Markov Switching Dynamic Regression Model

Importing the necessary libraries and modules

In [52]:

```
import numpy as np
import pandas as pd
import statsmodels.api as sm
import matplotlib.pyplot as plt
import warnings
plt.rcParams['figure.figsize']=10,5
warnings.filterwarnings('ignore')
```

In [53]:

```
df=pd.read_excel("bond_stock_data.xlsx",sheet_name=0)
```

In [54]:

```
#Examine the first few columns
df.head()
```

Out[54]:

	Months	10YBond Returns	Stock Returns	Monetary Policy Rate	Inflation Rate	Exchange Rate
0	2015-01-01	0.153	0.00001	0.11	165.766401	66.466240
1	2015-02-28	0.159	0.01830	0.11	166.901129	76.353096
2	2015-03-31	0.161	0.05450	0.11	168.419862	73.372332
3	2015-04-30	0.144	0.09330	0.11	169.708184	73.047738
4	2015-05-31	0.140	-0.01150	0.11	171.577356	73.208693

In [55]:

```
#Check the columns
df.columns
```

Out[55]:

```
Index(['Months', '10YBond Returns', 'Stock Returns', 'Monetary Policy Rate',
       'Inflation Rate', 'Exchange Rate'],
      dtype='object')
```

In [56]:

```
#Examine the data type of the columns
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 60 entries, 0 to 59
Data columns (total 6 columns):
 #   Column                Non-Null Count  Dtype         
---  ------                --------------  -----         
 0   Months                60 non-null     datetime64[ns]
 1   10YBond Returns       60 non-null     float64       
 2   Stock Returns         60 non-null     float64       
 3   Monetary Policy Rate  60 non-null     float64       
 4   Inflation Rate        60 non-null     float64       
 5   Exchange Rate         60 non-null     float64       
dtypes: datetime64[ns](1), float64(5)
memory usage: 2.9 KB
```

In [57]:

```
#Ensure the Month column is indeed in  datetime format
df['Months']=pd.to_datetime(df['Months'])
```

In [58]:

```
#Examine the data again
df.head()
```

Out[58]:

	Months	10YBond Returns	Stock Returns	Monetary Policy Rate	Inflation Rate	Exchange Rate
0	2015-01-01	0.153	0.00001	0.11	165.766401	66.466240
1	2015-02-28	0.159	0.01830	0.11	166.901129	76.353096
2	2015-03-31	0.161	0.05450	0.11	168.419862	73.372332
3	2015-04-30	0.144	0.09330	0.11	169.708184	73.047738
4	2015-05-31	0.140	-0.01150	0.11	171.577356	73.208693

In [59]:

```
#Plotting the stock 10YBond Returns value to see the trends
plt.plot('Months','10YBond Returns',data=df);
```

Estimating the model with 2 regimes

In [60]:

```
exog = pd.concat((df["Stock Returns"],df["Monetary Policy Rate"],df["Inflation Rate"],df["Exchange Rate"]), axis=1)
```

In [61]:

```
# Fit the model
#exog=df["Stock Returns","Monetary Policy Rate","Inflation Rate","Exchange Rate"]
df_model = sm.tsa.MarkovRegression(df['10YBond Returns'], k_regimes=2,exog=exog1)
result = df_model.fit()
```

In [62]:

```
result.summary()
```

Out[62]:

Markov Switching Model Results

Dep. Variable:	10YBond Returns	**No. Observations:**	60
Model:	MarkovRegression	**Log Likelihood**	186.305
Date:	Sun, 03 Jan 2021	**AIC**	-346.610
Time:	06:56:17	**BIC**	-319.384
Sample:	0	**HQIC**	-335.961
	- 60		
Covariance Type:	approx		

Regime 0 parameters

	coef	std err	z	P>|z|	[0.025	0.975]
const	-0.0028	0.000	-6.146	0.000	-0.004	-0.002
x1	-0.0497	0.0001	-497.244	0.000	-0.050	-0.050
x2	0.5097	6.12e-05	8322.582	0.000	0.510	0.510
x3	-0.0001	0.139	-0.001	0.999	-0.272	0.272
x4	0.0012	0.027	0.044	0.965	-0.052	0.055

Regime 1 parameters

	coef	std err	z	P>|z|	[0.025	0.975]
const	0.1324	0.016	8.172	0.000	0.101	0.164
x1	0.0017	0.024	0.071	0.944	-0.046	0.049
x2	-0.2795	0.170	-1.641	0.101	-0.613	0.054
x3	-5.468e-05	4.07e-05	-1.344	0.179	-0.000	2.51e-05
x4	0.0007	0.000	4.961	0.000	0.000	0.001

Non-switching parameters

	coef	std err	z	P>|z|	[0.025	0.975]
sigma2	0.0001	2.15e-05	5.477	0.000	7.55e-05	0.000

Regime transition parameters

	coef	std err	z	P>|z|	[0.025	0.975]
p[0->0]	1.219e-10	0.000	3.62e-07	1.000	-0.001	0.001
p[1->0]	2.201e-20	nan	nan	nan	nan	nan

Warnings:
[1] Covariance matrix calculated using numerical (complex-step) differentiation.
[2] Covariance matrix is singular or near-singular, with condition number 1.22e+23. Standard errors may be unstable.

Estimating the model for 3 regimes

In [67]:

```
# Fit the model
#exog=df["Stock Returns","Monetary Policy Rate","Inflation Rate","Exchange Rate"]
df_model2 = sm.tsa.MarkovRegression(df['10YBond Returns'], k_regimes=3,exog=exog1)
result2 = df_model.fit()
```

In [68]:

```
result2.summary()
```

Out[68]:

Markov Switching Model Results

Markov Switching Model Results

Dep. Variable:	10YBond Returns	**No. Observations:**	60
Model:	MarkovRegression	**Log Likelihood**	186.305
Date:	Sun, 03 Jan 2021	**AIC**	-328.610
Time:	07:02:58	**BIC**	-282.535
Sample:	0	**HQIC**	-310.588
	- 60		
Covariance Type:	approx		

Regime 0 parameters

	coef	std err	z	P>|z|	[0.025	0.975]
const	-0.0228	0.018	-1.269	0.204	-0.058	0.012
x1	-0.0485	0.001	-72.203	0.000	-0.050	-0.047
x2	0.2901	0.003	97.994	0.000	0.284	0.296
x3	-0.0001	4.134	-3.5e-05	1.000	-8.103	8.103
x4	0.0020	2.298	0.001	0.999	-4.502	4.506

Regime 1 parameters

	coef	std err	z	P>|z|	[0.025	0.975]
const	0.0298	53.772	0.001	1.000	-105.362	105.422
x1	-0.0526	7.264	-0.007	0.994	-14.290	14.185
x2	0.5023	1.746	0.288	0.774	-2.920	3.925
x3	-7.165e-05	0.875	-8.19e-05	1.000	-1.716	1.716
x4	0.0006	2.705	0.000	1.000	-5.302	5.303

Regime 2 parameters

	coef	std err	z	P>|z|	[0.025	0.975]
const	0.1324	0.016	8.172	0.000	0.101	0.164
x1	0.0017	0.024	0.071	0.944	-0.046	0.049
x2	-0.2795	0.170	-1.641	0.101	-0.613	0.054
x3	-5.468e-05	4.07e-05	-1.344	0.179	-0.000	2.51e-05
x4	0.0007	0.000	4.961	0.000	0.000	0.001

Non-switching parameters

	coef	std err	z	P>|z|	[0.025	0.975]
sigma2	0.0001	2.15e-05	5.477	0.000	7.55e-05	0.000

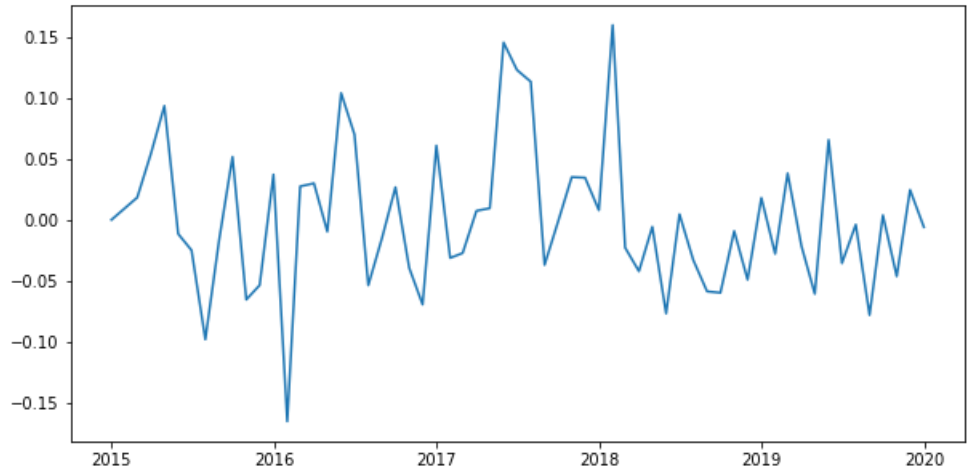
Regime transition parameters

	coef	std err	z	P>|z|	[0.025	0.975]
p[0->0]	3.83e-20	0.028	1.38e-18	1.000	-0.054	0.054
p[1->0]	5.976e-18	nan	nan	nan	nan	nan
p[2->0]	1.631e-17	nan	nan	nan	nan	nan
p[0->1]	0.9895	0.135	7.305	0.000	0.724	1.255
p[1->1]	1.044e-05	45.739	2.28e-07	1.000	-89.646	89.646
p[2->1]	7.447e-09	nan	nan	nan	nan	nan

Warnings:
[1] Covariance matrix calculated using numerical (complex-step) differentiation.
[2] Covariance matrix is singular or near-singular, with condition number 1.96e+25. Standard errors may be unstable.

In [49]:

```
#Plotting the Stock Returns values to see the trends
plt.plot('Months','Stock Returns',data=df);
```



In [22]:

```
## Descriptive statistics of the data
df.describe()
```

Out[22]:

	10YBond Returns	Stock Returns	Monetary Policy Rate	Inflation Rate	Exchange Rate
count	60.000000	60.000000	60.00000	60.000000	60.000000
mean	0.145617	0.000142	0.13300	231.947597	84.771377
std	0.013192	0.059974	0.01176	43.422691	12.276301
min	0.112000	-0.165000	0.11000	165.766401	62.154535
25%	0.139250	-0.037525	0.13500	192.229193	73.331423
50%	0.145000	-0.005800	0.14000	235.595284	86.935094
75%	0.156250	0.031050	0.14000	268.906596	93.995561
max	0.166000	0.159500	0.14000	307.473107	107.348376

In [23]:

```
## Correlation matrix of the data
df.corr()
```

Out[23]:

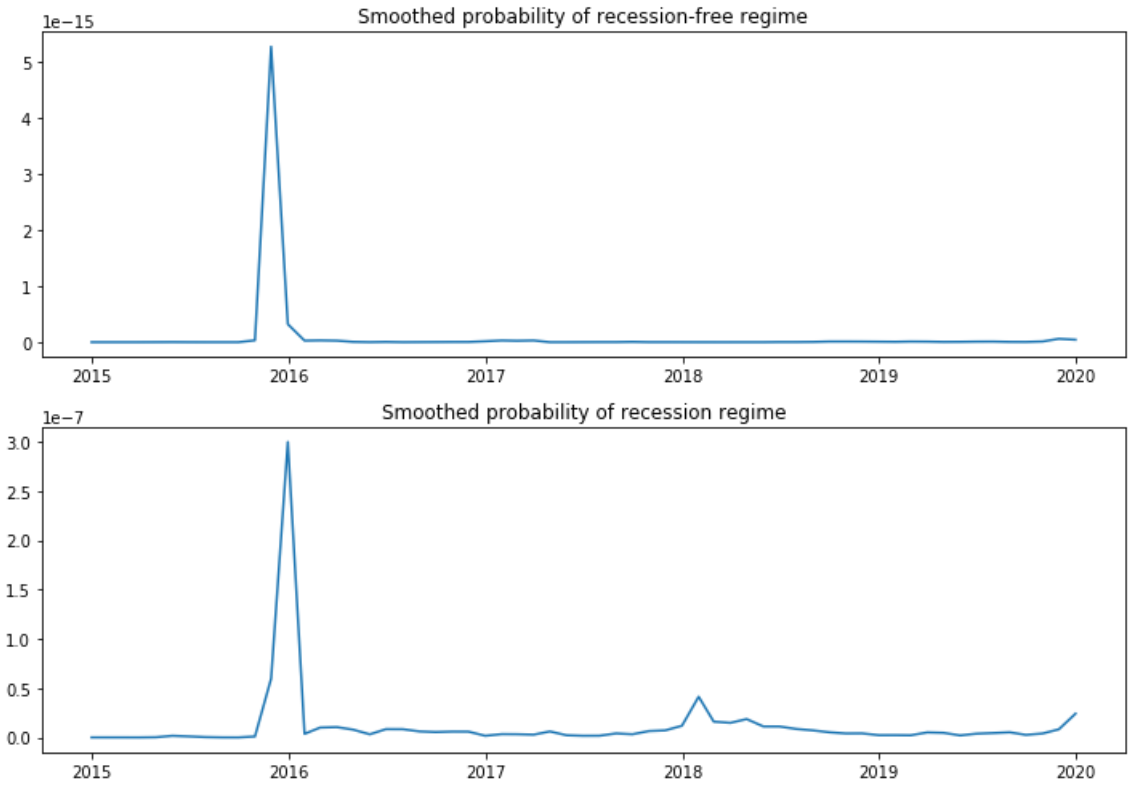
	10YBond Returns	Stock Returns	Monetary Policy Rate	Inflation Rate	Exchange Rate
10YBond Returns	1.000000	0.145354	0.068170	-0.033807	0.465805
Stock Returns	0.145354	1.000000	0.029720	-0.074271	0.190054
Monetary Policy Rate	0.068170	0.029720	1.000000	0.584491	0.609954
Inflation Rate	-0.033807	-0.074271	0.584491	1.000000	0.422335
Exchange Rate	0.465805	0.190054	0.609954	0.422335	1.000000

Smoothed probablity for 2 regimes

In [51]:

```
fig, axes = plt.subplots(2, figsize=(10,7))

ax = axes[0]
```

```
ax.plot(df["Months"],result.smoothed_marginal_probabilities[0])
ax.set(title='Smoothed probability of recession-free regime')

ax = axes[1]
ax.plot(df["Months"],result.smoothed_marginal_probabilities[1])
ax.set(title='Smoothed probability of recession regime')

fig.tight_layout()
```



In [ ]:

```
```

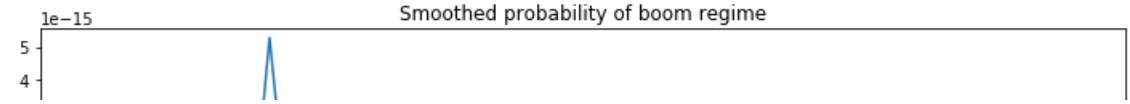
In [ ]:

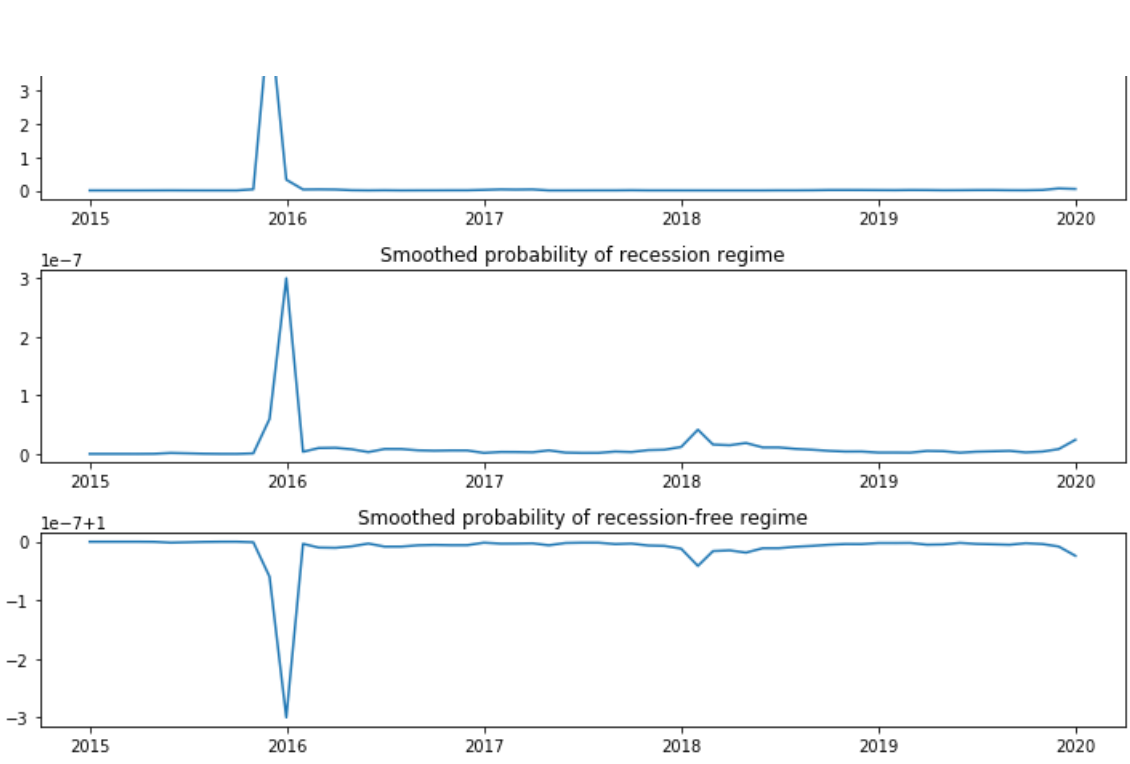
```
```

Smoothed probability for 3 regimes

In [70]:

```
fig, axes = plt.subplots(3, figsize=(10,7))

ax = axes[0]
ax.plot(df["Months"],result2.smoothed_marginal_probabilities[0])
ax.set(title='Smoothed probability of boom regime')

ax = axes[1]
ax.plot(df["Months"],result2.smoothed_marginal_probabilities[1])
ax.set(title='Smoothed probability of recession regime')

ax = axes[2]
ax.plot(df["Months"],result2.smoothed_marginal_probabilities[2])
ax.set(title='Smoothed probability of recession-free regime')

fig.tight_layout()
```




Smoothed probability of recession regime
1e−7
Smoothed probability of recession-free regime
1e−7+1
2015
2016
2017
2018
2019
2020

In [ ]:

In [ ]: