In [1]:

```
import pandas as pd
import matplotlib.pyplot as plt
import datetime as dt
import seaborn as sns
from numpy.polynomial.polynomial import polyfit
import matplotlib.gridspec as gridspec
import numpy as np
import matplotlib as mpl
mpl.rcParams.update(mpl.rcParamsDefault)
import math
import os
import requests, io
import zipfile as zf
import shutil
import statsmodels.formula.api as smf
import matplotlib.ticker as mtick
from sklearn.neighbors import KNeighborsRegressor as knn
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LinearRegression as linreg
from scipy.stats import kde
import matplotlib.dates as mdates
from sklearn.preprocessing import MinMaxScaler

%matplotlib inline
```

In [ ]:

In [2]:

```
path_world_covid = '/Users/jarrodhoran/Downloads/COVID-19-geographic-disbtribution-worldwide.csv'
world_covid = pd.read_csv(path_world_covid)
world_covid['dateRep'] = pd.to_datetime(world_covid['dateRep'])
world_covid
```

Out[2]:

	dateRep	day	month	year	cases	deaths	countriesAndTerritories	geoId	countryterri
0	2020-10-27	27	10	2020	199	8	Afghanistan	AF	
1	2020-10-26	26	10	2020	65	3	Afghanistan	AF	
2	2020-10-25	25	10	2020	81	4	Afghanistan	AF	
3	2020-10-24	24	10	2020	61	2	Afghanistan	AF	
4	2020-10-23	23	10	2020	116	4	Afghanistan	AF	
...	...	...	...	...	...	...	...	...	
51678	2020-03-25	25	3	2020	0	0	Zimbabwe	ZW	
51679	2020-03-24	24	3	2020	0	1	Zimbabwe	ZW	
51680	2020-03-23	23	3	2020	0	0	Zimbabwe	ZW	
51681	2020-03-22	22	3	2020	1	0	Zimbabwe	ZW	
51682	2020-03-21	21	3	2020	1	0	Zimbabwe	ZW	

51683 rows × 12 columns

In [3]:
```
world_covid['geoId'].nunique()
world_covid['countriesAndTerritories'].nunique()
```

Out[3]:
```
212
```

In [4]:
```
#drop the countries that aren't in world COVID
path_country_coordinate = '/Users/jarrodhoran/Downloads/countries.csv'
country_coord = pd.read_csv(path_country_coordinate)
#country_coord
```

In [5]:
```
path_us_counties = '/Users/jarrodhoran/Downloads/us-counties.csv'
us_counties = pd.read_csv(path_us_counties)
us_counties['date'] = pd.to_datetime(us_counties['date'])
#us_counties
```

In [6]:

```
path_netflix = '/Users/jarrodhoran/Downloads/Netflix.csv'
netflix = pd.read_csv(path_netflix).tail(365)
netflix['Date'] = pd.to_datetime(netflix['Date'])
netflix = netflix[netflix['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#pd.set_option('display.max_rows', None)
#netflix
```

In [7]:

```
path_amazon = '/Users/jarrodhoran/Downloads/Amazon.csv'
amazon = pd.read_csv(path_amazon).tail(365)
amazon['Date'] = pd.to_datetime(amazon['Date'])
amazon = amazon[amazon['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#amazon
```

In [8]:

```
path_google = '/Users/jarrodhoran/Downloads/Google.csv'
google = pd.read_csv(path_google).tail(365)
google['Date'] = pd.to_datetime(google['Date'])
google = google[google['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#google
```

In [9]:

```
path_apple = '/Users/jarrodhoran/Downloads/Apple.csv'
apple = pd.read_csv(path_apple).tail(365)
apple['Date'] = pd.to_datetime(apple['Date'])
apple = apple[apple['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#apple
```

In [10]:

```
path_facebook = '/Users/jarrodhoran/Downloads/Facebook.csv'
facebook = pd.read_csv(path_facebook).tail(365)
facebook = facebook
facebook['Date'] = pd.to_datetime(facebook['Date'])
facebook = facebook[facebook['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#facebook
```

In [11]:

```
path_usd_adv_econ = '/Users/jarrodhoran/Downloads/DTWEXAFEGS.csv'
usd_adv_econ = pd.read_csv(path_usd_adv_econ)
usd_adv_econ['DATE'] = pd.to_datetime(usd_adv_econ['DATE'])
usd_adv_econ = usd_adv_econ[usd_adv_econ['DATE'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#usd_adv_econ
```

In [12]:
```
path_usd_em_econ = '/Users/jarrodhoran/Downloads/DTWEXEMEGS.csv'
usd_em_econ = pd.read_csv(path_usd_em_econ)
usd_em_econ['DATE'] = pd.to_datetime(usd_em_econ['DATE'])
usd_em_econ = usd_em_econ[usd_em_econ['DATE'].dt.year == 2020]
#usd_em_econ
```

In [13]:
```
path_usd_rmb = '/Users/jarrodhoran/Downloads/DEXCHUS.csv'
usd_rmb = pd.read_csv(path_usd_rmb)
usd_rmb['DATE'] = pd.to_datetime(usd_rmb['DATE'])
usd_rmb = usd_rmb[usd_rmb['DATE'].dt.year == 2020]
#usd_rmb
```

World Covid per Month and FAANGs

In [14]:
```
# merge stocks
netflix2 = netflix.drop(columns = ['Open','High','Low','Adj Close','Volume'])
netflix2 = netflix2.rename(columns={"Close": "Close_Netflix"})
google2 = google.drop(columns = ['Open','High','Low','Adj Close','Volume'])
google2 = google2.rename(columns={"Close": "Close_Google"})
amazon2 = amazon.drop(columns = ['Open','High','Low','Adj Close','Volume'])
amazon2 = amazon2.rename(columns={"Close": "Close_Amazon"})
apple2 = apple.drop(columns = ['Open','High','Low','Adj Close','Volume'])
apple2 = apple2.rename(columns={"Close": "Close_Apple"})
facebook2 = facebook.drop(columns = ['Open','High','Low','Adj Close','Volume'])
facebook2 = facebook2.rename(columns={"Close": "Close_FB"})

faangs = facebook2.merge(apple2, on = 'Date', how = 'left')
faangs = faangs.merge(amazon2, on = 'Date', how = 'left')
faangs = faangs.merge(google2, on = 'Date', how = 'left')
faangs = faangs.merge(netflix2, on = 'Date', how = 'left')
faangs['Date'] = faangs['Date'].dt.strftime('%Y-%m-%d')


faangs.drop([147,148,149,150,151,152,153,154,155,156,157,158], inplace = True)
#faangs
```

In [15]:
```
faangs['Month'] = faangs.Date.str[6:7]

#April
```

```
faangs_april = faangs.loc[faangs['Month'] == '4']

faangs_april['Day_Close'] = (faangs_april['Close_FB'] + faangs_april['Close_Apple'] +
                             faangs_april['Close_Amazon'] + faangs_april['Close_Google'] +
                             faangs_april['Close_Netflix'])

faangs_april['Date'] = pd.to_datetime(faangs_april['Date'])

f4_piv = faangs_april.pivot_table(index = 'Date',columns = 'Month',values = 'Day_Close', aggfunc = 'sum')
f4_piv = f4_piv.pct_change()
f4_piv

#May

faangs_may = faangs.loc[faangs['Month'] == '5']

faangs_may['Day_Close'] = (faangs_may['Close_FB'] + faangs_may['Close_Apple'] +
                           faangs_may['Close_Amazon'] + faangs_may['Close_Google'] +
                           faangs_may['Close_Netflix'])

faangs_may['Date'] = pd.to_datetime(faangs_may['Date'])

f5_piv = faangs_may.pivot_table(index = 'Date',columns = 'Month',values = 'Day_Close', aggfunc = 'sum')
f5_piv = f5_piv.pct_change()
#f5_piv

#June

faangs_june = faangs.loc[faangs['Month'] == '6']

faangs_june['Day_Close'] = (faangs_june['Close_FB'] + faangs_june['Close_Apple'] +
                           faangs_june['Close_Amazon'] + faangs_june['Close_Google'] +
                           faangs_june['Close_Netflix'])

faangs_june['Date'] = pd.to_datetime(faangs_june['Date'])

f6_piv = faangs_june.pivot_table(index = 'Date',columns = 'Month',values = 'Day_Close', aggfunc = 'sum')
f6_piv = f6_piv.pct_change()
#f6_piv
```

```
#July

faangs_july = faangs.loc[faangs['Month'] == '7']

faangs_july['Day_Close'] = (faangs_july['Close_FB'] + faangs_july['Close_Apple'] +
                            faangs_july['Close_Amazon'] + faangs_july['Close_Google'] +
                            faangs_july['Close_Netflix'])

faangs_july['Date'] = pd.to_datetime(faangs_july['Date'])

f7_piv = faangs_july.pivot_table(index = 'Date',columns = 'Month',values = 'Day_Close', aggfunc = 'sum')
f7_piv = f7_piv.pct_change()
#f7_piv
```

```
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:9:
SettingWithCopyWarning:
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/user_guide/indexing.html#returning-a-view-versus-a-copy
  if __name__ == '__main__':
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:11:
SettingWithCopyWarning:
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/user_guide/indexing.html#returning-a-view-versus-a-copy
  # This is added back by InteractiveShellApp.init_path()
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:23:
SettingWithCopyWarning:
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/user_guide/indexing.html#returning-a-view-versus-a-copy
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:25:
SettingWithCopyWarning:
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/user_guide/indexing.html#returning-a-view-versus-a-cop
```

```
y
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:37:
SettingWithCopyWarning:
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/panda
s-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-cop
y
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:39:
SettingWithCopyWarning:
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/panda
s-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-cop
y
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:51:
SettingWithCopyWarning:
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/panda
s-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-cop
y
/opt/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:53:
SettingWithCopyWarning:
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/panda
s-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-cop
y
```

In [16]:

```
#f6_piv = f6_piv.reset_index()
#f6_piv.dtypes
#f6_piv.ix[index.to_datetime()]
f6_piv.index
```

Out[16]:

```
DatetimeIndex(['2020-06-01', '2020-06-02', '2020-06-03', '2020-06-04
',
               '2020-06-05', '2020-06-08', '2020-06-09', '2020-06-10
',
               '2020-06-11', '2020-06-12', '2020-06-15', '2020-06-16
',
               '2020-06-17', '2020-06-18', '2020-06-19', '2020-06-22
',
               '2020-06-23', '2020-06-24', '2020-06-25', '2020-06-26
',
               '2020-06-29', '2020-06-30'],
              dtype='datetime64[ns]', name='Date', freq=None)
```

In [17]:

```
#fig, ax = plt.subplots()
#ax.axhline(june_mean, color = 'red',linestyle = 'dashed')
#f6_piv.plot.line(ax = ax,x = 'Date', y = '6')
```

In [18]:

```
country_coord = country_coord.rename(columns={"country": "geoId"})
#country_coord
```

In [19]:

```
covid_location = world_covid.merge(country_coord, on = 'geoId', how =
'left', indicator = True)
covid_location = covid_location[covid_location['_merge']=='both']

covid_location = covid_location.drop(columns = ['day','year','countryt
erritoryCode',
                               'popData2019','name','Cumulative_number
_for_14_days_of_COVID-19_cases_per_100000'])

covid_location = covid_location.rename(columns={"dateRep": "Date","con
tinentExp":"Continent",
                                                "countriesAndTerritori
es":"Country","latitude":"Latitude",
                                               "longitude":"Longitude"
,"cases":"New Cases",
                                               'deaths':"Deaths"})

covid_location['month'] = covid_location['month'].astype(str)
covid_location = covid_location.loc[(covid_location['month'].str.conta
ins('4|5|6|7|8') == True),:]

covid_location = covid_location.groupby(['month','Date','Country',
                                         'Continent','Latitude','Longi
tude'], as_index = False)[['New Cases', 'Deaths']].sum()
covid_location.loc[covid_location['Country'] == 'Afghanistan',:]
covid_location['month'] = covid_location['month'].astype(int)

covid_april = covid_location.loc[covid_location['month'] == 4]
covid_april = covid_april.groupby(['Country','Latitude','Longitude','C
ontinent','month'], as_index = False)[['New Cases', 'Deaths']].sum()

covid_may = covid_location.loc[covid_location['month'] == 5]
covid_may = covid_may.groupby(['Country','Latitude','Longitude','Conti
nent','month'], as_index = False)[['New Cases', 'Deaths']].sum()

covid_june = covid_location.loc[covid_location['month'] == 6]
covid_june = covid_june.groupby(['Country','Latitude','Longitude','Con
tinent','month'], as_index = False)[['New Cases', 'Deaths']].sum()

covid_july = covid_location.loc[covid_location['month'] == 7]
covid_july = covid_july.groupby(['Country','Latitude','Longitude','Con
tinent','month'], as_index = False)[['New Cases', 'Deaths']].sum()
```

In [20]:

```
world_covid = world_covid.rename(columns={"dateRep": "Date"})
```

In [21]:

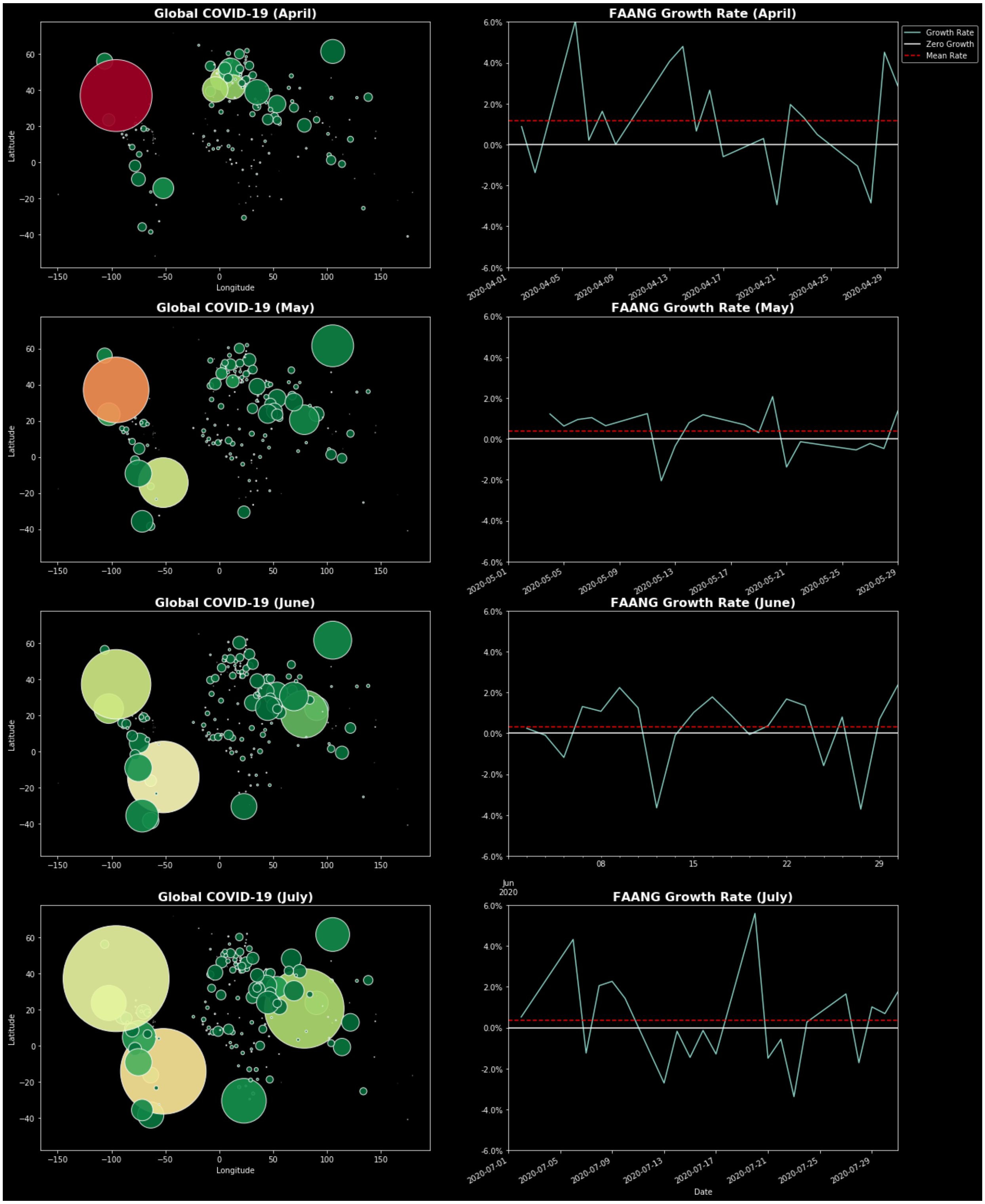
```
cmap = mpl.cm.RdYlGn
reversed_cmap = cmap.reversed()
n = mpl.colors.Normalize()
plt.style.use('dark_background')
```

In [22]:

```
fig, ax = plt.subplots(ncols = 2,nrows = 4)
plt.subplots_adjust(bottom = .7)

#APRIL

covid_april.plot.scatter(ax = ax[0,0],figsize=(20,30), y='Latitude',x=
'Longitude',s=covid_april['New Cases'] * .01,
                         color=reversed_cmap(n(covid_april['Deaths'].v
alues * 2500)),
                        edgecolors = 'white',alpha = .9)
ax[0,0].set_title("Global COVID-19 (April)", fontsize = 16, fontweight
= 'bold')

f4_piv.plot.line(ax = ax[0,1])

ax[0,1].axhline(0, color = 'white')
april_mean = f4_piv['4'].mean()
ax[0,1].axhline(april_mean, color = 'red',linestyle = 'dashed')

ax[0,1].legend(bbox_to_anchor = (1, 1), labels = ['Growth Rate','Zero
Growth','Mean Rate'])
ax[0,1].set_title("FAANG Growth Rate (April)", fontsize = 16, fontweig
ht = 'bold')
ax[0,1].set_ylim(-.06, .06)
ax[0,1].set_xlabel(xlabel = '')
ax[0,1].yaxis.set_major_formatter(mtick.PercentFormatter(1.0))


#MAY

covid_may.plot.scatter(ax = ax[1,0], y='Latitude',x='Longitude',s=covi
d_may['New Cases'] * .01,
                         color=reversed_cmap(n(covid_may['Deaths'].val
ues * 2500)),
                        edgecolors = 'white',alpha = .9)
ax[1,0].set_title("Global COVID-19 (May)", fontsize = 16, fontweight =
'bold')
ax[1,0].set_xlabel(xlabel = '')

f5_piv.plot.line(ax = ax[1,1])

ax[1,1].axhline(0, color = 'white')
may_mean = f5_piv['5'].mean()
ax[1,1].axhline(may_mean, color = 'red',linestyle = 'dashed')
```

```
ax[1,1].legend().remove()
ax[1,1].set_title("FAANG Growth Rate (May)", fontsize = 16, fontweight = 'bold')
ax[1,1].set_ylim(-.06, .06)
ax[1,1].set_xlabel(xlabel = '')
ax[1,1].yaxis.set_major_formatter(mtick.PercentFormatter(1.0))

#JUNE

covid_june.plot.scatter(ax = ax[2,0], y='Latitude',x='Longitude',s=covid_june['New Cases'] * .01,
                         color=reversed_cmap(n(covid_june['Deaths'].values * 2500)),
                        edgecolors = 'white',alpha = .9)
ax[2,0].set_title("Global COVID-19 (June)", fontsize = 16, fontweight = 'bold')
ax[2,0].set_xlabel(xlabel = '')

f6_piv.plot.line(ax = ax[2,1])
ax[2,1].set_title("FAANG Growth Rate (June)", fontsize = 16, fontweight = 'bold')
ax[2,1].axhline(0, color = 'white')
june_mean = f6_piv['6'].mean()
ax[2,1].axhline(june_mean, color = 'red',linestyle = 'dashed')

ax[2,1].legend().remove()
ax[2,1].set_ylim(-.06, .06)
ax[2,1].set_xlabel(xlabel = '')
ax[2,1].yaxis.set_major_formatter(mtick.PercentFormatter(1.0))



#JULY

covid_july.plot.scatter(ax = ax[3,0], y='Latitude',x='Longitude',s=covid_july['New Cases'] * .01,
                         color=reversed_cmap(n(covid_july['Deaths'].values * 2500)),
                        edgecolors = 'white',alpha = .9)
ax[3,0].set_title("Global COVID-19 (July)", fontsize = 16, fontweight = 'bold')

f7_piv.plot.line(ax = ax[3,1])
ax[3,1].axhline(0, color = 'white')
july_mean = f7_piv['7'].mean()
ax[3,1].axhline(july_mean, color = 'red',linestyle = 'dashed')
ax[3,1].legend().remove()
ax[3,1].set_title("FAANG Growth Rate (July)", fontsize = 16, fontweight = 'bold')
ax[3,1].set_ylim(-.06, .06)
```

```
ax[3,1].yaxis.set_major_formatter(mtick.PercentFormatter(1.0))
plt.savefig('Covid_stocks.png')
```



Analysis

The column one scatter plots visualize the relationship between the number of new COVID-19 cases (size of bubble) and the number of COVID-19 related deaths (color of bubble) per country from April to July. Smaller and green bubbles are indicative of fewer new cases and deaths, whereas larger and red bubbles are the opposite. The general trends by continent are as follows:

-In North America the United States experiences a decrease in monthly deaths and cases from April to June. However, in July, the resurgence of new cases in America reaches new heights. Canada sees a general of decreasing cases with consistently low fatalities. In Mexico the graphs indicate an increase in both cases and deaths.
-In South America, Brazil is the serious case of the trend, which is increasing new cases and deaths. Brazil's situation can be considered a result of the lack of lockdown measures.
-Europe undergoes a decrease in both new cases and deaths during the summer months. Likely a result of strict lockdown measures utilized during the first wave of COVID. Russia is an exception and experiences higher levels of new cases.
-Africa does see an increase in cases, especially in South Africa. However, there does not appear to be a substantial increase in COVID-19 related deaths.
-Both Australia and New Zealand retain both low case growth and fatalities.
-In Asia there is a contrast between East Asia and India/Middle East. East Asian countries have near miniscule new cases and deaths, with exception to Japan, which experienced case growth in July. However, the Middle East and India are the opposite, experiencing both an increase in new cases and deaths throughout the summer. India is the most notable as it appears to have the largest case and death increase in Asia. There is also an increase in new cases in South East Asia countries: Indonesia and the Philippines.

Column two line charts depict the aggregated growth rate of FAANG stocks in the aforementioned time period. The dashed, red line represents the mean growth rate for that month. In April the FAANG growth rate was larger, slightly higher than 1%, however from May-July that rate was depressed and near zero growth (~.3%)

What is surprising is the FAANG growth rate was higher when the United States' death count was its worst and started to decrease as deaths decreased, but cases rose. Potentially due to stock speculation.

Given that East Asian and European cases are low/decreasing there does not seem to be much of a visual relationship between these continents and the FAANG growth rate. In fact when the new cases were at the highest level in the United States in July, the FAANG growth rate had slightly increased from .32% in June to .35% in July.

Monthly FAANG growth rates are below:

April FAANG Rate: 1.18%
May FAANG Rate: 0.37%
June FAANG Rate: 0.32%
July FAANG Rate: 0.35%

In [23]:
```
#print("April FAANG Rate: {:.2%}".format(april_mean))
#print("May FAANG Rate: {:.2%}".format(may_mean))
#print("June FAANG Rate: {:.2%}".format(june_mean))
#print("July FAANG Rate: {:.2%}".format(july_mean))
```

U.S. COVID vs. USD/EM, USD/AFE

In [24]:
```
#us_counties
```

In [25]:
```
#usd_em_econ
```

In [26]:
```
usd_afe = usd_adv_econ[usd_adv_econ['DATE'].dt.date.astype(str) >= '2020-01-21']
#usd_afe
```

In [27]:
```
usd_em = usd_em_econ[usd_em_econ['DATE'].dt.date.astype(str) >= '2020-01-21']
#usd_em
```

In [28]:
```
us_covid = us_counties[us_counties['date'].dt.date.astype(str) <= '2020-11-06']
us_covid = us_covid.drop(columns = ['fips'], axis = 1)
us_covid = us_covid.set_index(['date'])
us_covid = us_covid.rename(columns={"date":"Date","state":"State","cases": "Cases","deaths":"Deaths"})
#us_covid = us_covid.iloc[::,:]

#us_covid = us_covid.groupby(['Date','State'])['Cases','Deaths'].sum()
us_covid = us_covid.groupby([(us_covid.index.month)]).sum()
#piv = us_covid.pivot_table(index = 'date',columns = 'State', values = 'Cases', aggfunc = 'sum')
#piv.pct_change()
```

In [29]:
```
#us_covid
```

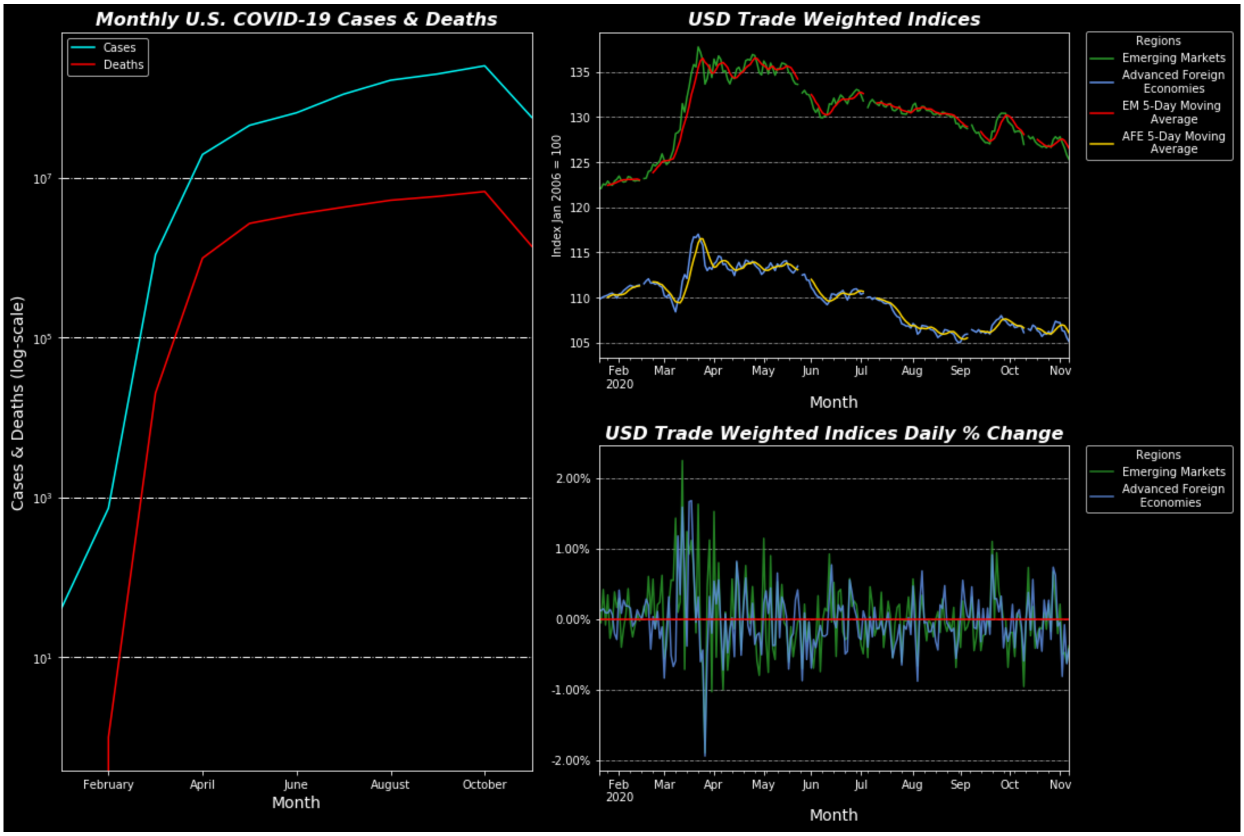
In [30]:
```
#usd_afe
```

In [31]:
```
usd_em
usd = usd_em.merge(usd_afe, on = 'DATE', how = 'left')
usd['DTWEXAFEGS'] = pd.to_numeric(usd['DTWEXAFEGS'],errors = 'coerce')
usd['DTWEXEMEGS'] = pd.to_numeric(usd['DTWEXEMEGS'],errors = 'coerce')
numeric = usd.copy()
usd.dtypes
numeric['EM_Rolling'] = numeric.iloc[:,1].rolling(window=5).mean()
numeric['AFE_Rolling'] = numeric.iloc[:,2].rolling(window=5).mean()
#numeric
```

In [32]:
```
usd_pct = usd.copy()
usd_pct['DTWEXEMEGS'] = pd.to_numeric(usd_pct['DTWEXEMEGS'],errors = 'coerce').pct_change()
usd_pct['DTWEXAFEGS'] = pd.to_numeric(usd_pct['DTWEXAFEGS'],errors = 'coerce').pct_change()
```

In [33]:
```
plt.style.use('dark_background')
fig2 = plt.figure(constrained_layout = True, figsize = (15,10))
gs = fig2.add_gridspec(2,2)
covid = fig2.add_subplot(gs[:,0])

us_covid[['Cases','Deaths']].plot(ax = covid, color = ['cyan','red'])

covid.set_yscale('log')
covid.set_title('Monthly U.S. COVID-19 Cases & Deaths', fontsize = 16, fontweight = 'bold', fontstyle = 'oblique')
covid.set_xlabel('Month', fontsize = 14)
covid.set_ylabel('Cases & Deaths (log-scale)', fontsize = 14)
covid.set_xticklabels(['','February', 'April','June','August','October'], fontsize = 10, rotation = 'horizontal')
covid.grid(color = 'white', linestyle = '-.', linewidth = 1, axis = 'y')

### top right

num = fig2.add_subplot(gs[0,1:])
numeric.plot(ax = num, color = 'tab:green', x = 'DATE', y ='DTWEXEMEGS')
numeric.plot(ax = num, color = 'cornflowerblue', x = 'DATE', y = 'DTWEXAFEGS')
numeric.plot(ax = num, color = 'red', x='DATE', y= 'EM_Rolling')
numeric.plot(ax = num, color = 'gold', x='DATE', y= 'AFE_Rolling')

num.legend(title = 'Regions', labels = ['Emerging Markets', """Advanced Foreign
      Economies""", """EM 5-Day Moving
        Average""", """AFE 5-Day Moving
        Average"""], loc='upper right',bbox_to_anchor=(1.36, 1.02))
```

```
num.set_title('USD Trade Weighted Indices', fontsize = 16, fontweight
= 'bold', fontstyle = 'oblique')
num.set_xlabel('Month', fontsize = 14)
num.grid(color = 'white', linestyle = '-.', linewidth = .5, axis = 'y'
)
num.set_ylabel('Index Jan 2006 = 100', fontsize = 10)


### bottom right

pct = fig2.add_subplot(gs[1:,1:])
usd_pct.plot(ax = pct, color = 'tab:green',alpha = .8, x = 'DATE', y =
'DTWEXEMEGS')
usd_pct.plot(ax = pct, color = 'cornflowerblue', alpha = .8, x = 'DATE
', y = 'DTWEXAFEGS')

pct.set_xlabel('Month', fontsize = 14)
pct.axhline(0, color = 'red')
pct.set_title('USD Trade Weighted Indices Daily % Change', fontsize =
16, fontweight = 'bold', fontstyle = 'oblique')
pct.yaxis.set_major_formatter(mtick.PercentFormatter(1.0))
pct.legend(title = 'Regions', labels = ['Emerging Markets', """Advance
d Foreign
     Economies"""],loc='upper right',bbox_to_anchor=(1.36, 1.02))
pct.grid(color = 'white', linestyle = '-.', linewidth = .5, axis = 'y'
)
```



Analysis

The first graph depicts daily U.S. COVID cases from 1/21 - 11/6 on the logarithmic scale. It is visible that from February to March cases and deaths more than doubled, experiencing the greatest growth of any month. From March to April the growth slows however both cases and deaths still nearly double. In the months after the curve begins to flatten and in October begins to decrease.

