Stock prices analysis

In this project, we will try to analysis time series data on Google stock prices from 2010 to 2016.
Specificly, we want to estimate the last 10 day of the dataset using other data as training set.
Data from [https://www.kaggle.com/dgawlik/nyse (https://www.kaggle.com/dgawlik/nyse)](https://www.kaggle.com/dgawlik/nyse).

Libray import

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import math
from sklearn.model_selection import train_test_split, TimeSeriesSplit, GridSea
rchCV
from sklearn.preprocessing import scale
from sklearn.linear_model import LinearRegression, Lasso

#import seaborn as sns
from statsmodels.tsa.stattools import adfuller
from statsmodels.tsa.arima_model import ARIMA

#from keras.models import Sequential
#from keras.layers.core import Dense, Dropout, Activation
#from keras.layers.recurrent import LSTM
#from keras.models import load_model
#import math, time
#import tensorflow as tf
%matplotlib inline
```

Data cleaning

In [2]:

```
priceDF = pd.read_csv('prices-split-adjusted.csv', index_col=0)
priceDF.head()
```

Out[2]:

	symbol	open	close	low	high	volume
date						
2016-01-05	WLTW	123.430000	125.839996	122.309998	126.250000	2163600.0
2016-01-06	WLTW	125.239998	119.980003	119.940002	125.540001	2386400.0
2016-01-07	WLTW	116.379997	114.949997	114.930000	119.739998	2489500.0
2016-01-08	WLTW	115.480003	116.620003	113.500000	117.440002	2006300.0
2016-01-11	WLTW	117.010002	114.970001	114.089996	117.330002	1408600.0

In [3]:
```
priceDF.isnull().any()
```

Out[3]:
```
symbol    False
open      False
close     False
low       False
high      False
volume    False
dtype: bool
```

In [4]:
```
priceDF.dtypes
```

Out[4]:
```
symbol     object
open      float64
close     float64
low       float64
high      float64
volume    float64
dtype: object
```

Data is already cleaned. Missing values were dropped due to weekends or company special event.

In this project, we will only use data from Google.

In [5]:
```
gDF = priceDF[priceDF['symbol'] == 'GOOGL']
gDF.drop(['symbol'], axis=1, inplace=True)
```

```
/dst1_env/lib/python3.6/site-packages/pandas/core/frame.py:3940: SettingWithC
opyWarning:
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/st
able/indexing.html#indexing-view-versus-copy
  errors=errors)
```

Data Summary

In [6]:
```
gDF.head()
```

Out[6]:

	open	close	low	high	volume
date					
2010-01-04	313.788792	313.688694	312.432438	315.070073	3908400.0
2010-01-05	313.903904	312.307316	311.081089	314.234226	6003300.0
2010-01-06	313.243260	304.434452	303.483494	313.243260	7949400.0
2010-01-07	305.005009	297.347355	296.621617	305.305302	12815700.0
2010-01-08	296.296299	301.311314	294.849857	301.926945	9439100.0

In [7]:
```
gDF.describe()
```

Out[7]:

	open	close	low	high	volume
count	1762.000000	1762.000000	1762.000000	1762.000000	1.762000e+03
mean	467.296599	467.088977	463.037583	471.042921	4.096043e+06
std	181.343840	181.223168	179.767145	182.608562	2.884423e+06
min	219.374377	218.253253	217.032031	221.361361	5.206000e+05
25%	299.672184	299.807316	297.302311	302.253514	2.004075e+06
50%	438.628637	438.786291	436.166174	440.785803	3.670550e+06
75%	587.770005	587.598039	583.287491	591.472856	5.171750e+06
max	838.500000	835.739990	829.039978	839.000000	2.961990e+07

We found that the 4 prices are highly correlated to each other, according to their quantile values, mean and std.

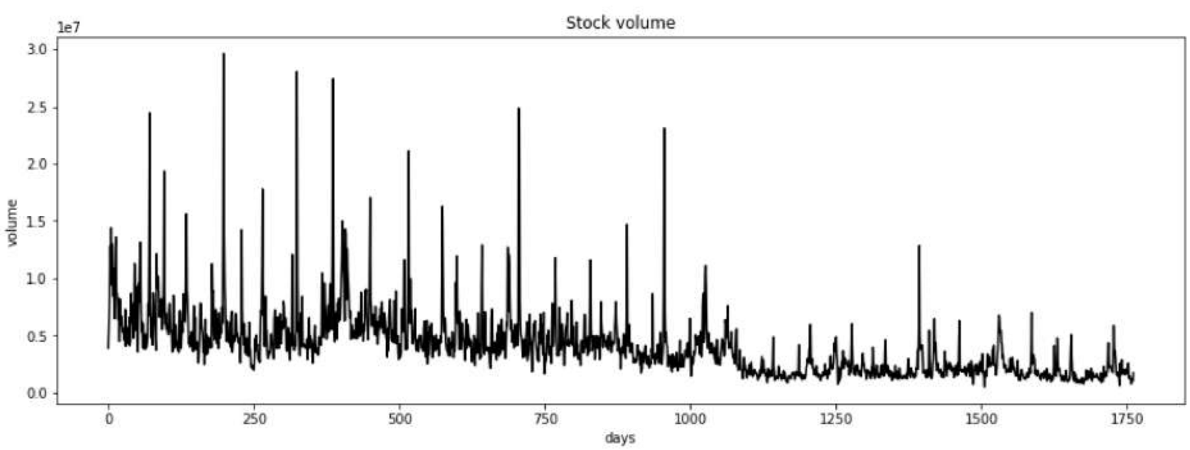
In [8]:
```
plt.figure(figsize=(15, 5))
plt.plot(gDF.open.values, color='red', label='open')
plt.plot(gDF.close.values, color='yellow', label='close')
plt.plot(gDF.low.values, color='blue', label='low')
plt.plot(gDF.high.values, color='green', label='high')
plt.title('Google stock price')
plt.xlabel('days')
plt.ylabel('price')
plt.legend()
```

Out[8]: `<matplotlib.legend.Legend at 0x7f07822a87f0>`

The above graph plots 4 prices from open, close, low , high together of 6 years(2010-2016).
From the long run, the 4 prices, shows high correlation with each other.

In [9]:
```
plt.figure(figsize=(15, 5))
plt.plot(gDF.volume.values, color='black')
plt.title('Stock volume')
plt.xlabel('days')
plt.ylabel('volume')
```

Out[9]: `Text(0, 0.5, 'volume')`



The above graph shows the volumne of transaction per day.
From the graph, we can see multiple spikes indicating high transaction volumne at that day.
For both graph, outliers are not dropped due to the nature of the dataset, as they are actual values.

Method 1: Simple Linear Regression

Since time series data is influenced by previous(more recent) data, we design an experiment by shift the "close" price back for 10 days as acutal data in 10 days, and see if a simple lasso linear regression using open, close, low, high and volumne, 5 predictors can have a good prediction.

In [16]:
```
slrDF = gDF.copy()
num = 10
slrDF['actual'] = slrDF['close'].shift(-num)
slrDF.tail(15)
```

Out[16]:

date	open	close	low	high	volume	actual
2016-12-09	799.299988	809.450012	798.049988	809.950012	1894000.0	807.799988
2016-12-12	804.820007	807.900024	804.530029	811.349976	1627300.0	809.929993
2016-12-13	812.390015	815.340027	811.940002	824.299988	2103300.0	804.570007
2016-12-14	815.919983	817.890015	812.780029	824.260010	1769700.0	802.880005
2016-12-15	817.359985	815.650024	812.000000	823.000000	1768500.0	792.450012
2016-12-16	818.309998	809.840027	808.119995	819.200012	2589100.0	NaN
2016-12-19	809.280029	812.500000	804.500000	816.219971	1259600.0	NaN
2016-12-20	813.369995	815.200012	811.000000	816.489990	1270200.0	NaN
2016-12-21	815.719971	812.200012	805.099976	815.719971	1454500.0	NaN
2016-12-22	809.099976	809.679993	806.030029	811.070007	1131600.0	NaN
2016-12-23	808.010010	807.799988	805.109985	810.969971	764100.0	NaN
2016-12-27	808.679993	809.929993	805.799988	816.000000	974400.0	NaN
2016-12-28	813.330017	804.570007	802.440002	813.330017	1199700.0	NaN
2016-12-29	802.330017	802.880005	798.140015	805.750000	1056500.0	NaN
2016-12-30	803.210022	792.450012	789.619995	803.289978	1728300.0	NaN

In [17]:
```
slrDF.dropna(inplace=True)
slrDF.shape
```

Out[17]: (1752, 6)

Shape of Full data set

In [18]:
```
full_X = scale(slrDF.drop(['actual'], axis=1))
full_y = slrDF['actual']
full_X.shape, full_y.shape
```

Out[18]:
```
((1752, 5), (1752,))
```

In [19]:
```
test_X = full_X[-10:]
test_y = full_y[-10:]
test_X.shape, test_y.shape
```

Out[19]:
```
((10, 5), (10,))
```

In [20]:
```
train_X = full_X[:-10]
train_y = full_y[:-10]
train_X.shape, train_y.shape
```

Out[20]:
```
((1742, 5), (1742,))
```

Lasso regression has only one hyperparameter, the alpha value, which controls how strong we restrain the model to prevent overfitting.

In [21]:
```
lasso = Lasso(random_state=0)
alphas = np.logspace(-4, -0.5, 30)
tuned_parameters = [{'alpha': alphas}]
clf = GridSearchCV(lasso, tuned_parameters, cv=5)
clf.fit(train_X, train_y)
```

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e precision problems.
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```

Out[21]:
```
GridSearchCV(cv=5, error_score='raise-deprecating',
       estimator=Lasso(alpha=1.0, copy_X=True, fit_intercept=True, max_iter=1
000,
   normalize=False, positive=False, precompute=False, random_state=0,
   selection='cyclic', tol=0.0001, warm_start=False),
       fit_params=None, iid='warn', n_jobs=None,
       param_grid=[{'alpha': array([1.00000e-04, 1.32035e-04, 1.74333e-04, 2.
30181e-04, 3.03920e-04,
       4.01281e-04, 5.29832e-04, 6.99564e-04, 9.23671e-04, 1.21957e-03,
       1.61026e-03, 2.12611e-03, 2.80722e-03, 3.70651e-03, 4.89390e-03,
       6.46167e-03, 8.53168e-03, 1.12648e-02, 1.48735e-02, 1.96383e-02,
       2.59294e-02, 3.42360e-02, 4.52035e-02, 5.96846e-02, 7.88046e-02,
       1.04050e-01, 1.37382e-01, 1.81393e-01, 2.39503e-01, 3.16228e-01])}],
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring=None, verbose=0)
```

In [22]:
```
clf.score(train_X, train_y)
```

Out[22]:
```
0.9845008394201962
```

r^2 for training set is above 0.98, may indicating strong overfitting

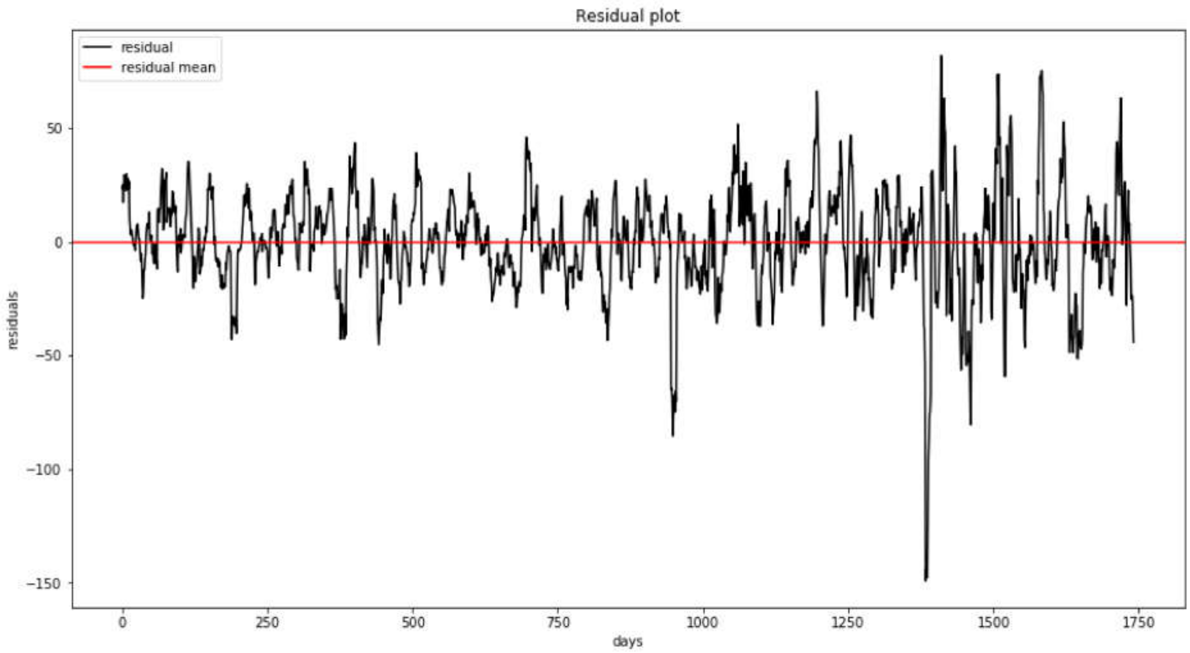
In [23]:
```
train_predict = clf.predict(train_X)
residual = train_predict - train_y
np.mean(np.square(residual))
```

Out[23]:
```
874060.4080640645
```

The fitted value plot is too close to the actual plot, showing residual plot instead.

In [19]:
```
plt.figure(figsize=(15,8))
plt.plot(residual.values, color='black', label='residual')
plt.axhline(np.mean(residual), color='red', label='residual mean')
plt.title('Residual plot')
plt.xlabel('days')
plt.ylabel('residuals')
plt.legend()
```

Out[19]: <matplotlib.legend.Legend at 0x7f07800d3dd8>



In [21]:
```
forecast = clf.predict(test_X)
Predict_df = pd.DataFrame(test_y)
Predict_df['predict'] = forecast
Predict_df
```

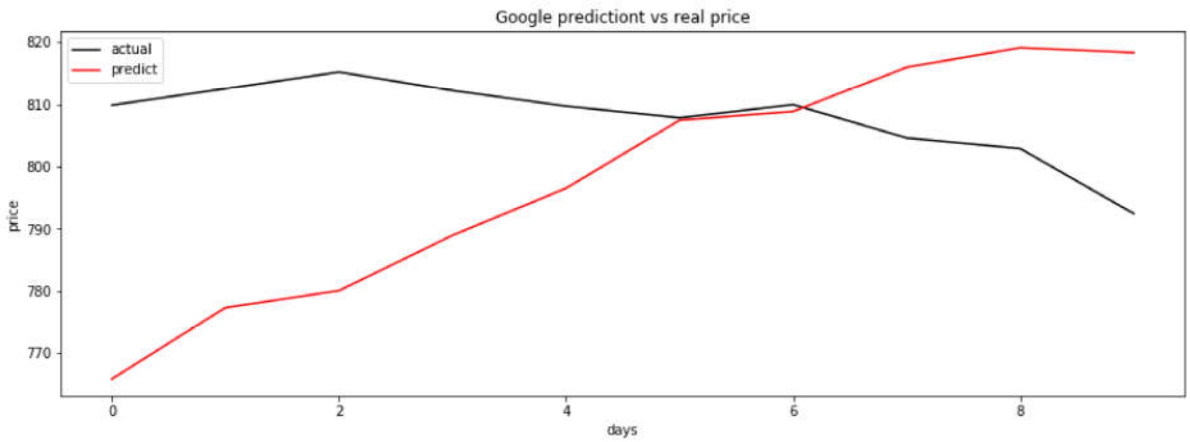
Out[21]:

date	actual	predict
2016-12-02	809.840027	765.836783
2016-12-05	812.500000	777.293919
2016-12-06	815.200012	780.029506
2016-12-07	812.200012	788.941011
2016-12-08	809.679993	796.532437
2016-12-09	807.799988	807.421103
2016-12-12	809.929993	808.828574
2016-12-13	804.570007	815.955605
2016-12-14	802.880005	819.093322
2016-12-15	792.450012	818.311222

Note: since we shift back 10 days, the result is actual predicting the last 10 days in the dataset.

In [23]:
```
plt.figure(figsize=(15, 5))
plt.plot(Predict_df.actual.values, color='black', label='actual')
plt.plot(Predict_df.predict.values, color='red', label='predict')
plt.title('Google predictiont vs real price')
plt.xlabel('days')
plt.ylabel('price')
plt.legend()
```

Out[23]: <matplotlib.legend.Legend at 0x7f077a3c8cc0>



By the look of the prediction, the experiment failed.
Maybe just using todays value to predict exactly 10 days later is not eough.

Method 2: ARIMA

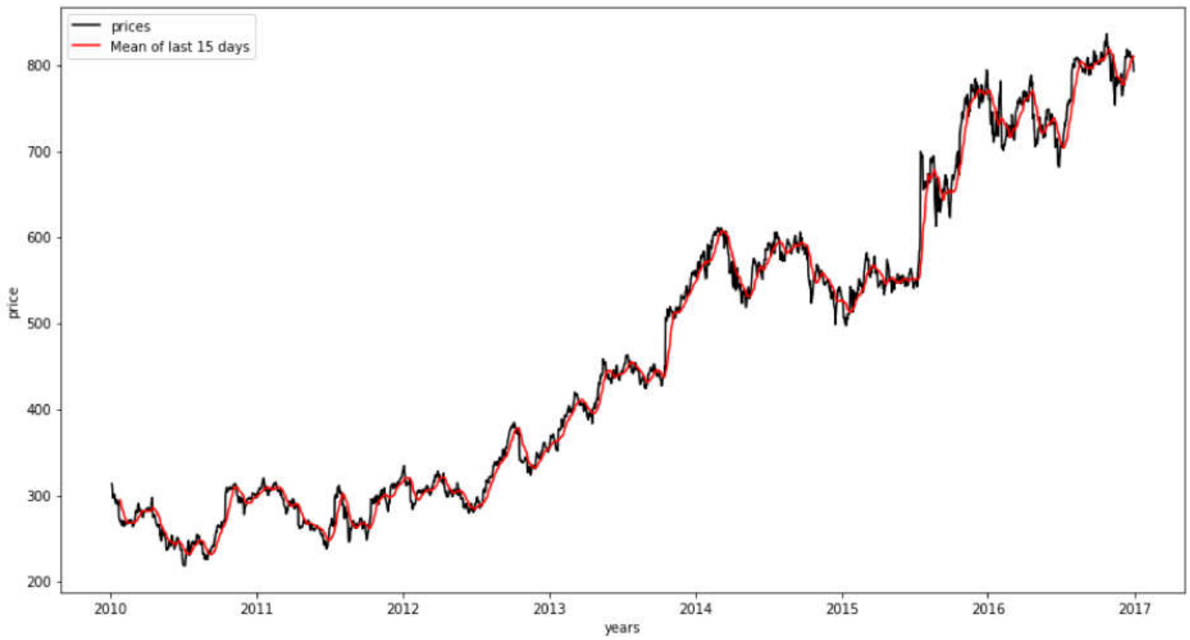
$X_t - \alpha_1 X_{t-1} - \ldots - \alpha_p X_{t-p} = \epsilon_t + \theta_1 \epsilon_{t-1} + \ldots + \theta_q \epsilon_{t-q}$
The left side is autoregressive, the current value minus some value times 1 day before minus some value times 2 day before....
This gives the error that is described by the moving average on the right.
ARIMA also reuqire stationary, a one-day difference can do the job.
Dickey-Fuller test is a way to test stationary

In [85]:
```
arimaDF=gDF.copy()
arimaDF.index = pd.to_datetime(arimaDF.index, format="%Y/%m/%d")
arimaDF_close = pd.Series(arimaDF['close'])
```

In [86]:
```
roll_mean = arimaDF_close.rolling(15).mean()

fig = plt.figure(figsize=(15,8))
plt.plot(arimaDF_close, color='black', label='prices')
plt.plot(roll_mean, color='red', label='Mean of last 15 days')
plt.xlabel('years')
plt.ylabel('price')
plt.legend()
```

Out[86]: <matplotlib.legend.Legend at 0x7f92f5e37f60>



In [87]:
```
print('Dickey-Fuller test')
pvalue = adfuller(arimaDF_close, regresults=False)[1]
print('pvalue:',pvalue)
```

```
Dickey-Fuller test
pvalue: 0.9461691091878139
```

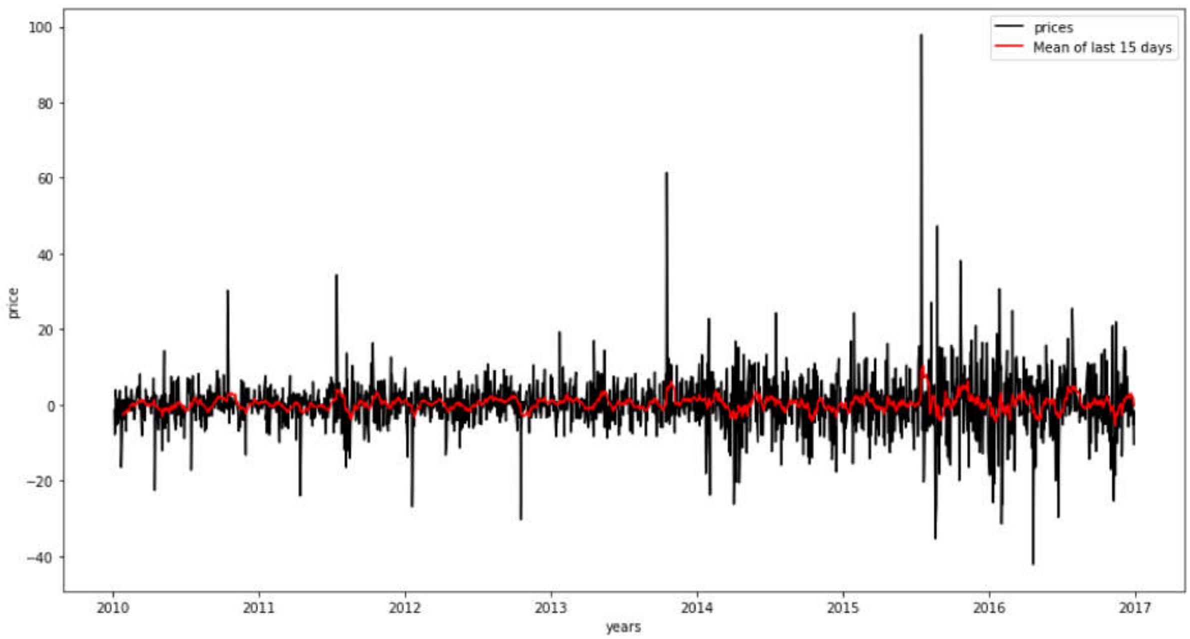
With large pvalue, the data is more likely to be non-stationary

In [88]:
```
arimaDF_close_diff = arimaDF_close - arimaDF_close.shift()
arimaDF_close_diff.dropna(inplace=True)
```

In [89]:
```
roll_mean = arimaDF_close_diff.rolling(15).mean()

fig = plt.figure(figsize=(15,8))
plt.plot(arimaDF_close_diff, color='black', label='prices')
plt.plot(roll_mean, color='red', label='Mean of last 15 days')
plt.xlabel('years')
plt.ylabel('price')
plt.legend()
```

Out[89]: <matplotlib.legend.Legend at 0x7f92f5da4a90>



In [84]:
```
print('Dickey-Fuller test')
pvalue = adfuller(arimaDF_close_diff, regresults=False)[1]
print('pvalue:',pvalue)
```

```
Dickey-Fuller test
pvalue: 0.0
```

With a small pvalue, we can reject the null hypothesis. Proceed to ARIMA

ARIMA has three hyperparameter p, d, and q. Where as: p is the number of lag observations in the model.
d is the number of times that the raw observations are differenced.
q is the size of the moving average window.
MSE is used to select the best hyperparameter since it is composite of both Bias and Variance.

The following grid serach Cross Validation code are referenced from [https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/ (https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/)](https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/), "How to Grid Search ARIMA Model Hyperparameters with Python".

Warning: long running time (can skip)

In [90]:
```
import warnings
from pandas import Series
from sklearn.metrics import mean_squared_error
```

In [91]:
```
def evaluate_arima_model(X, arima_order):
    # prepare training dataset
    train_size = int(len(X) * 0.66)
    train, test = X[0:train_size], X[train_size:]
    history = [x for x in train]
    # make predictions
    predictions = list()
    for t in range(len(test)):
        model = ARIMA(history, order=arima_order)
        model_fit = model.fit(disp=0)
        yhat = model_fit.forecast()[0]
        predictions.append(yhat)
        history.append(test[t])
    # calculate out of sample error
    error = mean_squared_error(test, predictions)
    return error
```

In [92]:
```
def evaluate_models(dataset, p_values, d_values, q_values):
    dataset = dataset.astype('float32')
    best_score, best_cfg = float("inf"), None
    for p in p_values:
        for d in d_values:
            for q in q_values:
                order = (p,d,q)
                try:
                    mse = evaluate_arima_model(dataset, order)
                    if mse < best_score:
                        best_score, best_cfg = mse, order
                    print('ARIMA%s MSE=%.3f' % (order,mse))
                except:
                    continue
    print('Best ARIMA%s MSE=%.3f' % (best_cfg, best_score))
```

In [93]:
```
p_values = [0, 1, 2]
d_values = range(0, 1)
q_values = range(0, 1)
warnings.filterwarnings("ignore")
evaluate_models(arimaDF_close_diff.values, p_values, d_values, q_values)
```

```
ARIMA(0, 0, 0) MSE=98.669
ARIMA(0, 0, 1) MSE=98.803
ARIMA(0, 1, 0) MSE=183.706
ARIMA(0, 1, 1) MSE=98.927
ARIMA(1, 0, 0) MSE=98.805
ARIMA(1, 1, 0) MSE=144.196
Best ARIMA(0, 0, 0) MSE=98.669
```

The above grid serach Cross Validation code are referenced from https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/ (https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/), "How to Grid Search ARIMA Model Hyperparameters with Python".

In [203]:
```
arima = ARIMA(arimaDF_close_diff, (1,1,0))
fitted_model = arima.fit()
```

However, the fitted values are differences from the previous one. Recovering by using cumulative sum, then add back to original data.

In [225]:
```
pred=arimaDF_close.add(fitted_model.fittedvalues.cumsum(), fill_value=0)
```

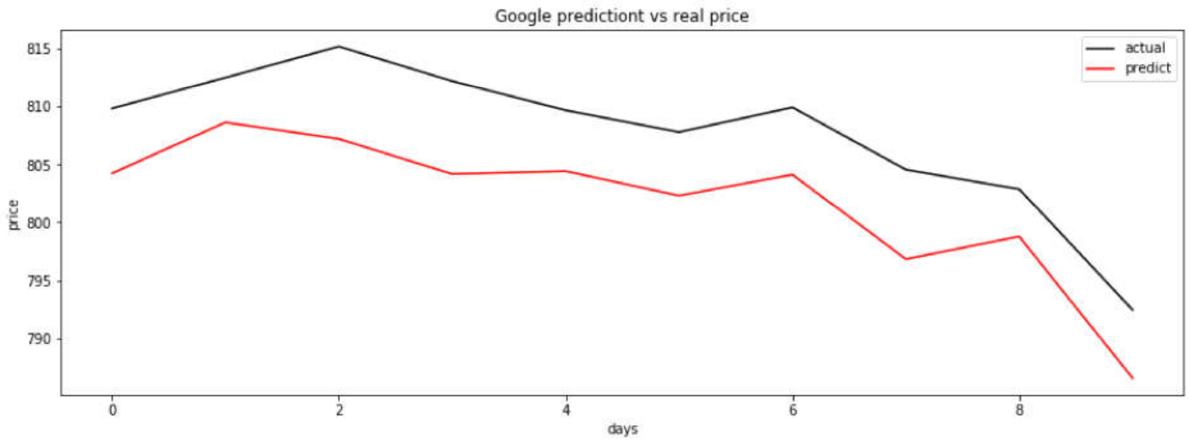
In [226]:
```
pred_df = pd.DataFrame(arimaDF_close[-10:])
pred_df['predict'] = pred[-10:]
pred_df
```

Out[226]:

	close	predict
date		
2016-12-16	809.840027	804.245161
2016-12-19	812.500000	808.637451
2016-12-20	815.200012	807.215895
2016-12-21	812.200012	804.192994
2016-12-22	809.679993	804.440909
2016-12-23	807.799988	802.324101
2016-12-27	809.929993	804.139494
2016-12-28	804.570007	796.826391
2016-12-29	802.880005	798.774618
2016-12-30	792.450012	786.556830

In [228]:
```
plt.figure(figsize=(15, 5))
plt.plot(pred_df.close.values, color='black', label='actual')
plt.plot(pred_df.predict.values, color='red', label='predict')
plt.title('Google predictiont vs real price')
plt.xlabel('days')
plt.ylabel('price')
plt.legend()
```

Out[228]:
```
<matplotlib.legend.Legend at 0x7f92f58ddfd0>
```



References:

- How To Identify Patterns in Time Series Data: Time Series Analysis
  http://www.statsoft.com/Textbook/Time-Series-Analysis (http://www.statsoft.com/Textbook/Time-Series-Analysis)
- NYSE Stock Data - ARIMA Mode
  https://www.kaggle.com/ravishankars/nyse-stock-data-arima-model#ARIMA-model-for-NYSE-stock-data (https://www.kaggle.com/ravishankars/nyse-stock-data-arima-model#ARIMA-model-for-NYSE-stock-data)
- How to Grid Search ARIMA Model Hyperparameters with Python
  https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/ (https://machinelearningmastery.com/grid-search-arima-hyperparameters-with-python/)
- Time Series Nested Cross-Validation
  https://towardsdatascience.com/time-series-nested-cross-validation-76adba623eb9 (https://towardsdatascience.com/time-series-nested-cross-validation-76adba623eb9)

In [ ]: