

Tony Chen Final Project

In [299]:

```
import pandas as pd
import numpy as np
import matplotlib
matplotlib.use('Agg')
%pylab inline
import matplotlib.pyplot as plt
import weightedcalcs as wc
import datetime as dt
import ffmpeg
import matplotlib.animation as animation
```

Populating the interactive namespace from numpy and matplotlib

1. Produce Yields Dataframe

In [300]:

```
three_month="/Users/apple/Desktop/DB Final/3-Month.CSV"
six_month="/Users/apple/Desktop/DB Final/6-Month.CSV"
one_year="/Users/apple/Desktop/DB Final/1-Year.CSV"
two_year="/Users/apple/Desktop/DB Final/2-Year.CSV"
five_year="/Users/apple/Desktop/DB Final/5-Year.CSV"
ten_year="/Users/apple/Desktop/DB Final/10-Year.CSV"
unem="/Users/apple/Desktop/DB Final/Unem.CSV"
ipi="/Users/apple/Desktop/DB Final/IPI.CSV"
dateref="/Users/apple/Desktop/DB Final/Dateref.CSV"
```

In [301]:

```
df3m=pd.read_csv(three_month)
df3m["DATE"]=pd.to_datetime(df3m["DATE"])

df6m=pd.read_csv(six_month)
df6m["DATE"]=pd.to_datetime(df6m["DATE"])

df1y=pd.read_csv(one_year)
df1y["DATE"]=pd.to_datetime(df1y["DATE"])

df2y=pd.read_csv(two_year)
df2y["DATE"]=pd.to_datetime(df2y["DATE"])

df5y=pd.read_csv(five_year)
df5y["DATE"]=pd.to_datetime(df5y["DATE"])

df10y=pd.read_csv(ten_year)
df10y["DATE"]=pd.to_datetime(df10y["DATE"])

dfun=pd.read_csv(unem)
dfun["DATE"]=pd.to_datetime(dfun["DATE"])

dfipi=pd.read_csv(ipi)
dfipi["DATE"]=pd.to_datetime(dfipi["DATE"])

dftimeref=pd.read_csv(dateref)
```

In [302]:

```
combo = pd.merge(df3m,df6m,on="DATE",how='left')
combo = pd.merge(combo,df1y,on="DATE",how='left')
combo = pd.merge(combo,df2y,on="DATE",how='left')
combo = pd.merge(combo,df5y,on="DATE",how='left')
combo = pd.merge(combo,df10y,on="DATE",how='left')
# Merge all treasuries yields data
```

In [303]:

```
combo.dtypes
```

Out[303]:

```
DATE      datetime64[ns]
DTB3      object
DTB6      object
DGS1      object
DGS2      object
DGS5      object
DGS10     object
dtype: object
```

In [304]:

```
new_column=["Date","Three_Month","Six_Month","One_Year","Two_Year","Five_Year",
"Ten_Year"]
```

In [305]:

```
combo.columns=new_column  
# Renaming Columns
```

In [306]:

```
combo.set_index("Date",inplace=True)
```

In [307]:

```
columnlist=list(combo)  
for i in columnlist:  
    combo[i]=pd.to_numeric(combo[i],errors='coerce')  
# Convert all numbers into float type
```

In [308]:

```
combo=combo.dropna(axis=0)
```

In [309]:

```
combo
```

Out[309]:

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year
Date						
1976-06-01	5.55	5.90	6.70	7.26	7.71	7.94
1976-06-02	5.57	5.94	6.72	7.23	7.74	7.94
1976-06-03	5.52	5.92	6.73	7.22	7.75	7.92
1976-06-04	5.46	5.82	6.60	7.12	7.67	7.89
1976-06-07	5.45	5.77	6.51	7.09	7.64	7.88
1976-06-08	5.45	5.77	6.55	7.11	7.67	7.90
1976-06-09	5.44	5.74	6.53	7.08	7.66	7.90
1976-06-10	5.43	5.73	6.53	7.00	7.61	7.86
1976-06-11	5.42	5.72	6.49	7.03	7.58	7.86
1976-06-14	5.40	5.70	6.44	7.01	7.56	7.84
1976-06-15	5.37	5.74	6.47	7.02	7.59	7.85
1976-06-16	5.40	5.78	6.52	7.06	7.62	7.87
1976-06-17	5.38	5.75	6.51	7.06	7.60	7.85
1976-06-18	5.35	5.72	6.46	6.99	7.54	7.81
1976-06-21	5.36	5.73	6.45	6.95	7.51	7.80
1976-06-22	5.38	5.75	6.48	7.01	7.53	7.81
1976-06-23	5.33	5.72	6.46	7.01	7.53	7.81
1976-06-24	5.31	5.68	6.43	6.99	7.53	7.81
1976-06-25	5.31	5.69	6.45	7.02	7.56	7.83
1976-06-28	5.35	5.75	6.50	7.02	7.58	7.86
1976-06-29	5.37	5.76	6.47	7.02	7.59	7.86
1976-06-30	5.37	5.76	6.46	7.02	7.58	7.86
1976-07-01	5.36	5.74	6.46	7.02	7.59	7.88
1976-07-02	5.35	5.72	6.43	6.99	7.57	7.84
1976-07-06	5.39	5.69	6.38	6.96	7.55	7.82
1976-07-07	5.40	5.70	6.39	6.99	7.57	7.84
1976-07-08	5.33	5.58	6.25	6.92	7.52	7.82
1976-07-09	5.25	5.47	6.11	6.77	7.45	7.78
1976-07-12	5.16	5.42	6.07	6.72	7.40	7.76
1976-07-13	5.15	5.45	6.13	6.74	7.42	7.77
...
2019-03-18	2.39	2.44	2.52	2.45	2.42	2.60
2019-03-19	2.41	2.45	2.50	2.46	2.42	2.61
2019-03-20	2.42	2.42	2.47	2.40	2.34	2.54

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year
Date						
2019-03-21	2.43	2.43	2.48	2.41	2.34	2.54
2019-03-22	2.41	2.41	2.45	2.31	2.24	2.44
2019-03-25	2.41	2.42	2.41	2.26	2.21	2.43
2019-03-26	2.41	2.42	2.44	2.24	2.18	2.41
2019-03-27	2.39	2.39	2.40	2.22	2.18	2.39
2019-03-28	2.38	2.37	2.40	2.23	2.20	2.39
2019-03-29	2.35	2.37	2.40	2.27	2.23	2.41
2019-04-01	2.38	2.39	2.41	2.33	2.31	2.49
2019-04-02	2.37	2.38	2.41	2.30	2.28	2.48
2019-04-03	2.39	2.38	2.41	2.33	2.32	2.52
2019-04-04	2.39	2.39	2.41	2.33	2.32	2.51
2019-04-05	2.39	2.39	2.43	2.35	2.31	2.50
2019-04-08	2.38	2.41	2.43	2.36	2.33	2.52
2019-04-09	2.37	2.39	2.42	2.35	2.31	2.51
2019-04-10	2.38	2.39	2.41	2.31	2.28	2.48
2019-04-11	2.38	2.39	2.44	2.35	2.31	2.51
2019-04-12	2.39	2.40	2.44	2.40	2.38	2.56
2019-04-15	2.38	2.39	2.43	2.40	2.37	2.55
2019-04-16	2.38	2.40	2.45	2.41	2.41	2.60
2019-04-17	2.39	2.40	2.44	2.40	2.40	2.59
2019-04-18	2.37	2.40	2.44	2.38	2.38	2.57
2019-04-22	2.39	2.40	2.46	2.38	2.39	2.59
2019-04-23	2.40	2.39	2.43	2.36	2.36	2.57
2019-04-24	2.39	2.39	2.42	2.32	2.32	2.53
2019-04-25	2.38	2.39	2.42	2.33	2.33	2.54
2019-04-26	2.37	2.39	2.41	2.28	2.29	2.51
2019-04-29	2.39	2.40	2.42	2.30	2.32	2.54

10723 rows × 6 columns

In [310]:

```
combomon=pd.DataFrame([ ])
for i in columnlist:
    combomon[i]=combo[i].resample('m').mean()

#Create a new dataframe that has the monthly average yields for each treasury
```

In [311]:

```
combomon  
combomon2=combomon
```

2. Adding in unemployment data

The monthly unemployment rate measures the percentage of people looking for a job but could not obtain one. Unemployment rate usually rises as economic performances dissappoint and it usually falls when the economy is robust

In [312]:

```
combomonunem=combomon
```

In [313]:

```
dfun.set_index("DATE", inplace=True)
```

In [314]:

```
combomonunem.index=dfun.index
```

In [315]:

```
combomonunem["Unem"]=dfun["UNRATENSA"]
```

In [316]:

```
combomonunem
```


Out[316]:

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem
DATE							
1976-06-01	5.407727	5.765455	6.520909	7.060000	7.606818	7.861364	8.0
1976-07-01	5.230000	5.527143	6.200476	6.850000	7.487619	7.831905	7.8
1976-08-01	5.142727	5.400909	6.002727	6.631364	7.306818	7.768636	7.6
1976-09-01	5.083333	5.304762	5.844286	6.416190	7.129524	7.594286	7.4
1976-10-01	4.918500	5.060500	5.496500	5.984000	6.752000	7.411000	7.2
1976-11-01	4.752632	4.878947	5.294211	5.810000	6.519474	7.291053	7.4
1976-12-01	4.346364	4.512273	4.893182	5.376818	6.104545	6.869091	7.4
1977-01-01	4.617619	4.826667	5.290952	5.899524	6.583333	7.213333	8.3
1977-02-01	4.665263	4.897368	5.467368	6.088421	6.830000	7.391053	8.5
1977-03-01	4.602609	4.878261	5.500435	6.086522	6.928261	7.460000	7.9
1977-04-01	4.535500	4.798000	5.441000	5.963500	6.792000	7.370500	6.9
1977-05-01	4.956190	5.200000	5.843810	6.254762	6.939048	7.456667	6.4
1977-06-01	5.016364	5.211818	5.798182	6.127273	6.756818	7.275455	7.5
1977-07-01	5.185789	5.399474	5.936842	6.274737	6.844211	7.330000	7.0
1977-08-01	5.490870	5.826957	6.369565	6.611304	7.028261	7.396522	6.8
1977-09-01	5.808571	6.037619	6.526667	6.714286	7.040476	7.343810	6.6
1977-10-01	6.160000	6.425000	6.965000	7.106000	7.320000	7.523500	6.4
1977-11-01	6.104737	6.410526	6.954737	7.142632	7.338947	7.577368	6.5
1977-12-01	6.065238	6.396190	6.957619	7.176667	7.478571	7.685238	6.0
1978-01-01	6.440476	6.702381	7.283333	7.485714	7.766190	7.956190	7.1
1978-02-01	6.445556	6.737222	7.337778	7.565000	7.832222	8.033333	6.9
1978-03-01	6.293636	6.634091	7.310455	7.575000	7.857727	8.035909	6.6
1978-04-01	6.286000	6.733000	7.454500	7.743500	7.982500	8.154000	5.8
1978-05-01	6.408095	7.019524	7.820000	8.006190	8.175714	8.345714	5.5
1978-06-01	6.734091	7.232273	8.094545	8.239545	8.355000	8.462273	6.2
1978-07-01	7.007500	7.440000	8.391500	8.489500	8.536500	8.640000	6.3
1978-08-01	7.077826	7.373043	8.312609	8.366522	8.333913	8.410870	5.9
1978-09-01	7.845000	7.988000	8.638500	8.565500	8.427500	8.416500	5.8
1978-10-01	7.990952	8.545238	9.136667	8.853810	8.614762	8.642381	5.4
1978-11-01	8.643500	9.235500	10.014000	9.424500	8.835000	8.805000	5.6
...
2016-11-01	0.446000	0.574000	0.736000	0.979500	1.596000	2.142000	4.4
2016-12-01	0.505238	0.628095	0.866190	1.196667	1.959048	2.491905	4.5
2017-01-01	0.511500	0.607000	0.825500	1.206500	1.916500	2.432500	5.1