The graph in the top right corner shows a Trade Weighted USD compared to Advanced Foreign Economies (AFE) and Emerging Markets (EM) for goods & services. There is an initial appreciation of the dollar against both regions before depreciation beginning in late March. This depreciation trend continues through the end of the graphed time period. The dollar is weaker in November than in March.

The lower right corner graph visualizes daily growth rates in both Trade Weighted USD vs. AFE and EM for goods & services. Heading into March volatility begins to increase and growth rates will break +2% and nearly break -2%. The USD had both substantial increases and decreases relative to both regions, appreciating 2% against EMs and depreciating nearly -2% to AFEs. From the end of March onwards volatility decreased, and with exception to a few days, remained between -1% and 1%.

What’s interesting is that in March, when the U.S. COVID cases and deaths growth substantially increases there is both an increase in volatility and an appreciation of the USD. However, when COVID cases begin to flatten circa beginning of April both Trade Weighted Indices also flatten until late-May, early-June before a depreciation trend. Volatility also decreases from the beginning of April, remaining in the -1% to 1% bounds throughout the rest of the time period. However, after April, as U.S. case and death curves continue to flatten, the depreciation trend continues. Thus, the depreciation of the USD is likely not solely due to COVID but relates to other factors in the economy at large.

However, during the period the USD actually appreciated to EMs by 3.1615 from 122.1471 to 125.3086 while the USD depreciated to AFEs by 4.6691 from 109.7980 to 105.1289.

Does USD or COVID Cases Best Explain FAANG Data

In [34]:

```
usd_rmb.dtypes
usd_rmb.DEXCHUS = pd.to_numeric(usd_rmb.DEXCHUS, errors='coerce')

usd_rmb = usd_rmb.rename(columns={"DATE": "Date"})
usd_rmb = usd_rmb.set_index('Date')
usd_rmb = usd_rmb.loc['2020-01-21':'2020-07-31']

usd_rmb = usd_rmb.reset_index()
#usd_rmb = usd_rmb.drop(columns = ['RMB_Growth_Rate'], axis = 1)
usd_rmb['RMB_GR'] = usd_rmb['DEXCHUS'].pct_change()
usd_rmb = usd_rmb.iloc[1:]
#usd_rmb
```

In [35]:

```
#faangs = faangs.drop(columns = ['total', 'Month'], axis = 1)
faangs1 = faangs
faangs1['Total'] = (faangs['Close_FB'] + faangs['Close_Apple'] + faang
s['Close_Amazon'] +
                   faangs['Close_Google'] + faangs['Close_Netflix'])
faangs1['Date'] =  pd.to_datetime(faangs1['Date'])
faangs1 = faangs1.set_index('Date')
faangs1 = faangs1.loc['2020-01-21':'2020-07-31']
faangs1 = faangs1.reset_index()
faangs1 = faangs1.groupby('Date', as_index = False)['Total'].sum()
faangs1['Faang_GR'] = faangs1['Total'].pct_change()
faangs1 = faangs1.iloc[1:]
#faangs1
```

In [36]:

```
us_covid2 = us_counties.rename(columns={"date":"Date","state":"State",
"cases": "Cases","deaths":"Deaths"})
us_covid2 = us_covid2.set_index('Date')
us_covid2 = us_covid2.loc['2020-01-21':'2020-07-31']
us_covid2 = us_covid2.reset_index()
us_covid2 = us_covid2.groupby('Date', as_index = False)['Cases'].sum()
us_covid2['Case_GR'] = us_covid2['Cases'].pct_change()
us_covid2 = us_covid2.iloc[1:]
#us_covid2
```

In [37]:

```
covid_faang = us_covid2.merge(faangs1, on = 'Date', how = 'left')
covid_faang = covid_faang.dropna()
covid_faang = usd_rmb.merge(covid_faang, on = 'Date', how = 'left')
covid_faang = covid_faang.drop(columns = ['Total','Cases','DEXCHUS'])
covid_faang = covid_faang.dropna()
covid_faang = covid_faang.drop(2)
#covid_faang
```

In [38]:

```
reg = linreg().fit(X = covid_faang[['Case_GR']], y = covid_faang['Faang_GR'])
covid_faang['yhat1'] = reg.predict(covid_faang[['Case_GR']])
```

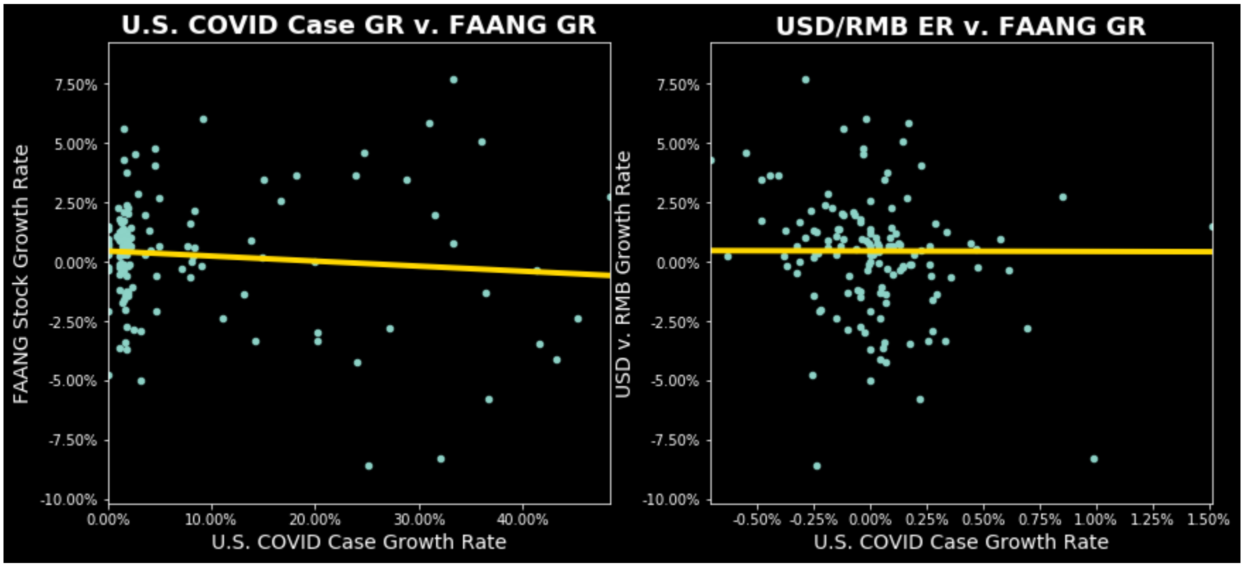
In [39]:

```
reg2 = linreg().fit(X = covid_faang[['RMB_GR']], y = covid_faang['Faang_GR'])
covid_faang['yhat2'] = reg.predict(covid_faang[['RMB_GR']])
```

In [40]:

```
plt.style.use('dark_background')

fig, ax = plt.subplots(nrows = 1, ncols = 2, figsize = (14,6))

#COVID, FAANG

covid_faang.plot.scatter(ax = ax[0], x = 'Case_GR',y='Faang_GR')
covid_faang.sort_values('Case_GR').set_index('Case_GR')['yhat1'].plot(ax = ax[0], color = 'gold', lw = 4)

vals = ax[0].get_yticks()
ax[0].set_yticklabels(['{:,.2%}'.format(x) for x in vals])

valsx = ax[0].get_xticks()
ax[0].set_xticklabels(['{:,.2%}'.format(y) for y in valsx])

ax[0].set_title('U.S. COVID Case GR v. FAANG GR', fontsize = 18, fontweight = 'bold')
ax[0].set_ylabel('FAANG Stock Growth Rate', fontsize = 14)
ax[0].set_xlabel('U.S. COVID Case Growth Rate', fontsize = 14)


#RMB, FAANG

covid_faang.plot.scatter(ax = ax[1], x = 'RMB_GR', y = 'Faang_GR')
covid_faang.sort_values('RMB_GR').set_index('RMB_GR')['yhat2'].plot(ax = ax[1], color = 'gold',lw = 4)

vals1 = ax[1].get_yticks()
ax[1].set_yticklabels(['{:,.2%}'.format(x) for x in vals1])

valsx1 = ax[1].get_xticks()
ax[1].set_xticklabels(['{:,.2%}'.format(y) for y in valsx1])

ax[1].set_title('USD/RMB ER v. FAANG GR', fontsize = 18, fontweight = 'bold')
ax[1].set_ylabel('USD v. RMB Growth Rate', fontsize = 14)
ax[1].set_xlabel('U.S. COVID Case Growth Rate', fontsize = 14)
```

```
Out[40]: Text(0.5, 0, 'U.S. COVID Case Growth Rate')
```



```
In [41]: reg.score(X = covid_faang[['Case_GR']], y = covid_faang['Faang_GR'])

Out[41]: 0.009477868000497658
```

```
In [42]: reg2.score(X = covid_faang[['RMB_GR']], y = covid_faang['Faang_GR'])

Out[42]: 0.048063144472155546
```

Analysis

The graphs depict the relationships between USD v. RMB and FAANG stock growth rates with U.S. COVID case percent change from 1/21 - 9/31. It is visible that increases in COVID growth rates caused a decrease in FAANG growth rate, while a slight increase in USD v. RMB growth rate. While it is expected that increased COVID cases is correlated worse stock performance, it is surprising that increases in COVID growth had a relationship with USD appreciation.

The analysis that US COVID Case GR and FAANGs are negatively correlated. However, there is a slight positive correlation between the the USD v. RMB GR and FAANG GR.

In [43]:

```
import pandas as pd
import matplotlib.pyplot as plt
import datetime as dt
import seaborn as sns
from numpy.polynomial.polynomial import polyfit
import matplotlib.gridspec as gridspec
import numpy as np
import matplotlib as mpl
mpl.rcParams.update(mpl.rcParamsDefault)
import math
import os
import requests, io
import zipfile as zf
import shutil
import statsmodels.formula.api as smf
%matplotlib inline
```

In [44]:

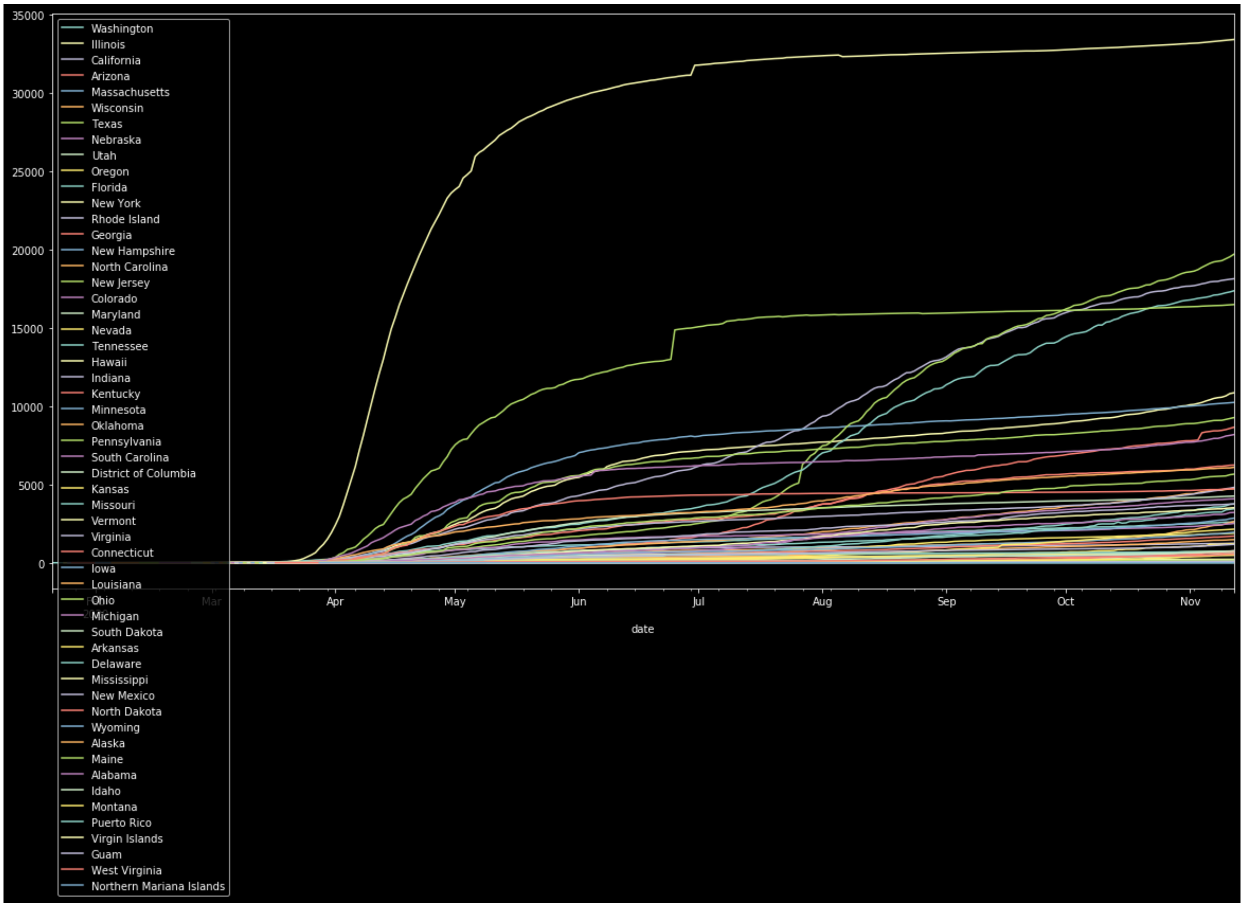
```
state_level = pd.DataFrame(us_counties.groupby(['date','state'])['deaths'].sum())
state_level = state_level.reset_index('state')
state_level = state_level.reset_index('date')
state_level = state_level.sort_values(by=['date','state'])
state_level = state_level.set_index('date')
#state_level
```

In [45]:

```
state = pd.Series(state_level['state'].unique())
#plt.style.available
```

In [46]:

```
plt.style.use('dark_background')
fig,ax = plt.subplots()
for i in state:
    state_level.loc[state_level['state'] == i,:]['deaths'].plot(ax =ax,figsize = (20,10),label=i)
    ax.legend(loc='best')
#ax.legend()
#state_level['deaths'].mean().plot(ax =ax,figsize = (10,5))
#state_level['death'].plot(ax =ax,figsize = (10,5))
#plt.plot(state_level['date'],state_level['deaths'],label=state_level['state'])
#plot(state_level['death'], label=state_level['state'])
```



In [47]:
```
state_level.iloc[:,1]
```

Out[47]:
```
date
2020-01-21       0
2020-01-22       0
2020-01-23       0
2020-01-24       0
2020-01-24       0
              ...
2020-11-12    3758
2020-11-12    2619
2020-11-12     555
2020-11-12    2626
2020-11-12     127
Name: deaths, Length: 14039, dtype: int64
```

In [48]:
```
state_level_pivot = pd.pivot_table(state_level,index=['date'],columns=
['state'],
               values=['deaths'],fill_value=np.nan)
state_level_pivot = state_level_pivot.dropna()
state_level_pivot
```

Out[48]:

	deaths								
state	**Alabama**	**Alaska**	**Arizona**	**Arkansas**	**California**	**Colorado**	**Connecticut**	**Delaware**	**Dist of Colu**
date									
2020-03-28	4.0	1.0	15.0	5.0	122.0	44.0	33.0	5.0	
2020-03-29	5.0	2.0	18.0	6.0	132.0	47.0	34.0	6.0	
2020-03-30	11.0	2.0	20.0	7.0	147.0	51.0	36.0	7.0	
2020-03-31	14.0	2.0	24.0	8.0	184.0	69.0	69.0	10.0	
2020-04-01	28.0	2.0	29.0	10.0	212.0	80.0	85.0	11.0	
...	...	...	...	...	...	...	...	...	...
2020-11-08	3084.0	79.0	6164.0	2085.0	17975.0	2421.0	4671.0	718.0	
2020-11-09	3084.0	79.0	6164.0	2108.0	18035.0	2438.0	4698.0	719.0	
2020-11-10	3120.0	87.0	6198.0	2112.0	18073.0	2469.0	4707.0	722.0	
2020-11-11	3201.0	90.0	6228.0	2126.0	18109.0	2481.0	4716.0	724.0	
2020-11-12	3213.0	90.0	6240.0	2144.0	18141.0	2512.0	4726.0	732.0	

230 rows × 55 columns

In [49]:
```python
for i in range(0,55):
    state_level_pivot['death_'+str(i)] = state_level_pivot.iloc[:,i].r
olling(window=7).mean()

state_level_pivot
```

Out[49]:

	deaths								
state	**Alabama**	**Alaska**	**Arizona**	**Arkansas**	**California**	**Colorado**	**Connecticut**	**Delaware**	**Dist of Colu**
date									
2020-03-28	4.0	1.0	15.0	5.0	122.0	44.0	33.0	5.0	
2020-03-29	5.0	2.0	18.0	6.0	132.0	47.0	34.0	6.0	
2020-03-30	11.0	2.0	20.0	7.0	147.0	51.0	36.0	7.0	
2020-03-31	14.0	2.0	24.0	8.0	184.0	69.0	69.0	10.0	
2020-04-01	28.0	2.0	29.0	10.0	212.0	80.0	85.0	11.0	
...	...	...	...	...	...	...	...	...	
2020-11-08	3084.0	79.0	6164.0	2085.0	17975.0	2421.0	4671.0	718.0	
2020-11-09	3084.0	79.0	6164.0	2108.0	18035.0	2438.0	4698.0	719.0	
2020-11-10	3120.0	87.0	6198.0	2112.0	18073.0	2469.0	4707.0	722.0	
2020-11-11	3201.0	90.0	6228.0	2126.0	18109.0	2481.0	4716.0	724.0	
2020-11-12	3213.0	90.0	6240.0	2144.0	18141.0	2512.0	4726.0	732.0	

230 rows × 110 columns

In [50]:

```
import datetime
df2_2 = state_level.reset_index('date')
df2_2['Date'] = pd.to_datetime(df2_2['date'])
df2_2['Date'] = df2_2['Date'].dt.strftime('%d.%m.%Y')
df2_2['month'] = pd.DatetimeIndex(df2_2['Date']).month
df2_2['day'] = pd.DatetimeIndex(df2_2['Date']).day
df2_2['dayofyear'] = pd.DatetimeIndex(df2_2['Date']).dayofyear
df2_2['weekofyear'] = pd.DatetimeIndex(df2_2['Date']).weekofyear
df2_2['weekday'] = pd.DatetimeIndex(df2_2['Date']).weekday
df2_2['quarter'] = pd.DatetimeIndex(df2_2['Date']).quarter
df2_2['is_month_start'] = pd.DatetimeIndex(df2_2['Date']).is_month_start
df2_2['is_month_end'] = pd.DatetimeIndex(df2_2['Date']).is_month_end
df2_2 = df2_2.drop(['Date'], axis = 1)
df2_2 = df2_2.drop(['date'], axis = 1)
df2_2= pd.get_dummies(df2_2, columns=['month'], drop_first=True, prefix='month')
df2_2 = pd.get_dummies(df2_2, columns=['weekday'], drop_first=True, prefix='wday')
df2_2 = pd.get_dummies(df2_2, columns=['quarter'], drop_first=True, prefix='qrtr')
df2_2= pd.get_dummies(df2_2, columns=['is_month_start'], drop_first=True, prefix='m_start')
df2_2 = pd.get_dummies(df2_2, columns=['is_month_end'], drop_first=True, prefix='m_end')
df2_2= pd.get_dummies(df2_2, columns=['state'], drop_first=True, prefix='state')
df2_2
df2_2
```

Out[50]:

	deaths	day	dayofyear	weekofyear	month_2	month_3	month_4	month_5	month_6
0	0	21	21	4	0	0	0	0	0
1	0	22	22	4	0	0	0	0	0
2	0	23	23	4	0	0	0	0	0
3	0	24	24	4	0	0	0	0	0
4	0	24	24	4	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...
14034	3758	11	346	50	0	0	0	0	0
14035	2619	11	346	50	0	0	0	0	0
14036	555	11	346	50	0	0	0	0	0
14037	2626	11	346	50	0	0	0	0	0
14038	127	11	346	50	0	0	0	0	0

14039 rows × 79 columns

In [127]:

```
from sklearn.model_selection import train_test_split

X = df2_2.drop(columns=["deaths"]).values
y = df2_2.deaths.values
X_train, X_holdout, y_train, y_holdout = train_test_split(X, y, shuffle=False, test_size=0.5, random_state = 0)
X_val, X_test, y_val, y_test = train_test_split(X_holdout, y_holdout, shuffle=False, test_size=0.5, random_state = 0)
```

In [128]:

```
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_absolute_error
model_1 = LinearRegression()
model_1.fit(X_train,y_train)

y_predicted    = model_1.predict(X_val)
MAE_sklearn = mean_absolute_error(y_val, y_predicted)
yy = model_1.predict(X_train)
MAE_sklearn_train = mean_absolute_error(y_train, yy)
```

In [129]:

```
MAE_sklearn
```

Out[129]:

```
1846.8099381232194
```

In [130]:

```
us_level = pd.DataFrame(state_level.groupby('date')['deaths'].sum())
#us_level
```

In [195]:

```
path_netflix = '/Users/jarrodhoran/Downloads/Netflix.csv'
netflix = pd.read_csv(path_netflix).tail(365)
netflix['Date'] = pd.to_datetime(netflix['Date'])
netflix = netflix[netflix['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
#pd.set_option('display.max_rows', None)
netflix = netflix.set_index('Date')
#netflix
```

In [196]:

```
netflix_sub = netflix.iloc[:,3:4]
#netflix_sub
```

In [197]:

```
path_amazon = '/Users/jarrodhoran/Downloads/Amazon.csv'
amazon = pd.read_csv(path_amazon).tail(365)
amazon['Date'] = pd.to_datetime(amazon['Date'])
amazon = amazon[amazon['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
amazon = amazon.set_index('Date')
```

In [198]:

```
amazon_sub = amazon.iloc[:,3:4]
#amazon_sub
```

In [199]:

```
amazon_sub1 = amazon_sub.reset_index('Date')
amazon_sub1
```

Out[199]:

```
           Date        Close
  0  2020-01-02  1898.010010
  1  2020-01-03  1874.969971
  2  2020-01-06  1902.880005
  3  2020-01-07  1906.859985
  4  2020-01-08  1891.969971
...         ...          ...
152  2020-08-10  3148.159912
153  2020-08-11  3080.669922
154  2020-08-12  3162.239990
155  2020-08-13  3161.020020
156  2020-08-14  3148.020020

157 rows × 2 columns
```

In [200]:

```
path_google = '/Users/jarrodhoran/Downloads/Google.csv'
google = pd.read_csv(path_google).tail(365)
google['Date'] = pd.to_datetime(google['Date'])
google = google[google['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
google = google.set_index('Date')
#google
```

In [201]:

```
google_sub = google.iloc[:,3:4]
#google_sub
```

In [202]:
```
google_sub1 = google_sub.reset_index('Date')
google_sub1
```

Out[202]:
```
           Date        Close
  0  2020-01-02  1368.680054
  1  2020-01-03  1361.520020
  2  2020-01-06  1397.810059
  3  2020-01-07  1395.109985
  4  2020-01-08  1405.040039
...         ...          ...
167  2020-08-31  1629.530029
168  2020-09-01  1655.079956
169  2020-09-02  1717.390015
170  2020-09-03  1629.510010
171  2020-09-04  1581.209961

172 rows × 2 columns
```

In [203]:
```
path_apple = '/Users/jarrodhoran/Downloads/Apple.csv'
apple = pd.read_csv(path_apple).tail(365)
apple['Date'] = pd.to_datetime(apple['Date'])
apple = apple[apple['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
apple = apple.set_index('Date')
#apple
```

In [204]:
```
apple_sub = apple.iloc[:,3:4]
apple_sub1 = apple_sub.reset_index('Date')
apple_sub1
```

Out[204]:

	Date	Close
0	2020-01-02	75.087502
1	2020-01-03	74.357498
2	2020-01-06	74.949997
3	2020-01-07	74.597504
4	2020-01-08	75.797501
...	...	...
164	2020-08-26	126.522499
165	2020-08-27	125.010002
166	2020-08-28	124.807503
167	2020-08-31	129.039993
168	2020-09-01	134.179993

169 rows × 2 columns

In [205]:
```
path_facebook = '/Users/jarrodhoran/Downloads/Facebook.csv'
facebook = pd.read_csv(path_facebook).tail(365)
facebook = facebook
facebook['Date'] = pd.to_datetime(facebook['Date'])
facebook = facebook[facebook['Date'].dt.year == 2020]
#pd.reset_option('display.max_rows', None)
facebook = facebook.set_index('Date')
#facebook
```

In [206]:

```python
facebook_sub = facebook.iloc[:,3:4]
facebook_sub1 = facebook_sub.reset_index('Date')
facebook_sub1
```

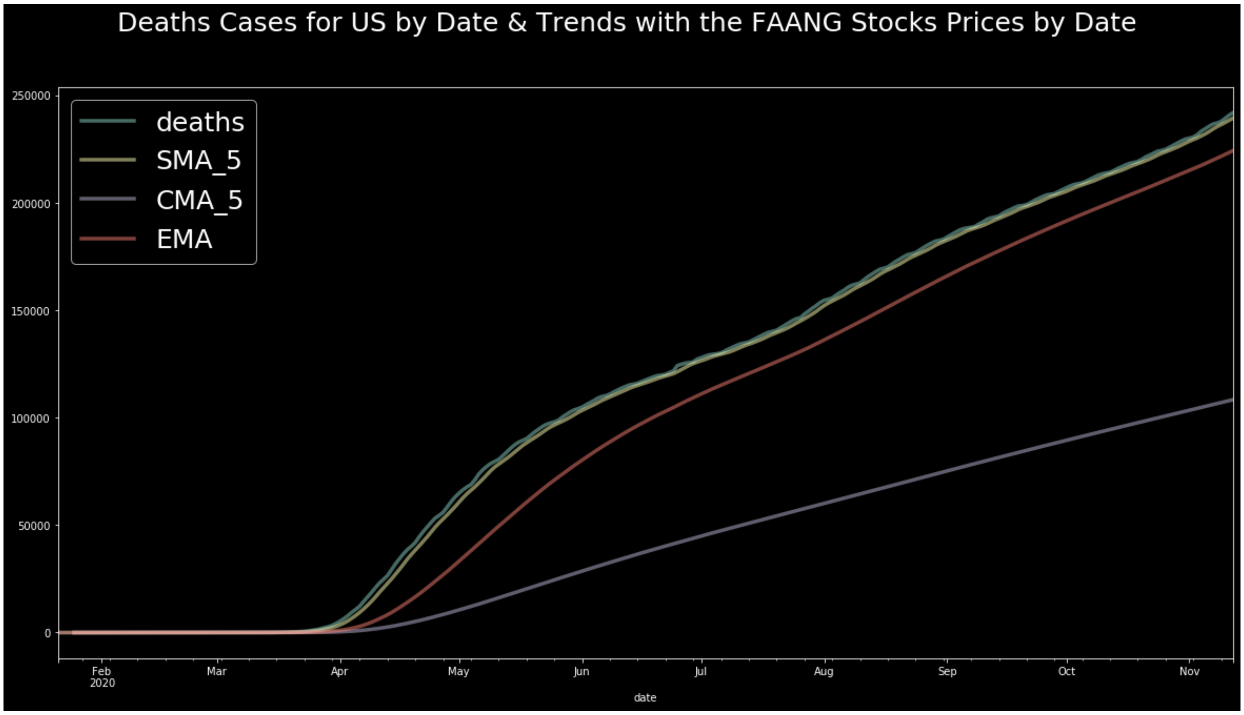
Out[206]:

	Date	Close
0	2020-01-02	209.779999
1	2020-01-03	208.669998
2	2020-01-06	212.600006
3	2020-01-07	213.059998
4	2020-01-08	215.220001
...	...	...
154	2020-08-12	259.890015
155	2020-08-13	261.299988
156	2020-08-14	261.239990
157	2020-08-17	261.160004
158	2020-08-18	262.339996

159 rows × 2 columns

In [207]:

```
fig, ax1 = plt.subplots()
fig.suptitle('Deaths Cases for US by Date & Trends with the FAANG Stocks Prices by Date',fontsize=25)
us_level['deaths'].plot(ax =ax1,figsize = (20,10),lw=3.5,alpha = 0.5)
#us_level['SMA_3'] = us_level.iloc[:,0].rolling(window=3).mean()
#us_level['SMA_4'] = us_level.iloc[:,0].rolling(window=4).mean()
us_level['SMA_5'] = us_level.iloc[:,0].rolling(window=5).mean()
us_level['CMA_5'] = us_level.iloc[:,0].expanding(min_periods=5).mean()
us_level['EMA'] = us_level.iloc[:,0].ewm(span=40,adjust=False).mean()
#us_level['SMA_3'].plot(ax=ax,lw=4)
#us_level['SMA_4'].plot(ax=ax)
us_level['SMA_5'].plot(ax=ax1,alpha = 0.5,lw=3.5)
us_level['CMA_5'].plot(ax=ax1,alpha = 0.5,lw=3.5)
us_level['EMA'].plot(ax=ax1,alpha = 0.5,lw=3.5)
ax1.legend(fontsize=25)
plt.savefig('COVID19.png')
```



In [208]:
```
amazon_sub1
```

Out[208]:

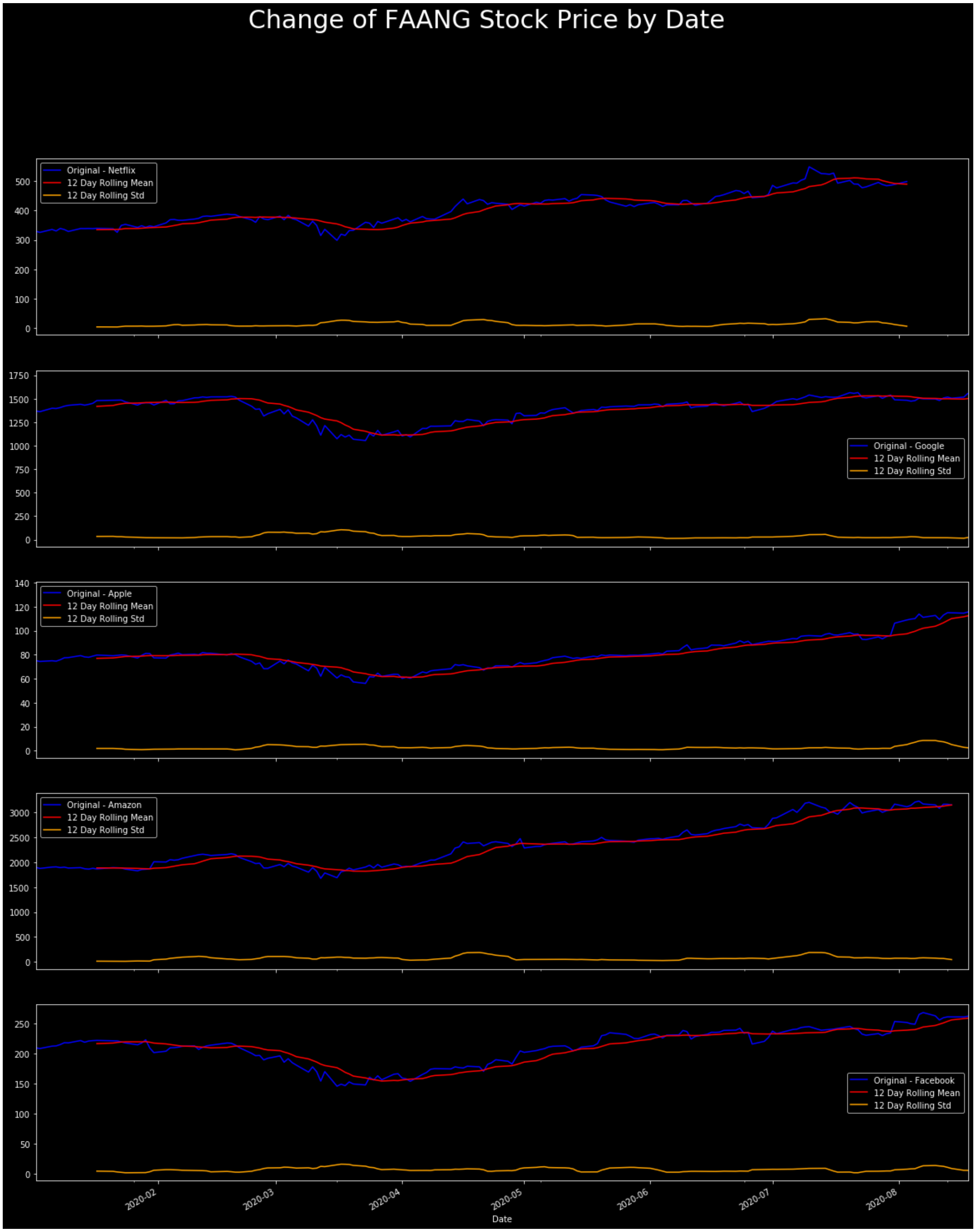
	Date	Close
0	2020-01-02	1898.010010
1	2020-01-03	1874.969971
2	2020-01-06	1902.880005
3	2020-01-07	1906.859985
4	2020-01-08	1891.969971
...	...	...
152	2020-08-10	3148.159912
153	2020-08-11	3080.669922
154	2020-08-12	3162.239990
155	2020-08-13	3161.020020
156	2020-08-14	3148.020020

157 rows × 2 columns

In [209]:
```
netflix_sub1 = netflix_sub.reset_index('Date')
```

In [210]:

```
fig,ax = plt.subplots(5,figsize=(20,25),sharex=True)
from statsmodels.tsa.stattools import adfuller
def test_stationarity(timeseries,i,name):

    #Determing rolling statistics
    timeseries['rolmean'] = timeseries.iloc[:,1:2].rolling(window=12).
mean()
    timeseries['rolstd']= timeseries.iloc[:,1:2].rolling(window=12).st
d()

    #Plot rolling statistics:
    plt.style.use('dark_background')
    timeseries.plot(x='Date',y='Close',color='blue',label='Original'+'
- '+str(name).title(),ax=ax[i])
    timeseries.plot(x='Date',y='rolmean',color='red', label='12 Day Ro
lling Mean',ax=ax[i])
    timeseries.plot(x='Date',y='rolstd',color='orange', label = '12 Da
y Rolling Std',ax=ax[i])
    ax[i].legend(loc='best')
    #ax[i].show(block=False)

#ax[0].title('Rolling Mean & Standard Deviation - Netflix')
fig.suptitle('Change of FAANG Stock Price by Date',fontsize = 30)
test_stationarity(netflix_sub1,0,'netflix')
test_stationarity(google_sub1,1,'google')
test_stationarity(apple_sub1,2,'apple')
test_stationarity(amazon_sub1,3,'amazon')
test_stationarity(facebook_sub1,4,'facebook')
plt.savefig('FAANG1.png')
```


Change of FAANG Stock Price by Date
Original - Netflix
12 Day Rolling Mean
12 Day Rolling Std
500
400
300
200
100
0
Original - Google
12 Day Rolling Mean
12 Day Rolling Std
1750
1500
1250
1000
750
500
250
0
Original - Apple
12 Day Rolling Mean
12 Day Rolling Std
140
120
100
80
60
40
20
0
Original - Amazon
12 Day Rolling Mean
12 Day Rolling Std
3000
2500
2000
1500
1000
500
0
Original - Facebook
12 Day Rolling Mean
12 Day Rolling Std
250
200
150
100
50
0
2020-02
2020-03
2020-04
2020-05
2020-06
2020-07
2020-08
Date

In [216]:

```
netflix_sub1 = netflix_sub1.rename(columns={"Close": "Close_Netflix",'
rolmean':'rolmean_Netflix',
                                            'rolstd':'rolstd_Netflix'})
amazon_sub1 = amazon_sub1.rename(columns={"Close": "Close_Amazon",'rol
mean':'rolmean_Amazon',
                                          "rolstd":'rolstd_Amazon'})
apple_sub1 = apple_sub1.rename(columns={"Close": "Close_Apple",
                                        'rolmean':'rolmean_Apple',
                                       'rolstd':'rolstd_Apple'})
google_sub1 = google_sub1.rename(columns={"Close": "Close_Google",
                                          "rolmean":"rolmean_Google",
                                         "rolstd":'rolstd_Google'})
facebook_sub1 = facebook_sub1.rename(columns={"Close": "Close_Facebook
",
                                              'rolmean':'rolmean_FB',
                                              'rolstd':'rolstd_FB'})
facebook_sub1
```

Out[216]:

```
           Date  Close_Facebook  rolmean_FB  rolstd_FB
  0  2020-01-02      209.779999         NaN        NaN
  1  2020-01-03      208.669998         NaN        NaN
  2  2020-01-06      212.600006         NaN        NaN
  3  2020-01-07      213.059998         NaN        NaN
  4  2020-01-08      215.220001         NaN        NaN
...         ...             ...         ...        ...
154  2020-08-12      259.890015  251.269168  12.761358
155  2020-08-13      261.299988  253.867500  11.134257
156  2020-08-14      261.239990  256.196667   9.192429
157  2020-08-17      261.160004  258.418334   6.209728
158  2020-08-18      262.339996  259.140834   6.110621

159 rows × 4 columns
```

In [219]:

```
stonks = apple_sub1.merge(google_sub1, on = 'Date', how = 'left')
stonks = stonks.merge(amazon_sub1, on = 'Date', how = 'left')
stonks = stonks.merge(netflix_sub1, on ='Date', how = 'left')
stonks = stonks.merge(facebook_sub1, on ='Date', how = 'left')
#stonks = stonks.rename(columns = {"Close_x": "Close_Apple"})
```

In [228]:

```
stonks = stonks.set_index('Date')
```

In [237]:
```
normalized_stonks = pd.DataFrame(index = stonks.index)
```

In [238]:
```
from sklearn import preprocessing
x = stonks.values #returns a numpy array
min_max_scaler = preprocessing.MinMaxScaler()
x_scaled = min_max_scaler.fit_transform(x)
normalized_stonks = pd.DataFrame(x_scaled)
```

In [245]:
```
normalized_stonks = normalized_stonks.rename(columns = {0:"Close_Apple",1:'rolmean_Apple',2:'rolstd_Apple',
                                   3: "Close_Google",4:"rolmean_Google",5:'rolstd_Google',
                                   6: "Close_Amazon",7:'rolmean_Amazon',8:'rolstd_Amazon',
                                   9: "Close_Netflix",10:'rolmean_Netflix',11:'rolstd_Netflix',
                                   12:  "Close_Facebook",13:'rolmean_FB',14:'rolstd_FB'})
```

In [255]:
```
normalized_stonks=normalized_stonks.dropna()
```

In [256]:
```
normalized_stonks
```

Out[256]:

	Close_Apple	rolmean_Apple	rolstd_Apple	Close_Google	rolmean_Google	rolstd_Google
11	0.302097	0.255136	0.153935	0.707863	0.632779	0.229406
12	0.295182	0.260576	0.153595	0.712405	0.652269	0.238148
13	0.298799	0.267374	0.133660	0.715101	0.673267	0.202292
14	0.303698	0.273890	0.115346	0.716466	0.688178	0.202118
15	0.300752	0.280571	0.064062	0.685648	0.700373	0.161476
...	...	...	...	...	...	...
143	0.475876	0.557973	0.161666	0.748016	0.857255	0.097246
144	0.498767	0.557386	0.162943	0.781063	0.859191	0.092303
145	0.513495	0.556222	0.158179	0.805791	0.862196	0.093037
146	0.642452	0.567672	0.372055	0.721890	0.857231	0.125054
147	0.676741	0.584327	0.565441	0.713254	0.851711	0.157788

137 rows × 15 columns

In [282]:

```
reg1 = smf.ols('Close_Google ~ Close_Amazon',normalized_stonks).fit()
normalized_stonks['yhat1'] = reg1.predict()
```

In [283]:

```
reg2 = smf.ols('Close_Google ~ Close_Apple',normalized_stonks).fit()
normalized_stonks['yhat2'] = reg2.predict()
```

In [286]:

```
reg3 = smf.ols('Close_Google ~ Close_Netflix',normalized_stonks).fit()
normalized_stonks['yhat3'] = reg3.predict()
```

In [293]:

```
reg4 = smf.ols('Close_Google ~ Close_Facebook',normalized_stonks).fit(
)
normalized_stonks['yhat4'] = reg4.predict()
```

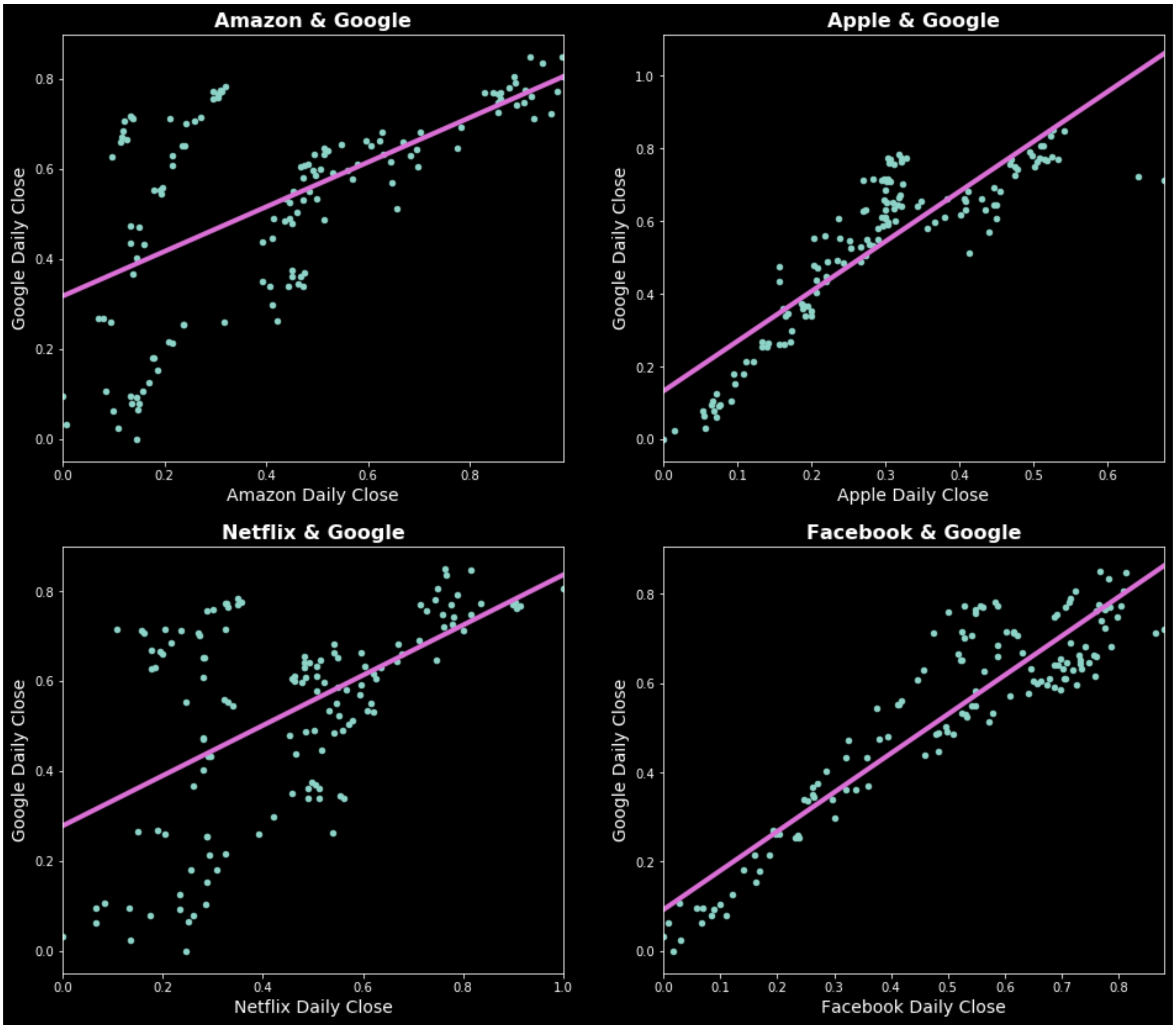
In [309]:

```
fig,ax = plt.subplots(nrows = 2, ncols = 2, figsize = (16,14))

#top left

normalized_stonks.plot.scatter(ax = ax[0,0], x = 'Close_Amazon', y = '
Close_Google')
normalized_stonks.sort_values('Close_Amazon').set_index('Close_Amazon'
)['yhat1'].plot(ax = ax[0,0],

color = 'orchid',lw = 4)


ax[0,0].set_xlabel('Amazon Daily Close', fontsize = 14)
ax[0,0].set_ylabel('Google Daily Close', fontsize = 14)
ax[0,0].set_title('Amazon & Google', fontsize = 16, fontweight = 'bold
')


#top right

normalized_stonks.plot.scatter(ax = ax[0,1], x = 'Close_Apple', y = 'C
lose_Google')
normalized_stonks.sort_values('Close_Apple').set_index('Close_Apple')[
'yhat2'].plot(ax = ax[0,1],

color = 'orchid',lw = 4)

ax[0,1].set_xlabel('Apple Daily Close', fontsize = 14)
ax[0,1].set_ylabel('Google Daily Close', fontsize = 14)
ax[0,1].set_title('Apple & Google', fontsize = 16, fontweight = 'bold'
)

#bottom left
```

```
normalized_stonks.plot.scatter(ax = ax[1,1], x = 'Close_Facebook', y = 'Close_Google')
normalized_stonks.sort_values('Close_Facebook').set_index('Close_Facebook')['yhat4'].plot(ax = ax[1,1],

color = 'orchid',lw = 4)

ax[1,1].set_xlabel('Facebook Daily Close', fontsize = 14)
ax[1,1].set_ylabel('Google Daily Close', fontsize = 14)
ax[1,1].set_title('Facebook & Google', fontsize = 16, fontweight = 'bold')


#bottom right

normalized_stonks.plot.scatter(ax = ax[1,0], x = 'Close_Netflix', y = 'Close_Google')
normalized_stonks.sort_values('Close_Netflix').set_index('Close_Netflix')['yhat3'].plot(ax = ax[1,0],

color = ['orchid']

,lw = 4)

ax[1,0].set_xlabel('Netflix Daily Close', fontsize = 14)
ax[1,0].set_ylabel('Google Daily Close', fontsize = 14)
ax[1,0].set_title('Netflix & Google', fontsize = 16, fontweight = 'bold')
```

Out[309]:

```
Text(0.5, 1.0, 'Netflix & Google')
```



In [314]:
```
print(reg4.summary(),reg2.summary(),reg1.summary(),reg3.summary())
```

```
                            OLS Regression Results
======================================================================
==========
Dep. Variable:          Close_Google   R-squared:
0.848
Model:                           OLS   Adj. R-squared:
0.847
Method:                Least Squares   F-statistic:
753.0
Date:               Wed, 09 Dec 2020   Prob (F-statistic):
4.47e-57
Time:                       20:54:21   Log-Likelihood:
141.27
No. Observations:                137   AIC:
-278.5
Df Residuals:                    135   BIC:
-272.7
```

```
Df Model:                           1
Covariance Type:            nonrobust
====================================================================
==============
                     coef    std err          t      P>|t|      [0.0
25      0.975]
--------------------------------------------------------------------
--------------
Intercept          0.0922      0.018      5.216      0.000       0.0
57       0.127
Close_Facebook     0.8769      0.032     27.441      0.000       0.8
14       0.940
====================================================================
==========
Omnibus:                       10.678   Durbin-Watson:
0.193
Prob(Omnibus):                  0.005   Jarque-Bera (JB):
11.732
Skew:                           0.706   Prob(JB):
0.00283
Kurtosis:                       2.755   Cond. No.
5.44
====================================================================
==========

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors
is correctly specified.                             OLS Regression R
esults
====================================================================
==========
Dep. Variable:           Close_Google   R-squared:
0.762
Model:                            OLS   Adj. R-squared:
0.760
Method:                 Least Squares   F-statistic:
431.2
Date:                Wed, 09 Dec 2020   Prob (F-statistic):
7.33e-44
Time:                        20:54:21   Log-Likelihood:
110.44
No. Observations:                 137   AIC:
-216.9
Df Residuals:                     135   BIC:
-211.0
Df Model:                           1
Covariance Type:            nonrobust
====================================================================
===========
                  coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------
-----------
Intercept       0.1324      0.021      6.188      0.000       0.090
0.175
Close_Apple     1.3703      0.066     20.766      0.000       1.240
1.501
====================================================================
==========
Omnibus:                        0.145   Durbin-Watson:
0.130
Prob(Omnibus):                  0.930   Jarque-Bera (JB):
0.043
Skew:                           0.043   Prob(JB):
0.979
Kurtosis:                       3.013   Cond. No.
7.71
====================================================================
==========

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors
is correctly specified.                             OLS Regression R
esults
====================================================================
==========
Dep. Variable:           Close_Google   R-squared:
0.361
Model:                            OLS   Adj. R-squared:
0.357
Method:                 Least Squares   F-statistic:
76.41
Date:                Wed, 09 Dec 2020   Prob (F-statistic):
8.01e-15
Time:                        20:54:21   Log-Likelihood:
42.954
No. Observations:                 137   AIC:
-81.91
Df Residuals:                     135   BIC:
-76.07
Df Model:                           1
Covariance Type:            nonrobust
====================================================================
============
                   coef    std err          t      P>|t|      [0.025
0.975]
--------------------------------------------------------------------
------------
Intercept        0.3174      0.029     10.964      0.000       0.260
0.375
```

```
Close_Amazon     0.4960      0.057      8.741      0.000       0.384
0.608
======================================================================
==========
Omnibus:                        2.358   Durbin-Watson:
0.079
Prob(Omnibus):                  0.308   Jarque-Bera (JB):
1.754
Skew:                           0.084   Prob(JB):
0.416
Kurtosis:                       2.472   Cond. No.
4.47
======================================================================
==========

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors
is correctly specified.                             OLS Regression R
esults
======================================================================
==========
Dep. Variable:           Close_Google   R-squared:
0.301
Model:                            OLS   Adj. R-squared:
0.295
Method:                 Least Squares   F-statistic:
58.03
Date:                Wed, 09 Dec 2020   Prob (F-statistic):
4.05e-12
Time:                        20:54:21   Log-Likelihood:
36.725
No. Observations:                 137   AIC:
-69.45
Df Residuals:                     135   BIC:
-63.61
Df Model:                           1
Covariance Type:            nonrobust
======================================================================
=============
                    coef    std err          t      P>|t|      [0.02
5      0.975]
----------------------------------------------------------------------
-------------
Intercept         0.2781      0.037      7.513      0.000       0.20
5      0.351
Close_Netflix     0.5582      0.073      7.618      0.000       0.41
3      0.703
======================================================================
==========
Omnibus:                        4.002   Durbin-Watson:
```

```
0.071
Prob(Omnibus):                  0.135   Jarque-Bera (JB):
2.337
Skew:                           0.033   Prob(JB):
0.311
Kurtosis:                       2.363   Cond. No.
5.59
======================================================================
==========

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors
is correctly specified.
```

Analysis

The charts above use a normalized end-of-day price for the FAANG stocks. The analysis reveals that when predicting the stock price of Google, the end-of-day price for Facebook is the best predictor with an R^2 of .848. The remaining order is Apple (R^2: .762), Amazon (R^2: .361), and Netflix (R^2: .301). Thus, it is likely that the stock prices for Facebook and Google experienced the most similar percent change throughout the time period.
There is a low P-value, which is indicative that the results are unlikely to occur randomly.

In [ ]: