for x in x_ticks])
        ax.set_xticklabels(x_tickslabels, fontsize=fontsize)
        #ax.set_xticks(pred2018['x'])
        ax.legend(handles=legend_elements, loc='upper center', shadow=True, fontsize=fonts
    def barPlotFeatImp(df):
        feat_df=df[['mean', 'std']].sort_values(by=['mean'], ascending=True).copy()
        fig, ax = plt.subplots(1, 1, figsize=(8, len(feat_df)/3))
        fig.suptitle('Feature importance', fontsize=24, y=1)
        ax.barh(feat_df.index, feat_df['mean'], alpha=0.5)
        ax.set_xlabel('Score')
    #plot staged scores on ax
    def plotScoreVsIter(boost, X, y, ax, label='Train set, AdaBoost', linestyle='-', color
        xticks=np.arange(1,len(boost.estimators_)+1)
        ax.plot(xticks, list(boost.staged_score(X,y)), linestyle, c=color, label = label)
    #plot a list of models scores
    def PlotAdaBoost3(modelList, X_train, y_train, X_test, y_test, title):
        fig, ax = plt.subplots(1, 1, figsize=(12, 8))
        fig.suptitle(title, fontsize=24, y=1.0)
        colors=sns.color_palette('colorblind', len(modelList))
        for model, c in zip(modelList, colors):
            plotScoreVsIter(model['model'], X_train, y_train, ax, 'Train set, {}'.format(mo
            plotScoreVsIter(model['model'], X_test, y_test, ax, 'Test set, {}'.format(model
        ax.set_xlabel('number of iterations')
        ax.set_ylabel('Score')
        lgd = ax.legend(bbox_to_anchor=(1, 0.1), loc='lower left', borderaxespad=1);
        #fig.savefig('samplefigure', bbox_extra_artists=(lgd,), bbox_inches='tight') #to a
        #I choosed to use the same color for train and test sets and changing only the lin
        #It is more convenient when displaying more than one boosting model
        #As a future improvement I would split the legend in 2, one for colors and one for
```

Feature engineering

Partisanship

`deductPartisanship`: - for a given `x_train` set, we look at the prevalence of one party to win in each district, looking at the `y_train` data. - a district is partisan for a specific party, if the winning rate of that party in history is greater than 66.7%. (we assign 3=traditionally Republican, 2=traditionally Democrat) - if no parties have a winning rate grater than 2/3 (66.7%), then that is a "swing district" (we assign 1) - if we don't have enough historical data, because the district is new, we don't conclude anything (we assign 0)

Then with `assignPartisanship` we assign the 3,2,1 or 0 value for partisanship to each district in the `x_test` data, using the `deductPartisanship` function.

This is a model by itself, with a train step and a predict step. When using this feature into another model, we do a kind of stacking, in fact.

```
In [8]: def deductPartisanship(trainData):
            #compute the prevalence of one party win against the other
            house_df_all_districts=trainData[(trainData['won']==1)].groupby(['state', 'distric
            house_df_all_districts['R_occurence']=house_df_all_districts['party'].str.count('R

            avgHistData=house_df_all_districts['party'].str.len().mean() #Average amount of hi
            histDataThreshold=avgHistData/2

            #3=traditionally Republican district
            #2=traditionally Democrat district
            #1=swing district
            #0=Recent district (Not enough historical data)
            house_df_all_districts['partisanship']=(house_df_all_districts['party'].str.len()>
                              (house_df_all_districts['R_occurence']>(2/3))*3
                            + (house_df_all_districts['R_occurence']<=(1/3))*2
                            + ((house_df_all_districts['R_occurence']>(1/3))
                              &(house_df_all_districts['R_occurence']<=(2/3)))*1
                            )
            house_df_all_districts['partisanship']=house_df_all_districts['partisanship'].asty
            return house_df_all_districts[['state', 'district', 'partisanship']]

        def assignPartisanship(x_train, y_train, indexed_districts, x_test):
            train_df=x_train.copy()
            train_df['won']=y_train
            train_df=indexed_districts.join(train_df).dropna()
            test_df=indexed_districts.join(x_test.copy()).dropna()

            out_df=test_df.join(deductPartisanship(train_df).set_index(['state', 'district']),
            out_df['partisanship']=out_df['partisanship'].astype(int)
            return out_df
```

Design features, drop features

In the `designFeatures` function we applied mathematical transformations, convert strings to numbers, produced an amount of interaction terms, fixed a bug in the `first_time_elected` feature.

The partisanship function gives an indication in case a district is traditionally tied to a party rather than the other.

All features referring to an absolute party (R or D) have been changed so that they relate to the candidate's party, instead. For example, the district partisanship (democrat or republican or none) is changed to district partisanship for candidate's party.

To decide which columns to drop, we looked at the feature importance of the logistic regression model.

```
In [9]: def designFeatures(x_train, y_train, indexed_districts, df):
            df_out=df.copy()
```

```python
    #first_time_elected relative to election year and non-negative
    df_out.loc[df_out['first_time_elected']>0, 'first_time_elected']=df_out['year']-df_
    df_out.loc[df_out['first_time_elected']<0, 'first_time_elected']=0

    #Assign district partisanship
    df_out=assignPartisanship(x_train, y_train, indexed_districts, df_out)

    #calculate Log10 of fundraising
    df_out['Log10fundraising']=df_out['fundraising']
    df_out.loc[df_out['Log10fundraising']<=0, 'Log10fundraising']=np.NaN
    df_out['Log10fundraising']=np.log10(df_out['Log10fundraising']) #take the log10
    df_out.loc[df_out['Log10fundraising'].isna(), 'Log10fundraising']=0

    #president party is same party as candidate
    df_out['own_president_party']=(df_out['president_party']==df_out['party']).astype(
    df_out['own_last_house_majority']=(df_out['last_house_majority']==df_out['party'])

    #replace 'D' and 'R' with 0 and 1
    df_out['party']=df_out['party'].replace(['D', 'R'], [0, 1])
    df_out['president_party']=df_out['president_party'].replace(['D', 'R'], [0, 1])
    df_out['last_house_majority']=df_out['last_house_majority'].replace(['D', 'R'], [0

    #Is district partisan of the candidate's party?
    df_out['ownPartisan']=((df_out['partisanship'].astype(int))-df_out['party'].astype
    df_out['swingDistrict']=(df_out['partisanship'].astype(int)==1).astype(int)
    df_out=pd.get_dummies(df_out, columns=['partisanship'], drop_first=True) #

    #Ratio of R vs D seats before election. Percentage of opponent seats in House
    df_out['last_R_vs_D_Seats']=df_out['last_R_house_seats']/(df_out['last_R_house_sea
    df_out=df_out.drop('last_R_house_seats', axis=1).drop('last_D_house_seats', axis=1

    #Percentage of own party seats in House. Non-linear interaction term (because of a
    df_out['last_own_party_Seats']=(1-df_out['party']-df_out['last_R_vs_D_Seats']).abs

    #President job approval or opposition
    df_out['own_president_job_approval']=((df_out['own_president_party']).abs()*df_out
    df_out['president_opposition_job_approval']=((df_out['party']-df_out['president_pa

    #Own president unemployment rate or opposition
    df_out['unemployement_rate_own_president']=df_out['own_president_party']*df_out['u
    df_out['unemployement_rate_president_opposition']=(df_out['party']-df_out['presider
    return df_out

def drop_features(df):
    df_out=df.copy()

    #drop linear fundraising
```

```
    df_out=df_out.drop('fundraising', axis=1)

    #drop party-related features
    df_out=df_out.drop('last_R_vs_D_Seats', axis=1) #
    df_out=df_out.drop('president_party', axis=1) #
    #df_out=df_out.drop('party', axis=1)
    df_out=df_out.drop('last_house_majority', axis=1) #

    #drop president-related features, without specification for candidates party
    df_out=df_out.drop('president_can_be_re_elected', axis=1) #
    df_out=df_out.drop('president_overall_avg_job_approval', axis=1) #

    #drop low importance features
    df_out=df_out.drop('is_presidential_year', axis=1) #
    #df_out=df_out.drop('year', axis=1)
    #df_out=df_out.drop('own_president_party', axis=1) #
    if 'partisanship_1' in list(df_out): #check before dropping: districts which are '
        df_out=df_out.drop('partisanship_1', axis=1)
    #df_out=df_out.drop('partisanship_2', axis=1)
    #df_out=df_out.drop('partisanship_3', axis=1)

    #drop collinear features
    df_out=df_out.drop('unemployement_rate', axis=1)
    #df_out=df_out.drop('first_time_elected', axis=1)
    #df_out=df_out.drop('count_victories', axis=1)
    #df_out=df_out.drop('is_incumbent', axis=1)

    return df_out
```

Functions for running predictions and compute accuracy

Mutual exclusive selection

The `MutuallyExclusivePredictions` function is used to tangibly increase the prediction accuracy, leveraging the fact that we need one winner per district: - calculates score of the fitted input `model` on training and test set - perform a mutual exclusive win assignment - return predictions and all three accuracy scores (train, test, test mutual exclusive)

About the mutual exclusive assignment, at that point we have a prediction per each candidate, but we don't check to have only one predicted winner per district, so we need to take only one winner per district: - Group by district and assign win only to the candidate with highest win probability - In case of more than one candidate with exact the same winning probability in the same district: - If those candidates belong to the same party, assign win only to the first one (in our scope we care about the winning party, not the candidate) - If those candidates belong to different parties, we can say nothing therefore we don't have a winner prediction for that district - Calculate the accuracy score of the resulting predictions - The accuracy score of the candidates predictions at this point, is affected by a little component of randomness, as in case of conflict between candidates of the same party, we take the first one. But that is lower or equal, not greater than the score having selected the "right" candidate when taking the first one. So we should not take it for comparison between models, rather to see that the score has increased from simple cross validation score - The `MutuallyExclusivePredictions` function displays a detailed report during execution, which helps understanding the results. In case of more than one winner per district, it will prompt a warning, followed by the list of affected districts and all the details related to the first occurrence

```
In [10]: def MutuallyExclusivePredictions(model, x_train, x_test, y_train, y_test, indexed_dis
             #y_test is used only for accuracy score

             x_traincopy=x_train.copy()
             x_testcopy=x_test.copy()

             def Accuracy(y, y_pred):
                 return np.sum(y == y_pred) / len(y)

             #predict results
             y_pred_train=model.predict(x_traincopy)
             y_pred_test=model.predict(x_testcopy)

             #calculate accuracy
             Accu_train=Accuracy(y_train, y_pred_train)
             Accu_val=Accuracy(y_test, y_pred_test)

             #At this stage, our predictions could lead to more than one winner per district (
             #We will take the maximum prediction probabilities to be sure to have one and onl
             #predict probabilities
             #y_pred_train=model.predict_proba(x_traincopy)[:,1]
             y_pred_test=model.predict_proba(x_testcopy)[:,1]

             #Add index to predictions from X set
             #y_pred_train_df=pd.DataFrame(y_pred_train, index=x_traincopy.index, columns=['ab
             y_pred_test_df=pd.DataFrame(y_pred_test, index=x_testcopy.index, columns=['abs_wo

             #Join party data to train and test datasets by index
             if 'party' not in list(x_traincopy):
                 #x_traincopy=indexed_party.join(x_traincopy).dropna()
                 x_testcopy=indexed_party.join(x_testcopy).dropna()

             #Join district data, party and predictions by index
             #districts_pred_train=indexed_districts.join(x_traincopy[['party']]).join(y_pred_
             districts_pred_test=indexed_districts.join(x_testcopy[['party']]).join(y_pred_tes

             #Group by district and aggregate predictions with max probability
             districts_pred_test_grouped=districts_pred_test.groupby(['state', 'district']).ag
             districts_pred_test_grouped.columns = ['max_won_proba', 'sum_won_proba']
             districts_pred_test_grouped = districts_pred_test_grouped.reset_index(drop=False)

             #Create won_pred response variable (at this stage we have only the winner candida
             districts_pred_test_grouped['won_pred']=1
```

```
    #join district and party data with max predictions probabilities
    out_df=districts_pred_test.join(districts_pred_test_grouped.set_index(['state', 'd

    #join district and party data with sum predictions probabilities
    out_df=out_df.join(districts_pred_test_grouped.set_index(['state', 'district'])['s

    #calculate relative probability. That takes into account the predictions of the o
    out_df['rel_won_proba']=out_df['abs_won_proba']/out_df['sum_won_proba']

    #check to have only and one only winner per district
    districtWinners=out_df.groupby(['state', 'district'])['won_pred'].sum().reset_inde
    NotJustOneWinner=districtWinners[districtWinners['won_pred']!=1]
    if (len(NotJustOneWinner)>0):
        #display warning
        warnings.warn("\n{} districts have no winner or more than one winner.\nFollow
        #print('List of affected districts:')
        display(districtWinners[districtWinners['won_pred']!=1])
        print('First occurrence from list:')
        display(out_df[(out_df['state']==NotJustOneWinner.iloc[0]['state'])&(out_df['d
        districts_x_test=indexed_districts.join(x_testcopy).join(y_pred_test_df).dropn
        print('Data of the occurrence from list:')
        display(districts_x_test[(districts_x_test['state']==NotJustOneWinner.iloc[0]
        #manage conflicts: if more than one candidate have the same prediction probab
        #if they are all from the same party, though, set the first to one (we aim to
        for state in NotJustOneWinner['state'].unique():
            for district in NotJustOneWinner[NotJustOneWinner['state']==state]['distri
                i=np.zeros(len(out_df.loc[(out_df['state']==state)&(out_df['district']
                if (len(out_df.loc[(out_df['state']==state)&(out_df['district']==distr
                    print('The conflict in {}, {} is between candidates from the same
                    i[0]=1
                out_df.loc[(out_df['state']==state)&(out_df['district']==district)&(ou
                #display(out_df.loc[(out_df['state']==state)&(out_df['district']==dis
    #assert len(NotJustOneWinner) == 0, "{} districts have no winner or more than one

    #validation accuracy score
    Accu_val_2=Accuracy(y_test, out_df['won_pred'])

    return Accu_train, Accu_val, Accu_val_2, out_df.drop('sum_won_proba', axis=1)
```

The pre_process function is meant to put together a sequence of actions which is repeated multiple times through the study: split, feature engineering, feature drop, standardization

```
In [11]: #pre-process of the data: split, design features, standardization
         def pre_process(df, year):
             #split dataset
             x_train, y_train, x_test, y_test, df_districts, df_party = splitDf(df, year)

             #designFeatures
```

```
        x_train_designFeatures=designFeatures(x_train, y_train, df_districts, x_train)
        x_test_designFeatures=designFeatures(x_train, y_train, df_districts, x_test)

        #drop features
        x_train_designFeatures=drop_features(x_train_designFeatures)
        x_test_designFeatures=drop_features(x_test_designFeatures)

        #Standardize
        columns=list(x_train_designFeatures.select_dtypes(include='float'))
        scaler = StandardScaler().fit(x_train_designFeatures[columns])
        x_train_designFeatures.loc[:, columns]=scaler.transform(x_train_designFeatures[co
        x_test_designFeatures.loc[:, columns]=scaler.transform(x_test_designFeatures[colu

        #remove columns which are not in both datasets (it can happen with partisanship_1
        x_train_designFeatures=x_train_designFeatures[list(x_test_designFeatures)]

        return x_train_designFeatures, x_test_designFeatures, y_train, y_test, df_distric
```

Function for cross-validation

The `modelListTrain` is training all models, performing cross-validation through the years: - it is taking a list of models, in form of a list of dictionaries - given a list of years, the dataset is split and transformed using the `pre_process` function - for each year: - the current year is taken as validation fold, while the rest of the dataset is used as training set - for each model: - the function `MutuallyExclusivePredictions` is used to generate predictions and calculate training score, validation score and mutually exclusive validation score - we include the missing districts, if any, after having consolidated predictions taking only the winner per each district, then recalculate accuracy per district using the `districtAccuracy` function - the cross-validation accuracy scores are stored in the model dictionary

```
In [12]: #train all models doing cross-validation through the years and store accuracy
         def modelListTrain(modelList, train_df, years):
             train_data=train_df.copy()
             for i in range(len(modelList)):
                 model=modelList[i]
                 #intialize lists
                 train_acc=[] #list with training accuracy
                 val_acc=[] #list with validation accuracy
                 val_acc_2=[] #list with mutually exclusive validation accuracy
                 Accu_val_2_byDistrict=[] #list with mutually exclusive validation accuracy by
                 for year in years:
                     print('model: {}'.format(model['name']))
                     print('year: {}'.format(year))

                     #pre_process
                     x_train_designFeatures, x_test_designFeatures, y_train, y_test, house_df_

                     #fit model
                     fitted_model=model['model'].fit(x_train_designFeatures, y_train)
```

```
            #generate predictions and calculate accuracy
            Accu_train, Accu_val, Accu_val_2, pred_df = MutuallyExclusivePredictions(

            #store accuracy
            train_acc.append(Accu_train)
            val_acc.append(Accu_val)
            val_acc_2.append(Accu_val_2)
            Accu_val_2_byDistrict.append(districtAccuracy(pred_df[pred_df['won_pred']

            #print accuracy scores
            print('Training accuracy: {:.2%}\nValidation accuracy: {:.2%}\nMutually e
        #plot this model scores through years
        title='Scores of model {} through years'.format(modelList[i]['name'])
        plotYearscores(years, train_acc, val_acc, val_acc_2, Accu_val_2_byDistrict, t
        #store model scores into model list (mean of all years folds)
        modelList[i]['score train']=np.mean(train_acc)
        modelList[i]['score validation']=np.mean(val_acc)
        modelList[i]['score val mut exclusive']=np.mean(val_acc_2)
        modelList[i]['score val mut exclusive by district']=np.mean(Accu_val_2_byDist

    display(modelList)
```

Define test and training data

We consider our training set on data starting from `yearStart` until before 2018, then test set on 2018 data.

```
In [13]: #training set on data starting from yearStart until before 2018, test set on 2018 dat
         yearStart=1900
         #train_data=house_df[(house_df['is_presidential_year']==0)&(house_df['year']>=yearSta
         #test_data=house_df[house_df['year']==2018]
         train_data, test_data = house_df[(house_df['year']>=yearStart)&(house_df['year']<2018
```

Then we select for which years we want to perform cross-validation. We take the last ten mid-term elections before 2018

```
In [14]: #Years lists for cross-validation folds
         Midterm_recent_years=2014-4*np.arange(10)
         display(Midterm_recent_years)
```

```
array([2014, 2010, 2006, 2002, 1998, 1994, 1990, 1986, 1982, 1978])
```

The model list

Here we define a model list in form of list of dictionaries.

The hyper-parameters of decision trees, random forests and boosting algorithms have been selected by running specific functions plotting indicators from several configurations (see at the end of the notebook)

```
In [15]: #define models to be trained
         modelList=[]
         #Logistic regression
         model=dict()
         model['name']='Logistic Regression CV=5'
         model['model']=LogisticRegressionCV(cv=5, penalty='l2', max_iter=2500)
         modelList.append(model)
         #Logistic regression
         #model=dict()
         #model['name']='Logistic Regression CV=5, penalty=l1'
         #model['model']=LogisticRegressionCV(cv=5, penalty='l1', solver='liblinear', max_iter
         #modelList.append(model)
         #LDA
         model=dict()
         model['name']='LDA'
         model['model']=LinearDiscriminantAnalysis(store_covariance=True)
         modelList.append(model)
         #Simple decision tree
         max_depth=4
         model=dict()
         model['name']='Decision Tree, depth={}'.format(max_depth)
         model['model']=DecisionTreeClassifier(max_depth = max_depth)
         modelList.append(model)
         #Simple decision tree
         #max_depth=11
         #model=dict()
         #model['name']='Decision Tree, depth={}'.format(max_depth)
         #model['model']=DecisionTreeClassifier(max_depth = max_depth)
         #modelList.append(model)
         #Random forest
         max_depth=17
         n_trees=100
         model=dict()
         model['name']='Random Forest of {} depth-{} trees'.format(n_trees, max_depth)
         model['model']=RandomForestClassifier(n_estimators=n_trees, max_depth=max_depth )
         modelList.append(model)
         #Boosting
         max_depth=1
         n_trees=400
         lrate=0.01
         abc = AdaBoostClassifier(base_estimator=DecisionTreeClassifier(max_depth=max_depth), 
         model=dict()
         model['name']='AdaBoost Classifier {} depth-{} trees'.format(n_trees, max_depth)
         model['model']=abc
         modelList.append(model)
```

Run cross-validation predictions and compute accuracy

- Here we execute the whole process of folds definition, pre-process, predictions and accuracy computation per each fold and then cross-validate.

- We can see the detailed report which helps us understand better the results
- At the end of the report, we see a plot of how each model performs through the years

```
In [16]: #train models using cross-validation through the years and calculate accuracies
         modelListTrain(modelList, train_data, Midterm_recent_years)
```

```
model: Logistic Regression CV=5
year: 2014
Training accuracy: 88.19%
Validation accuracy: 89.88%
Mutually exclusive validation accuracy: 91.75%
Mutually exclusive validation accuracy by district: 92.56%

model: Logistic Regression CV=5
year: 2010
Training accuracy: 88.46%
Validation accuracy: 84.09%
Mutually exclusive validation accuracy: 82.95%
Mutually exclusive validation accuracy by district: 83.64%

model: Logistic Regression CV=5
year: 2006


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


     state     district  won_pred
247  Texas  District 22       2.0


First occurrence from list:


      state     district  party  abs_won_proba  won_pred  sum_won_proba  \
5537  Texas  District 22    0.0       0.161234       0.0       0.624092
5538  Texas  District 22    1.0       0.231429       1.0       0.624092
5539  Texas  District 22    1.0       0.231429       1.0       0.624092

      rel_won_proba
5537       0.258349
5538       0.370825
5539       0.370825
```

```
Data of the occurrence from list:


     state     district  is_incumbent  party      year  first_time_elected  \
5537  Texas  District 22     -0.905769    0.0  0.533415           -0.518873
5538  Texas  District 22     -0.905769    1.0  0.533415           -0.518873
5539  Texas  District 22     -0.905769    1.0  0.533415           -0.518873

     count_victories  Log10fundraising  own_president_party  \
5537       -0.518943          0.150083                  0.0
5538       -0.518943          0.150083                  1.0
5539       -0.518943          0.150083                  1.0

     own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5537                     0.0          0.0            0.0             0.0
5538                     1.0          0.0            0.0             0.0
5539                     1.0          0.0            0.0             0.0

     partisanship_3  last_own_party_Seats  own_president_job_approval  \
5537            0.0             -0.424937                   -0.984829
5538            0.0              0.424673                    0.954201
5539            0.0              0.424673                    0.954201

     president_opposition_job_approval  unemployement_rate_own_president  \
5537                          0.951740                         -0.913506
5538                         -0.987421                          0.315819
5539                         -0.987421                          0.315819

     unemployement_rate_president_opposition  abs_won_proba
5537                                 0.318491       0.161234
5538                                -0.918027       0.231429
5539                                -0.918027       0.231429


The conflict in Texas, District 22 is between candidates from the same party, so we predict as
Training accuracy: 88.25%
Validation accuracy: 87.96%
Mutually exclusive validation accuracy: 89.51%
Mutually exclusive validation accuracy by district: 90.07%

model: Logistic Regression CV=5
year: 2002


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
3 districts have no winner or more than one winner.
Following the list of affected districts:
```

```
          state    district  won_pred
144   Louisiana  District 1       3.0
145   Louisiana  District 2       3.0
179  New Mexico  District 2       2.0
```

First occurrence from list:

```
          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4458  Louisiana  District 1    1.0       0.401848       1.0       1.205545
4460  Louisiana  District 1    1.0       0.401848       1.0       1.205545
4461  Louisiana  District 1    1.0       0.401848       1.0       1.205545

      rel_won_proba
4458       0.333333
4460       0.333333
4461       0.333333
```

Data of the occurrence from list:

```
          state    district  is_incumbent  party      year  \
4458  Louisiana  District 1     -0.924743    1.0  0.370007
4460  Louisiana  District 1     -0.924743    1.0  0.370007
4461  Louisiana  District 1     -0.924743    1.0  0.370007

      first_time_elected  count_victories  Log10fundraising  \
4458           -0.532362        -0.531787         -2.013639
4460           -0.532362        -0.531787         -2.013639
4461           -0.532362        -0.531787         -2.013639

      own_president_party  own_last_house_majority  ownPartisan  \
4458                  1.0                      1.0          1.0
4460                  1.0                      1.0          1.0
4461                  1.0                      1.0          1.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
4458            0.0             0.0             1.0              0.128864
4460            0.0             0.0             1.0              0.128864
4461            0.0             0.0             1.0              0.128864

      own_president_job_approval  president_opposition_job_approval  \
4458                     0.95807                          -0.991078
4460                     0.95807                          -0.991078
4461                     0.95807                          -0.991078

      unemployement_rate_own_president  \
```

```
4458                          0.698522
4460                          0.698522
4461                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4458                                -0.915336       0.401848
4460                                -0.915336       0.401848
4461                                -0.915336       0.401848


The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predict
Training accuracy: 88.68%
Validation accuracy: 83.76%
Mutually exclusive validation accuracy: 87.94%
Mutually exclusive validation accuracy by district: 89.70%

model: Logistic Regression CV=5
year: 1998
Training accuracy: 88.23%
Validation accuracy: 93.94%
Mutually exclusive validation accuracy: 95.67%
Mutually exclusive validation accuracy by district: 95.90%

model: Logistic Regression CV=5
year: 1994
Training accuracy: 88.37%
Validation accuracy: 89.22%
Mutually exclusive validation accuracy: 89.22%
Mutually exclusive validation accuracy by district: 89.53%

model: Logistic Regression CV=5
year: 1990
Training accuracy: 88.52%
Validation accuracy: 86.52%
Mutually exclusive validation accuracy: 91.49%
Mutually exclusive validation accuracy by district: 91.89%

model: Logistic Regression CV=5
year: 1986
Training accuracy: 88.50%
Validation accuracy: 89.39%
Mutually exclusive validation accuracy: 95.45%
Mutually exclusive validation accuracy by district: 95.52%

model: Logistic Regression CV=5
year: 1982
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
36  California  District 43       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2513  California  District 43    1.0       0.231145       1.0       0.654716
2528  California  District 43    0.0       0.192425       0.0       0.654716
2569  California  District 43    1.0       0.231145       1.0       0.654716

      rel_won_proba
2513       0.353047
2528       0.293907
2569       0.353047


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2513  California  District 43     -0.909482    1.0 -0.412345
2528  California  District 43     -0.909482    0.0 -0.412345
2569  California  District 43     -0.909482    1.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2513             -0.5259        -0.525692         -0.062539
2528             -0.5259        -0.525692         -0.062539
2569             -0.5259        -0.525692         -0.062539

      own_president_party  own_last_house_majority  ownPartisan  \
2513                  1.0                      0.0          0.0
2528                  0.0                      1.0          0.0
2569                  1.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2513            1.0             0.0             0.0             -0.734935
2528            1.0             0.0             0.0              0.736978
2569            1.0             0.0             0.0             -0.734935

      own_president_job_approval  president_opposition_job_approval  \
```

```
2513                  1.094421                          -0.990568
2528                 -0.982864                           1.087002
2569                  1.094421                          -0.990568

      unemployement_rate_own_president  \
2513                          2.074204
2528                         -0.910201
2569                          2.074204

      unemployement_rate_president_opposition  abs_won_proba
2513                                -0.919018       0.231145
2528                                 2.085907       0.192425
2569                                -0.919018       0.231145


The conflict in California, District 43 is between candidates from the same party, so we predi
Training accuracy: 88.48%
Validation accuracy: 87.50%
Mutually exclusive validation accuracy: 87.50%
Mutually exclusive validation accuracy by district: 89.55%

model: Logistic Regression CV=5
year: 1978
Training accuracy: 88.37%
Validation accuracy: 85.09%
Mutually exclusive validation accuracy: 87.72%
Mutually exclusive validation accuracy by district: 88.14%

model: LDA
year: 2014
Training accuracy: 86.14%
Validation accuracy: 90.38%
Mutually exclusive validation accuracy: 92.00%
Mutually exclusive validation accuracy by district: 92.79%

model: LDA
year: 2010
Training accuracy: 86.83%
Validation accuracy: 81.63%
Mutually exclusive validation accuracy: 82.95%
Mutually exclusive validation accuracy by district: 83.64%

model: LDA
year: 2006


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
```

Following the list of affected districts:

	state	district	won_pred
247	Texas	District 22	2.0

First occurrence from list:

	state	district	party	abs_won_proba	won_pred	sum_won_proba	\
5537	Texas	District 22	0.0	0.062984	0.0	0.284783	
5538	Texas	District 22	1.0	0.110899	1.0	0.284783	
5539	Texas	District 22	1.0	0.110899	1.0	0.284783	

	rel_won_proba
5537	0.221166
5538	0.389417
5539	0.389417

Data of the occurrence from list:

	state	district	is_incumbent	party	year	first_time_elected	\
5537	Texas	District 22	-0.905769	0.0	0.533415	-0.518873	
5538	Texas	District 22	-0.905769	1.0	0.533415	-0.518873	
5539	Texas	District 22	-0.905769	1.0	0.533415	-0.518873	

	count_victories	Log10fundraising	own_president_party	\
5537	-0.518943	0.150083	0.0	
5538	-0.518943	0.150083	1.0	
5539	-0.518943	0.150083	1.0	

	own_last_house_majority	ownPartisan	swingDistrict	partisanship_2	\
5537	0.0	0.0	0.0	0.0	
5538	1.0	0.0	0.0	0.0	
5539	1.0	0.0	0.0	0.0	

	partisanship_3	last_own_party_Seats	own_president_job_approval	\
5537	0.0	-0.424937	-0.984829	
5538	0.0	0.424673	0.954201	
5539	0.0	0.424673	0.954201	

	president_opposition_job_approval	unemployement_rate_own_president	\
5537	0.951740	-0.913506	
5538	-0.987421	0.315819	
5539	-0.987421	0.315819	

```
      unemployement_rate_president_opposition  abs_won_proba
5537                                 0.318491       0.062984
5538                                -0.918027       0.110899
5539                                -0.918027       0.110899
```

```
The conflict in Texas, District 22 is between candidates from the same party, so we predict as
Training accuracy: 86.47%
Validation accuracy: 88.16%
Mutually exclusive validation accuracy: 89.51%
Mutually exclusive validation accuracy by district: 90.07%

model: LDA
year: 2002
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
3 districts have no winner or more than one winner.
Following the list of affected districts:


          state    district  won_pred
144   Louisiana  District 1       3.0
145   Louisiana  District 2       3.0
179  New Mexico  District 2       2.0


First occurrence from list:


          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4458  Louisiana  District 1    1.0       0.176881       1.0       0.530642
4460  Louisiana  District 1    1.0       0.176881       1.0       0.530642
4461  Louisiana  District 1    1.0       0.176881       1.0       0.530642

      rel_won_proba
4458       0.333333
4460       0.333333
4461       0.333333


Data of the occurrence from list:


          state    district  is_incumbent  party      year  \
4458  Louisiana  District 1     -0.924743    1.0  0.370007
4460  Louisiana  District 1     -0.924743    1.0  0.370007
4461  Louisiana  District 1     -0.924743    1.0  0.370007
```

```
      first_time_elected  count_victories  Log10fundraising  \
4458           -0.532362        -0.531787         -2.013639
4460           -0.532362        -0.531787         -2.013639
4461           -0.532362        -0.531787         -2.013639

      own_president_party  own_last_house_majority  ownPartisan  \
4458                  1.0                      1.0          1.0
4460                  1.0                      1.0          1.0
4461                  1.0                      1.0          1.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
4458            0.0             0.0             1.0              0.128864
4460            0.0             0.0             1.0              0.128864
4461            0.0             0.0             1.0              0.128864

      own_president_job_approval  president_opposition_job_approval  \
4458                     0.95807                          -0.991078
4460                     0.95807                          -0.991078
4461                     0.95807                          -0.991078

      unemployement_rate_own_president  \
4458                          0.698522
4460                          0.698522
4461                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4458                                -0.915336       0.176881
4460                                -0.915336       0.176881
4461                                -0.915336       0.176881


The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predict
Training accuracy: 87.21%
Validation accuracy: 72.85%
Mutually exclusive validation accuracy: 87.94%
Mutually exclusive validation accuracy by district: 89.70%

model: LDA
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


        state    district  won_pred
```

```
0  California  District 1       2.0


First occurrence from list:


           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.062131       0.0       0.193147
3719  California  District 1    1.0       0.065508       1.0       0.193147
3720  California  District 1    1.0       0.065508       1.0       0.193147

      rel_won_proba
3714       0.321677
3719       0.339161
3720       0.339161


Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714            1.0             0.0             0.0              -0.31434
3719            1.0             0.0             0.0               0.31661
3720            1.0             0.0             0.0               0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935

      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648
```

```
      unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.062131
3719                                 0.358830       0.065508
3720                                 0.358830       0.065508
```

```
The conflict in California, District 1 is between candidates from the same party, so we predic
Training accuracy: 86.37%
Validation accuracy: 91.77%
Mutually exclusive validation accuracy: 97.40%
Mutually exclusive validation accuracy by district: 97.54%

model: LDA
year: 1994
Training accuracy: 86.49%
Validation accuracy: 87.43%
Mutually exclusive validation accuracy: 89.22%
Mutually exclusive validation accuracy by district: 89.53%

model: LDA
year: 1990
Training accuracy: 86.50%
Validation accuracy: 86.52%
Mutually exclusive validation accuracy: 91.49%
Mutually exclusive validation accuracy by district: 91.89%

model: LDA
year: 1986
Training accuracy: 86.47%
Validation accuracy: 90.15%
Mutually exclusive validation accuracy: 93.94%
Mutually exclusive validation accuracy by district: 94.03%

model: LDA
year: 1982
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:
```

```
         state     district  won_pred
36  California  District 43       2.0
```

```
First occurrence from list:
```

```
           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2513  California  District 43    1.0       0.095103       1.0       0.241411   
2528  California  District 43    0.0       0.051206       0.0       0.241411   
2569  California  District 43    1.0       0.095103       1.0       0.241411   

      rel_won_proba  
2513       0.393945  
2528       0.212109  
2569       0.393945  


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2513  California  District 43     -0.909482    1.0 -0.412345   
2528  California  District 43     -0.909482    0.0 -0.412345   
2569  California  District 43     -0.909482    1.0 -0.412345   

      first_time_elected  count_victories  Log10fundraising  \
2513             -0.5259        -0.525692         -0.062539   
2528             -0.5259        -0.525692         -0.062539   
2569             -0.5259        -0.525692         -0.062539   

      own_president_party  own_last_house_majority  ownPartisan  \
2513                  1.0                      0.0          0.0   
2528                  0.0                      1.0          0.0   
2569                  1.0                      0.0          0.0   

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2513            1.0             0.0             0.0             -0.734935   
2528            1.0             0.0             0.0              0.736978   
2569            1.0             0.0             0.0             -0.734935   

      own_president_job_approval  president_opposition_job_approval  \
2513                    1.094421                          -0.990568   
2528                   -0.982864                           1.087002   
2569                    1.094421                          -0.990568   

      unemployement_rate_own_president  \
2513                          2.074204   
2528                         -0.910201   
2569                          2.074204   

      unemployement_rate_president_opposition  abs_won_proba  
2513                                -0.919018       0.095103  
2528                                 2.085907       0.051206  
2569                                -0.919018       0.095103  
```

```
The conflict in California, District 43 is between candidates from the same party, so we predi
Training accuracy: 86.50%
Validation accuracy: 86.72%
Mutually exclusive validation accuracy: 87.50%
Mutually exclusive validation accuracy by district: 89.55%

model: LDA
year: 1978
Training accuracy: 86.55%
Validation accuracy: 84.21%
Mutually exclusive validation accuracy: 87.72%
Mutually exclusive validation accuracy by district: 88.14%

model: Decision Tree, depth=4
year: 2014


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
22 districts have no winner or more than one winner.
Following the list of affected districts:


              state     district  won_pred
17         Arkansas   District 2       2.0
22       California  District 11       2.0
37       California  District 25       2.0
46       California  District 33       2.0
48       California  District 35       2.0
76         Colorado   District 4       2.0
158            Iowa   District 1       2.0
179           Maine   District 2       2.0
193   Massachusetts   District 6       2.0
199        Michigan  District 11       2.0
200        Michigan  District 12       2.0
201        Michigan  District 14       2.0
204        Michigan   District 4       2.0
208        Michigan   District 8       2.0
240      New Jersey   District 1       2.0
243      New Jersey  District 12       2.0
285  North Carolina  District 12       2.0
291  North Carolina   District 6       2.0
315        Oklahoma   District 5       2.0
385           Texas  District 36       2.0
412      Washington   District 4       2.0
426       Wisconsin   District 6       2.0
```

```
First occurrence from list:


         state     district  party  abs_won_proba  won_pred  sum_won_proba  \
8114  Arkansas  District 2    0.0       0.177745       1.0       0.355489
8120  Arkansas  District 2    1.0       0.177745       1.0       0.355489

      rel_won_proba
8114            0.5
8120            0.5


Data of the occurrence from list:


         state     district  is_incumbent  party      year  first_time_elected  \
8114  Arkansas  District 2     -0.904043    0.0  0.891256           -0.525298
8120  Arkansas  District 2     -0.904043    1.0  0.891256           -0.525298

      count_victories  Log10fundraising  own_president_party  \
8114        -0.525246          0.431761                  1.0
8120        -0.525246          0.210567                  0.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
8114                      0.0          0.0            1.0             0.0
8120                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
8114             0.0             -0.459887                    0.896607
8120             0.0              0.460877                   -0.980536

      president_opposition_job_approval  unemployement_rate_own_president  \
8114                          -0.991331                          0.909545
8120                           0.886373                         -0.908020

      unemployement_rate_president_opposition  abs_won_proba
8114                                -0.918595       0.177745
8120                                 0.902908       0.177745


The conflict in California, District 25 is between candidates from the same party, so we predic
The conflict in California, District 35 is between candidates from the same party, so we predic
The conflict in Washington, District 4 is between candidates from the same party, so we predict
Training accuracy: 88.80%
Validation accuracy: 90.50%
Mutually exclusive validation accuracy: 92.38%
Mutually exclusive validation accuracy by district: 90.93%

model: Decision Tree, depth=4
```

```
year: 2010


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
17 districts have no winner or more than one winner.
Following the list of affected districts:


           state     district  won_pred
4        Alabama   District 5       2.0
10       Arizona   District 3       2.0
16      Arkansas   District 1       2.0
17      Arkansas   District 2       2.0
30    California  District 19       3.0
45    California  District 33       2.0
84      Delaware     At-Large       2.0
104      Florida   District 5       2.0
142       Kansas   District 3       2.0
152    Louisiana   District 3       2.0
176  Mississippi   District 4       2.0
198     New York  District 20       2.0
221         Ohio   District 2       2.0
222         Ohio   District 3       2.0
223         Ohio   District 5       2.0
248        Texas  District 25       2.0
250        Texas  District 27       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
6569  Alabama  District 5    1.0       0.169442       1.0       0.338885
6570  Alabama  District 5    0.0       0.169442       1.0       0.338885

      rel_won_proba
6569            0.5
6570            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party     year  first_time_elected  \
6569  Alabama  District 5     -0.908171    1.0  0.69794           -0.518637
6570  Alabama  District 5     -0.908171    0.0  0.69794           -0.518637

      count_victories  Log10fundraising  own_president_party  \
6569        -0.519557          0.213818                  0.0
```

```
6570       -0.519557         0.254646                 1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
6569                      0.0          0.0            1.0             0.0
6570                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
6569             0.0             -1.156670                   -0.984363
6570             0.0              1.153816                    0.896663

      president_opposition_job_approval  unemployement_rate_own_president  \
6569                           0.892834                         -0.911645
6570                          -0.988160                          1.838533

      unemployement_rate_president_opposition  abs_won_proba
6569                                 1.860769       0.169442
6570                                -0.917740       0.169442


Training accuracy: 88.95%
Validation accuracy: 84.28%
Mutually exclusive validation accuracy: 84.66%
Mutually exclusive validation accuracy by district: 82.18%

model: Decision Tree, depth=4
year: 2006

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
12 districts have no winner or more than one winner.
Following the list of affected districts:


            state     district  won_pred
15        Arizona   District 8       2.0
86        Florida  District 11       2.0
108       Florida   District 9       2.0
110       Georgia  District 10       2.0
115       Georgia   District 3       2.0
120       Georgia   District 8       2.0
121       Georgia   District 9       2.0
137          Iowa   District 1       2.0
229  Pennsylvania  District 10       2.0
245         Texas  District 20       2.0
247         Texas  District 22       3.0
265       Vermont     At-Large       2.0

First occurrence from list:
```

```
       state    district  party  abs_won_proba  won_pred  sum_won_proba  \
5533  Arizona  District 8    0.0       0.188011       1.0       0.376022
5534  Arizona  District 8    1.0       0.188011       1.0       0.376022

      rel_won_proba
5533            0.5
5534            0.5
```

Data of the occurrence from list:

```
       state    district  is_incumbent  party      year  first_time_elected  \
5533  Arizona  District 8     -0.905769    0.0  0.533415           -0.518873
5534  Arizona  District 8     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5533        -0.518943          0.652626                  0.0
5534        -0.518943          0.652626                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5533                      0.0          0.0            0.0             0.0
5534                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5533             0.0             -0.424937                   -0.984829
5534             0.0              0.424673                    0.954201

      president_opposition_job_approval  unemployement_rate_own_president  \
5533                           0.951740                         -0.913506
5534                          -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5533                                 0.318491       0.188011
5534                                -0.918027       0.188011
```

Training accuracy: 88.69%
Validation accuracy: 89.32%
Mutually exclusive validation accuracy: 91.07%
Mutually exclusive validation accuracy by district: 89.34%

model: Decision Tree, depth=4
year: 2002

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
30 districts have no winner or more than one winner.
```

Following the list of affected districts:

	state	district	won_pred
4	Alabama	District 5	2.0
7	Arizona	District 1	2.0
9	Arizona	District 3	2.0
10	Arizona	District 4	2.0
14	Arizona	District 8	2.0
15	Arkansas	District 1	2.0
18	Arkansas	District 4	2.0
28	California	District 18	2.0
32	California	District 21	2.0
74	Colorado	District 4	2.0
93	Florida	District 2	2.0
98	Florida	District 24	2.0
100	Florida	District 3	2.0
102	Florida	District 5	2.0
122	Indiana	District 2	2.0
130	Iowa	District 1	2.0
132	Iowa	District 3	2.0
136	Kansas	District 3	2.0
144	Louisiana	District 1	3.0
145	Louisiana	District 2	3.0
151	Maine	District 2	2.0
169	Mississippi	District 4	2.0
179	New Mexico	District 2	2.0
192	New York	District 20	2.0
194	New York	District 22	2.0
198	New York	District 26	2.0
199	New York	District 27	2.0
208	North Carolina	District 2	2.0
222	Texas	District 17	2.0
223	Utah	District 1	2.0

First occurrence from list:

	state	district	party	abs_won_proba	won_pred	sum_won_proba	\
4511	Alabama	District 5	0.0	0.168421	1.0	0.336842	
4512	Alabama	District 5	1.0	0.168421	1.0	0.336842	

	rel_won_proba
4511	0.5
4512	0.5

Data of the occurrence from list:

```
       state    district  is_incumbent  party      year  first_time_elected  \
4511  Alabama  District 5     -0.924743    0.0  0.370007           -0.532362
4512  Alabama  District 5     -0.924743    1.0  0.370007           -0.532362

      count_victories  Log10fundraising  own_president_party  \
4511        -0.531787          0.005329                  0.0
4512        -0.531787          0.005329                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
4511                      0.0          0.0            1.0             0.0
4512                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
4511             0.0             -0.126579                   -0.981452
4512             0.0              0.128864                    0.958070

      president_opposition_job_approval  unemployement_rate_own_president  \
4511                           0.948793                         -0.905028
4512                          -0.991078                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4511                                 0.699480       0.168421
4512                                -0.915336       0.168421


The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predic
Training accuracy: 89.16%
Validation accuracy: 84.69%
Mutually exclusive validation accuracy: 87.24%
Mutually exclusive validation accuracy by district: 83.26%

model: Decision Tree, depth=4
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
0   California   District 1       3.0
83    New York  District 13       2.0
92    New York  District 22       2.0
97    New York  District 27       2.0
```

```
First occurrence from list:


           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.222222       1.0       0.666667
3719  California  District 1    1.0       0.222222       1.0       0.666667
3720  California  District 1    1.0       0.222222       1.0       0.666667

      rel_won_proba
3714       0.333333
3719       0.333333
3720       0.333333


Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714            1.0             0.0             0.0              -0.31434
3719            1.0             0.0             0.0               0.31661
3720            1.0             0.0             0.0               0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935

      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648

      unemployement_rate_president_opposition  abs_won_proba
```

```
3714                                -0.917771       0.222222
3719                                 0.358830       0.222222
3720                                 0.358830       0.222222


Training accuracy: 88.68%
Validation accuracy: 93.94%
Mutually exclusive validation accuracy: 97.40%
Mutually exclusive validation accuracy by district: 95.90%

model: Decision Tree, depth=4
year: 1994


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
37  California  District 44       2.0
64       Maine   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
3294  California  District 44    0.0       0.220151       1.0       0.440303
3354  California  District 44    1.0       0.220151       1.0       0.440303

      rel_won_proba
3294            0.5
3354            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
3294  California  District 44     -0.907499    0.0  0.052753
3354  California  District 44     -0.907499    1.0  0.052753

      first_time_elected  count_victories  Log10fundraising  \
3294           -0.527344        -0.527182           0.30113
3354           -0.527344        -0.527182           0.30113

      own_president_party  own_last_house_majority  ownPartisan  \
3294                  1.0                      1.0          0.0
```

```
3354                 0.0                     0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3294            1.0             0.0             0.0              1.195709
3354            1.0             0.0             0.0             -1.193918

      own_president_job_approval  president_opposition_job_approval  \
3294                    1.187299                          -0.990527
3354                   -0.983013                           1.180121

      unemployement_rate_own_president  \
3294                          0.733431
3354                         -0.907410

      unemployement_rate_president_opposition  abs_won_proba
3294                                -0.915850       0.220151
3354                                 0.736017       0.220151


Training accuracy: 88.83%
Validation accuracy: 88.02%
Mutually exclusive validation accuracy: 89.22%
Mutually exclusive validation accuracy by district: 88.37%

model: Decision Tree, depth=4
year: 1990


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


       state    district  won_pred
45  Colorado  District 4       2.0
70   Vermont    At-Large       2.0


First occurrence from list:


         state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3062  Colorado  District 4    0.0       0.219359       1.0       0.438717
3063  Colorado  District 4    1.0       0.219359       1.0       0.438717

      rel_won_proba
3062            0.5
3063            0.5
```

```
Data of the occurrence from list:


         state    district  is_incumbent  party      year  first_time_elected  \
3062  Colorado  District 4     -0.907765    0.0 -0.102275           -0.523513
3063  Colorado  District 4     -0.907765    1.0 -0.102275           -0.523513

      count_victories  Log10fundraising  own_president_party  \
3062        -0.523862          0.379619                  0.0
3063        -0.523862          0.379619                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
3062                      1.0          0.0            1.0             0.0
3063                      0.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
3062             0.0              1.237058                   -0.983563
3063             0.0             -1.234712                    1.420308

      president_opposition_job_approval  unemployement_rate_own_president  \
3062                           1.413230                         -0.907511
3063                          -0.991066                          0.762707

      unemployement_rate_president_opposition  abs_won_proba
3062                                 0.765490       0.219359
3063                                -0.915934       0.219359


Training accuracy: 88.89%
Validation accuracy: 85.82%
Mutually exclusive validation accuracy: 90.07%
Mutually exclusive validation accuracy by district: 89.19%

model: Decision Tree, depth=4
year: 1986


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
6 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
11  California   District 2       2.0
13  California  District 21       2.0
54    Maryland   District 8       2.0
62        Utah   District 2       2.0
65    Virginia   District 2       2.0
```

```
First occurrence from list:


          state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2735  California  District 12    1.0        0.21814       1.0        0.43628
2736  California  District 12    0.0        0.21814       1.0        0.43628

      rel_won_proba
2735            0.5
2736            0.5


Data of the occurrence from list:


          state     district  is_incumbent  party    year  \
2735  California  District 12     -0.909019    1.0 -0.2572
2736  California  District 12     -0.909019    0.0 -0.2572

      first_time_elected  count_victories  Log10fundraising  \
2735           -0.523678        -0.523866          0.634395
2736           -0.523678        -0.523866          0.634395

      own_president_party  own_last_house_majority  ownPartisan  \
2735                  1.0                      0.0          0.0
2736                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2735            1.0             0.0             0.0             -1.027179
2736            1.0             0.0             0.0              1.029704

      own_president_job_approval  president_opposition_job_approval  \
2735                    1.094214                          -0.990337
2736                   -0.983083                           1.087296

      unemployement_rate_own_president  \
2735                          1.078907
2736                         -0.907294

      unemployement_rate_president_opposition  abs_won_proba
2735                                -0.915517        0.21814
2736                                 1.084153        0.21814


Training accuracy: 88.88%
Validation accuracy: 90.91%
Mutually exclusive validation accuracy: 92.42%
```

```
Mutually exclusive validation accuracy by district: 88.06%

model: Decision Tree, depth=4
year: 1982


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
6 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
9   California  District 18       2.0
19  California  District 27       2.0
36  California  District 43       3.0
37  California  District 44       2.0
40  California   District 6       2.0


First occurrence from list:


          state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2445  California  District 12    1.0       0.217566       1.0       0.435132
2500  California  District 12    0.0       0.217566       1.0       0.435132

      rel_won_proba
2445            0.5
2500            0.5


Data of the occurrence from list:


          state     district  is_incumbent  party      year  \
2445  California  District 12     -0.909482    1.0 -0.412345
2500  California  District 12     -0.909482    0.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2445             -0.5259        -0.525692          0.634763
2500             -0.5259        -0.525692          0.634763

      own_president_party  own_last_house_majority  ownPartisan  \
2445                  1.0                      0.0          0.0
2500                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2445            1.0             0.0             0.0             -0.734935
```

```
2500           1.0             0.0             0.0              0.736978

     own_president_job_approval  president_opposition_job_approval  \
2445                   1.094421                          -0.990568
2500                  -0.982864                           1.087002

     unemployement_rate_own_president  \
2445                         2.074204
2500                        -0.910201

     unemployement_rate_president_opposition  abs_won_proba
2445                                -0.919018       0.217566
2500                                 2.085907       0.217566


Training accuracy: 88.92%
Validation accuracy: 85.94%
Mutually exclusive validation accuracy: 90.62%
Mutually exclusive validation accuracy by district: 86.57%

model: Decision Tree, depth=4
year: 1978


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
9   California  District 18       2.0
25  California  District 33       2.0
42    Colorado   District 3       2.0
48       Maine   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2214  California  District 18    1.0       0.218861       1.0       0.437722
2216  California  District 18    0.0       0.218861       1.0       0.437722

     rel_won_proba
2214           0.5
2216           0.5


Data of the occurrence from list:
```

```
           state     district  is_incumbent  party      year  \
2214  California  District 18     -0.908567    1.0 -0.567381
2216  California  District 18     -0.908567    0.0 -0.567381

      first_time_elected  count_victories  Log10fundraising  \
2214           -0.525551        -0.525457          0.147788
2216           -0.525551        -0.525457          0.147788

      own_president_party  own_last_house_majority  ownPartisan  \
2214                  0.0                      0.0          0.0
2216                  1.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2214            1.0             0.0             0.0             -2.209922
2216            1.0             0.0             0.0              2.212019

      own_president_job_approval  president_opposition_job_approval  \
2214                   -0.983016                           0.796337
2216                    0.803759                          -0.990708

      unemployement_rate_own_president  \
2214                         -0.907662
2216                          0.734766

      unemployement_rate_president_opposition  abs_won_proba
2214                                 0.737173       0.218861
2216                                -0.916271       0.218861


Training accuracy: 89.04%
Validation accuracy: 83.33%
Mutually exclusive validation accuracy: 85.96%
Mutually exclusive validation accuracy by district: 83.05%

model: Random Forest of 100 depth-17 trees
year: 2014
Training accuracy: 97.73%
Validation accuracy: 90.88%
Mutually exclusive validation accuracy: 94.50%
Mutually exclusive validation accuracy by district: 94.88%

model: Random Forest of 100 depth-17 trees
year: 2010
Training accuracy: 97.79%
Validation accuracy: 81.25%
Mutually exclusive validation accuracy: 85.23%
Mutually exclusive validation accuracy by district: 85.82%
```

```
model: Random Forest of 100 depth-17 trees
year: 2006


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


     state     district  won_pred
247  Texas  District 22       2.0


First occurrence from list:


      state     district  party  abs_won_proba  won_pred  sum_won_proba  \
5537  Texas  District 22    0.0       0.164447       0.0       1.283114
5538  Texas  District 22    1.0       0.559334       1.0       1.283114
5539  Texas  District 22    1.0       0.559334       1.0       1.283114

      rel_won_proba
5537       0.128163
5538       0.435919
5539       0.435919


Data of the occurrence from list:


      state     district  is_incumbent  party      year  first_time_elected  \
5537  Texas  District 22     -0.905769    0.0  0.533415           -0.518873
5538  Texas  District 22     -0.905769    1.0  0.533415           -0.518873
5539  Texas  District 22     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5537        -0.518943          0.150083                  0.0
5538        -0.518943          0.150083                  1.0
5539        -0.518943          0.150083                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5537                      0.0          0.0            0.0             0.0
5538                      1.0          0.0            0.0             0.0
5539                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5537             0.0             -0.424937                   -0.984829
5538             0.0              0.424673                    0.954201
5539             0.0              0.424673                    0.954201
```

```
      president_opposition_job_approval  unemployement_rate_own_president  \
5537                           0.951740                         -0.913506
5538                          -0.987421                          0.315819
5539                          -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5537                                 0.318491       0.164447
5538                                -0.918027       0.559334
5539                                -0.918027       0.559334


The conflict in Texas, District 22 is between candidates from the same party, so we predict as
Training accuracy: 97.82%
Validation accuracy: 88.54%
Mutually exclusive validation accuracy: 89.90%
Mutually exclusive validation accuracy by district: 90.44%

model: Random Forest of 100 depth-17 trees
year: 2002


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
3 districts have no winner or more than one winner.
Following the list of affected districts:


          state    district  won_pred
144   Louisiana  District 1       3.0
145   Louisiana  District 2       3.0
179  New Mexico  District 2       2.0


First occurrence from list:


          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4458  Louisiana  District 1    1.0       0.635277       1.0       1.905831
4460  Louisiana  District 1    1.0       0.635277       1.0       1.905831
4461  Louisiana  District 1    1.0       0.635277       1.0       1.905831

      rel_won_proba
4458       0.333333
4460       0.333333
4461       0.333333


Data of the occurrence from list:
```

```
          state    district  is_incumbent  party      year  \
4458  Louisiana  District 1     -0.924743    1.0  0.370007
4460  Louisiana  District 1     -0.924743    1.0  0.370007
4461  Louisiana  District 1     -0.924743    1.0  0.370007

      first_time_elected  count_victories  Log10fundraising  \
4458           -0.532362        -0.531787         -2.013639
4460           -0.532362        -0.531787         -2.013639
4461           -0.532362        -0.531787         -2.013639

      own_president_party  own_last_house_majority  ownPartisan  \
4458                  1.0                      1.0          1.0
4460                  1.0                      1.0          1.0
4461                  1.0                      1.0          1.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
4458            0.0             0.0             1.0              0.128864
4460            0.0             0.0             1.0              0.128864
4461            0.0             0.0             1.0              0.128864

      own_president_job_approval  president_opposition_job_approval  \
4458                     0.95807                          -0.991078
4460                     0.95807                          -0.991078
4461                     0.95807                          -0.991078

      unemployement_rate_own_president  \
4458                          0.698522
4460                          0.698522
4461                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4458                                -0.915336       0.635277
4460                                -0.915336       0.635277
4461                                -0.915336       0.635277

The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predict
Training accuracy: 98.01%
Validation accuracy: 85.61%
Mutually exclusive validation accuracy: 90.26%
Mutually exclusive validation accuracy by district: 91.85%

model: Random Forest of 100 depth-17 trees
year: 1998

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
```

```
1 districts have no winner or more than one winner.
Following the list of affected districts:


        state    district  won_pred
0  California  District 1       2.0


First occurrence from list:


           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.062114       0.0       0.364398
3719  California  District 1    1.0       0.151142       1.0       0.364398
3720  California  District 1    1.0       0.151142       1.0       0.364398

      rel_won_proba
3714       0.170457
3719       0.414772
3720       0.414772


Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714            1.0             0.0             0.0              -0.31434
3719            1.0             0.0             0.0               0.31661
3720            1.0             0.0             0.0               0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935
```

```
      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648

      unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.062114
3719                                 0.358830       0.151142
3720                                 0.358830       0.151142


The conflict in California, District 1 is between candidates from the same party, so we predict
Training accuracy: 97.77%
Validation accuracy: 95.67%
Mutually exclusive validation accuracy: 97.40%
Mutually exclusive validation accuracy by district: 97.54%

model: Random Forest of 100 depth-17 trees
year: 1994
Training accuracy: 97.77%
Validation accuracy: 89.22%
Mutually exclusive validation accuracy: 89.22%
Mutually exclusive validation accuracy by district: 89.53%

model: Random Forest of 100 depth-17 trees
year: 1990
Training accuracy: 97.51%
Validation accuracy: 86.52%
Mutually exclusive validation accuracy: 90.07%
Mutually exclusive validation accuracy by district: 90.54%

model: Random Forest of 100 depth-17 trees
year: 1986
Training accuracy: 97.81%
Validation accuracy: 90.91%
Mutually exclusive validation accuracy: 93.94%
Mutually exclusive validation accuracy by district: 94.03%

model: Random Forest of 100 depth-17 trees
year: 1982


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
```

```
36  California  District 43       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2513  California  District 43    1.0       0.241619       1.0       0.706757
2528  California  District 43    0.0       0.223520       0.0       0.706757
2569  California  District 43    1.0       0.241619       1.0       0.706757

      rel_won_proba
2513       0.341869
2528       0.316262
2569       0.341869


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2513  California  District 43     -0.909482    1.0 -0.412345
2528  California  District 43     -0.909482    0.0 -0.412345
2569  California  District 43     -0.909482    1.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2513             -0.5259        -0.525692         -0.062539
2528             -0.5259        -0.525692         -0.062539
2569             -0.5259        -0.525692         -0.062539

      own_president_party  own_last_house_majority  ownPartisan  \
2513                  1.0                      0.0          0.0
2528                  0.0                      1.0          0.0
2569                  1.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2513            1.0             0.0             0.0             -0.734935
2528            1.0             0.0             0.0              0.736978
2569            1.0             0.0             0.0             -0.734935

      own_president_job_approval  president_opposition_job_approval  \
2513                    1.094421                          -0.990568
2528                   -0.982864                           1.087002
2569                    1.094421                          -0.990568

      unemployement_rate_own_president  \
2513                          2.074204
2528                         -0.910201
2569                          2.074204
```

```
     unemployement_rate_president_opposition  abs_won_proba
2513                                -0.919018       0.241619
2528                                 2.085907       0.223520
2569                                -0.919018       0.241619


The conflict in California, District 43 is between candidates from the same party, so we predic
Training accuracy: 97.73%
Validation accuracy: 87.50%
Mutually exclusive validation accuracy: 90.62%
Mutually exclusive validation accuracy by district: 92.54%

model: Random Forest of 100 depth-17 trees
year: 1978
Training accuracy: 97.65%
Validation accuracy: 84.21%
Mutually exclusive validation accuracy: 85.96%
Mutually exclusive validation accuracy by district: 86.44%

model: AdaBoost Classifier 400 depth-1 trees
year: 2014


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
19 districts have no winner or more than one winner.
Following the list of affected districts:


             state     district  won_pred
17        Arkansas   District 2       2.0
22      California  District 11       2.0
37      California  District 25       2.0
46      California  District 33       2.0
158           Iowa   District 1       2.0
179          Maine   District 2       2.0
193  Massachusetts   District 6       2.0
199       Michigan  District 11       2.0
208       Michigan   District 8       2.0
240     New Jersey   District 1       2.0
243     New Jersey  District 12       2.0
245     New Jersey   District 3       2.0
291 North Carolina   District 6       2.0
325   Pennsylvania  District 13       2.0
334   Pennsylvania   District 6       2.0
395           Utah   District 4       2.0
412     Washington   District 4       2.0
419  West Virginia   District 2       2.0
```

```
426       Wisconsin   District 6       2.0


First occurrence from list:


         state    district  party  abs_won_proba  won_pred  sum_won_proba  \
8114  Arkansas  District 2    0.0       0.405907       1.0       0.811813
8120  Arkansas  District 2    1.0       0.405907       1.0       0.811813

      rel_won_proba
8114            0.5
8120            0.5


Data of the occurrence from list:


         state    district  is_incumbent  party      year  first_time_elected  \
8114  Arkansas  District 2     -0.904043    0.0  0.891256           -0.525298
8120  Arkansas  District 2     -0.904043    1.0  0.891256           -0.525298

      count_victories  Log10fundraising  own_president_party  \
8114        -0.525246          0.431761                  1.0
8120        -0.525246          0.210567                  0.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
8114                      0.0          0.0            1.0             0.0
8120                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
8114             0.0             -0.459887                    0.896607
8120             0.0              0.460877                   -0.980536

      president_opposition_job_approval  unemployement_rate_own_president  \
8114                          -0.991331                          0.909545
8120                           0.886373                         -0.908020

      unemployement_rate_president_opposition  abs_won_proba
8114                                -0.918595       0.405907
8120                                 0.902908       0.405907


The conflict in California, District 25 is between candidates from the same party, so we predic
The conflict in Washington, District 4 is between candidates from the same party, so we predict
Training accuracy: 88.06%
Validation accuracy: 90.62%
Mutually exclusive validation accuracy: 93.12%
Mutually exclusive validation accuracy by district: 91.63%
```

```
model: AdaBoost Classifier 400 depth-1 trees
year: 2010


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
10 districts have no winner or more than one winner.
Following the list of affected districts:


            state    district  won_pred
4         Alabama  District 5       2.0
10        Arizona  District 3       2.0
16       Arkansas  District 1       2.0
17       Arkansas  District 2       2.0
84       Delaware    At-Large       2.0
142        Kansas  District 3       2.0
152     Louisiana  District 3       2.0
221          Ohio  District 2       2.0
234  Rhode Island  District 1       2.0
270      Virginia  District 5       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
6569  Alabama  District 5    1.0       0.406221       1.0       0.812442
6570  Alabama  District 5    0.0       0.406221       1.0       0.812442

      rel_won_proba
6569            0.5
6570            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party     year  first_time_elected  \
6569  Alabama  District 5     -0.908171    1.0  0.69794           -0.518637
6570  Alabama  District 5     -0.908171    0.0  0.69794           -0.518637

      count_victories  Log10fundraising  own_president_party  \
6569        -0.519557          0.213818                  0.0
6570        -0.519557          0.254646                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
6569                      0.0          0.0            1.0             0.0
6570                      1.0          0.0            1.0             0.0
```

```
      partisanship_3  last_own_party_Seats  own_president_job_approval  \
6569             0.0             -1.156670                   -0.984363
6570             0.0              1.153816                    0.896663

      president_opposition_job_approval  unemployement_rate_own_president  \
6569                           0.892834                         -0.911645
6570                          -0.988160                          1.838533

      unemployement_rate_president_opposition  abs_won_proba
6569                                 1.860769       0.406221
6570                                -0.917740       0.406221
```

```
Training accuracy: 86.92%
Validation accuracy: 81.63%
Mutually exclusive validation accuracy: 84.47%
Mutually exclusive validation accuracy by district: 83.27%

model: AdaBoost Classifier 400 depth-1 trees
year: 2006
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
12 districts have no winner or more than one winner.
Following the list of affected districts:
```

	state	district	won_pred
15	Arizona	District 8	2.0
86	Florida	District 11	2.0
108	Florida	District 9	2.0
110	Georgia	District 10	2.0
115	Georgia	District 3	2.0
120	Georgia	District 8	2.0
121	Georgia	District 9	2.0
137	Iowa	District 1	2.0
229	Pennsylvania	District 10	2.0
245	Texas	District 20	2.0
247	Texas	District 22	3.0
265	Vermont	At-Large	2.0

```
First occurrence from list:
```

```
        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
5533  Arizona  District 8    0.0       0.408714       1.0       0.817427
5534  Arizona  District 8    1.0       0.408714       1.0       0.817427
```

```
      rel_won_proba
5533            0.5
5534            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
5533  Arizona  District 8     -0.905769    0.0  0.533415           -0.518873
5534  Arizona  District 8     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5533        -0.518943          0.652626                  0.0
5534        -0.518943          0.652626                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5533                      0.0          0.0            0.0             0.0
5534                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5533             0.0             -0.424937                   -0.984829
5534             0.0              0.424673                    0.954201

      president_opposition_job_approval  unemployement_rate_own_president  \
5533                           0.951740                         -0.913506
5534                          -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5533                                 0.318491       0.408714
5534                                -0.918027       0.408714


Training accuracy: 88.11%
Validation accuracy: 88.74%
Mutually exclusive validation accuracy: 90.29%
Mutually exclusive validation accuracy by district: 88.60%

model: AdaBoost Classifier 400 depth-1 trees
year: 2002


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
30 districts have no winner or more than one winner.
Following the list of affected districts:


              state     district  won_pred
```

```
4          Alabama   District 5       2.0
7          Arizona   District 1       2.0
9          Arizona   District 3       2.0
10         Arizona   District 4       2.0
14         Arizona   District 8       2.0
15        Arkansas   District 1       2.0
18        Arkansas   District 4       2.0
28      California  District 18       2.0
32      California  District 21       2.0
74        Colorado   District 4       2.0
93         Florida   District 2       2.0
98         Florida  District 24       2.0
100        Florida   District 3       2.0
102        Florida   District 5       2.0
122        Indiana   District 2       2.0
130           Iowa   District 1       2.0
132           Iowa   District 3       2.0
136         Kansas   District 3       2.0
144      Louisiana   District 1       3.0
145      Louisiana   District 2       3.0
151          Maine   District 2       2.0
169    Mississippi   District 4       2.0
179     New Mexico   District 2       2.0
192       New York  District 20       2.0
194       New York  District 22       2.0
198       New York  District 26       2.0
199       New York  District 27       2.0
208 North Carolina   District 2       2.0
222          Texas  District 17       2.0
223           Utah   District 1       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4511  Alabama  District 5    0.0       0.405382       1.0       0.810763
4512  Alabama  District 5    1.0       0.405382       1.0       0.810763

      rel_won_proba
4511            0.5
4512            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
4511  Alabama  District 5     -0.924743    0.0  0.370007           -0.532362
```

```
4512  Alabama  District 5     -0.924743    1.0  0.370007          -0.532362

     count_victories  Log10fundraising  own_president_party  \
4511       -0.531787          0.005329                  0.0
4512       -0.531787          0.005329                  1.0

     own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
4511                     0.0          0.0            1.0             0.0
4512                     1.0          0.0            1.0             0.0

     partisanship_3  last_own_party_Seats  own_president_job_approval  \
4511            0.0             -0.126579                   -0.981452
4512            0.0              0.128864                    0.958070

     president_opposition_job_approval  unemployement_rate_own_president  \
4511                          0.948793                         -0.905028
4512                         -0.991078                          0.698522

     unemployement_rate_president_opposition  abs_won_proba
4511                                 0.699480       0.405382
4512                                -0.915336       0.405382

The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predict
Training accuracy: 87.32%
Validation accuracy: 72.85%
Mutually exclusive validation accuracy: 88.17%
Mutually exclusive validation accuracy by district: 84.12%

model: AdaBoost Classifier 400 depth-1 trees
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
0   California   District 1       3.0
83    New York  District 13       2.0
92    New York  District 22       2.0
97    New York  District 27       2.0


First occurrence from list:
```

```
           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.409137       1.0        1.22741
3719  California  District 1    1.0       0.409137       1.0        1.22741
3720  California  District 1    1.0       0.409137       1.0        1.22741

      rel_won_proba
3714       0.333333
3719       0.333333
3720       0.333333
```

Data of the occurrence from list:

```
           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714            1.0             0.0             0.0              -0.31434
3719            1.0             0.0             0.0               0.31661
3720            1.0             0.0             0.0               0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935

      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648

      unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.409137
3719                                 0.358830       0.409137
3720                                 0.358830       0.409137
```

```
Training accuracy: 88.00%
Validation accuracy: 94.37%
Mutually exclusive validation accuracy: 96.54%
Mutually exclusive validation accuracy by district: 95.08%

model: AdaBoost Classifier 400 depth-1 trees
year: 1994


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


        state     district  won_pred
37  California  District 44       2.0
64       Maine   District 2       2.0


First occurrence from list:


          state     district  party  abs_won_proba  won_pred  sum_won_proba  \
3294  California  District 44    0.0       0.408496       1.0       0.816992
3354  California  District 44    1.0       0.408496       1.0       0.816992

      rel_won_proba
3294            0.5
3354            0.5


Data of the occurrence from list:


          state     district  is_incumbent  party      year  \
3294  California  District 44     -0.907499    0.0  0.052753
3354  California  District 44     -0.907499    1.0  0.052753

      first_time_elected  count_victories  Log10fundraising  \
3294           -0.527344        -0.527182           0.30113
3354           -0.527344        -0.527182           0.30113

      own_president_party  own_last_house_majority  ownPartisan  \
3294                  1.0                      1.0          0.0
3354                  0.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
```

```
3294           1.0           0.0           0.0            1.195709
3354           1.0           0.0           0.0           -1.193918

      own_president_job_approval  president_opposition_job_approval  \
3294                    1.187299                          -0.990527
3354                   -0.983013                           1.180121

      unemployement_rate_own_president  \
3294                          0.733431
3354                         -0.907410

      unemployement_rate_president_opposition  abs_won_proba
3294                                -0.915850       0.408496
3354                                 0.736017       0.408496


Training accuracy: 88.16%
Validation accuracy: 88.62%
Mutually exclusive validation accuracy: 89.22%
Mutually exclusive validation accuracy by district: 88.37%

model: AdaBoost Classifier 400 depth-1 trees
year: 1990


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


       state    district  won_pred
45  Colorado  District 4       2.0
70   Vermont    At-Large       2.0


First occurrence from list:


         state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3062  Colorado  District 4    0.0       0.408459       1.0       0.816918
3063  Colorado  District 4    1.0       0.408459       1.0       0.816918

      rel_won_proba
3062            0.5
3063            0.5


Data of the occurrence from list:
```

```
        state    district  is_incumbent  party      year  first_time_elected  \
3062  Colorado  District 4     -0.907765    0.0 -0.102275           -0.523513
3063  Colorado  District 4     -0.907765    1.0 -0.102275           -0.523513

      count_victories  Log10fundraising  own_president_party  \
3062        -0.523862          0.379619                  0.0
3063        -0.523862          0.379619                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
3062                      1.0          0.0            1.0             0.0
3063                      0.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
3062             0.0              1.237058                   -0.983563
3063             0.0             -1.234712                    1.420308

      president_opposition_job_approval  unemployement_rate_own_president  \
3062                           1.413230                         -0.907511
3063                          -0.991066                          0.762707

      unemployement_rate_president_opposition  abs_won_proba
3062                                 0.765490       0.408459
3063                                -0.915934       0.408459


Training accuracy: 88.24%
Validation accuracy: 89.36%
Mutually exclusive validation accuracy: 90.07%
Mutually exclusive validation accuracy by district: 89.19%

model: AdaBoost Classifier 400 depth-1 trees
year: 1986


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
5 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
11  California   District 2       2.0
13  California  District 21       2.0
54    Maryland   District 8       2.0
65    Virginia   District 2       2.0


First occurrence from list:
```

```
          state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2735  California  District 12    1.0       0.408643       1.0       0.817286
2736  California  District 12    0.0       0.408643       1.0       0.817286

      rel_won_proba
2735            0.5
2736            0.5
```

Data of the occurrence from list:

```
          state     district  is_incumbent  party    year  \
2735  California  District 12     -0.909019    1.0 -0.2572
2736  California  District 12     -0.909019    0.0 -0.2572

      first_time_elected  count_victories  Log10fundraising  \
2735           -0.523678        -0.523866          0.634395
2736           -0.523678        -0.523866          0.634395

      own_president_party  own_last_house_majority  ownPartisan  \
2735                  1.0                      0.0          0.0
2736                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2735            1.0             0.0             0.0             -1.027179
2736            1.0             0.0             0.0              1.029704

      own_president_job_approval  president_opposition_job_approval  \
2735                    1.094214                          -0.990337
2736                   -0.983083                           1.087296

      unemployement_rate_own_president  \
2735                          1.078907
2736                         -0.907294

      unemployement_rate_president_opposition  abs_won_proba
2735                                -0.915517       0.408643
2736                                 1.084153       0.408643
```

Training accuracy: 88.27%
Validation accuracy: 87.88%
Mutually exclusive validation accuracy: 93.18%
Mutually exclusive validation accuracy by district: 89.55%

model: AdaBoost Classifier 400 depth-1 trees
year: 1982

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
6 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
9   California  District 18       2.0
19  California  District 27       2.0
36  California  District 43       3.0
37  California  District 44       2.0
40  California   District 6       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2445  California  District 12    1.0       0.408167       1.0       0.816335
2500  California  District 12    0.0       0.408167       1.0       0.816335

      rel_won_proba
2445            0.5
2500            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2445  California  District 12     -0.909482    1.0 -0.412345
2500  California  District 12     -0.909482    0.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2445             -0.5259        -0.525692          0.634763
2500             -0.5259        -0.525692          0.634763

      own_president_party  own_last_house_majority  ownPartisan  \
2445                  1.0                      0.0          0.0
2500                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2445            1.0             0.0             0.0             -0.734935
2500            1.0             0.0             0.0              0.736978

      own_president_job_approval  president_opposition_job_approval  \
2445                    1.094421                          -0.990568
2500                   -0.982864                           1.087002
```

```
      unemployement_rate_own_president  \
2445                          2.074204
2500                         -0.910201

      unemployement_rate_president_opposition  abs_won_proba
2445                                -0.919018       0.408167
2500                                 2.085907       0.408167


Training accuracy: 88.27%
Validation accuracy: 87.50%
Mutually exclusive validation accuracy: 90.62%
Mutually exclusive validation accuracy by district: 86.57%

model: AdaBoost Classifier 400 depth-1 trees
year: 1978


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
9   California  District 18       2.0
25  California  District 33       2.0
42    Colorado   District 3       2.0
48       Maine   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2214  California  District 18    1.0       0.407383       1.0       0.814765
2216  California  District 18    0.0       0.407383       1.0       0.814765

      rel_won_proba
2214            0.5
2216            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2214  California  District 18     -0.908567    1.0 -0.567381
2216  California  District 18     -0.908567    0.0 -0.567381
```

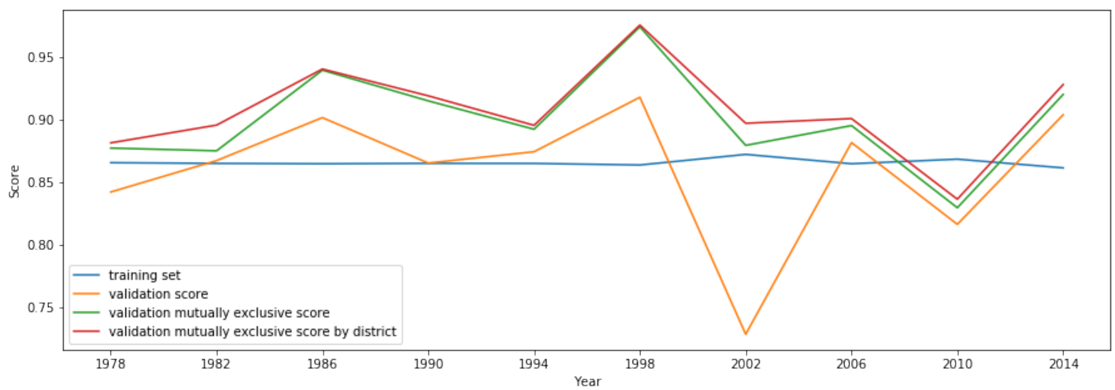
```
      first_time_elected  count_victories  Log10fundraising  \
2214           -0.525551        -0.525457          0.147788
2216           -0.525551        -0.525457          0.147788

      own_president_party  own_last_house_majority  ownPartisan  \
2214                  0.0                      0.0          0.0
2216                  1.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2214            1.0             0.0             0.0             -2.209922
2216            1.0             0.0             0.0              2.212019

      own_president_job_approval  president_opposition_job_approval  \
2214                   -0.983016                           0.796337
2216                    0.803759                          -0.990708

      unemployement_rate_own_president  \
2214                         -0.907662
2216                          0.734766

      unemployement_rate_president_opposition  abs_won_proba
2214                                 0.737173       0.407383
2216                                -0.916271       0.407383


Training accuracy: 88.29%
Validation accuracy: 83.33%
Mutually exclusive validation accuracy: 85.96%
Mutually exclusive validation accuracy by district: 83.05%
```

```
[{'name': 'Logistic Regression CV=5',
  'model': LogisticRegressionCV(Cs=10, class_weight=None, cv=5, dual=False,
             fit_intercept=True, intercept_scaling=1.0, max_iter=2500,
             multi_class='warn', n_jobs=None, penalty='l2',
             random_state=None, refit=True, scoring=None, solver='lbfgs',
             tol=0.0001, verbose=0),
  'score train': 0.8840503918750178,
  'score validation': 0.8773532070483505,
  'score val mut exclusive': 0.8992099013236363,
  'score val mut exclusive by district': 0.9065062384415578},
 {'name': 'LDA',
  'model': LinearDiscriminantAnalysis(n_components=None, priors=None, shrinkage=None,
                solver='svd', store_covariance=True, tol=0.0001),
  'score train': 0.8655299924084723,
  'score validation': 0.8598186116287083,
  'score val mut exclusive': 0.8996763515400865,
```

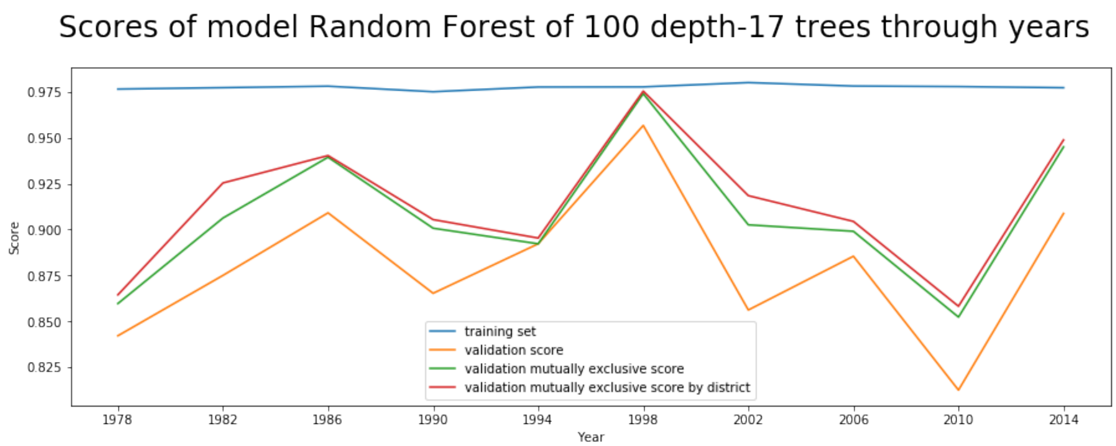
```
 'score val mut exclusive by district': 0.9068856035299548},
{'name': 'Decision Tree, depth=4',
 'model': DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=4,
             max_features=None, max_leaf_nodes=None,
             min_impurity_decrease=0.0, min_impurity_split=None,
             min_samples_leaf=1, min_samples_split=2,
             min_weight_fraction_leaf=0.0, presort=False, random_state=None,
             splitter='best'),
 'score train': 0.8888179794322459,
 'score validation': 0.8767463394363191,
 'score val mut exclusive': 0.9010502621720538,
 'score val mut exclusive by district': 0.876852723295159},
{'name': 'Random Forest of 100 depth-17 trees',
 'model': RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
             max_depth=17, max_features='auto', max_leaf_nodes=None,
             min_impurity_decrease=0.0, min_impurity_split=None,
             min_samples_leaf=1, min_samples_split=2,
             min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=None,
             oob_score=False, random_state=None, verbose=0,
             warm_start=False),
 'score train': 0.9775797529164791,
 'score validation': 0.8803205309854626,
 'score val mut exclusive': 0.9071097882610015,
 'score val mut exclusive by district': 0.9136128227944689},
{'name': 'AdaBoost Classifier 400 depth-1 trees',
 'model': AdaBoostClassifier(algorithm='SAMME.R',
           base_estimator=DecisionTreeClassifier(class_weight=None, criterion='gini', max_dep
             max_features=None, max_leaf_nodes=None,
             min_impurity_decrease=0.0, min_impurity_split=None,
             min_samples_leaf=1, min_samples_split=2,
             min_weight_fraction_leaf=0.0, presort=False, random_state=None,
             splitter='best'),
           learning_rate=0.01, n_estimators=400, random_state=None),
 'score train': 0.8796367154460969,
 'score validation': 0.8649143524658154,
 'score val mut exclusive': 0.901654018341248,
 'score val mut exclusive by district': 0.8794372469680234}]
```

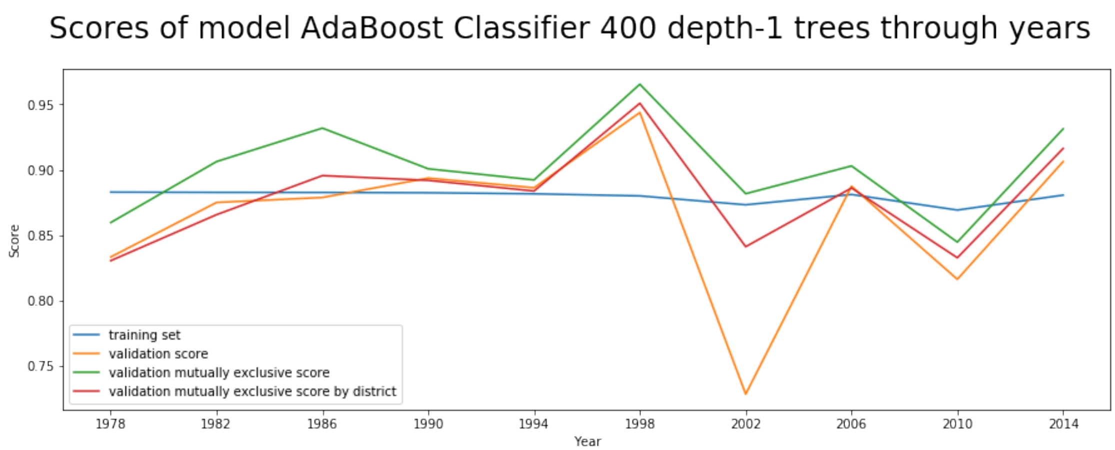
Scores of model Logistic Regression CV=5 through years

Scores of model LDA through years



Scores of model Decision Tree, depth=4 through years





Show models scores

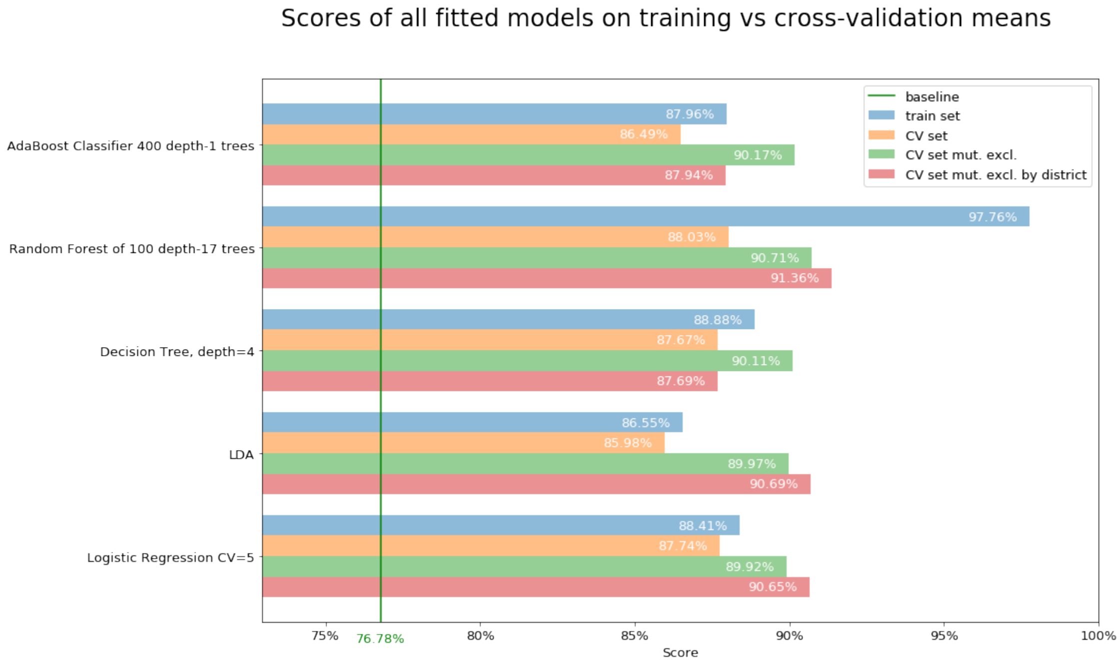
We notice how the single best performing model is random forest, with depth=17 and 100 iterations

The mean score over the validation folds improved by doing the mutually exclusive selection. This score is still relative to the single candidates.

Then we extract only the predicted winners in each district and we compare them with the party of real winners. That is the validation set mutually excusive by district.

That last score type is the one we aim to optimize, as our purpose is to predict the winning party in each district.

```
In [17]: plotModelsScores(modelList, baseline_accuracy)
```



Feature importance

As random forest is our best model, we select features using the `var_sel_RF_2` function, which is a slight variation of the `var_sel_RF` function from the EDA phase. The main difference is that we don't need to split the dataset inside the function but we provide the datasets directly as inputs

```
In [18]: #def var_sel_RF(forest_df,forest_cat=forest_cat,y_year=2018, threshold=0.003):
         def var_sel_RF_2(x_train, y_train, x_test, y_test, threshold=0.003):
             #returns 1) sorted list of most important features
             #        2) Accuracy of model with all features and with selected features
             #thresold: minimum feature importance

             #x_train, y_train, x_test, y_test = one_hot_coding(forest_df,forest_cat,y_year)

             # Create a random forest classifier. number of trees set to 100
             clf = RandomForestClassifier(n_estimators=100, random_state=0, n_jobs=-1)

             # Train the classifier
             clf.fit(x_train, y_train)
             feat_labels = x_train.columns
             feat_imp = []

             # name and gini importance of each feature
             for feature in zip(clf.feature_importances_,feat_labels):
                 feat_imp.append(feature)
             feat_imp.sort(reverse=True)

             #sorted list with most important features
```

```
    feat_imp = list(filter(lambda x: x[0] > threshold, feat_imp))

    # Create a selector object that will use the random forest classifier to identify
    # features that have an importance of more than 0.003
    sfm = SelectFromModel(clf, threshold=threshold)

    # Train the selector
    sfm.fit(x_train, y_train)

    # Transform the data to create a new dataset containing only the most important f
    # Note: We have to apply the transform to both the training X and test X data.
    X_important_train = sfm.transform(x_train)
    X_important_test = sfm.transform(x_test)

    # Create a new random forest classifier for the most important features
    clf_important = RandomForestClassifier(n_estimators=100, random_state=0, n_jobs=-

    # Train the new classifier on the new dataset containing the most important featu
    clf_important.fit(X_important_train, y_train)

    # Accuracy of model with all features
    y_pred = clf.predict(x_test)
    #print('Accuracy of model with all features: {}'.format(accuracy_score(y_test, y_

    # Accuracy of model with most important features
    y_important_pred = clf_important.predict(X_important_test)
    #print('Accuracy of model with most important features: {}'.format(accuracy_score
    featList=pd.DataFrame(feat_imp)[1]
    if threshold>0.0:
        print('Features below threshold {}: {}'.format(threshold, list(set(x_train)-se
    return feat_imp
```

Here we run feature importance taking 2018 data as test set and all remaining years as training. We take 0.01 as threshold:

```
In [19]: x_train_designFeatures, x_test_designFeatures, y_train, y_test, df_districts, df_party
         var_sel_RF_2(x_train_designFeatures, y_train, x_test_designFeatures, y_test, 0.01)
```

```
Features below threshold 0.01: ['own_president_party', 'party', 'own_last_house_majority', 'par


Out[19]: [(0.26206147725037143, 'is_incumbent'),
          (0.20108023310493323, 'Log10fundraising'),
          (0.14468732535625148, 'count_victories'),
          (0.09796038119929334, 'first_time_elected'),
          (0.07350195490398631, 'ownPartisan'),
          (0.0482982557728986, 'year'),
          (0.03807989685092155, 'last_own_party_Seats'),
          (0.030296322445838176, 'unemployement_rate_own_president'),
```

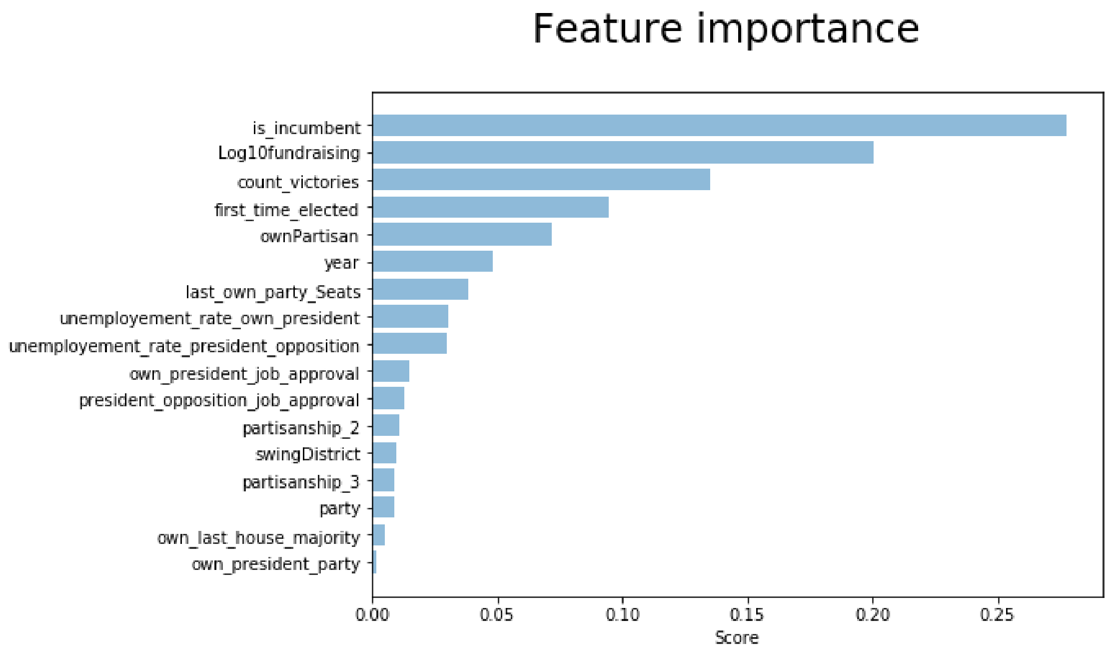
```
(0.02981822182381279, 'unemployement_rate_president_opposition'),
(0.014524993657334628, 'own_president_job_approval'),
(0.012639476196769995, 'president_opposition_job_approval'),
(0.011289015290131902, 'partisanship_2'),
(0.010644151577198568, 'swingDistrict')]
```

Now we look at feature importance for each fold from `Midterm_recent_years`, store their values for each year and show the averages:

```
In [20]: #evaluate feature importance for random forest, through all folds, excluding 2018 data
         feat_df=pd.DataFrame(list(x_train_designFeatures), columns=['feature']).set_index('fea
         for year in Midterm_recent_years:
             #print('year: {}'.format(year))
             x_train_designFeatures, x_test_designFeatures, y_train, y_test, df_districts, df_p
             feat_imp=var_sel_RF_2(x_train_designFeatures, y_train, x_test_designFeatures, y_te
             feat_df=feat_df.join(pd.DataFrame(feat_imp).set_index([1]).rename(index=str, colum
         feat_df['mean']=feat_df.mean(axis=1)
         feat_df['std']=feat_df.std(axis=1)
         display(feat_df[['mean', 'std']].sort_values(by=['mean'], ascending=False))
```

feature	mean	std
is_incumbent	0.277915	0.005145
Log10fundraising	0.200733	0.003773
count_victories	0.135327	0.004970
first_time_elected	0.094803	0.005741
ownPartisan	0.071608	0.003116
year	0.048395	0.001018
last_own_party_Seats	0.038416	0.001059
unemployement_rate_own_president	0.030516	0.000585
unemployement_rate_president_opposition	0.029744	0.000687
own_president_job_approval	0.014679	0.000646
president_opposition_job_approval	0.012887	0.000341
partisanship_2	0.011133	0.000814
swingDistrict	0.009456	0.000393
partisanship_3	0.009028	0.000685
party	0.008992	0.000888
own_last_house_majority	0.004798	0.000187
own_president_party	0.001571	0.000170

```
In [21]: barPlotFeatImp(feat_df)
```



We can conclude that feature importance is consistent through the years

```
In [22]: #This function was used to evaluate feature importance for logistic regression
         def featureImportance(x, y):
             scores, pvalues = chi2(x, y)
             featureImportance=pd.DataFrame([list(x), list(pvalues)]).T
             featureImportance.columns=['coeff', 'p-value']
             featureImportance=featureImportance.set_index('coeff')
             display(featureImportance)
```

Stacking

To do stacking, we will store the predictions of each model from a list of models into a dataframe, one column per model predictions and one for their probability

The `predictForStack` function generates those predictions for each year in a list of years and then appends them together

```
In [23]: #Stacking all models
         def predictForStack(df, years, modelList):
             train_data=df.copy()
             stackCols=['state', 'district', 'baseline', 'baseline_proba']
             for i in range(len(modelList)):
                 stackCols.append('pred_{}'.format(i))
                 stackCols.append('proba_{}'.format(i))
             stackCols.append('party')
             predictionsToStack=pd.DataFrame(columns=stackCols)
             for year in years:
                 #pre_process
```

```
        x_train_designFeatures, x_test_designFeatures, y_train, y_test, house_df_dist

        #baseline model predictions
        y_pred=baselineTrain_(train_data[train_data['year']!=year]).set_index(['state
        y_pred=y_pred.rename(index=str, columns={'party': 'baseline', 'proba': 'basel

        for i, model in enumerate(modelList):
            print('model: {}'.format(model['name']))
            print('year: {}'.format(year))
            #fit model
            fitted_model=model['model'].fit(x_train_designFeatures, y_train)

            #generate predictions and calculate accuracy
            Accu_train, Accu_val, Accu_val_2, pred_df = MutuallyExclusivePredictions(

            #predictions by district and winning party only
            y_pred_i=pred_df[pred_df['won_pred']==1].set_index(['state', 'district'])
            y_pred_i['proba_{}'.format(i)]=y_pred_i['rel_won_proba']
            y_pred_i=y_pred_i.drop(columns=['abs_won_proba', 'won_pred', 'rel_won_prob
            y_pred_i=y_pred_i.rename(index=str, columns={'party': 'pred_{}'.format(i)

            #Add column with current model predictions
            y_pred = pd.concat([y_pred, y_pred_i], axis=1).fillna(-1)
            y_pred['proba_{}'.format(i)]=y_pred['proba_{}'.format(i)].replace(-1,0)
        y_pred['baseline_proba']=y_pred['baseline_proba'].replace(-1,0)
        #Add last column with actual results
        y_val=winnerFilter_(train_data[train_data['year']==year]).set_index(['state',
        y_pred=y_pred.join(y_val).dropna()

        #Append all models predictions for current year to the other years' predictio
        predictionsToStack=predictionsToStack.append(y_pred.reset_index(drop=False)[s
    #if asking only for one year, return predictions by state and district, without a
    if (len(years)==1):
        return predictionsToStack.drop('party', axis=1).set_index(['state', 'district
    #if asking for several years, predictions and actual results will be used to fit
    return predictionsToStack.drop(columns=['state', 'district'])
```

We will predict results for a list of years (excluding 2018), using the remaining years (still excluding 2018) data as training.

Then we will use this data to fit the stacking linear model

First we generate the predictions for all available models:

```
In [24]: #Generate predictions for stacking
         predictionsToStack=predictForStack(train_data, Midterm_recent_years, modelList)
```

```
model: Logistic Regression CV=5
year: 2014
model: LDA
```

```
year: 2014
model: Decision Tree, depth=4
year: 2014


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
22 districts have no winner or more than one winner.
Following the list of affected districts:


              state     district  won_pred
17         Arkansas   District 2       2.0
22       California  District 11       2.0
37       California  District 25       2.0
46       California  District 33       2.0
48       California  District 35       2.0
76         Colorado   District 4       2.0
158            Iowa   District 1       2.0
179           Maine   District 2       2.0
193   Massachusetts   District 6       2.0
199        Michigan  District 11       2.0
200        Michigan  District 12       2.0
201        Michigan  District 14       2.0
204        Michigan   District 4       2.0
208        Michigan   District 8       2.0
240      New Jersey   District 1       2.0
243      New Jersey  District 12       2.0
285  North Carolina  District 12       2.0
291  North Carolina   District 6       2.0
315        Oklahoma   District 5       2.0
385           Texas  District 36       2.0
412      Washington   District 4       2.0
426       Wisconsin   District 6       2.0


First occurrence from list:


         state    district  party  abs_won_proba  won_pred  sum_won_proba  \
8114  Arkansas  District 2    0.0       0.177745       1.0       0.355489
8120  Arkansas  District 2    1.0       0.177745       1.0       0.355489

      rel_won_proba
8114            0.5
8120            0.5


Data of the occurrence from list:
```

```
         state    district  is_incumbent  party      year  first_time_elected  \
8114  Arkansas  District 2     -0.904043    0.0  0.891256           -0.525298
8120  Arkansas  District 2     -0.904043    1.0  0.891256           -0.525298

      count_victories  Log10fundraising  own_president_party  \
8114        -0.525246          0.431761                  1.0
8120        -0.525246          0.210567                  0.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
8114                      0.0          0.0            1.0             0.0
8120                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
8114             0.0             -0.459887                    0.896607
8120             0.0              0.460877                   -0.980536

      president_opposition_job_approval  unemployement_rate_own_president  \
8114                          -0.991331                          0.909545
8120                           0.886373                         -0.908020

      unemployement_rate_president_opposition  abs_won_proba
8114                                -0.918595       0.177745
8120                                 0.902908       0.177745
```

```
The conflict in California, District 25 is between candidates from the same party, so we predic
The conflict in California, District 35 is between candidates from the same party, so we predic
The conflict in Washington, District 4 is between candidates from the same party, so we predict
model: Random Forest of 100 depth-17 trees
year: 2014
model: AdaBoost Classifier 400 depth-1 trees
year: 2014
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
19 districts have no winner or more than one winner.
Following the list of affected districts:


             state     district  won_pred
17        Arkansas   District 2       2.0
22      California  District 11       2.0
37      California  District 25       2.0
46      California  District 33       2.0
158           Iowa   District 1       2.0
179          Maine   District 2       2.0
193  Massachusetts   District 6       2.0
199       Michigan  District 11       2.0
```

```
208        Michigan   District 8       2.0
240      New Jersey   District 1       2.0
243      New Jersey  District 12       2.0
245      New Jersey   District 3       2.0
291  North Carolina   District 6       2.0
325    Pennsylvania  District 13       2.0
334    Pennsylvania   District 6       2.0
395            Utah   District 4       2.0
412      Washington   District 4       2.0
419   West Virginia   District 2       2.0
426       Wisconsin   District 6       2.0


First occurrence from list:


         state    district  party  abs_won_proba  won_pred  sum_won_proba  \
8114  Arkansas  District 2    0.0       0.405907       1.0       0.811813
8120  Arkansas  District 2    1.0       0.405907       1.0       0.811813

      rel_won_proba
8114            0.5
8120            0.5


Data of the occurrence from list:


         state    district  is_incumbent  party      year  first_time_elected  \
8114  Arkansas  District 2     -0.904043    0.0  0.891256           -0.525298
8120  Arkansas  District 2     -0.904043    1.0  0.891256           -0.525298

      count_victories  Log10fundraising  own_president_party  \
8114        -0.525246          0.431761                  1.0
8120        -0.525246          0.210567                  0.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
8114                      0.0          0.0            1.0             0.0
8120                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
8114             0.0             -0.459887                    0.896607
8120             0.0              0.460877                   -0.980536

      president_opposition_job_approval  unemployement_rate_own_president  \
8114                          -0.991331                          0.909545
8120                           0.886373                         -0.908020

      unemployement_rate_president_opposition  abs_won_proba
```

```
8114                                    -0.918595       0.405907
8120                                     0.902908       0.405907
```

```
The conflict in California, District 25 is between candidates from the same party, so we predic
The conflict in Washington, District 4 is between candidates from the same party, so we predict
model: Logistic Regression CV=5
year: 2010
model: LDA
year: 2010
model: Decision Tree, depth=4
year: 2010
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
17 districts have no winner or more than one winner.
Following the list of affected districts:
```

	state	district	won_pred
4	Alabama	District 5	2.0
10	Arizona	District 3	2.0
16	Arkansas	District 1	2.0
17	Arkansas	District 2	2.0
30	California	District 19	3.0
45	California	District 33	2.0
84	Delaware	At-Large	2.0
104	Florida	District 5	2.0
142	Kansas	District 3	2.0
152	Louisiana	District 3	2.0
176	Mississippi	District 4	2.0
198	New York	District 20	2.0
221	Ohio	District 2	2.0
222	Ohio	District 3	2.0
223	Ohio	District 5	2.0
248	Texas	District 25	2.0
250	Texas	District 27	2.0

```
First occurrence from list:
```

	state	district	party	abs_won_proba	won_pred	sum_won_proba	\
6569	Alabama	District 5	1.0	0.169442	1.0	0.338885	
6570	Alabama	District 5	0.0	0.169442	1.0	0.338885	

	rel_won_proba
6569	0.5
6570	0.5

```
Data of the occurrence from list:


       state    district  is_incumbent  party     year  first_time_elected  \
6569  Alabama  District 5     -0.908171    1.0  0.69794           -0.518637
6570  Alabama  District 5     -0.908171    0.0  0.69794           -0.518637

      count_victories  Log10fundraising  own_president_party  \
6569        -0.519557          0.213818                  0.0
6570        -0.519557          0.254646                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
6569                      0.0          0.0            1.0             0.0
6570                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
6569             0.0             -1.156670                   -0.984363
6570             0.0              1.153816                    0.896663

      president_opposition_job_approval  unemployement_rate_own_president  \
6569                           0.892834                         -0.911645
6570                          -0.988160                          1.838533

      unemployement_rate_president_opposition  abs_won_proba
6569                                 1.860769       0.169442
6570                                -0.917740       0.169442


model: Random Forest of 100 depth-17 trees
year: 2010
model: AdaBoost Classifier 400 depth-1 trees
year: 2010


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
10 districts have no winner or more than one winner.
Following the list of affected districts:


            state    district  won_pred
4         Alabama  District 5       2.0
10        Arizona  District 3       2.0
16       Arkansas  District 1       2.0
17       Arkansas  District 2       2.0
84       Delaware    At-Large       2.0
142        Kansas  District 3       2.0
152     Louisiana  District 3       2.0
221          Ohio  District 2       2.0
234  Rhode Island  District 1       2.0
```

```
270      Virginia  District 5       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
6569  Alabama  District 5    1.0       0.406221       1.0       0.812442
6570  Alabama  District 5    0.0       0.406221       1.0       0.812442

      rel_won_proba
6569            0.5
6570            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party     year  first_time_elected  \
6569  Alabama  District 5     -0.908171    1.0  0.69794           -0.518637
6570  Alabama  District 5     -0.908171    0.0  0.69794           -0.518637

      count_victories  Log10fundraising  own_president_party  \
6569        -0.519557          0.213818                  0.0
6570        -0.519557          0.254646                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
6569                      0.0          0.0            1.0             0.0
6570                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
6569             0.0             -1.156670                   -0.984363
6570             0.0              1.153816                    0.896663

      president_opposition_job_approval  unemployement_rate_own_president  \
6569                           0.892834                         -0.911645
6570                          -0.988160                          1.838533

      unemployement_rate_president_opposition  abs_won_proba
6569                                 1.860769       0.406221
6570                                -0.917740       0.406221


model: Logistic Regression CV=5
year: 2006


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
```

Following the list of affected districts:

	state	district	won_pred
247	Texas	District 22	2.0

First occurrence from list:

	state	district	party	abs_won_proba	won_pred	sum_won_proba	rel_won_proba
5537	Texas	District 22	0.0	0.161234	0.0	0.624092	0.258349
5538	Texas	District 22	1.0	0.231429	1.0	0.624092	0.370825
5539	Texas	District 22	1.0	0.231429	1.0	0.624092	0.370825

Data of the occurrence from list:

	state	district	is_incumbent	party	year	first_time_elected
5537	Texas	District 22	-0.905769	0.0	0.533415	-0.518873
5538	Texas	District 22	-0.905769	1.0	0.533415	-0.518873
5539	Texas	District 22	-0.905769	1.0	0.533415	-0.518873

	count_victories	Log10fundraising	own_president_party
5537	-0.518943	0.150083	0.0
5538	-0.518943	0.150083	1.0
5539	-0.518943	0.150083	1.0

	own_last_house_majority	ownPartisan	swingDistrict	partisanship_2
5537	0.0	0.0	0.0	0.0
5538	1.0	0.0	0.0	0.0
5539	1.0	0.0	0.0	0.0

	partisanship_3	last_own_party_Seats	own_president_job_approval
5537	0.0	-0.424937	-0.984829
5538	0.0	0.424673	0.954201
5539	0.0	0.424673	0.954201

	president_opposition_job_approval	unemployement_rate_own_president
5537	0.951740	-0.913506
5538	-0.987421	0.315819
5539	-0.987421	0.315819

```
      unemployement_rate_president_opposition  abs_won_proba
5537                                 0.318491       0.161234
5538                                -0.918027       0.231429
5539                                -0.918027       0.231429


The conflict in Texas, District 22 is between candidates from the same party, so we predict as
model: LDA
year: 2006


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


     state     district  won_pred
247  Texas  District 22       2.0


First occurrence from list:


      state     district  party  abs_won_proba  won_pred  sum_won_proba  \
5537  Texas  District 22    0.0       0.062984       0.0       0.284783
5538  Texas  District 22    1.0       0.110899       1.0       0.284783
5539  Texas  District 22    1.0       0.110899       1.0       0.284783

      rel_won_proba
5537       0.221166
5538       0.389417
5539       0.389417


Data of the occurrence from list:


      state     district  is_incumbent  party      year  first_time_elected  \
5537  Texas  District 22     -0.905769    0.0  0.533415           -0.518873
5538  Texas  District 22     -0.905769    1.0  0.533415           -0.518873
5539  Texas  District 22     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5537        -0.518943          0.150083                  0.0
5538        -0.518943          0.150083                  1.0
5539        -0.518943          0.150083                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5537                      0.0          0.0            0.0             0.0
```

```
5538                     1.0          0.0            0.0               0.0
5539                     1.0          0.0            0.0               0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5537             0.0             -0.424937                   -0.984829
5538             0.0              0.424673                    0.954201
5539             0.0              0.424673                    0.954201

      president_opposition_job_approval  unemployement_rate_own_president  \
5537                           0.951740                         -0.913506
5538                          -0.987421                          0.315819
5539                          -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5537                                 0.318491       0.062984
5538                                -0.918027       0.110899
5539                                -0.918027       0.110899


The conflict in Texas, District 22 is between candidates from the same party, so we predict as
model: Decision Tree, depth=4
year: 2006


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
12 districts have no winner or more than one winner.
Following the list of affected districts:


            state     district  won_pred
15        Arizona   District 8       2.0
86        Florida  District 11       2.0
108       Florida   District 9       2.0
110       Georgia  District 10       2.0
115       Georgia   District 3       2.0
120       Georgia   District 8       2.0
121       Georgia   District 9       2.0
137          Iowa   District 1       2.0
229  Pennsylvania  District 10       2.0
245         Texas  District 20       2.0
247         Texas  District 22       3.0
265       Vermont     At-Large       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
5533  Arizona  District 8    0.0       0.188011       1.0       0.376022
```

```
5534  Arizona  District 8    1.0       0.188011       1.0       0.376022

      rel_won_proba
5533            0.5
5534            0.5
```

Data of the occurrence from list:

```
        state    district  is_incumbent  party      year  first_time_elected  \
5533  Arizona  District 8     -0.905769    0.0  0.533415           -0.518873
5534  Arizona  District 8     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5533        -0.518943          0.652626                  0.0
5534        -0.518943          0.652626                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5533                      0.0          0.0            0.0             0.0
5534                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5533             0.0             -0.424937                   -0.984829
5534             0.0              0.424673                    0.954201

      president_opposition_job_approval  unemployement_rate_own_president  \
5533                           0.951740                         -0.913506
5534                          -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5533                                 0.318491       0.188011
5534                                -0.918027       0.188011
```

model: Random Forest of 100 depth-17 trees
year: 2006

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:

```
     state     district  won_pred
247  Texas  District 22       2.0
```

First occurrence from list:

```
      state     district  party  abs_won_proba  won_pred  sum_won_proba  \
5537  Texas  District 22    0.0       0.186879       0.0        1.25952
5538  Texas  District 22    1.0       0.536321       1.0        1.25952
5539  Texas  District 22    1.0       0.536321       1.0        1.25952

      rel_won_proba
5537       0.148373
5538       0.425813
5539       0.425813
```

Data of the occurrence from list:

```
      state     district  is_incumbent  party      year  first_time_elected  \
5537  Texas  District 22     -0.905769    0.0  0.533415           -0.518873
5538  Texas  District 22     -0.905769    1.0  0.533415           -0.518873
5539  Texas  District 22     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5537        -0.518943          0.150083                  0.0
5538        -0.518943          0.150083                  1.0
5539        -0.518943          0.150083                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5537                      0.0          0.0            0.0             0.0
5538                      1.0          0.0            0.0             0.0
5539                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5537             0.0             -0.424937                   -0.984829
5538             0.0              0.424673                    0.954201
5539             0.0              0.424673                    0.954201

      president_opposition_job_approval  unemployement_rate_own_president  \
5537                           0.951740                         -0.913506
5538                          -0.987421                          0.315819
5539                          -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5537                                 0.318491       0.186879
5538                                -0.918027       0.536321
5539                                -0.918027       0.536321
```

The conflict in Texas, District 22 is between candidates from the same party, so we predict as
model: AdaBoost Classifier 400 depth-1 trees
year: 2006

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
12 districts have no winner or more than one winner.
Following the list of affected districts:


            state     district  won_pred
15        Arizona   District 8       2.0
86        Florida  District 11       2.0
108       Florida   District 9       2.0
110       Georgia  District 10       2.0
115       Georgia   District 3       2.0
120       Georgia   District 8       2.0
121       Georgia   District 9       2.0
137          Iowa   District 1       2.0
229  Pennsylvania  District 10       2.0
245         Texas  District 20       2.0
247         Texas  District 22       3.0
265       Vermont     At-Large       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
5533  Arizona  District 8    0.0       0.408714       1.0       0.817427
5534  Arizona  District 8    1.0       0.408714       1.0       0.817427

      rel_won_proba
5533            0.5
5534            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
5533  Arizona  District 8     -0.905769    0.0  0.533415           -0.518873
5534  Arizona  District 8     -0.905769    1.0  0.533415           -0.518873

      count_victories  Log10fundraising  own_president_party  \
5533        -0.518943          0.652626                  0.0
5534        -0.518943          0.652626                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
5533                      0.0          0.0            0.0             0.0
5534                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
5533             0.0             -0.424937                   -0.984829
```

```
5534            0.0             0.424673                   0.954201

      president_opposition_job_approval  unemployement_rate_own_president  \
5533                          0.951740                         -0.913506
5534                         -0.987421                          0.315819

      unemployement_rate_president_opposition  abs_won_proba
5533                                 0.318491       0.408714
5534                                -0.918027       0.408714
```

```
model: Logistic Regression CV=5
year: 2002
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
3 districts have no winner or more than one winner.
Following the list of affected districts:


          state    district  won_pred
144   Louisiana  District 1       3.0
145   Louisiana  District 2       3.0
179  New Mexico  District 2       2.0


First occurrence from list:


          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4458  Louisiana  District 1    1.0       0.401848       1.0       1.205545
4460  Louisiana  District 1    1.0       0.401848       1.0       1.205545
4461  Louisiana  District 1    1.0       0.401848       1.0       1.205545

      rel_won_proba
4458       0.333333
4460       0.333333
4461       0.333333


Data of the occurrence from list:


          state    district  is_incumbent  party      year  \
4458  Louisiana  District 1     -0.924743    1.0  0.370007
4460  Louisiana  District 1     -0.924743    1.0  0.370007
4461  Louisiana  District 1     -0.924743    1.0  0.370007

      first_time_elected  count_victories  Log10fundraising  \
```

```
4458          -0.532362       -0.531787        -2.013639
4460          -0.532362       -0.531787        -2.013639
4461          -0.532362       -0.531787        -2.013639

      own_president_party  own_last_house_majority  ownPartisan  \
4458                  1.0                      1.0          1.0
4460                  1.0                      1.0          1.0
4461                  1.0                      1.0          1.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
4458            0.0             0.0             1.0              0.128864
4460            0.0             0.0             1.0              0.128864
4461            0.0             0.0             1.0              0.128864

      own_president_job_approval  president_opposition_job_approval  \
4458                     0.95807                          -0.991078
4460                     0.95807                          -0.991078
4461                     0.95807                          -0.991078

      unemployement_rate_own_president  \
4458                          0.698522
4460                          0.698522
4461                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4458                                -0.915336       0.401848
4460                                -0.915336       0.401848
4461                                -0.915336       0.401848

The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predic
model: LDA
year: 2002

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
3 districts have no winner or more than one winner.
Following the list of affected districts:


          state    district  won_pred
144   Louisiana  District 1       3.0
145   Louisiana  District 2       3.0
179  New Mexico  District 2       2.0


First occurrence from list:
```

```
          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4458  Louisiana  District 1    1.0       0.176881       1.0       0.530642
4460  Louisiana  District 1    1.0       0.176881       1.0       0.530642
4461  Louisiana  District 1    1.0       0.176881       1.0       0.530642

      rel_won_proba
4458       0.333333
4460       0.333333
4461       0.333333
```

```
Data of the occurrence from list:
```

```
          state    district  is_incumbent  party      year  \
4458  Louisiana  District 1     -0.924743    1.0  0.370007
4460  Louisiana  District 1     -0.924743    1.0  0.370007
4461  Louisiana  District 1     -0.924743    1.0  0.370007

      first_time_elected  count_victories  Log10fundraising  \
4458           -0.532362        -0.531787         -2.013639
4460           -0.532362        -0.531787         -2.013639
4461           -0.532362        -0.531787         -2.013639

      own_president_party  own_last_house_majority  ownPartisan  \
4458                  1.0                      1.0          1.0
4460                  1.0                      1.0          1.0
4461                  1.0                      1.0          1.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
4458            0.0             0.0             1.0              0.128864
4460            0.0             0.0             1.0              0.128864
4461            0.0             0.0             1.0              0.128864

      own_president_job_approval  president_opposition_job_approval  \
4458                     0.95807                          -0.991078
4460                     0.95807                          -0.991078
4461                     0.95807                          -0.991078

      unemployement_rate_own_president  \
4458                          0.698522
4460                          0.698522
4461                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4458                                -0.915336       0.176881
4460                                -0.915336       0.176881
4461                                -0.915336       0.176881
```

```
The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predict
model: Decision Tree, depth=4
year: 2002


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
30 districts have no winner or more than one winner.
Following the list of affected districts:


              state     district  won_pred
4           Alabama   District 5       2.0
7           Arizona   District 1       2.0
9           Arizona   District 3       2.0
10          Arizona   District 4       2.0
14          Arizona   District 8       2.0
15         Arkansas   District 1       2.0
18         Arkansas   District 4       2.0
28       California  District 18       2.0
32       California  District 21       2.0
74         Colorado   District 4       2.0
93          Florida   District 2       2.0
98          Florida  District 24       2.0
100         Florida   District 3       2.0
102         Florida   District 5       2.0
122         Indiana   District 2       2.0
130            Iowa   District 1       2.0
132            Iowa   District 3       2.0
136          Kansas   District 3       2.0
144       Louisiana   District 1       3.0
145       Louisiana   District 2       3.0
151           Maine   District 2       2.0
169     Mississippi   District 4       2.0
179      New Mexico   District 2       2.0
192        New York  District 20       2.0
194        New York  District 22       2.0
198        New York  District 26       2.0
199        New York  District 27       2.0
208  North Carolina   District 2       2.0
222           Texas  District 17       2.0
223            Utah   District 1       2.0


First occurrence from list:
```

```
        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4511  Alabama  District 5    0.0       0.168421       1.0       0.336842
4512  Alabama  District 5    1.0       0.168421       1.0       0.336842

      rel_won_proba
4511            0.5
4512            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
4511  Alabama  District 5     -0.924743    0.0  0.370007           -0.532362
4512  Alabama  District 5     -0.924743    1.0  0.370007           -0.532362

      count_victories  Log10fundraising  own_president_party  \
4511        -0.531787          0.005329                  0.0
4512        -0.531787          0.005329                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
4511                      0.0          0.0            1.0             0.0
4512                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
4511             0.0             -0.126579                   -0.981452
4512             0.0              0.128864                    0.958070

      president_opposition_job_approval  unemployement_rate_own_president  \
4511                           0.948793                         -0.905028
4512                          -0.991078                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4511                                 0.699480       0.168421
4512                                -0.915336       0.168421


The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predic
model: Random Forest of 100 depth-17 trees
year: 2002


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
3 districts have no winner or more than one winner.
Following the list of affected districts:
```

```
          state    district  won_pred
144   Louisiana  District 1       3.0
145   Louisiana  District 2       3.0
179  New Mexico  District 2       2.0
```

```
First occurrence from list:
```

```
          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4458  Louisiana  District 1    1.0       0.678738       1.0       2.036214
4460  Louisiana  District 1    1.0       0.678738       1.0       2.036214
4461  Louisiana  District 1    1.0       0.678738       1.0       2.036214

      rel_won_proba
4458       0.333333
4460       0.333333
4461       0.333333
```

```
Data of the occurrence from list:
```

```
          state    district  is_incumbent  party      year  \
4458  Louisiana  District 1     -0.924743    1.0  0.370007
4460  Louisiana  District 1     -0.924743    1.0  0.370007
4461  Louisiana  District 1     -0.924743    1.0  0.370007

      first_time_elected  count_victories  Log10fundraising  \
4458           -0.532362        -0.531787         -2.013639
4460           -0.532362        -0.531787         -2.013639
4461           -0.532362        -0.531787         -2.013639

      own_president_party  own_last_house_majority  ownPartisan  \
4458                  1.0                      1.0          1.0
4460                  1.0                      1.0          1.0
4461                  1.0                      1.0          1.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
4458            0.0             0.0             1.0              0.128864
4460            0.0             0.0             1.0              0.128864
4461            0.0             0.0             1.0              0.128864

      own_president_job_approval  president_opposition_job_approval  \
4458                     0.95807                          -0.991078
4460                     0.95807                          -0.991078
4461                     0.95807                          -0.991078

      unemployement_rate_own_president  \
```

```
4458                          0.698522
4460                          0.698522
4461                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4458                                -0.915336       0.678738
4460                                -0.915336       0.678738
4461                                -0.915336       0.678738


The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
The conflict in New Mexico, District 2 is between candidates from the same party, so we predic
model: AdaBoost Classifier 400 depth-1 trees
year: 2002


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
30 districts have no winner or more than one winner.
Following the list of affected districts:


              state     district  won_pred
4           Alabama   District 5       2.0
7           Arizona   District 1       2.0
9           Arizona   District 3       2.0
10          Arizona   District 4       2.0
14          Arizona   District 8       2.0
15         Arkansas   District 1       2.0
18         Arkansas   District 4       2.0
28       California  District 18       2.0
32       California  District 21       2.0
74         Colorado   District 4       2.0
93          Florida   District 2       2.0
98          Florida  District 24       2.0
100         Florida   District 3       2.0
102         Florida   District 5       2.0
122         Indiana   District 2       2.0
130            Iowa   District 1       2.0
132            Iowa   District 3       2.0
136          Kansas   District 3       2.0
144       Louisiana   District 1       3.0
145       Louisiana   District 2       3.0
151           Maine   District 2       2.0
169     Mississippi   District 4       2.0
179      New Mexico   District 2       2.0
192        New York  District 20       2.0
194        New York  District 22       2.0
```

```
198        New York  District 26       2.0
199        New York  District 27       2.0
208  North Carolina   District 2       2.0
222           Texas  District 17       2.0
223            Utah   District 1       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
4511  Alabama  District 5    0.0       0.405382       1.0       0.810763
4512  Alabama  District 5    1.0       0.405382       1.0       0.810763

      rel_won_proba
4511            0.5
4512            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
4511  Alabama  District 5     -0.924743    0.0  0.370007           -0.532362
4512  Alabama  District 5     -0.924743    1.0  0.370007           -0.532362

      count_victories  Log10fundraising  own_president_party  \
4511        -0.531787          0.005329                  0.0
4512        -0.531787          0.005329                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
4511                      0.0          0.0            1.0             0.0
4512                      1.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
4511             0.0             -0.126579                   -0.981452
4512             0.0              0.128864                    0.958070

      president_opposition_job_approval  unemployement_rate_own_president  \
4511                           0.948793                         -0.905028
4512                          -0.991078                          0.698522

      unemployement_rate_president_opposition  abs_won_proba
4511                                 0.699480       0.405382
4512                                -0.915336       0.405382


The conflict in Louisiana, District 1 is between candidates from the same party, so we predict
The conflict in Louisiana, District 2 is between candidates from the same party, so we predict
```

```
The conflict in New Mexico, District 2 is between candidates from the same party, so we predic
model: Logistic Regression CV=5
year: 1998
model: LDA
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


        state    district  won_pred
0  California  District 1       2.0


First occurrence from list:


           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.062131       0.0       0.193147
3719  California  District 1    1.0       0.065508       1.0       0.193147
3720  California  District 1    1.0       0.065508       1.0       0.193147

      rel_won_proba
3714       0.321677
3719       0.339161
3720       0.339161


Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
```

```
3714           1.0            0.0            0.0             -0.31434
3719           1.0            0.0            0.0              0.31661
3720           1.0            0.0            0.0              0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935

      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648

      unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.062131
3719                                 0.358830       0.065508
3720                                 0.358830       0.065508

The conflict in California, District 1 is between candidates from the same party, so we predic
model: Decision Tree, depth=4
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


        state     district  won_pred
0   California   District 1       3.0
83    New York  District 13       2.0
92    New York  District 22       2.0
97    New York  District 27       2.0


First occurrence from list:


          state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.222222       1.0       0.666667
3719  California  District 1    1.0       0.222222       1.0       0.666667
3720  California  District 1    1.0       0.222222       1.0       0.666667

      rel_won_proba
3714       0.333333
3719       0.333333
3720       0.333333
```

```
Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714            1.0             0.0             0.0              -0.31434
3719            1.0             0.0             0.0               0.31661
3720            1.0             0.0             0.0               0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935

      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648

      unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.222222
3719                                 0.358830       0.222222
3720                                 0.358830       0.222222


model: Random Forest of 100 depth-17 trees
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


        state    district  won_pred
```

```
0  California  District 1       2.0


First occurrence from list:


           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.065005       0.0       0.321826
3719  California  District 1    1.0       0.128410       1.0       0.321826
3720  California  District 1    1.0       0.128410       1.0       0.321826

      rel_won_proba
3714       0.201990
3719       0.399005
3720       0.399005


Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
3720           -0.525504        -0.524906          0.093515

      own_president_party  own_last_house_majority  ownPartisan  \
3714                  1.0                      0.0          0.0
3719                  0.0                      1.0          0.0
3720                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714            1.0             0.0             0.0              -0.31434
3719            1.0             0.0             0.0               0.31661
3720            1.0             0.0             0.0               0.31661

      own_president_job_approval  president_opposition_job_approval  \
3714                    1.188612                          -0.990281
3719                   -0.983169                           1.181935
3720                   -0.983169                           1.181935

      unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648
```

```
      unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.065005
3719                                 0.358830       0.128410
3720                                 0.358830       0.128410


The conflict in California, District 1 is between candidates from the same party, so we predic
model: AdaBoost Classifier 400 depth-1 trees
year: 1998


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
0   California   District 1       3.0
83    New York  District 13       2.0
92    New York  District 22       2.0
97    New York  District 27       2.0


First occurrence from list:


           state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3714  California  District 1    0.0       0.409137       1.0        1.22741
3719  California  District 1    1.0       0.409137       1.0        1.22741
3720  California  District 1    1.0       0.409137       1.0        1.22741

      rel_won_proba
3714       0.333333
3719       0.333333
3720       0.333333


Data of the occurrence from list:


           state    district  is_incumbent  party      year  \
3714  California  District 1     -0.908119    0.0  0.208818
3719  California  District 1     -0.908119    1.0  0.208818
3720  California  District 1     -0.908119    1.0  0.208818

      first_time_elected  count_victories  Log10fundraising  \
3714           -0.525504        -0.524906          0.093515
3719           -0.525504        -0.524906          0.093515
```

```
3720          -0.525504       -0.524906         0.093515

     own_president_party  own_last_house_majority  ownPartisan  \
3714                 1.0                      0.0          0.0
3719                 0.0                      1.0          0.0
3720                 0.0                      1.0          0.0

     swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3714           1.0             0.0             0.0              -0.31434
3719           1.0             0.0             0.0               0.31661
3720           1.0             0.0             0.0               0.31661

     own_president_job_approval  president_opposition_job_approval  \
3714                   1.188612                          -0.990281
3719                  -0.983169                           1.181935
3720                  -0.983169                           1.181935

     unemployement_rate_own_president  \
3714                          0.358551
3719                         -0.909648
3720                         -0.909648

     unemployement_rate_president_opposition  abs_won_proba
3714                                -0.917771       0.409137
3719                                 0.358830       0.409137
3720                                 0.358830       0.409137


model: Logistic Regression CV=5
year: 1994
model: LDA
year: 1994
model: Decision Tree, depth=4
year: 1994


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
37  California  District 44       2.0
64       Maine   District 2       2.0


First occurrence from list:
```

```
           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
3294  California  District 44    0.0       0.220151       1.0       0.440303
3354  California  District 44    1.0       0.220151       1.0       0.440303

      rel_won_proba
3294            0.5
3354            0.5
```

Data of the occurrence from list:

```
           state     district  is_incumbent  party      year  \
3294  California  District 44     -0.907499    0.0  0.052753
3354  California  District 44     -0.907499    1.0  0.052753

      first_time_elected  count_victories  Log10fundraising  \
3294           -0.527344        -0.527182           0.30113
3354           -0.527344        -0.527182           0.30113

      own_president_party  own_last_house_majority  ownPartisan  \
3294                  1.0                      1.0          0.0
3354                  0.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3294            1.0             0.0             0.0              1.195709
3354            1.0             0.0             0.0             -1.193918

      own_president_job_approval  president_opposition_job_approval  \
3294                    1.187299                          -0.990527
3354                   -0.983013                           1.180121

      unemployement_rate_own_president  \
3294                          0.733431
3354                         -0.907410

      unemployement_rate_president_opposition  abs_won_proba
3294                                -0.915850       0.220151
3354                                 0.736017       0.220151
```

```
model: Random Forest of 100 depth-17 trees
year: 1994
model: AdaBoost Classifier 400 depth-1 trees
year: 1994
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
```

```
Following the list of affected districts:


         state     district  won_pred
37  California  District 44       2.0
64       Maine   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
3294  California  District 44    0.0       0.408496       1.0       0.816992
3354  California  District 44    1.0       0.408496       1.0       0.816992

      rel_won_proba
3294            0.5
3354            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
3294  California  District 44     -0.907499    0.0  0.052753
3354  California  District 44     -0.907499    1.0  0.052753

      first_time_elected  count_victories  Log10fundraising  \
3294           -0.527344        -0.527182           0.30113
3354           -0.527344        -0.527182           0.30113

      own_president_party  own_last_house_majority  ownPartisan  \
3294                  1.0                      1.0          0.0
3354                  0.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
3294            1.0             0.0             0.0              1.195709
3354            1.0             0.0             0.0             -1.193918

      own_president_job_approval  president_opposition_job_approval  \
3294                    1.187299                          -0.990527
3354                   -0.983013                           1.180121

      unemployement_rate_own_president  \
3294                          0.733431
3354                         -0.907410

      unemployement_rate_president_opposition  abs_won_proba
3294                                -0.915850       0.408496
```

```
3354                                 0.736017      0.408496


model: Logistic Regression CV=5
year: 1990
model: LDA
year: 1990
model: Decision Tree, depth=4
year: 1990


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


      state    district  won_pred
45  Colorado  District 4       2.0
70   Vermont    At-Large       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3062  Colorado  District 4    0.0       0.219359       1.0       0.438717
3063  Colorado  District 4    1.0       0.219359       1.0       0.438717

      rel_won_proba
3062            0.5
3063            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
3062  Colorado  District 4     -0.907765    0.0 -0.102275           -0.523513
3063  Colorado  District 4     -0.907765    1.0 -0.102275           -0.523513

      count_victories  Log10fundraising  own_president_party  \
3062        -0.523862          0.379619                  0.0
3063        -0.523862          0.379619                  1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
3062                      1.0          0.0            1.0             0.0
3063                      0.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
```

```
3062           0.0           1.237058                     -0.983563
3063           0.0          -1.234712                      1.420308

      president_opposition_job_approval  unemployement_rate_own_president  \
3062                           1.413230                         -0.907511
3063                          -0.991066                          0.762707

      unemployement_rate_president_opposition  abs_won_proba
3062                                 0.765490       0.219359
3063                                -0.915934       0.219359


model: Random Forest of 100 depth-17 trees
year: 1990
model: AdaBoost Classifier 400 depth-1 trees
year: 1990


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
2 districts have no winner or more than one winner.
Following the list of affected districts:


       state    district  won_pred
45  Colorado  District 4       2.0
70   Vermont    At-Large       2.0


First occurrence from list:


         state    district  party  abs_won_proba  won_pred  sum_won_proba  \
3062  Colorado  District 4    0.0       0.408459       1.0       0.816918
3063  Colorado  District 4    1.0       0.408459       1.0       0.816918

      rel_won_proba
3062            0.5
3063            0.5


Data of the occurrence from list:


         state    district  is_incumbent  party      year  first_time_elected  \
3062  Colorado  District 4     -0.907765    0.0 -0.102275           -0.523513
3063  Colorado  District 4     -0.907765    1.0 -0.102275           -0.523513

      count_victories  Log10fundraising  own_president_party  \
3062        -0.523862          0.379619                  0.0
```

```
3063       -0.523862         0.379619                 1.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
3062                      1.0          0.0            1.0             0.0
3063                      0.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
3062             0.0              1.237058                   -0.983563
3063             0.0             -1.234712                    1.420308

      president_opposition_job_approval  unemployement_rate_own_president  \
3062                           1.413230                         -0.907511
3063                          -0.991066                          0.762707

      unemployement_rate_president_opposition  abs_won_proba
3062                                 0.765490       0.408459
3063                                -0.915934       0.408459


model: Logistic Regression CV=5
year: 1986
model: LDA
year: 1986
model: Decision Tree, depth=4
year: 1986


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
6 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
11  California   District 2       2.0
13  California  District 21       2.0
54    Maryland   District 8       2.0
62        Utah   District 2       2.0
65    Virginia   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2735  California  District 12    1.0        0.21814       1.0        0.43628
2736  California  District 12    0.0        0.21814       1.0        0.43628

      rel_won_proba
```

```
2735           0.5
2736           0.5


Data of the occurrence from list:


          state     district  is_incumbent  party    year  \
2735  California  District 12     -0.909019    1.0 -0.2572
2736  California  District 12     -0.909019    0.0 -0.2572

      first_time_elected  count_victories  Log10fundraising  \
2735           -0.523678        -0.523866          0.634395
2736           -0.523678        -0.523866          0.634395

      own_president_party  own_last_house_majority  ownPartisan  \
2735                  1.0                      0.0          0.0
2736                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2735            1.0             0.0             0.0             -1.027179
2736            1.0             0.0             0.0              1.029704

      own_president_job_approval  president_opposition_job_approval  \
2735                    1.094214                          -0.990337
2736                   -0.983083                           1.087296

      unemployement_rate_own_president  \
2735                          1.078907
2736                         -0.907294

      unemployement_rate_president_opposition  abs_won_proba
2735                                -0.915517        0.21814
2736                                 1.084153        0.21814


model: Random Forest of 100 depth-17 trees
year: 1986
model: AdaBoost Classifier 400 depth-1 trees
year: 1986


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
5 districts have no winner or more than one winner.
Following the list of affected districts:


        state     district  won_pred
3   California  District 12       2.0
```

```
11  California   District 2       2.0
13  California  District 21       2.0
54    Maryland   District 8       2.0
65    Virginia   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2735  California  District 12    1.0       0.408643       1.0       0.817286
2736  California  District 12    0.0       0.408643       1.0       0.817286

      rel_won_proba
2735            0.5
2736            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party    year  \
2735  California  District 12     -0.909019    1.0 -0.2572
2736  California  District 12     -0.909019    0.0 -0.2572

      first_time_elected  count_victories  Log10fundraising  \
2735           -0.523678        -0.523866          0.634395
2736           -0.523678        -0.523866          0.634395

      own_president_party  own_last_house_majority  ownPartisan  \
2735                  1.0                      0.0          0.0
2736                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2735            1.0             0.0             0.0             -1.027179
2736            1.0             0.0             0.0              1.029704

      own_president_job_approval  president_opposition_job_approval  \
2735                    1.094214                          -0.990337
2736                   -0.983083                           1.087296

      unemployement_rate_own_president  \
2735                          1.078907
2736                         -0.907294

      unemployement_rate_president_opposition  abs_won_proba
2735                                -0.915517       0.408643
2736                                 1.084153       0.408643
```

```
model: Logistic Regression CV=5
year: 1982


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
36  California  District 43       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2513  California  District 43    1.0       0.231145       1.0       0.654716
2528  California  District 43    0.0       0.192425       0.0       0.654716
2569  California  District 43    1.0       0.231145       1.0       0.654716

      rel_won_proba
2513       0.353047
2528       0.293907
2569       0.353047


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2513  California  District 43     -0.909482    1.0 -0.412345
2528  California  District 43     -0.909482    0.0 -0.412345
2569  California  District 43     -0.909482    1.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2513             -0.5259        -0.525692         -0.062539
2528             -0.5259        -0.525692         -0.062539
2569             -0.5259        -0.525692         -0.062539

      own_president_party  own_last_house_majority  ownPartisan  \
2513                  1.0                      0.0          0.0
2528                  0.0                      1.0          0.0
2569                  1.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2513            1.0             0.0             0.0             -0.734935
2528            1.0             0.0             0.0              0.736978
2569            1.0             0.0             0.0             -0.734935
```

```
      own_president_job_approval  president_opposition_job_approval  \
2513                    1.094421                          -0.990568
2528                   -0.982864                           1.087002
2569                    1.094421                          -0.990568

      unemployement_rate_own_president  \
2513                          2.074204
2528                         -0.910201
2569                          2.074204

      unemployement_rate_president_opposition  abs_won_proba
2513                                -0.919018       0.231145
2528                                 2.085907       0.192425
2569                                -0.919018       0.231145


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
1 districts have no winner or more than one winner.
Following the list of affected districts:


The conflict in California, District 43 is between candidates from the same party, so we predic
model: LDA
year: 1982


         state     district  won_pred
36  California  District 43       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2513  California  District 43    1.0       0.095103       1.0       0.241411
2528  California  District 43    0.0       0.051206       0.0       0.241411
2569  California  District 43    1.0       0.095103       1.0       0.241411

      rel_won_proba
2513       0.393945
2528       0.212109
2569       0.393945


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
```

```
2513  California  District 43     -0.909482    1.0 -0.412345
2528  California  District 43     -0.909482    0.0 -0.412345
2569  California  District 43     -0.909482    1.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2513             -0.5259        -0.525692         -0.062539
2528             -0.5259        -0.525692         -0.062539
2569             -0.5259        -0.525692         -0.062539

      own_president_party  own_last_house_majority  ownPartisan  \
2513                  1.0                      0.0          0.0
2528                  0.0                      1.0          0.0
2569                  1.0                      0.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2513            1.0             0.0             0.0             -0.734935
2528            1.0             0.0             0.0              0.736978
2569            1.0             0.0             0.0             -0.734935

      own_president_job_approval  president_opposition_job_approval  \
2513                    1.094421                          -0.990568
2528                   -0.982864                           1.087002
2569                    1.094421                          -0.990568

      unemployement_rate_own_president  \
2513                          2.074204
2528                         -0.910201
2569                          2.074204

      unemployement_rate_president_opposition  abs_won_proba
2513                                -0.919018       0.095103
2528                                 2.085907       0.051206
2569                                -0.919018       0.095103


The conflict in California, District 43 is between candidates from the same party, so we predi
model: Decision Tree, depth=4
year: 1982


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
6 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
9   California  District 18       2.0
```

```
19  California  District 27       2.0
36  California  District 43       3.0
37  California  District 44       2.0
40  California   District 6       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2445  California  District 12    1.0       0.217566       1.0       0.435132
2500  California  District 12    0.0       0.217566       1.0       0.435132

      rel_won_proba
2445            0.5
2500            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2445  California  District 12     -0.909482    1.0 -0.412345
2500  California  District 12     -0.909482    0.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2445             -0.5259        -0.525692          0.634763
2500             -0.5259        -0.525692          0.634763

      own_president_party  own_last_house_majority  ownPartisan  \
2445                  1.0                      0.0          0.0
2500                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2445            1.0             0.0             0.0             -0.734935
2500            1.0             0.0             0.0              0.736978

      own_president_job_approval  president_opposition_job_approval  \
2445                    1.094421                          -0.990568
2500                   -0.982864                           1.087002

      unemployement_rate_own_president  \
2445                          2.074204
2500                         -0.910201

      unemployement_rate_president_opposition  abs_won_proba
2445                                -0.919018       0.217566
2500                                 2.085907       0.217566
```

```
model: Random Forest of 100 depth-17 trees
year: 1982
model: AdaBoost Classifier 400 depth-1 trees
year: 1982


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
6 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
3   California  District 12       2.0
9   California  District 18       2.0
19  California  District 27       2.0
36  California  District 43       3.0
37  California  District 44       2.0
40  California   District 6       2.0


First occurrence from list:


          state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2445  California  District 12    1.0       0.408167       1.0       0.816335
2500  California  District 12    0.0       0.408167       1.0       0.816335

      rel_won_proba
2445            0.5
2500            0.5


Data of the occurrence from list:


          state     district  is_incumbent  party      year  \
2445  California  District 12     -0.909482    1.0 -0.412345
2500  California  District 12     -0.909482    0.0 -0.412345

      first_time_elected  count_victories  Log10fundraising  \
2445             -0.5259        -0.525692          0.634763
2500             -0.5259        -0.525692          0.634763

      own_president_party  own_last_house_majority  ownPartisan  \
2445                  1.0                      0.0          0.0
2500                  0.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2445            1.0             0.0             0.0             -0.734935
```

```
2500           1.0             0.0             0.0              0.736978

     own_president_job_approval  president_opposition_job_approval  \
2445                   1.094421                          -0.990568
2500                  -0.982864                           1.087002

     unemployement_rate_own_president  \
2445                         2.074204
2500                        -0.910201

     unemployement_rate_president_opposition  abs_won_proba
2445                                -0.919018       0.408167
2500                                 2.085907       0.408167


model: Logistic Regression CV=5
year: 1978
model: LDA
year: 1978
model: Decision Tree, depth=4
year: 1978


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
9   California  District 18       2.0
25  California  District 33       2.0
42    Colorado   District 3       2.0
48       Maine   District 2       2.0


First occurrence from list:


           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2214  California  District 18    1.0       0.218861       1.0       0.437722
2216  California  District 18    0.0       0.218861       1.0       0.437722

     rel_won_proba
2214           0.5
2216           0.5


Data of the occurrence from list:
```

```
           state     district  is_incumbent  party      year  \
2214  California  District 18     -0.908567    1.0 -0.567381
2216  California  District 18     -0.908567    0.0 -0.567381

      first_time_elected  count_victories  Log10fundraising  \
2214           -0.525551        -0.525457          0.147788
2216           -0.525551        -0.525457          0.147788

      own_president_party  own_last_house_majority  ownPartisan  \
2214                  0.0                      0.0          0.0
2216                  1.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2214            1.0             0.0             0.0             -2.209922
2216            1.0             0.0             0.0              2.212019

      own_president_job_approval  president_opposition_job_approval  \
2214                   -0.983016                           0.796337
2216                    0.803759                          -0.990708

      unemployement_rate_own_president  \
2214                         -0.907662
2216                          0.734766

      unemployement_rate_president_opposition  abs_won_proba
2214                                 0.737173       0.218861
2216                                -0.916271       0.218861


model: Random Forest of 100 depth-17 trees
year: 1978
model: AdaBoost Classifier 400 depth-1 trees
year: 1978


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
4 districts have no winner or more than one winner.
Following the list of affected districts:


         state     district  won_pred
9   California  District 18       2.0
25  California  District 33       2.0
42    Colorado   District 3       2.0
48       Maine   District 2       2.0


First occurrence from list:
```

```
           state     district  party  abs_won_proba  won_pred  sum_won_proba  \
2214  California  District 18    1.0       0.407383       1.0       0.814765
2216  California  District 18    0.0       0.407383       1.0       0.814765

      rel_won_proba
2214            0.5
2216            0.5


Data of the occurrence from list:


           state     district  is_incumbent  party      year  \
2214  California  District 18     -0.908567    1.0 -0.567381
2216  California  District 18     -0.908567    0.0 -0.567381

      first_time_elected  count_victories  Log10fundraising  \
2214           -0.525551        -0.525457          0.147788
2216           -0.525551        -0.525457          0.147788

      own_president_party  own_last_house_majority  ownPartisan  \
2214                  0.0                      0.0          0.0
2216                  1.0                      1.0          0.0

      swingDistrict  partisanship_2  partisanship_3  last_own_party_Seats  \
2214            1.0             0.0             0.0             -2.209922
2216            1.0             0.0             0.0              2.212019

      own_president_job_approval  president_opposition_job_approval  \
2214                   -0.983016                           0.796337
2216                    0.803759                          -0.990708

      unemployement_rate_own_president  \
2214                         -0.907662
2216                          0.734766

      unemployement_rate_president_opposition  abs_won_proba
2214                                 0.737173       0.407383
2216                                -0.916271       0.407383
```

Here we see how the predictions look like. The name of the columns are kept short as the model names are too long.

A legend is displayed to identify the model

```
In [25]: #display prediction table for stacking and model names legenda
         display(predictionsToStack.head())
         for i in range(len(modelList)):
             print(i, modelList[i]['name'])
```

```
   baseline  baseline_proba  pred_0   proba_0  pred_1   proba_1  pred_2  \
0       1.0        1.000000     1.0  0.963650     1.0  0.992239     1.0
1       1.0        0.857143     1.0  0.960939     1.0  0.991644     1.0
2       1.0        1.000000     1.0  0.965379     1.0  0.992509     1.0
3       1.0        1.000000     1.0  1.000000     1.0  1.000000     1.0
4       0.0        0.571429     1.0  1.000000     1.0  1.000000     1.0

    proba_2  pred_3   proba_3  pred_4   proba_4  party
0  0.943496     1.0  0.978861     1.0  0.646857    1.0
1  0.943496     1.0  0.998370     1.0  0.657175    1.0
2  0.943496     1.0  0.998435     1.0  0.657175    1.0
3  1.000000     1.0  1.000000     1.0  1.000000    1.0
4  1.000000     1.0  1.000000     1.0  1.000000    1.0
```

```
0 Logistic Regression CV=5
1 LDA
2 Decision Tree, depth=4
3 Random Forest of 100 depth-17 trees
4 AdaBoost Classifier 400 depth-1 trees
```

Then, we select which models to use to train our stacking model.
The selection is done by looking at the coefficients of the model, taking only the biggest ones

In [26]:
```
#Select which model predictions to stack
selCols=[4,8,12]
X=predictionsToStack.iloc[:,selCols].drop('party', axis=1).astype(float)
y=predictionsToStack.iloc[:,selCols]['party'].astype(float)
stackingModel = LogisticRegression(C=1000, solver='lbfgs').fit(X,y)
print('Training accuracy of the stacking model: {:.2%}'.format(stackingModel.score(X,y
print('Stacking model coefficients: {}'.format(stackingModel.coef_))
```

```
Training accuracy of the stacking model: 91.39%
Stacking model coefficients: [[1.83039939 3.14929837]]
```

Now we need to generate the predictions for 2018 data using all models:

In [27]:
```
#split dataset using 2018 data as test set
year=2018
#data=house_df[(house_df['year']>=yearStart)]
data=train_data.append(test_data)
predictions2018toStack=predictForStack(data, [year], modelList)
```

```
model: Logistic Regression CV=5
year: 2018
model: LDA
year: 2018
```

```
model: Decision Tree, depth=4
year: 2018


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
28 districts have no winner or more than one winner.
Following the list of affected districts:


              state     district  won_pred
95          Florida  District 17       2.0
106         Florida  District 27       2.0
144        Illinois   District 4       2.0
212       Minnesota   District 1       2.0
222     Mississippi   District 3       2.0
239          Nevada   District 4       2.0
244      New Jersey  District 11       2.0
246      New Jersey   District 2       2.0
296  North Carolina   District 9       2.0
297    North Dakota     At-Large       2.0
314        Oklahoma   District 1       2.0
328    Pennsylvania  District 13       2.0
329    Pennsylvania  District 14       2.0
332    Pennsylvania  District 17       2.0
336    Pennsylvania   District 4       2.0
338    Pennsylvania   District 6       2.0
339    Pennsylvania   District 7       2.0
341    Pennsylvania   District 9       2.0
344  South Carolina   District 1       2.0
347  South Carolina   District 4       2.0
351    South Dakota     At-Large       2.0
353       Tennessee   District 2       2.0
372           Texas   District 2       2.0
408        Virginia   District 5       2.0
409        Virginia   District 6       2.0
421      Washington   District 8       2.0
425   West Virginia   District 3       2.0
426       Wisconsin   District 1       2.0


First occurrence from list:


        state     district  party  abs_won_proba  won_pred  sum_won_proba  \
9865  Florida  District 17    1.0       0.217172       1.0       0.434343
9869  Florida  District 17    0.0       0.217172       1.0       0.434343

      rel_won_proba
9865            0.5
```

```
9869          0.5


Data of the occurrence from list:


        state     district  is_incumbent  party      year  first_time_elected  \
9865  Florida  District 17     -0.908244    1.0  0.974413           -0.525453
9869  Florida  District 17     -0.908244    0.0  0.974413           -0.525453

      count_victories  Log10fundraising  own_president_party  \
9865        -0.525503         -0.007582                  1.0
9869        -0.525503         -0.007582                  0.0

      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
9865                      1.0          0.0            1.0             0.0
9869                      0.0          0.0            1.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
9865             0.0              0.681514                    0.570016
9869             0.0             -0.679495                   -0.983090

      president_opposition_job_approval  unemployement_rate_own_president  \
9865                          -0.990684                          0.141504
9869                           0.562641                         -0.908416

      unemployement_rate_president_opposition  abs_won_proba
9865                                -0.916945       0.217172
9869                                 0.139951       0.217172


model: Random Forest of 100 depth-17 trees
year: 2018
model: AdaBoost Classifier 400 depth-1 trees
year: 2018


C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:59: UserWarning:
31 districts have no winner or more than one winner.
Following the list of affected districts:


           state     district  won_pred
16       Arizona   District 9       2.0
95       Florida  District 17       2.0
106      Florida  District 27       2.0
200     Michigan  District 11       2.0
212    Minnesota   District 1       2.0
219    Minnesota   District 8       2.0
```

```
222      Mississippi   District 3       2.0
239           Nevada   District 4       2.0
240    New Hampshire   District 1       2.0
244       New Jersey  District 11       2.0
246       New Jersey   District 2       2.0
296   North Carolina   District 9       2.0
297     North Dakota     At-Large       2.0
314         Oklahoma   District 1       2.0
328     Pennsylvania  District 13       2.0
329     Pennsylvania  District 14       2.0
332     Pennsylvania  District 17       2.0
336     Pennsylvania   District 4       2.0
338     Pennsylvania   District 6       2.0
339     Pennsylvania   District 7       2.0
341     Pennsylvania   District 9       2.0
344   South Carolina   District 1       2.0
347   South Carolina   District 4       2.0
351     South Dakota     At-Large       2.0
358        Tennessee   District 7       2.0
372            Texas   District 2       2.0
408         Virginia   District 5       2.0
409         Virginia   District 6       2.0
421       Washington   District 8       2.0
425    West Virginia   District 3       2.0
426        Wisconsin   District 1       2.0


First occurrence from list:


        state    district  party  abs_won_proba  won_pred  sum_won_proba  \
9291  Arizona  District 9    0.0       0.408031       1.0       0.816062
9292  Arizona  District 9    1.0       0.408031       1.0       0.816062

      rel_won_proba
9291            0.5
9292            0.5


Data of the occurrence from list:


        state    district  is_incumbent  party      year  first_time_elected  \
9291  Arizona  District 9     -0.908244    0.0  0.974413           -0.525453
9292  Arizona  District 9     -0.908244    1.0  0.974413           -0.525453

      count_victories  Log10fundraising  own_president_party  \
9291        -0.525503          0.492675                  0.0
9292        -0.525503          0.307241                  1.0
```

```
      own_last_house_majority  ownPartisan  swingDistrict  partisanship_2  \
9291                      0.0          0.0            0.0             0.0
9292                      1.0          0.0            0.0             0.0

      partisanship_3  last_own_party_Seats  own_president_job_approval  \
9291             0.0             -0.679495                   -0.983090
9292             0.0              0.681514                    0.570016

      president_opposition_job_approval  unemployement_rate_own_president  \
9291                           0.562641                         -0.908416
9292                          -0.990684                          0.141504

      unemployement_rate_president_opposition  abs_won_proba
9291                                 0.139951       0.408031
9292                                -0.916945       0.408031
```

Then we stack the 2018 predictions according to the selection used for model fit.
We have obtained our final predictions

```
In [28]: selCols_=selCols[:-1]
         X=predictions2018toStack.iloc[:,selCols_].copy().astype(float)
         X['stackedPredictions']=stackingModel.predict(X)
         X, y_pred_stacked_2018=X.drop('stackedPredictions', axis=1), X['stackedPredictions']
         pred2018_accuracy=districtAccuracy(y_pred_stacked_2018, 2018, 'stackedPredictions', 0)
         print('The accuracy of our predictions for 2018 midterm elections is {:.2%}'.format(pr
         pred2018=districtPredictions(y_pred_stacked_2018, 2018, 'stackedPredictions', 0) #yea
```

```
The accuracy of our predictions for 2018 midterm elections is 89.89%
```

What we need to do now is to prepare the table for the map, in csv format, with predictions, probabilities and actual results

```
In [29]: #calculate stacked probabilities
         probabilities=list(np.array(selCols_)+1)
         pred2018['proba']=predictions2018toStack.iloc[:,probabilities].dot(stackingModel.coef_
```

```
In [30]: #Salve .csv file
         pred2018=pred2018.rename(index=str, columns={'partyWon':'won', 'stackedPredictions':'w
         pred2018['correct_pred']=(pred2018['won']==pred2018['won_pred'])
         pred2018.to_csv('data/final_results_map.csv', index=True)
         display(pred2018.head())
```

```
                    won  won_pred  rel_won_proba  correct_pred
state   district
Alabama District 1    1       1.0       0.983862          True
        District 2    1       1.0       0.960887          True
```

```
District 3    1       1.0       0.871858          True
District 4    1       1.0       0.986864          True
District 5    1       1.0       0.934046          True
```

In [31]:
```python
pred2018.describe()
```

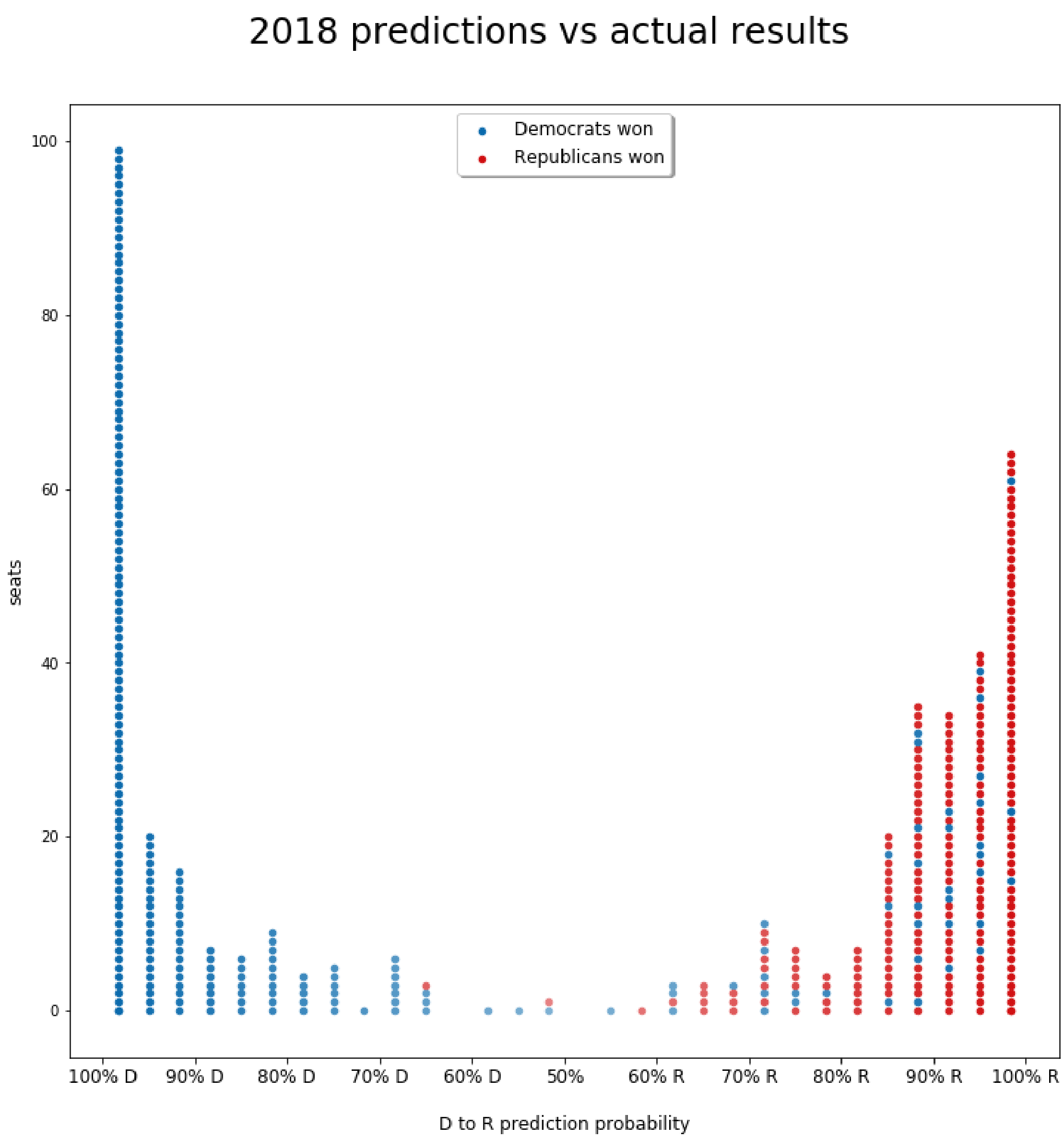
Out[31]:

	won	won_pred	rel_won_proba
count	435.000000	435.000000	435.000000
mean	0.471264	0.563218	0.904544
std	0.499748	0.496558	0.102699
min	0.000000	0.000000	0.514538
25%	0.000000	0.000000	0.863290
50%	0.000000	1.000000	0.938921
75%	1.000000	1.000000	0.981843
max	1.000000	1.000000	1.000000

In [32]:
```python
#print how many republican, how many democrat districts
DEM=pred2018[pred2018['won_pred']==0]
REP=pred2018[pred2018['won_pred']==1]
print('Predictions:\nN. Democrat districts: {}\nN. Republican districts: {}\n'.format
DEM=results[2018][results[2018]['partyWon']==0]
REP=results[2018][results[2018]['partyWon']==1]
print('Actual results:\nN. Democrat districts: {}\nN. Republican districts: {}'.forma
```

```
Predictions:
N. Democrat districts: 190
N. Republican districts: 245

Actual results:
N. Democrat districts: 230
N. Republican districts: 205
```

In [33]:
```python
#plot predictions vs actual results
plotDR(pred2018)
```



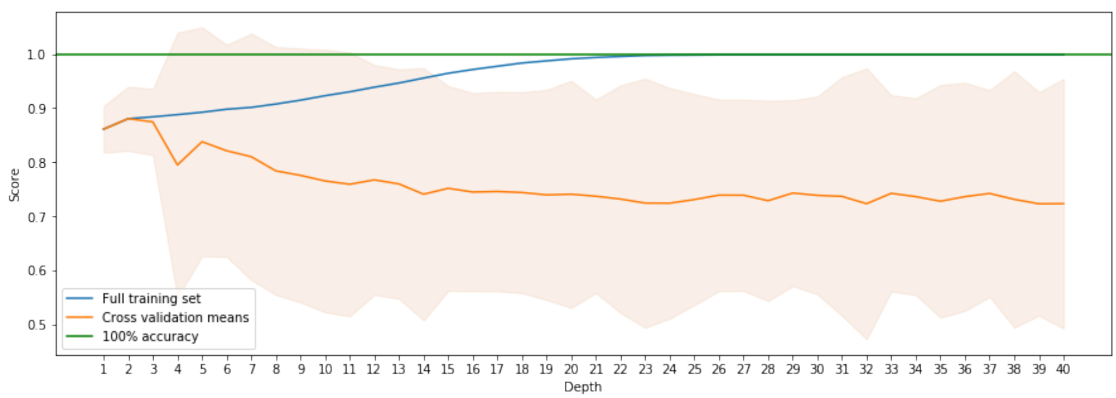
Hyper-parameters tuning

In the next lines we have evaluated the parameters to use for decision trees, random forest and boosting

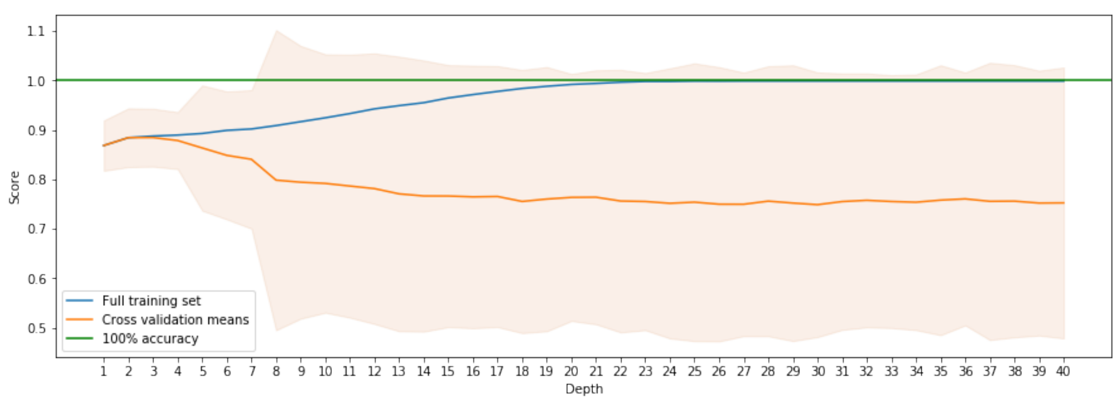
```
In [34]: #find best depth for decision tree
         years=Midterm_recent_years[:5]
         for year in years:
         #for year in []:
             #pre_process
             x_train_designFeatures, x_val_designFeatures, y_train, y_val, house_df_districts,

             #fit model
```

```
depths=list(range(1,41)) #set (maximum) tree depths 1, 2, 3, ..., 20
scores_train = []
scores_train_CV = []
scores_train_CVstd = []
for depth in depths:
    dt = DecisionTreeClassifier(max_depth = depth)
    scores = cross_val_score(estimator=dt, X=x_train_designFeatures, y=y_train, cv
    scores_train_CV.append(scores.mean()) #cross-validated score
    scores_train_CVstd.append(scores.std()) #cross-validated score
    dt.fit(x_train_designFeatures, y_train)
    scores_train.append(dt.score(x_train_designFeatures, y_train)) #score on trai

#plot
title='{}. Single decision tree score on full training vs CV=5 set'.format(year)
plotCVscores(depths, scores_train, scores_train_CV, scores_train_CVstd, title)
```

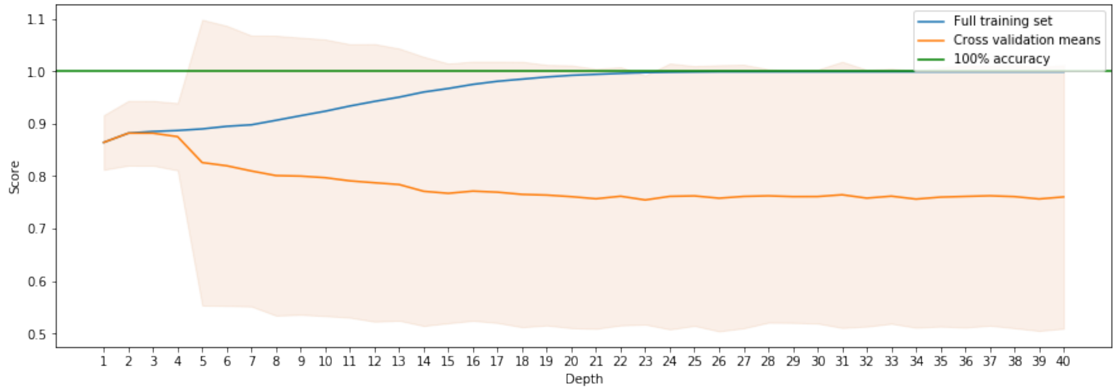
2014. Single decision tree score on full training vs CV=5 set



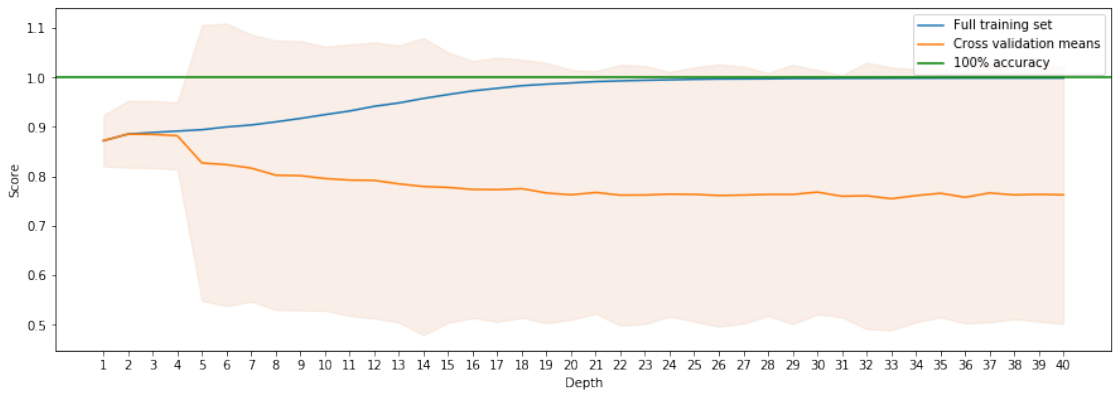
2010. Single decision tree score on full training vs CV=5 set



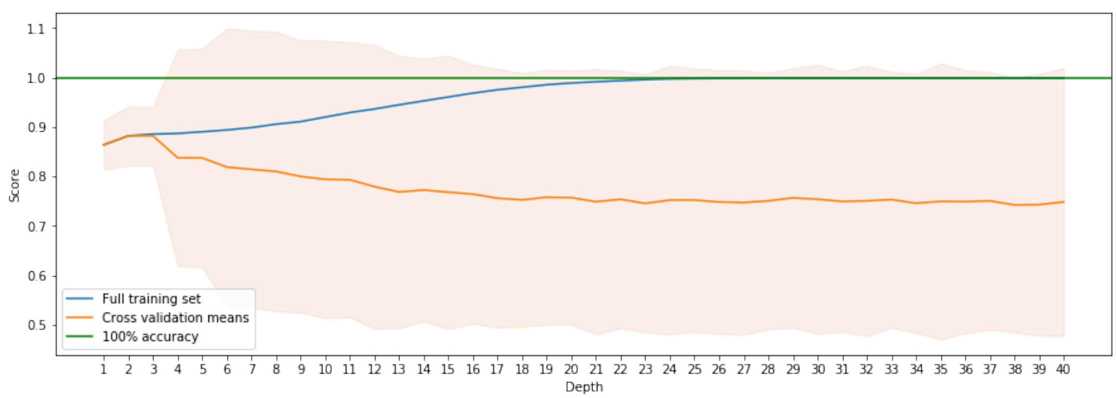
2006. Single decision tree score on full training vs CV=5 set



2002. Single decision tree score on full training vs CV=5 set

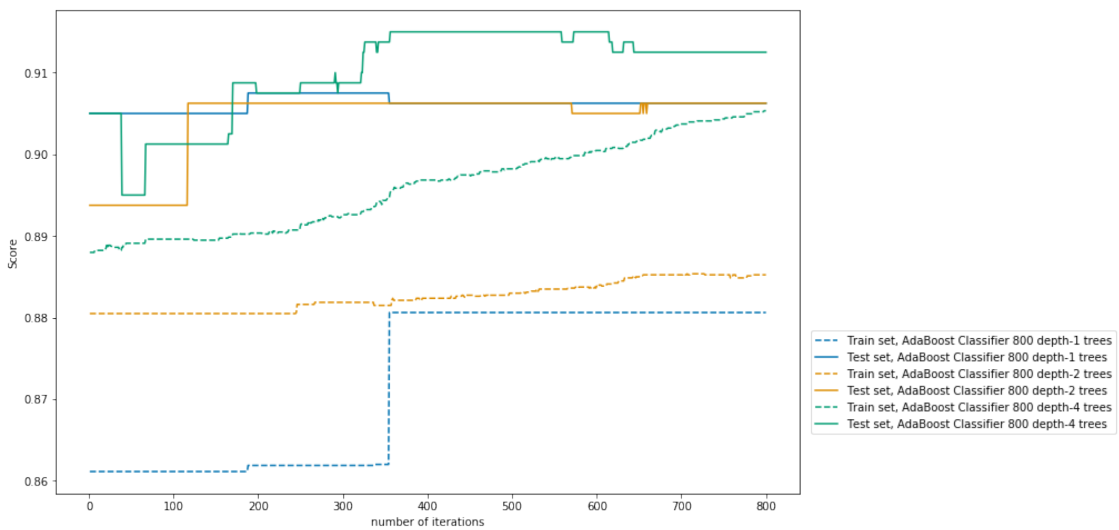


1998. Single decision tree score on full training vs CV=5 set

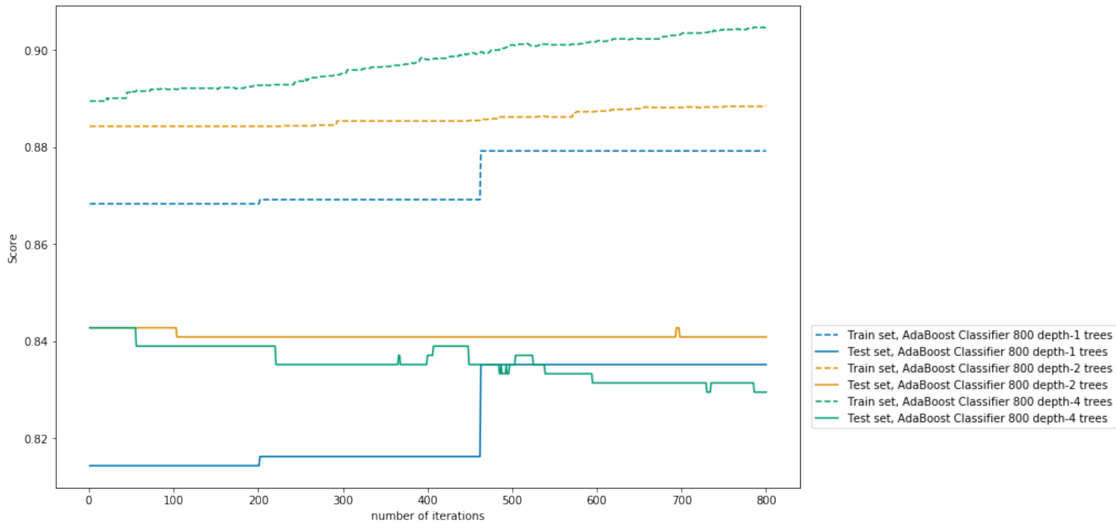


```
In [35]: #find best depth for decision tree and best n_estimators
         years=Midterm_recent_years[:5]
         for year in years:
         #for year in []:
             plotList=[]
             #pre_process
             x_train_designFeatures, x_val_designFeatures, y_train, y_val, house_df_districts,

             #fit AdaBoost classifiers for tree depth = 1,2,4
             n_trees=800
             lrate=0.01
             for i in [1,2,4]:
                 abc = AdaBoostClassifier(base_estimator=DecisionTreeClassifier(max_depth=i), n
                 model=dict()
                 model['name']='AdaBoost Classifier {} depth-{} trees'.format(n_trees, i)
                 model['model']=abc.fit(x_train_designFeatures, y_train)
                 model['training accuracy']=model['model'].score(x_train_designFeatures, y_trai
                 model['test accuracy']=model['model'].score(x_val_designFeatures, y_val)
                 plotList.append(model)
             title='{}. Boosting score vs number of iterations'.format(year)
             PlotAdaBoost3(plotList, x_train_designFeatures, y_train, x_val_designFeatures, y_v
```

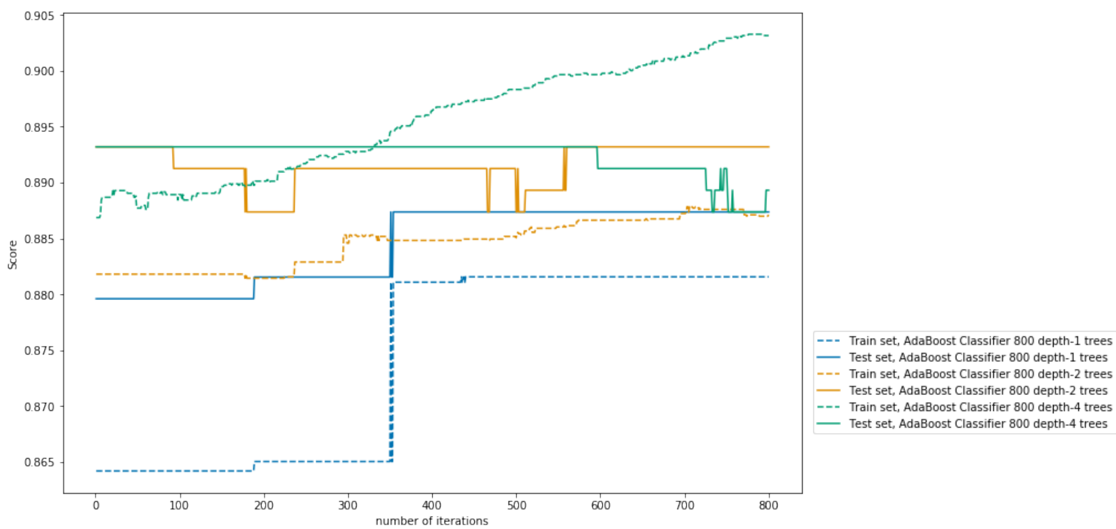
2014. Boosting score vs number of iterations



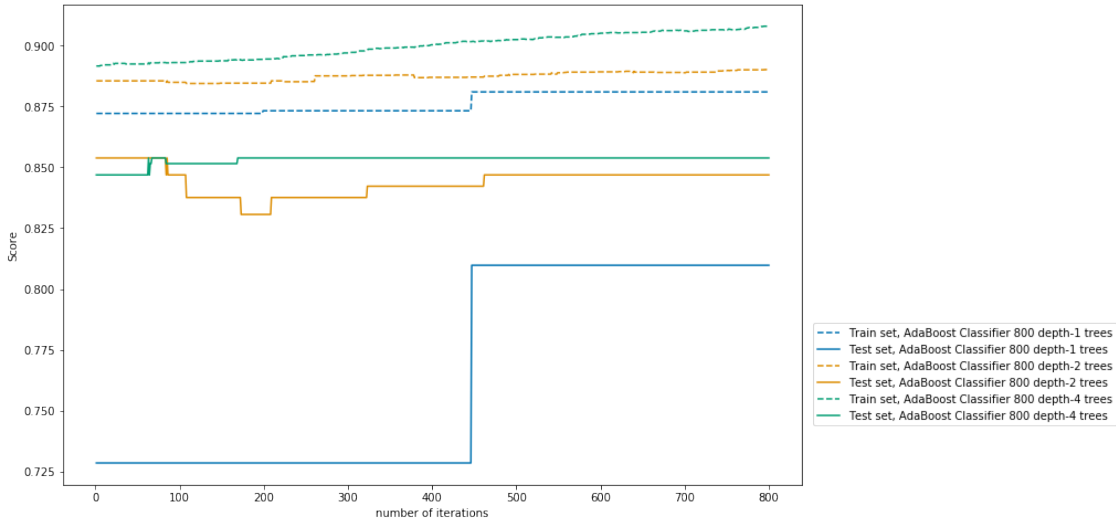
2010. Boosting score vs number of iterations



2006. Boosting score vs number of iterations



2002. Boosting score vs number of iterations



1998. Boosting score vs number of iterations