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem
DATE							
2017-02-01	0.521053	0.643158	0.820526	1.201053	1.901579	2.418947	4.9
2017-03-01	0.737391	0.866522	1.010435	1.313043	2.013478	2.481739	4.6
2017-04-01	0.798421	0.928947	1.042105	1.241053	1.824211	2.297368	4.1
2017-05-01	0.889091	1.015000	1.122727	1.301818	1.836818	2.303636	4.1
2017-06-01	0.982727	1.089545	1.200909	1.342273	1.774091	2.186818	4.5
2017-07-01	1.067000	1.108500	1.223500	1.372500	1.872000	2.318000	4.6
2017-08-01	1.014348	1.109130	1.229130	1.335217	1.776522	2.209130	4.5
2017-09-01	1.029500	1.151000	1.280000	1.384500	1.797500	2.202000	4.1
2017-10-01	1.074762	1.227143	1.397619	1.549524	1.980952	2.360000	3.9
2017-11-01	1.229524	1.362381	1.560000	1.696667	2.050000	2.353333	3.9
2017-12-01	1.322000	1.465000	1.700500	1.844000	2.182000	2.402500	3.9
2018-01-01	1.413333	1.589524	1.802857	2.031905	2.381905	2.583810	4.5
2018-02-01	1.567895	1.747368	1.963684	2.175263	2.599474	2.858947	4.4
2018-03-01	1.696667	1.870476	2.062857	2.275714	2.629524	2.842381	4.1
2018-04-01	1.757619	1.930952	2.153810	2.384286	2.701905	2.869048	3.7
2018-05-01	1.864091	2.023182	2.273636	2.511818	2.816818	2.977727	3.6
2018-06-01	1.899048	2.063810	2.328095	2.533333	2.775714	2.912381	4.2
2018-07-01	1.957143	2.114286	2.387619	2.606667	2.777619	2.889048	4.1
2018-08-01	2.033913	2.186522	2.445652	2.635652	2.767826	2.889130	3.9
2018-09-01	2.126316	2.285263	2.557895	2.767895	2.893684	3.004211	3.6
2018-10-01	2.249091	2.395909	2.651818	2.860909	3.000455	3.152273	3.5
2018-11-01	2.326500	2.457000	2.698500	2.859000	2.947000	3.117000	3.5
2018-12-01	2.365789	2.476842	2.655263	2.676316	2.681579	2.832632	3.7
2019-01-01	2.374286	2.446667	2.579524	2.543333	2.536190	2.713810	4.4
2019-02-01	2.388421	2.442632	2.549474	2.504211	2.487895	2.676316	4.1
2019-03-01	2.402381	2.435714	2.490952	2.409524	2.372857	2.570952	3.9
2019-04-01	2.383000	2.393000	2.426500	2.348500	2.336000	2.533500	3.3

515 rows × 7 columns

In [317]:

```
combomonunem["ChangeUnem"] = combomonunem["Unem"].diff().fillna(0)
# A separate column "ChangeUnem" is created to show the change in unemployment rate over month
```

In [318]:

```
combomonunem
```

Out[318]:

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
1976-06-01	5.407727	5.765455	6.520909	7.060000	7.606818	7.861364	8.0	
1976-07-01	5.230000	5.527143	6.200476	6.850000	7.487619	7.831905	7.8	-
1976-08-01	5.142727	5.400909	6.002727	6.631364	7.306818	7.768636	7.6	-
1976-09-01	5.083333	5.304762	5.844286	6.416190	7.129524	7.594286	7.4	-
1976-10-01	4.918500	5.060500	5.496500	5.984000	6.752000	7.411000	7.2	-
1976-11-01	4.752632	4.878947	5.294211	5.810000	6.519474	7.291053	7.4	
1976-12-01	4.346364	4.512273	4.893182	5.376818	6.104545	6.869091	7.4	
1977-01-01	4.617619	4.826667	5.290952	5.899524	6.583333	7.213333	8.3	
1977-02-01	4.665263	4.897368	5.467368	6.088421	6.830000	7.391053	8.5	
1977-03-01	4.602609	4.878261	5.500435	6.086522	6.928261	7.460000	7.9	-
1977-04-01	4.535500	4.798000	5.441000	5.963500	6.792000	7.370500	6.9	-
1977-05-01	4.956190	5.200000	5.843810	6.254762	6.939048	7.456667	6.4	-
1977-06-01	5.016364	5.211818	5.798182	6.127273	6.756818	7.275455	7.5	
1977-07-01	5.185789	5.399474	5.936842	6.274737	6.844211	7.330000	7.0	-
1977-08-01	5.490870	5.826957	6.369565	6.611304	7.028261	7.396522	6.8	-
1977-09-01	5.808571	6.037619	6.526667	6.714286	7.040476	7.343810	6.6	-
1977-10-01	6.160000	6.425000	6.965000	7.106000	7.320000	7.523500	6.4	-
1977-11-01	6.104737	6.410526	6.954737	7.142632	7.338947	7.577368	6.5	
1977-12-01	6.065238	6.396190	6.957619	7.176667	7.478571	7.685238	6.0	-
1978-01-01	6.440476	6.702381	7.283333	7.485714	7.766190	7.956190	7.1	
1978-02-01	6.445556	6.737222	7.337778	7.565000	7.832222	8.033333	6.9	-
1978-03-01	6.293636	6.634091	7.310455	7.575000	7.857727	8.035909	6.6	-

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
1978-04-01	6.286000	6.733000	7.454500	7.743500	7.982500	8.154000	5.8	-
1978-05-01	6.408095	7.019524	7.820000	8.006190	8.175714	8.345714	5.5	-
1978-06-01	6.734091	7.232273	8.094545	8.239545	8.355000	8.462273	6.2	
1978-07-01	7.007500	7.440000	8.391500	8.489500	8.536500	8.640000	6.3	
1978-08-01	7.077826	7.373043	8.312609	8.366522	8.333913	8.410870	5.9	-
1978-09-01	7.845000	7.988000	8.638500	8.565500	8.427500	8.416500	5.8	-
1978-10-01	7.990952	8.545238	9.136667	8.853810	8.614762	8.642381	5.4	-
1978-11-01	8.643500	9.235500	10.014000	9.424500	8.835000	8.805000	5.6	
...	
2016-11-01	0.446000	0.574000	0.736000	0.979500	1.596000	2.142000	4.4	-
2016-12-01	0.505238	0.628095	0.866190	1.196667	1.959048	2.491905	4.5	
2017-01-01	0.511500	0.607000	0.825500	1.206500	1.916500	2.432500	5.1	
2017-02-01	0.521053	0.643158	0.820526	1.201053	1.901579	2.418947	4.9	-
2017-03-01	0.737391	0.866522	1.010435	1.313043	2.013478	2.481739	4.6	-
2017-04-01	0.798421	0.928947	1.042105	1.241053	1.824211	2.297368	4.1	-
2017-05-01	0.889091	1.015000	1.122727	1.301818	1.836818	2.303636	4.1	
2017-06-01	0.982727	1.089545	1.200909	1.342273	1.774091	2.186818	4.5	
2017-07-01	1.067000	1.108500	1.223500	1.372500	1.872000	2.318000	4.6	
2017-08-01	1.014348	1.109130	1.229130	1.335217	1.776522	2.209130	4.5	-
2017-09-01	1.029500	1.151000	1.280000	1.384500	1.797500	2.202000	4.1	-
2017-10-01	1.074762	1.227143	1.397619	1.549524	1.980952	2.360000	3.9	-
2017-11-01	1.229524	1.362381	1.560000	1.696667	2.050000	2.353333	3.9	
2017-12-01	1.322000	1.465000	1.700500	1.844000	2.182000	2.402500	3.9	

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
2018-01-01	1.413333	1.589524	1.802857	2.031905	2.381905	2.583810	4.5	
2018-02-01	1.567895	1.747368	1.963684	2.175263	2.599474	2.858947	4.4	-
2018-03-01	1.696667	1.870476	2.062857	2.275714	2.629524	2.842381	4.1	-
2018-04-01	1.757619	1.930952	2.153810	2.384286	2.701905	2.869048	3.7	-
2018-05-01	1.864091	2.023182	2.273636	2.511818	2.816818	2.977727	3.6	-
2018-06-01	1.899048	2.063810	2.328095	2.533333	2.775714	2.912381	4.2	
2018-07-01	1.957143	2.114286	2.387619	2.606667	2.777619	2.889048	4.1	-
2018-08-01	2.033913	2.186522	2.445652	2.635652	2.767826	2.889130	3.9	-
2018-09-01	2.126316	2.285263	2.557895	2.767895	2.893684	3.004211	3.6	-
2018-10-01	2.249091	2.395909	2.651818	2.860909	3.000455	3.152273	3.5	-
2018-11-01	2.326500	2.457000	2.698500	2.859000	2.947000	3.117000	3.5	
2018-12-01	2.365789	2.476842	2.655263	2.676316	2.681579	2.832632	3.7	
2019-01-01	2.374286	2.446667	2.579524	2.543333	2.536190	2.713810	4.4	
2019-02-01	2.388421	2.442632	2.549474	2.504211	2.487895	2.676316	4.1	-
2019-03-01	2.402381	2.435714	2.490952	2.409524	2.372857	2.570952	3.9	-
2019-04-01	2.383000	2.393000	2.426500	2.348500	2.336000	2.533500	3.3	-

515 rows × 8 columns

3. Add Industrial Production Index Data

The industrial production index (IPI) is a monthly economic indicator that measures output in the manufacturing, mining, electric and gas industries, with respect to a base year. Higher number signifies an increase in industrial output, thus more vigorous economic performances.

In [319]:

```
combofinal=combomonunem
dfipi.set_index("DATE",inplace=True)
```

In [320]:

```
combofinal["IPI"]=dfipi["INDPRO"]
```

In [321]:

```
combofinal["ChangeIPI"]=combofinal["IPI"].diff().fillna(0)
```

In [322]:

```
combofinal["ChangeIPI"]=combofinal["ChangeIPI"]*(-1)
#To allign with the unemployment data, a negative number for ChangeIPI would act
ually signal more robust economic performance while a positive number signals do
wnturn
```

In [323]:

```
combofinal  
# This dataframe contains all the processed data we need
```


Out[323]:

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
1976-06-01	5.407727	5.765455	6.520909	7.060000	7.606818	7.861364	8.0	
1976-07-01	5.230000	5.527143	6.200476	6.850000	7.487619	7.831905	7.8	-
1976-08-01	5.142727	5.400909	6.002727	6.631364	7.306818	7.768636	7.6	-
1976-09-01	5.083333	5.304762	5.844286	6.416190	7.129524	7.594286	7.4	-
1976-10-01	4.918500	5.060500	5.496500	5.984000	6.752000	7.411000	7.2	-
1976-11-01	4.752632	4.878947	5.294211	5.810000	6.519474	7.291053	7.4	
1976-12-01	4.346364	4.512273	4.893182	5.376818	6.104545	6.869091	7.4	
1977-01-01	4.617619	4.826667	5.290952	5.899524	6.583333	7.213333	8.3	
1977-02-01	4.665263	4.897368	5.467368	6.088421	6.830000	7.391053	8.5	
1977-03-01	4.602609	4.878261	5.500435	6.086522	6.928261	7.460000	7.9	-
1977-04-01	4.535500	4.798000	5.441000	5.963500	6.792000	7.370500	6.9	-
1977-05-01	4.956190	5.200000	5.843810	6.254762	6.939048	7.456667	6.4	-
1977-06-01	5.016364	5.211818	5.798182	6.127273	6.756818	7.275455	7.5	
1977-07-01	5.185789	5.399474	5.936842	6.274737	6.844211	7.330000	7.0	-
1977-08-01	5.490870	5.826957	6.369565	6.611304	7.028261	7.396522	6.8	-
1977-09-01	5.808571	6.037619	6.526667	6.714286	7.040476	7.343810	6.6	-
1977-10-01	6.160000	6.425000	6.965000	7.106000	7.320000	7.523500	6.4	-
1977-11-01	6.104737	6.410526	6.954737	7.142632	7.338947	7.577368	6.5	
1977-12-01	6.065238	6.396190	6.957619	7.176667	7.478571	7.685238	6.0	-
1978-01-01	6.440476	6.702381	7.283333	7.485714	7.766190	7.956190	7.1	
1978-02-01	6.445556	6.737222	7.337778	7.565000	7.832222	8.033333	6.9	-
1978-03-01	6.293636	6.634091	7.310455	7.575000	7.857727	8.035909	6.6	-

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
1978-04-01	6.286000	6.733000	7.454500	7.743500	7.982500	8.154000	5.8	-
1978-05-01	6.408095	7.019524	7.820000	8.006190	8.175714	8.345714	5.5	-
1978-06-01	6.734091	7.232273	8.094545	8.239545	8.355000	8.462273	6.2	
1978-07-01	7.007500	7.440000	8.391500	8.489500	8.536500	8.640000	6.3	
1978-08-01	7.077826	7.373043	8.312609	8.366522	8.333913	8.410870	5.9	-
1978-09-01	7.845000	7.988000	8.638500	8.565500	8.427500	8.416500	5.8	-
1978-10-01	7.990952	8.545238	9.136667	8.853810	8.614762	8.642381	5.4	-
1978-11-01	8.643500	9.235500	10.014000	9.424500	8.835000	8.805000	5.6	
...	
2016-11-01	0.446000	0.574000	0.736000	0.979500	1.596000	2.142000	4.4	-
2016-12-01	0.505238	0.628095	0.866190	1.196667	1.959048	2.491905	4.5	
2017-01-01	0.511500	0.607000	0.825500	1.206500	1.916500	2.432500	5.1	
2017-02-01	0.521053	0.643158	0.820526	1.201053	1.901579	2.418947	4.9	-
2017-03-01	0.737391	0.866522	1.010435	1.313043	2.013478	2.481739	4.6	-
2017-04-01	0.798421	0.928947	1.042105	1.241053	1.824211	2.297368	4.1	-
2017-05-01	0.889091	1.015000	1.122727	1.301818	1.836818	2.303636	4.1	
2017-06-01	0.982727	1.089545	1.200909	1.342273	1.774091	2.186818	4.5	
2017-07-01	1.067000	1.108500	1.223500	1.372500	1.872000	2.318000	4.6	
2017-08-01	1.014348	1.109130	1.229130	1.335217	1.776522	2.209130	4.5	-
2017-09-01	1.029500	1.151000	1.280000	1.384500	1.797500	2.202000	4.1	-
2017-10-01	1.074762	1.227143	1.397619	1.549524	1.980952	2.360000	3.9	-
2017-11-01	1.229524	1.362381	1.560000	1.696667	2.050000	2.353333	3.9	
2017-12-01	1.322000	1.465000	1.700500	1.844000	2.182000	2.402500	3.9	

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
2018-01-01	1.413333	1.589524	1.802857	2.031905	2.381905	2.583810	4.5	
2018-02-01	1.567895	1.747368	1.963684	2.175263	2.599474	2.858947	4.4	-
2018-03-01	1.696667	1.870476	2.062857	2.275714	2.629524	2.842381	4.1	-
2018-04-01	1.757619	1.930952	2.153810	2.384286	2.701905	2.869048	3.7	-
2018-05-01	1.864091	2.023182	2.273636	2.511818	2.816818	2.977727	3.6	-
2018-06-01	1.899048	2.063810	2.328095	2.533333	2.775714	2.912381	4.2	
2018-07-01	1.957143	2.114286	2.387619	2.606667	2.777619	2.889048	4.1	-
2018-08-01	2.033913	2.186522	2.445652	2.635652	2.767826	2.889130	3.9	-
2018-09-01	2.126316	2.285263	2.557895	2.767895	2.893684	3.004211	3.6	-
2018-10-01	2.249091	2.395909	2.651818	2.860909	3.000455	3.152273	3.5	-
2018-11-01	2.326500	2.457000	2.698500	2.859000	2.947000	3.117000	3.5	
2018-12-01	2.365789	2.476842	2.655263	2.676316	2.681579	2.832632	3.7	
2019-01-01	2.374286	2.446667	2.579524	2.543333	2.536190	2.713810	4.4	
2019-02-01	2.388421	2.442632	2.549474	2.504211	2.487895	2.676316	4.1	-
2019-03-01	2.402381	2.435714	2.490952	2.409524	2.372857	2.570952	3.9	-
2019-04-01	2.383000	2.393000	2.426500	2.348500	2.336000	2.533500	3.3	-

515 rows × 10 columns

4. Yield Curve Graphs

This graph shows the change in yields on treasury securities of a variety of maturities from 1976-2019

In [324]:

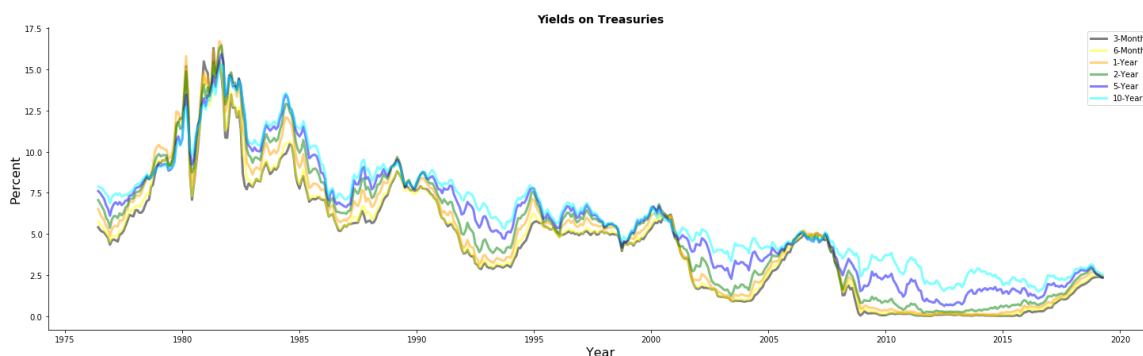
```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combomonunem.index, combomonunem.Three_Month, color = "black", linewidth
= 3,alpha=0.5,label="3-Month")
ax.plot(combomonunem.index, combomonunem.Six_Month, color = "yellow", linewidth
= 3,alpha=0.5,label="6-Month")
ax.plot(combomonunem.index, combomonunem.One_Year, color = "orange", linewidth =
3,alpha=0.5,label="1-Year")
ax.plot(combomonunem.index, combomonunem.Two_Year, color = "green", linewidth =
3,alpha=0.5,label="2-Year")
ax.plot(combomonunem.index, combomonunem.Five_Year, color = "blue", linewidth =
3,alpha=0.5,label="5-Year")
ax.plot(combomonunem.index, combomonunem.Ten_Year, color = "cyan", linewidth = 3
,alpha=0.5,label="10-Year")

ax.legend()

ax.set_title("Yields on Treasuries", fontsize = 14, fontweight = "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("Yield_Graph")
```



This graph selectively shows the change in yields on 3-month, 2-year and 10yr treasury securities, which will be the focus of this project.

In [325]:

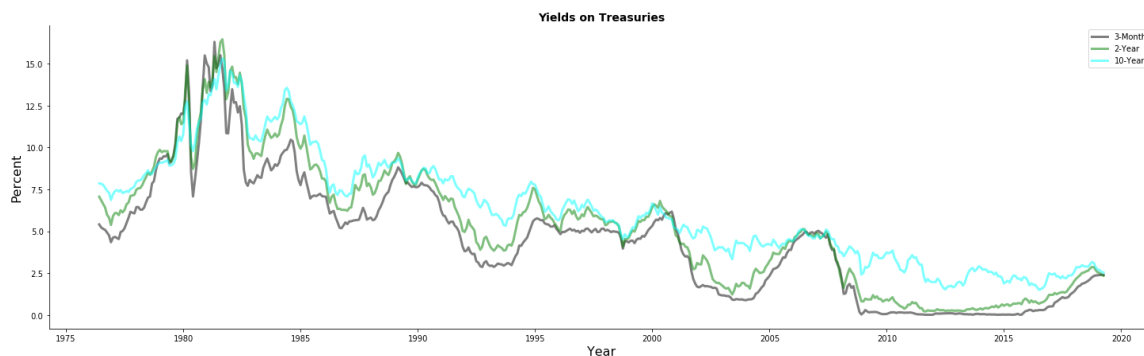
```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combomonunem.index, combomonunem.Three_Month, color = "black", linewidth = 3, alpha=0.5, label="3-Month")
ax.plot(combomonunem.index, combomonunem.Two_Year, color = "green", linewidth = 3, alpha=0.5, label="2-Year")
ax.plot(combomonunem.index, combomonunem.Ten_Year, color = "cyan", linewidth = 3, alpha=0.5, label="10-Year")

ax.legend()

ax.set_title("Yields on Treasuries", fontsize = 14, fontweight = "bold")
ax.set_ylabel("Percent", fontsize=16)
ax.set_xlabel("Year", fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("Yield_Graph2")
```



5. Finding Where Inversion Happened

We will create two extra columns to indicate when does yield curve inversion happen

In [326]:

```
def f1(row):
    if row["Three_Month"] > row["Ten_Year"]:
        val = "Inverted"

    else:
        val = "Normal"
    return val
# This function will highlight when does 3-month yield surpasses 10-year yield
```

In [327]:

```
comboinvert=combofinal
```

In [328]:

```
comboinvert['Inversion1'] = comboinvert.apply(f1, axis=1)
```

In [329]:

```
def f2(row):  
    if row["Three_Month"]>row["Two_Year"]:  
        val = "Inverted"  
  
    else:  
        val = "Normal"  
    return val  
# This function will highlight when does 3-month yield surpasses 2-year yield
```

In [330]:

```
comboinvert['Inversion2'] = comboinvert.apply(f2, axis=1)
```

In [331]:

```
comboinvertfinal=comboinvert[["Inversion1","Inversion2"]]
```

In [332]:

```
comboinvertfinal  
# A dataframe that shows when inversions happen
```

Out[332]:

	Inversion1	Inversion2
DATE		
1976-06-01	Normal	Normal
1976-07-01	Normal	Normal
1976-08-01	Normal	Normal
1976-09-01	Normal	Normal
1976-10-01	Normal	Normal
1976-11-01	Normal	Normal
1976-12-01	Normal	Normal
1977-01-01	Normal	Normal
1977-02-01	Normal	Normal
1977-03-01	Normal	Normal
1977-04-01	Normal	Normal
1977-05-01	Normal	Normal
1977-06-01	Normal	Normal
1977-07-01	Normal	Normal
1977-08-01	Normal	Normal
1977-09-01	Normal	Normal
1977-10-01	Normal	Normal
1977-11-01	Normal	Normal
1977-12-01	Normal	Normal
1978-01-01	Normal	Normal
1978-02-01	Normal	Normal
1978-03-01	Normal	Normal
1978-04-01	Normal	Normal
1978-05-01	Normal	Normal
1978-06-01	Normal	Normal
1978-07-01	Normal	Normal
1978-08-01	Normal	Normal
1978-09-01	Normal	Normal
1978-10-01	Normal	Normal
1978-11-01	Normal	Normal
...
2016-11-01	Normal	Normal
2016-12-01	Normal	Normal
2017-01-01	Normal	Normal

	Inversion1	Inversion2
DATE		
2017-02-01	Normal	Normal
2017-03-01	Normal	Normal
2017-04-01	Normal	Normal
2017-05-01	Normal	Normal
2017-06-01	Normal	Normal
2017-07-01	Normal	Normal
2017-08-01	Normal	Normal
2017-09-01	Normal	Normal
2017-10-01	Normal	Normal
2017-11-01	Normal	Normal
2017-12-01	Normal	Normal
2018-01-01	Normal	Normal
2018-02-01	Normal	Normal
2018-03-01	Normal	Normal
2018-04-01	Normal	Normal
2018-05-01	Normal	Normal
2018-06-01	Normal	Normal
2018-07-01	Normal	Normal
2018-08-01	Normal	Normal
2018-09-01	Normal	Normal
2018-10-01	Normal	Normal
2018-11-01	Normal	Normal
2018-12-01	Normal	Normal
2019-01-01	Normal	Normal
2019-02-01	Normal	Normal
2019-03-01	Normal	Normal
2019-04-01	Normal	Inverted

515 rows × 2 columns

In [333]:

```
comboinvertfinal.reset_index(inplace=True)
comboinvertfinal.set_index("Inversion1",inplace=True)
comboinvertfinal.loc["Inverted"]
# List of dates when 3m yields are higher than 10yr yields
```

Out[333]:

	DATE	Inversion2
Inversion1		
Inverted	1978-12-01	Normal
Inverted	1979-01-01	Normal
Inverted	1979-02-01	Normal
Inverted	1979-03-01	Normal
Inverted	1979-04-01	Normal
Inverted	1979-05-01	Normal
Inverted	1979-06-01	Normal
Inverted	1979-07-01	Inverted
Inverted	1979-08-01	Inverted
Inverted	1979-09-01	Inverted
Inverted	1979-10-01	Inverted
Inverted	1979-11-01	Normal
Inverted	1979-12-01	Inverted
Inverted	1980-01-01	Inverted
Inverted	1980-02-01	Normal
Inverted	1980-03-01	Inverted
Inverted	1980-04-01	Inverted
Inverted	1980-11-01	Inverted
Inverted	1980-12-01	Inverted
Inverted	1981-01-01	Inverted
Inverted	1981-02-01	Inverted
Inverted	1981-03-01	Normal
Inverted	1981-04-01	Normal
Inverted	1981-05-01	Inverted
Inverted	1981-06-01	Inverted
Inverted	1981-07-01	Normal
Inverted	1981-08-01	Normal
Inverted	2000-08-01	Normal
Inverted	2000-09-01	Normal
Inverted	2000-10-01	Inverted
Inverted	2000-11-01	Inverted
Inverted	2000-12-01	Inverted
Inverted	2006-08-01	Inverted
Inverted	2006-09-01	Inverted

DATE Inversion2		
Inversion1		
Inverted	2006-10-01	Inverted
Inverted	2006-11-01	Inverted
Inverted	2006-12-01	Inverted
Inverted	2007-01-01	Inverted
Inverted	2007-02-01	Inverted
Inverted	2007-03-01	Inverted
Inverted	2007-04-01	Inverted

In [334]:

```
comboinvertfinal.reset_index(inplace=True)
comboinvertfinal.set_index("Inversion2",inplace=True)
comboinvertfinal.loc["Inverted"]
# List of dates when 3m yields are higher than 2yr yields
```

Out[334]:

	Inversion1	DATE
Inversion2		
Inverted	Inverted	1979-07-01
Inverted	Inverted	1979-08-01
Inverted	Inverted	1979-09-01
Inverted	Inverted	1979-10-01
Inverted	Inverted	1979-12-01
Inverted	Inverted	1980-01-01
Inverted	Inverted	1980-03-01
Inverted	Inverted	1980-04-01
Inverted	Inverted	1980-11-01
Inverted	Inverted	1980-12-01
Inverted	Inverted	1981-01-01
Inverted	Inverted	1981-02-01
Inverted	Inverted	1981-05-01
Inverted	Inverted	1981-06-01
Inverted	Normal	1989-07-01
Inverted	Inverted	2000-10-01
Inverted	Inverted	2000-11-01
Inverted	Inverted	2000-12-01
Inverted	Normal	2001-01-01
Inverted	Normal	2001-02-01
Inverted	Normal	2001-03-01
Inverted	Inverted	2006-08-01
Inverted	Inverted	2006-09-01
Inverted	Inverted	2006-10-01
Inverted	Inverted	2006-11-01
Inverted	Inverted	2006-12-01
Inverted	Inverted	2007-01-01
Inverted	Inverted	2007-02-01
Inverted	Inverted	2007-03-01
Inverted	Inverted	2007-04-01
Inverted	Normal	2007-07-01
Inverted	Normal	2008-01-01
Inverted	Normal	2008-02-01
Inverted	Normal	2019-04-01

The above two table shows that historically, yield curve inversions happened during four different periods of time: 1980, 1990, 2001 and 2008.

6. Plotting Yield Difference & Change in Economic Indicators

6A. When 3m > 2yr

The following graphs plot out the difference between 3-month yield and 2-year yield with changes in economic indicators.

In [335]:

```
combofinal["ThrMon_TwoYear"]=combofinal['Three_Month']-combofinal["Two_Year"]  
# This column represents the difference between 3-month yield and 2-yr yield
```

In [336]:

```
combofinal["ThrMon_TenYear"]=combofinal['Three_Month']-combofinal["Ten_Year"]  
# This column represents the difference between 3-month yield and 10-yr yield
```

In [337]:

```
combofinal
```


Out[337]:

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
1976-06-01	5.407727	5.765455	6.520909	7.060000	7.606818	7.861364	8.0	
1976-07-01	5.230000	5.527143	6.200476	6.850000	7.487619	7.831905	7.8	-
1976-08-01	5.142727	5.400909	6.002727	6.631364	7.306818	7.768636	7.6	-
1976-09-01	5.083333	5.304762	5.844286	6.416190	7.129524	7.594286	7.4	-
1976-10-01	4.918500	5.060500	5.496500	5.984000	6.752000	7.411000	7.2	-
1976-11-01	4.752632	4.878947	5.294211	5.810000	6.519474	7.291053	7.4	
1976-12-01	4.346364	4.512273	4.893182	5.376818	6.104545	6.869091	7.4	
1977-01-01	4.617619	4.826667	5.290952	5.899524	6.583333	7.213333	8.3	
1977-02-01	4.665263	4.897368	5.467368	6.088421	6.830000	7.391053	8.5	
1977-03-01	4.602609	4.878261	5.500435	6.086522	6.928261	7.460000	7.9	-
1977-04-01	4.535500	4.798000	5.441000	5.963500	6.792000	7.370500	6.9	-
1977-05-01	4.956190	5.200000	5.843810	6.254762	6.939048	7.456667	6.4	-
1977-06-01	5.016364	5.211818	5.798182	6.127273	6.756818	7.275455	7.5	
1977-07-01	5.185789	5.399474	5.936842	6.274737	6.844211	7.330000	7.0	-
1977-08-01	5.490870	5.826957	6.369565	6.611304	7.028261	7.396522	6.8	-
1977-09-01	5.808571	6.037619	6.526667	6.714286	7.040476	7.343810	6.6	-
1977-10-01	6.160000	6.425000	6.965000	7.106000	7.320000	7.523500	6.4	-
1977-11-01	6.104737	6.410526	6.954737	7.142632	7.338947	7.577368	6.5	
1977-12-01	6.065238	6.396190	6.957619	7.176667	7.478571	7.685238	6.0	-
1978-01-01	6.440476	6.702381	7.283333	7.485714	7.766190	7.956190	7.1	
1978-02-01	6.445556	6.737222	7.337778	7.565000	7.832222	8.033333	6.9	-
1978-03-01	6.293636	6.634091	7.310455	7.575000	7.857727	8.035909	6.6	-

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
1978-04-01	6.286000	6.733000	7.454500	7.743500	7.982500	8.154000	5.8	-
1978-05-01	6.408095	7.019524	7.820000	8.006190	8.175714	8.345714	5.5	-
1978-06-01	6.734091	7.232273	8.094545	8.239545	8.355000	8.462273	6.2	
1978-07-01	7.007500	7.440000	8.391500	8.489500	8.536500	8.640000	6.3	
1978-08-01	7.077826	7.373043	8.312609	8.366522	8.333913	8.410870	5.9	-
1978-09-01	7.845000	7.988000	8.638500	8.565500	8.427500	8.416500	5.8	-
1978-10-01	7.990952	8.545238	9.136667	8.853810	8.614762	8.642381	5.4	-
1978-11-01	8.643500	9.235500	10.014000	9.424500	8.835000	8.805000	5.6	
...	
2016-11-01	0.446000	0.574000	0.736000	0.979500	1.596000	2.142000	4.4	-
2016-12-01	0.505238	0.628095	0.866190	1.196667	1.959048	2.491905	4.5	
2017-01-01	0.511500	0.607000	0.825500	1.206500	1.916500	2.432500	5.1	
2017-02-01	0.521053	0.643158	0.820526	1.201053	1.901579	2.418947	4.9	-
2017-03-01	0.737391	0.866522	1.010435	1.313043	2.013478	2.481739	4.6	-
2017-04-01	0.798421	0.928947	1.042105	1.241053	1.824211	2.297368	4.1	-
2017-05-01	0.889091	1.015000	1.122727	1.301818	1.836818	2.303636	4.1	
2017-06-01	0.982727	1.089545	1.200909	1.342273	1.774091	2.186818	4.5	
2017-07-01	1.067000	1.108500	1.223500	1.372500	1.872000	2.318000	4.6	
2017-08-01	1.014348	1.109130	1.229130	1.335217	1.776522	2.209130	4.5	-
2017-09-01	1.029500	1.151000	1.280000	1.384500	1.797500	2.202000	4.1	-
2017-10-01	1.074762	1.227143	1.397619	1.549524	1.980952	2.360000	3.9	-
2017-11-01	1.229524	1.362381	1.560000	1.696667	2.050000	2.353333	3.9	
2017-12-01	1.322000	1.465000	1.700500	1.844000	2.182000	2.402500	3.9	

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year	Unem	ChangeUn
DATE								
2018-01-01	1.413333	1.589524	1.802857	2.031905	2.381905	2.583810	4.5	
2018-02-01	1.567895	1.747368	1.963684	2.175263	2.599474	2.858947	4.4	-
2018-03-01	1.696667	1.870476	2.062857	2.275714	2.629524	2.842381	4.1	-
2018-04-01	1.757619	1.930952	2.153810	2.384286	2.701905	2.869048	3.7	-
2018-05-01	1.864091	2.023182	2.273636	2.511818	2.816818	2.977727	3.6	-
2018-06-01	1.899048	2.063810	2.328095	2.533333	2.775714	2.912381	4.2	
2018-07-01	1.957143	2.114286	2.387619	2.606667	2.777619	2.889048	4.1	-
2018-08-01	2.033913	2.186522	2.445652	2.635652	2.767826	2.889130	3.9	-
2018-09-01	2.126316	2.285263	2.557895	2.767895	2.893684	3.004211	3.6	-
2018-10-01	2.249091	2.395909	2.651818	2.860909	3.000455	3.152273	3.5	-
2018-11-01	2.326500	2.457000	2.698500	2.859000	2.947000	3.117000	3.5	
2018-12-01	2.365789	2.476842	2.655263	2.676316	2.681579	2.832632	3.7	
2019-01-01	2.374286	2.446667	2.579524	2.543333	2.536190	2.713810	4.4	
2019-02-01	2.388421	2.442632	2.549474	2.504211	2.487895	2.676316	4.1	-
2019-03-01	2.402381	2.435714	2.490952	2.409524	2.372857	2.570952	3.9	-
2019-04-01	2.383000	2.393000	2.426500	2.348500	2.336000	2.533500	3.3	-

515 rows × 14 columns

In [352]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal.index, combofinal.ThrMon_TwoYear, color = "yellow", linewidth
= 3,alpha=0.5,label="3m-2yr")
ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,a
lpha=0.5,label="Change in IPI")

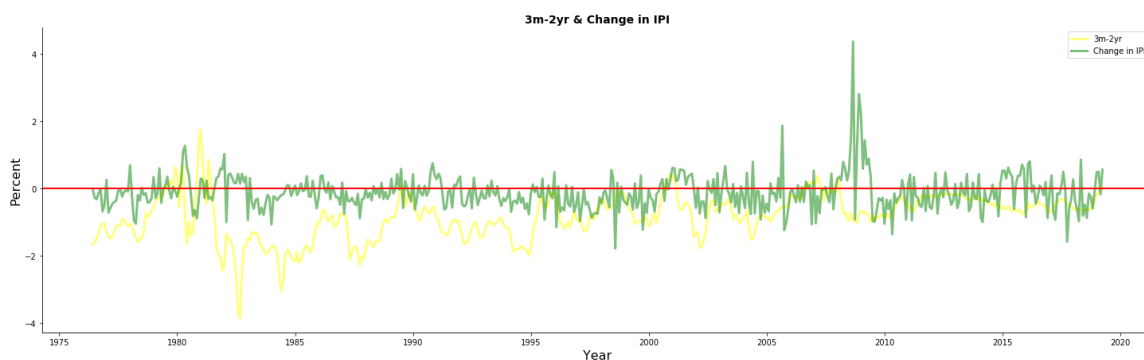
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-2yr & Change in IPI", fontsize = 14, fontweight = "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("3_2_IPI")
```



In [353]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal.index, combofinal.ChangeUnem, color = "black", linewidth = 3,
alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal.index, combofinal.ThrMon_TwoYear, color = "yellow", linewidth
= 3,alpha=0.5,label="3m-2yr")

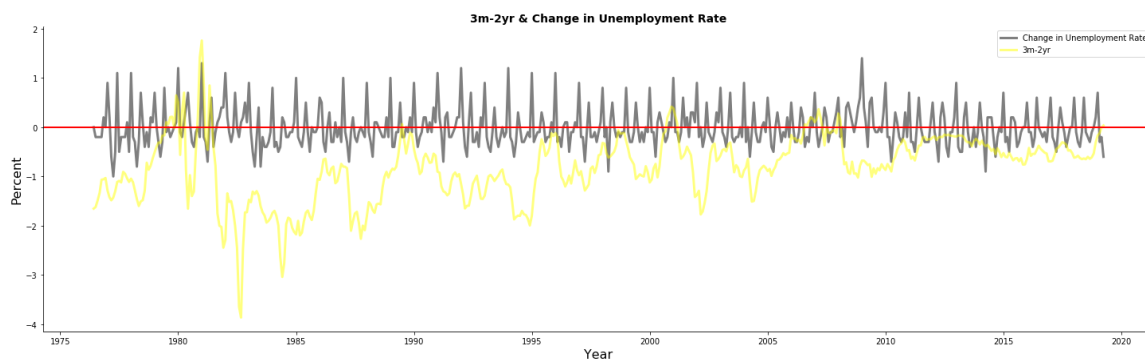
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-2yr & Change in Unemployment Rate", fontsize = 14, fontweight =
"bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("3_2_ur")
```



When 3-month yield surpasses the 2-yr yield, economic indicators usually start to worsen within a short period of time.

6B. When 3m>10yr

In [340]:

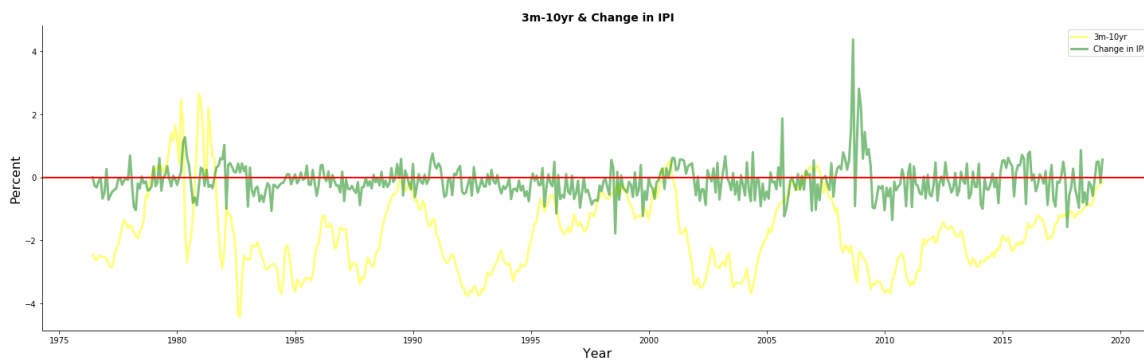
```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal.index, combofinal.ThrMon_TenYear, color = "yellow", linewidth
= 3,alpha=0.5,label="3m-10yr")
ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,a
lpha=0.5,label="Change in IPI")

axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-10yr & Change in IPI", fontsize = 14, fontweight = "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
```



In [354]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal.index, combofinal.ChangeUnem, color = "black", linewidth = 3,
alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal.index, combofinal.ThrMon_TenYear, color = "yellow", linewidth
= 3,alpha=0.5,label="3m-10yr")
#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,
alpha=0.5,label="Change in IPI")

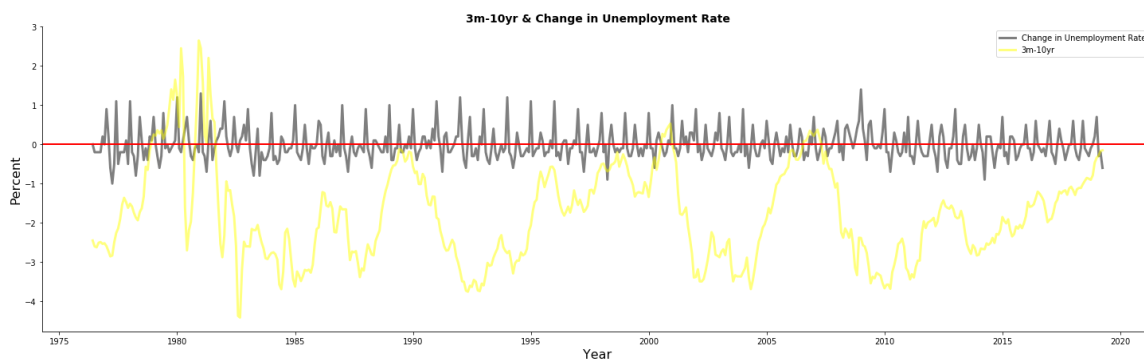
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-10yr & Change in Unemployment Rate", fontsize = 14, fontweight
= "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("3_10_ur")
```



The difference between 3-month yield and 10-year yield also seems to be a good leading indicator for economic performances.

7. Zooming in on Specific Period of Inversion

A. 1980-1982

In [350]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["1977":"1982"].index, combofinal["1977":"1982"].ChangeUnem, c
olor = "black", linewidth = 3,alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal["1977":"1982"].index, combofinal["1977":"1982"].ThrMon_TwoYea
r, color = "yellow", linewidth = 3,alpha=0.5,label="3m-2yr")
ax.plot(combofinal["1977":"1982"].index, combofinal["1977":"1982"].ChangeIPI, co
lor = "blue", linewidth = 3,alpha=0.5,label="Change in IPI")

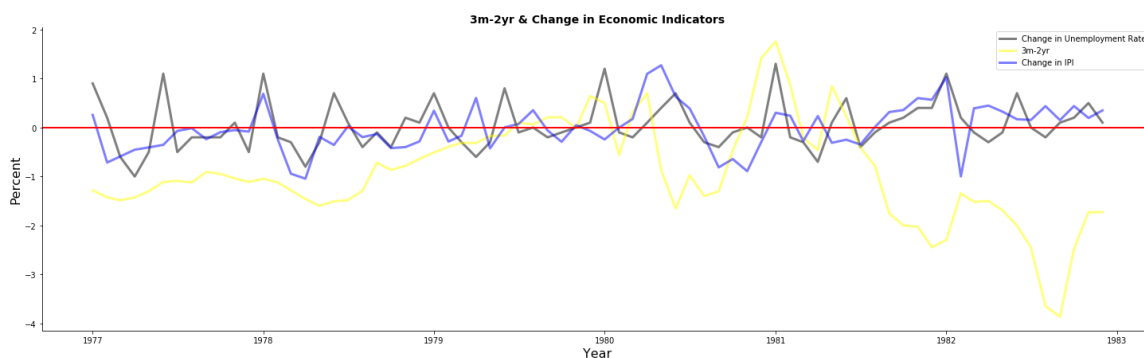
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-2yr & Change in Economic Indicators", fontsize = 14, fontweight
= "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("1980_3_10")
```



Inversion happened during mid 1979, and did not fully return to the norm until early 1981. Unemployment rate and IPI continued to worsen during that period. Please note that IPI has been multiplied by (-1) previously so that an increase in IPI actually signifies poorer economic performance.

In [342]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["1977":"1982"].index, combofinal["1977":"1982"].ChangeUnem, color = "black", linewidth = 3, alpha=0.5, label="Change in Unemployment Rate")
ax.plot(combofinal["1977":"1982"].index, combofinal["1977":"1982"].ThrMon_TenYear, color = "yellow", linewidth = 3, alpha=0.5, label="3m-10yr")
ax.plot(combofinal["1977":"1982"].index, combofinal["1977":"1982"].ChangeIPI, color = "blue", linewidth = 3, alpha=0.5, label="Change in IPI")

#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3, alpha=0.5, label="Change in IPI")

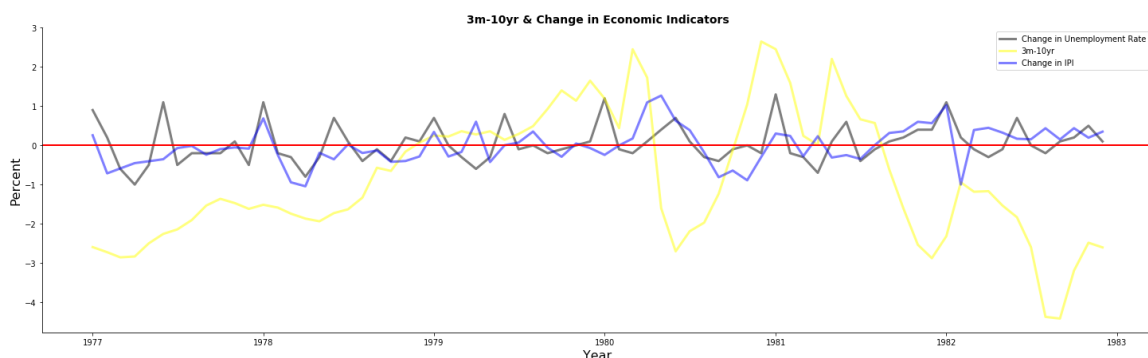
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-10yr & Change in Economic Indicators", fontsize = 14, fontweight = "bold")
ax.set_ylabel("Percent", fontsize=16)
ax.set_xlabel("Year", fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("1980_3_2")
```



Inversion happened at the end of 1978, and a period of higher unemployment rate and lower IPI soon followed.

B. 1990-1991

In [351]:

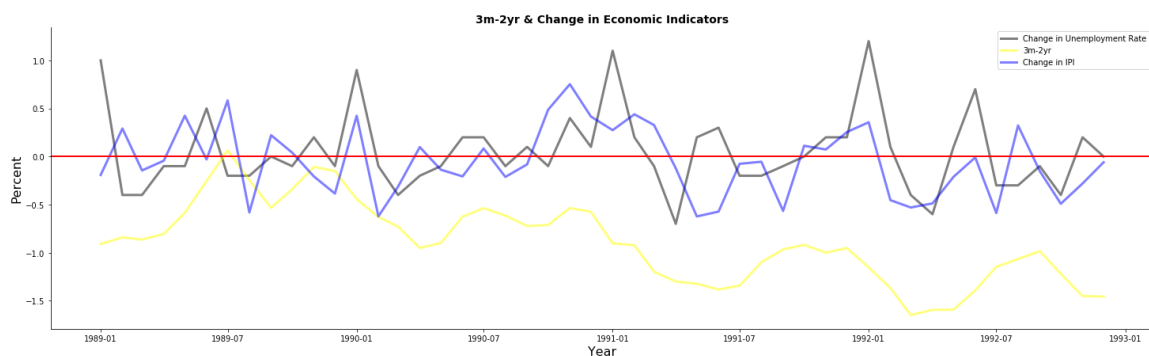
```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["1989":"1992"].index, combofinal["1989":"1992"].ChangeUnem, c
olor = "black", linewidth = 3,alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal["1989":"1992"].index, combofinal["1989":"1992"].ThrMon_TwoYea
r, color = "yellow", linewidth = 3,alpha=0.5,label="3m-2yr")
ax.plot(combofinal["1989":"1992"].index, combofinal["1989":"1992"].ChangeIPI, co
lor = "blue", linewidth = 3,alpha=0.5,label="Change in IPI")

axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-2yr & Change in Economic Indicators", fontsize = 14, fontweight
= "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
plt.savefig("1990_3_2")
```



3m-2yr curve inverted around July 1989. Unemployment rate and IPI numbers worsened starting from Dec 1989.

In [344]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["1989":"1992"].index, combofinal["1989":"1992"].ChangeUnem, c
olor = "black", linewidth = 3,alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal["1989":"1992"].index, combofinal["1989":"1992"].ThrMon_TenYea
r, color = "yellow", linewidth = 3,alpha=0.5,label="3m-10yr")
ax.plot(combofinal["1989":"1992"].index, combofinal["1989":"1992"].ChangeIPI, co
lor = "blue", linewidth = 3,alpha=0.5,label="Change in IPI")

#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,
alpha=0.5,label="Change in IPI")

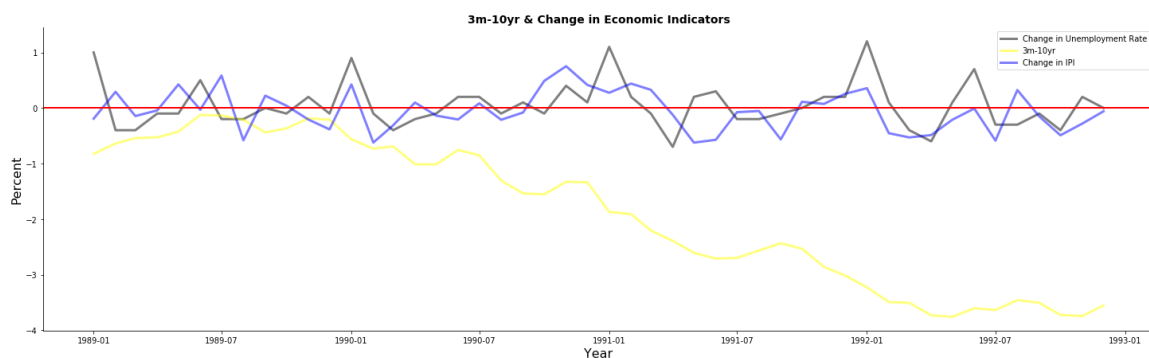
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-10yr & Change in Economic Indicators", fontsize = 14, fontweigh
t = "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("1990_3_10")
```



Monthly 3m-10yr data never inverted, but unemployment rate started to hike as the yield spread tightened throughout 1989.

In []:

C. 2001

In [346]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["2000":"2002"].index, combofinal["2000":"2002"].ChangeUnem, c
olor = "black", linewidth = 3,alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal["2000":"2002"].index, combofinal["2000":"2002"].ThrMon_TwoYea
r, color = "yellow", linewidth = 3,alpha=0.5,label="3m-2yr")
ax.plot(combofinal["2000":"2002"].index, combofinal["2000":"2002"].ChangeIPI, co
lor = "blue", linewidth = 3,alpha=0.5,label="Change in IPI")

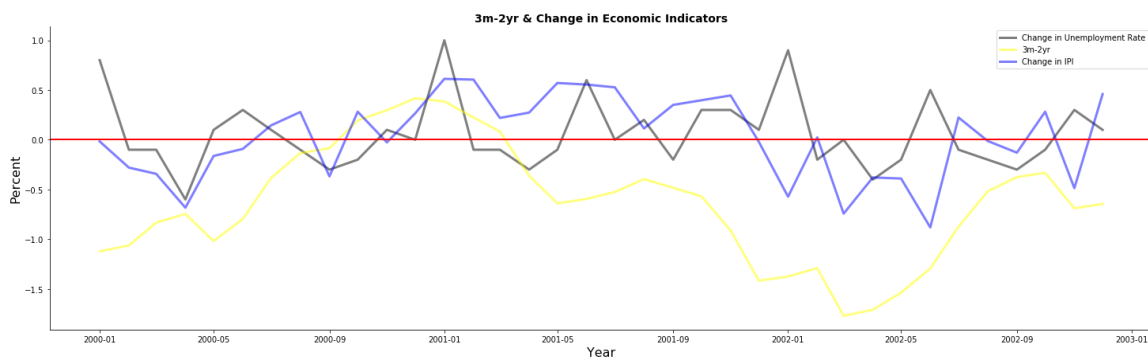
#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,
alpha=0.5,label="Change in IPI")

axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-2yr & Change in Economic Indicators", fontsize = 14, fontweight
= "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
plt.savefig("2001_3_2")
```



3m-2yr inverted around Sep 2000, and unemployemnt rate skyrocketed at the end of 2000.

In [347]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["2000":"2002"].index, combofinal["2000":"2002"].ChangeUnem, c
olor = "black", linewidth = 3,alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal["2000":"2002"].index, combofinal["2000":"2002"].ThrMon_TenYea
r, color = "yellow", linewidth = 3,alpha=0.5,label="3m-10yr")
ax.plot(combofinal["2000":"2002"].index, combofinal["2000":"2002"].ChangeIPI, co
lor = "blue", linewidth = 3,alpha=0.5,label="Change in IPI")

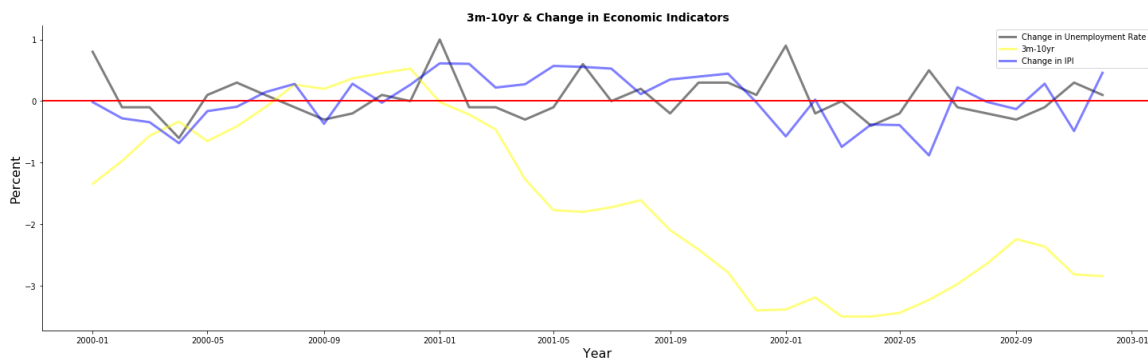
#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,
alpha=0.5,label="Change in IPI")

axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-10yr & Change in Economic Indicators", fontsize = 14, fontweigh
t = "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
plt.savefig("2001_3_10")
```



3m-10yr inverted around July 2000, and a period of dissapointing unemployment and IPI numbers followed.

D. 2008-2009

In [348]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["2006":"2009"].index, combofinal["2006":"2009"].ChangeUnem, c
olor = "black", linewidth = 3,alpha=0.5,label="Change in Unemployment Rate")
ax.plot(combofinal["2006":"2009"].index, combofinal["2006":"2009"].ThrMon_TwoYea
r, color = "yellow", linewidth = 3,alpha=0.5,label="3m-2yr")
ax.plot(combofinal["2006":"2009"].index, combofinal["2006":"2009"].ChangeIPI, co
lor = "blue", linewidth = 3,alpha=0.5,label="Change in IPI")

#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3,
alpha=0.5,label="Change in IPI")

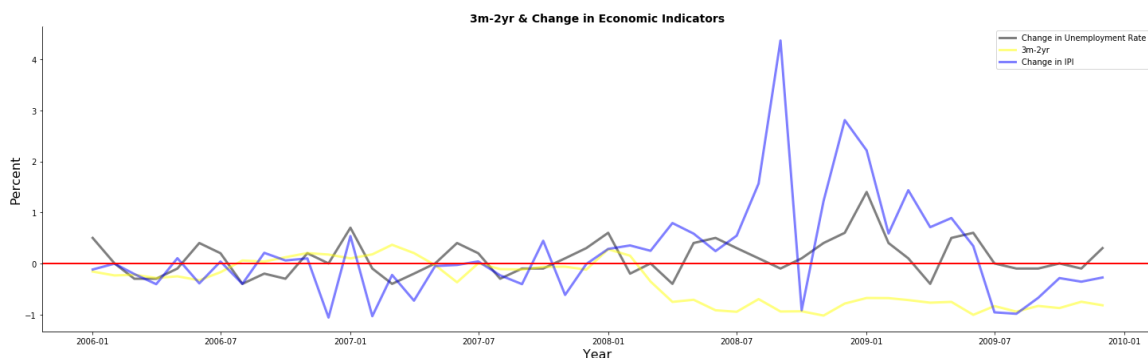
axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-2yr & Change in Economic Indicators", fontsize = 14, fontweight
= "bold")
ax.set_ylabel("Percent",fontsize=16)
ax.set_xlabel("Year",fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)

plt.savefig("2008_3_2")
```



Inversion and near inversion persisted from July 2006 to Feb 2008, preceding the worst depression in decades.

In [349]:

```
fig, ax = plt.subplots(figsize=(25,7))
ax.plot(combofinal["2006":"2009"].index, combofinal["2006":"2009"].ChangeUnem, color = "black", linewidth = 3, alpha=0.5, label="Change in Unemployment Rate")
ax.plot(combofinal["2006":"2009"].index, combofinal["2006":"2009"].ThrMon_TenYear, color = "yellow", linewidth = 3, alpha=0.5, label="3m-10yr")
ax.plot(combofinal["2006":"2009"].index, combofinal["2006":"2009"].ChangeIPI, color = "blue", linewidth = 3, alpha=0.5, label="Change in IPI")

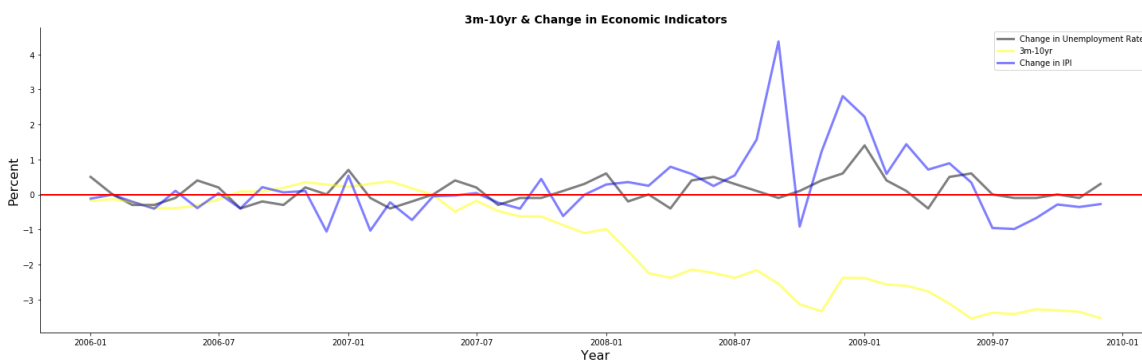
#ax.plot(combofinal.index, combofinal.ChangeIPI, color = "green", linewidth = 3, alpha=0.5, label="Change in IPI")

axhline(linewidth=2, color='r')

ax.legend()

ax.set_title("3m-10yr & Change in Economic Indicators", fontsize = 14, fontweight = "bold")
ax.set_ylabel("Percent", fontsize=16)
ax.set_xlabel("Year", fontsize=16)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
plt.savefig("2008_3_10")
```



Inversion persisted from July 2006 to May 2007, preceding the worst depression in decades.

Conclusion

After examining multiple periods when yield inversion took place, including 1980, 1990, 2001 and 2008, it could be concluded that there is indeed a correlation between yield curve inversion and economic downturn. Below are some observations extracted from the analysis:

1. 3m-2yr and 3m-10yr curves do not always invert at the same time. 3m-2yr curve inverted around July 1989, but 3m-10yr curve did not invert.
2. Although both seem to be reliable preceding indicators, for the same period, the inversion of 3m-10yr curve usually precedes the inversion of 3m-2yr curve, as seen during 1980, 2001 and 2008.
3. Another limit is that we are discussing based on the monthly yield data. It is possible that yield curve inversion happened for a few days within the month, but we are unable to capture that because our analysis is based on the monthly yield data, which is the mean of daily yield data.

In []:

In []:

Yield Curve Animation

In [51]:

```
combomon2.reset_index(inplace=True)
```

In [52]:

```
combomon2["Date"]=df.timeref["Date"]
```

In [53]:

```
combomon2.set_index("Date",inplace=True)
```

In [54]:

```
combomon2.index[2]
```

Out[54]:

```
'8/1/76'
```

In [55]:

```
l1list=[0,1,2,3,4,5]
```


In [56]:

```
combomon2
```

Out[56]:

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year
Date						
6/1/76	5.407727	5.765455	6.520909	7.060000	7.606818	7.861364
7/1/76	5.230000	5.527143	6.200476	6.850000	7.487619	7.831905
8/1/76	5.142727	5.400909	6.002727	6.631364	7.306818	7.768636
9/1/76	5.083333	5.304762	5.844286	6.416190	7.129524	7.594286
10/1/76	4.918500	5.060500	5.496500	5.984000	6.752000	7.411000
11/1/76	4.752632	4.878947	5.294211	5.810000	6.519474	7.291053
12/1/76	4.346364	4.512273	4.893182	5.376818	6.104545	6.869091
1/1/77	4.617619	4.826667	5.290952	5.899524	6.583333	7.213333
2/1/77	4.665263	4.897368	5.467368	6.088421	6.830000	7.391053
3/1/77	4.602609	4.878261	5.500435	6.086522	6.928261	7.460000
4/1/77	4.535500	4.798000	5.441000	5.963500	6.792000	7.370500
5/1/77	4.956190	5.200000	5.843810	6.254762	6.939048	7.456667
6/1/77	5.016364	5.211818	5.798182	6.127273	6.756818	7.275455
7/1/77	5.185789	5.399474	5.936842	6.274737	6.844211	7.330000
8/1/77	5.490870	5.826957	6.369565	6.611304	7.028261	7.396522
9/1/77	5.808571	6.037619	6.526667	6.714286	7.040476	7.343810
10/1/77	6.160000	6.425000	6.965000	7.106000	7.320000	7.523500
11/1/77	6.104737	6.410526	6.954737	7.142632	7.338947	7.577368
12/1/77	6.065238	6.396190	6.957619	7.176667	7.478571	7.685238
1/1/78	6.440476	6.702381	7.283333	7.485714	7.766190	7.956190
2/1/78	6.445556	6.737222	7.337778	7.565000	7.832222	8.033333
3/1/78	6.293636	6.634091	7.310455	7.575000	7.857727	8.035909
4/1/78	6.286000	6.733000	7.454500	7.743500	7.982500	8.154000
5/1/78	6.408095	7.019524	7.820000	8.006190	8.175714	8.345714
6/1/78	6.734091	7.232273	8.094545	8.239545	8.355000	8.462273
7/1/78	7.007500	7.440000	8.391500	8.489500	8.536500	8.640000
8/1/78	7.077826	7.373043	8.312609	8.366522	8.333913	8.410870
9/1/78	7.845000	7.988000	8.638500	8.565500	8.427500	8.416500
10/1/78	7.990952	8.545238	9.136667	8.853810	8.614762	8.642381
11/1/78	8.643500	9.235500	10.014000	9.424500	8.835000	8.805000
...
11/1/16	0.446000	0.574000	0.736000	0.979500	1.596000	2.142000
12/1/16	0.505238	0.628095	0.866190	1.196667	1.959048	2.491905
1/1/17	0.511500	0.607000	0.825500	1.206500	1.916500	2.432500

	Three_Month	Six_Month	One_Year	Two_Year	Five_Year	Ten_Year
Date						
2/1/17	0.521053	0.643158	0.820526	1.201053	1.901579	2.418947
3/1/17	0.737391	0.866522	1.010435	1.313043	2.013478	2.481739
4/1/17	0.798421	0.928947	1.042105	1.241053	1.824211	2.297368
5/1/17	0.889091	1.015000	1.122727	1.301818	1.836818	2.303636
6/1/17	0.982727	1.089545	1.200909	1.342273	1.774091	2.186818
7/1/17	1.067000	1.108500	1.223500	1.372500	1.872000	2.318000
8/1/17	1.014348	1.109130	1.229130	1.335217	1.776522	2.209130
9/1/17	1.029500	1.151000	1.280000	1.384500	1.797500	2.202000
10/1/17	1.074762	1.227143	1.397619	1.549524	1.980952	2.360000
11/1/17	1.229524	1.362381	1.560000	1.696667	2.050000	2.353333
12/1/17	1.322000	1.465000	1.700500	1.844000	2.182000	2.402500
1/1/18	1.413333	1.589524	1.802857	2.031905	2.381905	2.583810
2/1/18	1.567895	1.747368	1.963684	2.175263	2.599474	2.858947
3/1/18	1.696667	1.870476	2.062857	2.275714	2.629524	2.842381
4/1/18	1.757619	1.930952	2.153810	2.384286	2.701905	2.869048
5/1/18	1.864091	2.023182	2.273636	2.511818	2.816818	2.977727
6/1/18	1.899048	2.063810	2.328095	2.533333	2.775714	2.912381
7/1/18	1.957143	2.114286	2.387619	2.606667	2.777619	2.889048
8/1/18	2.033913	2.186522	2.445652	2.635652	2.767826	2.889130
9/1/18	2.126316	2.285263	2.557895	2.767895	2.893684	3.004211
10/1/18	2.249091	2.395909	2.651818	2.860909	3.000455	3.152273
11/1/18	2.326500	2.457000	2.698500	2.859000	2.947000	3.117000
12/1/18	2.365789	2.476842	2.655263	2.676316	2.681579	2.832632
1/1/19	2.374286	2.446667	2.579524	2.543333	2.536190	2.713810
2/1/19	2.388421	2.442632	2.549474	2.504211	2.487895	2.676316
3/1/19	2.402381	2.435714	2.490952	2.409524	2.372857	2.570952
4/1/19	2.383000	2.393000	2.426500	2.348500	2.336000	2.533500

515 rows × 6 columns

In [57]:

```
combomon2.columns=llist
```

In [58]:

```
combomon2.iloc[2].min()
```

Out[58]:

5.142727272727272

In []:

In []:

In [162]:

```

start_date = '1976-06-01'

end_date = '2019-03-29'

fig = plt.figure(figsize=(25,14))
ax = fig.add_subplot(1, 1, 1)
line, = ax.plot([], [], lw=4) # for line

line2, = ax.plot([], [], 'o',ms=10,c="r") # for point
line3, = ax.plot([], [], 'o',ms=10,c="r") # for point
line4, = ax.plot([], [], 'o',ms=10,c="r") # for point
line5, = ax.plot([], [], 'o',ms=10,c="r") # for point
line6, = ax.plot([], [], 'o',ms=10,c="r") # for point
line7, = ax.plot([], [], 'o',ms=10,c="r") # for point

ax.grid()
ax.set_xticks(range(7))
ax.set_yticks([0,2,4,6,8,10,12,14,16])
xlabels = ["3-Month", '6-Month', '1-Year', '2-Year', '5-Year', '10-Year']
ylabels = [0,2,4,6,8,10,12,14,16]

ax.set_xticklabels(xlabels,fontsize=20)
ax.set_yticklabels(ylabels,fontsize=20)

ax.spines["right"].set_visible(False)
ax.spines["top"].set_visible(False)
ax.grid(False)

figure_title = 'U.S. Treasury Bonds Yield Curve_Tony Chen'
figure_xlabel = 'Tenor'
figure_ylabel = 'Percent'

plt.text(0.5, 1.03, figure_title,horizontalalignment='center',fontsize=30,transform = ax.transAxes)
plt.text(0.5, -.1, figure_xlabel,horizontalalignment='center',fontsize=25,transform = ax.transAxes)
plt.text(-0.05, .5, figure_ylabel,horizontalalignment='center',fontsize=25,rotation='vertical',transform = ax.transAxes)

N = len(combomon2.index)

dateText = ax.text(5, 14, '',fontsize=18,horizontalalignment='right')

def init():
    line.set_data([], [])
    return line,

def animate(i):
    x=[0,1,2,3,4,5]
    y=list(combomon2.iloc[i])
    line.set_data(x, y)
    line2.set_data(0,combomon2.iloc[i][0])

```

```

line3.set_data(1,combomon2.iloc[i][1])
line4.set_data(2,combomon2.iloc[i][2])
line5.set_data(3,combomon2.iloc[i][3])
line6.set_data(4,combomon2.iloc[i][4])
line7.set_data(5,combomon2.iloc[i][5])

dateText.set_text(combomon2.index[i])

return line,line2,line3, line4, line5, line6, line7, dateText

Writer = animation.writers['ffmpeg']
writer = Writer(fps=10, metadata=dict(artist='Brian C Jenkins'), bitrate=1800)

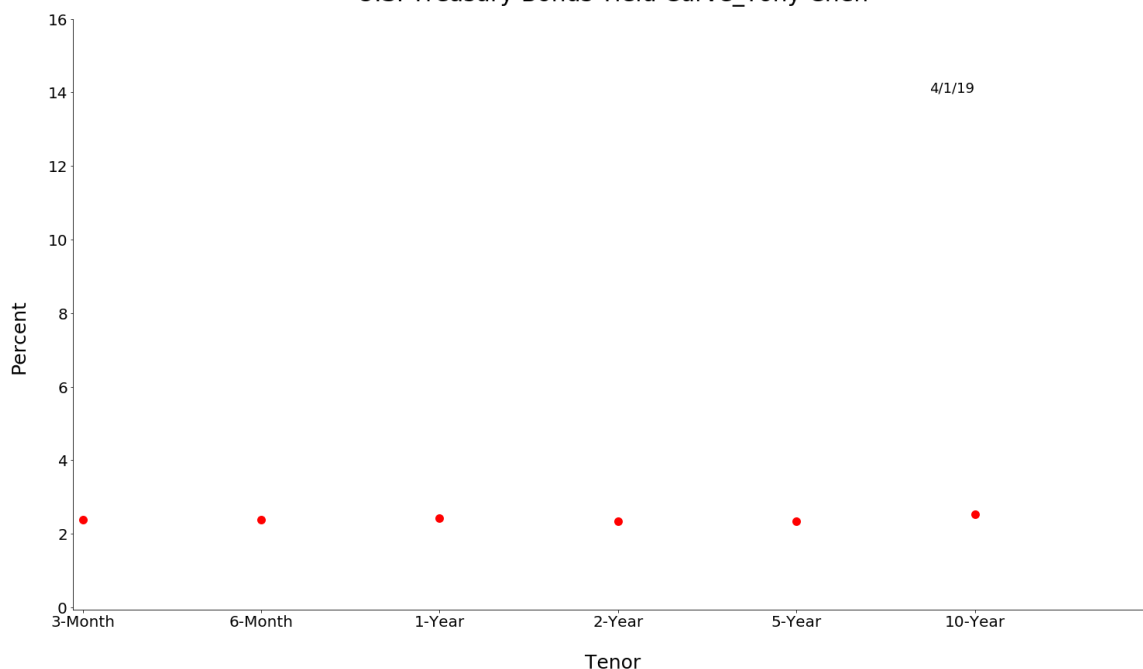
anim = animation.FuncAnimation(fig, animate, init_func=init,frames=N, interval=200)

anim.save("Yield_animation2"+"%.mp4", writer = writer)

# Video is exported as mp4 and attached in PPT

```

U.S. Treasury Bonds Yield Curve_Tony Chen



In []:

In []:

In []:

In []:

In []:

In []:

In []: