Modeling Temporal Effects

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
sns.set_context('poster')
import random
from sklearn.preprocessing import StandardScaler
```

In [2]:
```
from project_helper import *
```

Separate Data Subsets

In [3]:
```
# read source data
df = pd.DataFrame.from_csv('../data/merged/all_data_2006_to_2016.csv', index_col=None)
```

In [4]:
```
# save feature and label columns for later
label_col = 'murder_per_100_k'
feature_cols = df.drop(['MSA_orig', 'MSA_corr', 'MSA_abbr', 'year']+[label_col], axis=1).columns

# drop extra MSA names
df = df.drop(['MSA_orig', 'MSA_corr'], axis=1)
```

In [5]:
```
# remove outliers with atypically high murder rates
df = df[df.MSA_abbr != 'NEW_ORLEANS_LA']
df = df[(df.MSA_abbr != 'MEMPHIS_TN') | (df.year != 2016)]
df = df[(df.MSA_abbr != 'BATON_ROUGE_LA') | (df.year != 2007)]
```

In [6]:
```
# get dummies
df_d = pd.get_dummies(df, columns=['MSA_abbr'])
df_d['MSA_abbr'] = df.MSA_abbr

# store names of msa columns
msa_cols = [c for c in df_d.columns if c not in df.columns]

# train test split by year
split_yr = 2013

train_idxs = list((df_d.year <= split_yr).nonzero()[0])
test_idxs = list((df_d.year > split_yr).nonzero()[0])

print('Len train: {}'.format(len(train_idxs)))
print('Len test: {}'.format(len(test_idxs)))
```

```
Len train: 648
Len test: 268
```

In [7]:
```
# standardize features, fitting based on train rows only
standardizer = StandardScaler().fit(df_d.iloc[train_idxs][feature_cols])
df_fstd = pd.DataFrame(standardizer.transform(df_d[feature_cols]), columns=feature_cols)

# combine with previous MSA encodings and year
df_s = pd.concat([df_d.drop(feature_cols, axis=1).reset_index(drop=True), df_fstd.reset_index(drop=T

# split into train and test dataframes
df_train = df_s.iloc[train_idxs]
df_test = df_s.iloc[test_idxs]

print('Len data: {}'.format(len(df_train)))
print('Len test: {}'.format(len(df_test)))
```

```
Len data: 648
Len test: 268
```

In [8]:
```
def moving_average(df, ma_yrs, cols_to_smooth):
    '''
    Smooth data by averaging, for each observation, the values within each MSA
    across a moving window of [ma_yrs] years.
    '''

    # the min and max years in the dataset
    min_yr = int(df.year.min())
    max_yr = int(df.year.max())

    # get the list of unique MSAs to cycle through
    MSAs = df.MSA_abbr.unique()

    # holds list of pd.Series to become dataframe
    smoothed_rows = []

    # loop through MSAs
    for m in MSAs:
        # loop through years starting at the lowest
        for year in range(min_yr, max_yr+1):

            # bounds for searching years
            yr_l = max(year-(ma_yrs-1)/2, min_yr)
            yr_h = min(year+(ma_yrs-1)/2, max_yr)

            # get window of data
            window = df[(df.year >= yr_l) & (df.year <= yr_h) & (df.MSA_abbr == m)][feature_cols]

            # source row
            row_id = ((df.year == year) & (df.MSA_abbr == m)).nonzero()[0]

            if row_id.size > 0:
                row_id = row_id[0]
                row_data = df.iloc[row_id]

                # fill columns with window means and save it
                row_data[feature_cols] = window.mean()
                smoothed_rows.append(row_data)

    return pd.DataFrame(smoothed_rows)
```

In [9]:
```
# apply smoothing only to training data
df_train_smoothed = moving_average(df_train, 5, feature_cols+[label_col])
```

```
/Users/davidloving/anaconda3/envs/tf-gpu/lib/python3.6/site-packages/ipykernel/__main__.py:38: Se
ttingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#i
ndexing-view-versus-copy (http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-view
-versus-copy)
/Users/davidloving/anaconda3/envs/tf-gpu/lib/python3.6/site-packages/pandas/core/series.py:817: S
ettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#i
ndexing-view-versus-copy (http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-view
-versus-copy)
  self._set_labels(key, value)
```

In [10]:
```
# year still needs to be rescaled for all datasets
# rescale to approx [0.1 , 1.0]
df_train['year'] = (df_train['year']-2005)/11
df_train_smoothed['year'] = (df_train_smoothed['year']-2005)/11
df_test['year'] = (df_test['year']-2005)/11


# drop un-encoded MSA
df_train_r = df_train.drop('MSA_abbr', axis=1)
df_train_smoothed_r = df_train_smoothed.drop('MSA_abbr', axis=1)
df_test_r = df_test.drop('MSA_abbr', axis=1)


# split predictor and dependent variables
x_train = df_train_r.drop(label_col, axis=1)
x_train_smoothed = df_train_smoothed_r.drop(label_col, axis=1)
x_test = df_test_r.drop(label_col, axis=1)
```

```
y_train = df_train_r[label_col]
y_train_smoothed = df_train_smoothed_r[label_col]
y_test = df_test_r[label_col]


# make no-MSA subset
x_train_nmsa = df_train_r.drop([label_col]+msa_cols, axis=1)
x_train_smoothed_nmsa = df_train_smoothed_r.drop([label_col]+msa_cols, axis=1)
x_test_nmsa = df_test_r.drop([label_col]+msa_cols, axis=1)
```

```
/Users/davidloving/anaconda3/envs/tf-gpu/lib/python3.6/site-packages/ipykernel/__main__.py:3: Set
tingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#i
ndexing-view-versus-copy (http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-view
-versus-copy)
  app.launch_new_instance()
/Users/davidloving/anaconda3/envs/tf-gpu/lib/python3.6/site-packages/ipykernel/__main__.py:5: Set
tingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#i
ndexing-view-versus-copy (http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-view
-versus-copy)
```

Fitting The Models

In [11]:
```
from sklearn.linear_model import LinearRegression, RidgeCV, LassoCV, BayesianRidge, HuberRegressor
from sklearn.model_selection import GridSearchCV
from sklearn.neural_network import MLPRegressor
from sklearn.neighbors import KNeighborsRegressor
from sklearn.ensemble import AdaBoostRegressor
from sklearn.svm import SVR
```

In [12]:
```
# instantiate and fit models
def make_models(x_train, y_train):
    md = dict()

    md['linear'] = LinearRegression().fit(x_train, y_train)
    md['ridge'] = RidgeCV(cv=5).fit(x_train, y_train)
    md['huber'] = GridSearchCV(HuberRegressor(),{'epsilon': [1.0,1.2,1.4,1.6,1.8]}, n_jobs=-1).fit(x
    md['knn'] = GridSearchCV(KNeighborsRegressor(),{'n_neighbors':[5,10,20,40]}, n_jobs=-1).fit(x_tr
    md['adaboost'] = GridSearchCV(AdaBoostRegressor(), {'learning_rate':[0.1,0.3,0.6,1.0]}, n_jobs=-
    md['svr'] = GridSearchCV(SVR(), {'C':[0.01,0.1,1,10,100],'epsilon':[0.001,0.01,0.1,1,10]}, n_job

    return md
```

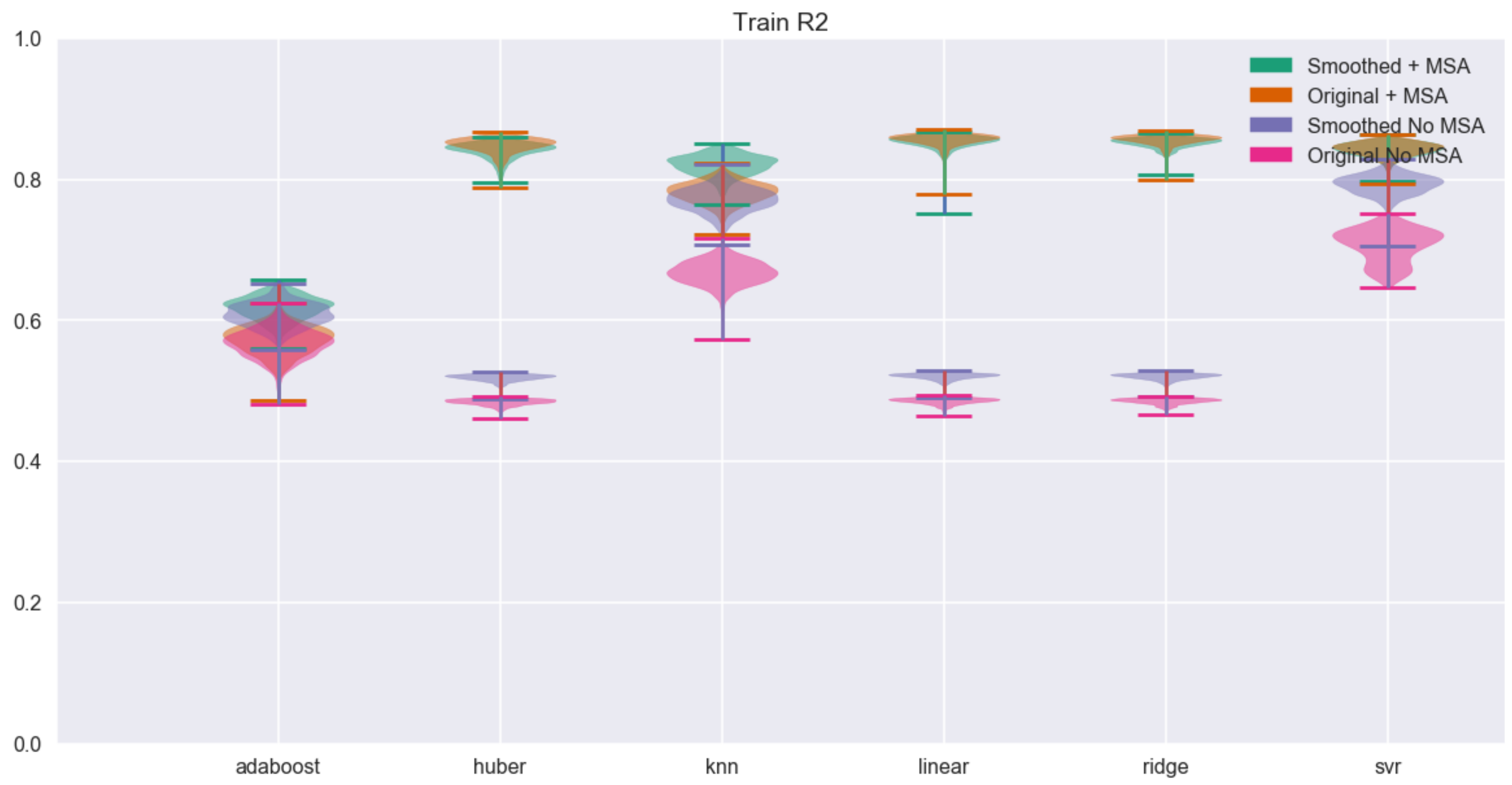
In [13]:
```
# Smoothed with MSA
exp_1 = run_experiment(make_models, 599, x_train_smoothed, y_train_smoothed, x_test, y_test)
print('1: Done')

# Not Smoothed with MSA
exp_2 = run_experiment(make_models, 599, x_train, y_train, x_test, y_test)
print('2: Done')

# Smoothed no MSA
exp_3 = run_experiment(make_models, 599, x_train_smoothed_nmsa, y_train_smoothed, x_test_nmsa, y_tes
print('3: Done')

# Not Smoothed no MSA
exp_4 = run_experiment(make_models, 599, x_train_nmsa, y_train, x_test_nmsa, y_test)
print('4: Done')
```

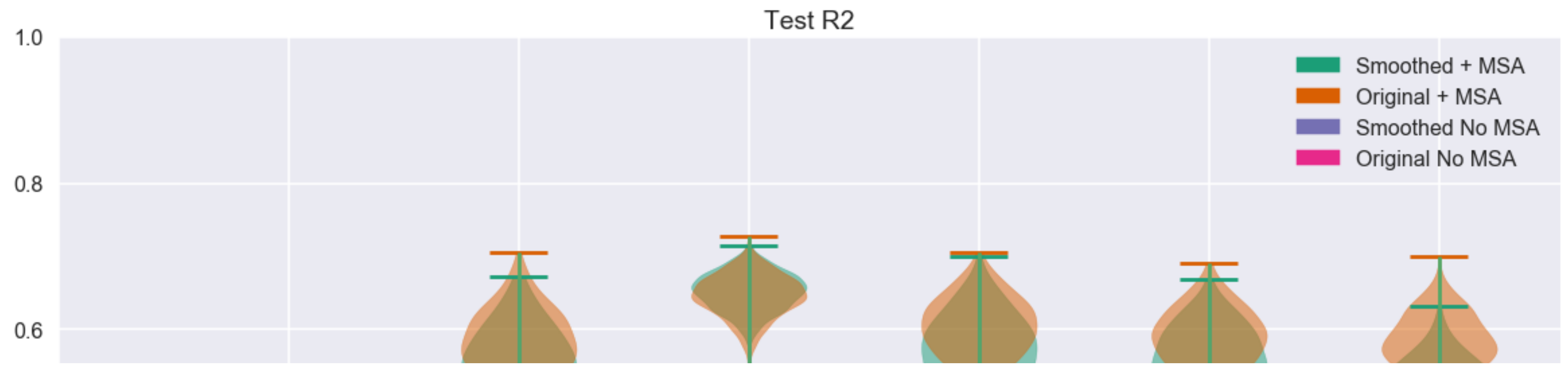
```
/Users/davidloving/anaconda3/envs/tf-gpu/lib/python3.6/site-packages/scipy/linalg/basic.py:1226:
RuntimeWarning: internal gelsd driver lwork query error, required iwork dimension not returned. T
his is likely the result of LAPACK bug 0038, fixed in LAPACK 3.2.2 (released July 21, 2010). Fall
ing back to 'gelss' driver.
  warnings.warn(mesg, RuntimeWarning)
```

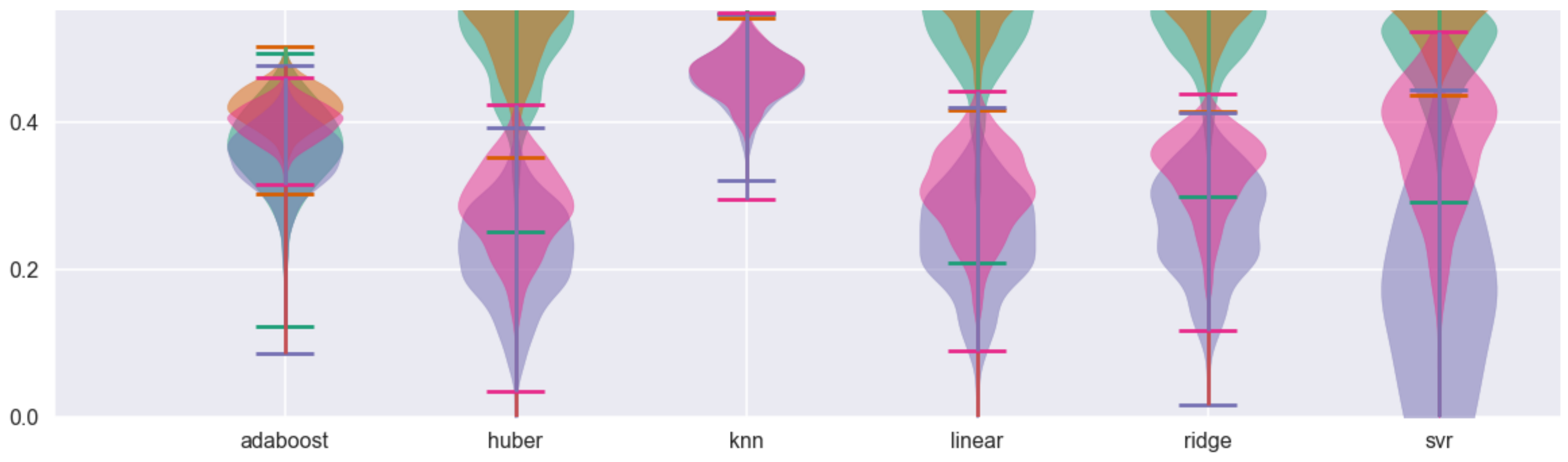
```
1: Done
2: Done
3: Done
4: Done
```

Accuracy Results

In [14]:
```
violin_plots([exp_1, exp_2, exp_3, exp_4],
             ['Train R2','Test R2'],
             experiment_name=['Smoothed + MSA','Original + MSA', 'Smoothed No MSA', 'Original No MSA
             center_zero=False)
```


Train R2
1.0
0.8
0.6
0.4
0.2
0.0
adaboost
huber
knn
linear
ridge
svr
Smoothed + MSA
Original + MSA
Smoothed No MSA
Original No MSA


Test R2
1.0
0.8
0.6
Smoothed + MSA
Original + MSA
Smoothed No MSA
Original No MSA


0.4
0.2
0.0
adaboost
huber
knn
linear
ridge
svr