

```
In [33]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

In [51]: # a.Download the dataset into pandas dataframe
df=pd.read_csv('yield-curve-rates-1990-2021.csv', index_col='Date')

In [52]: # b.Remove '1M' column and use the date from 1/1/2000 - 1/1/2018
df=df.loc['2000-01-01':'2018-01-01']
df=df.drop(['1 Mo','2 Mo','4 Mo'], axis=1)
```

Rates Data

```
In [61]: df

Out[61]:
```

	3 Mo	6 Mo	1 Yr	2 Yr	3 Yr	5 Yr	7 Yr	10 Yr	20 Yr	30 Yr
Date										
2000-01-03	5.48	5.81	6.09	6.38	6.42	6.50	6.65	6.58	6.94	6.61
2000-01-04	5.43	5.75	6.00	6.30	6.34	6.40	6.56	6.49	6.84	6.53
2000-01-05	5.44	5.74	6.05	6.38	6.43	6.51	6.68	6.62	6.95	6.64
2000-01-06	5.41	5.69	6.03	6.35	6.39	6.46	6.63	6.57	6.86	6.58
2000-01-07	5.38	5.66	6.00	6.31	6.35	6.42	6.58	6.52	6.82	6.55
...
2017-12-22	1.33	1.54	1.73	1.91	2.01	2.26	2.40	2.48	2.68	2.83
2017-12-26	1.47	1.52	1.75	1.92	2.02	2.25	2.38	2.47	2.66	2.82
2017-12-27	1.44	1.53	1.75	1.89	1.99	2.22	2.34	2.42	2.59	2.75
2017-12-28	1.39	1.54	1.76	1.91	2.00	2.23	2.36	2.43	2.60	2.75
2017-12-29	1.39	1.53	1.76	1.89	1.98	2.20	2.33	2.40	2.58	2.74

4504 rows × 10 columns

```
In [62]: # c.Construct series of daily differences
daily_diff=df.diff(1)
daily_diff.dropna(inplace=True)
```

Daily differences

```
In [77]: daily_diff

Out[77]:
```

	3 Mo	6 Mo	1 Yr	2 Yr	3 Yr	5 Yr	7 Yr	10 Yr	20 Yr	30 Yr
Date										
2000-01-04	-0.05	-0.06	-0.09	-0.08	-0.08	-0.10	-0.09	-0.09	-0.10	-0.08
2000-01-05	0.01	-0.01	0.05	0.08	0.09	0.11	0.12	0.13	0.11	0.11
2000-01-06	-0.03	-0.05	-0.02	-0.03	-0.04	-0.05	-0.05	-0.05	-0.09	-0.06
2000-01-07	-0.03	-0.03	-0.03	-0.04	-0.04	-0.04	-0.05	-0.05	-0.04	-0.03
2000-01-10	0.04	-0.02	0.07	0.07	0.07	0.07	0.04	0.05	0.04	0.04
...
2017-12-22	-0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	-0.01
2017-12-26	0.14	-0.02	0.02	0.01	0.01	-0.01	-0.02	-0.01	-0.02	-0.01
2017-12-27	-0.03	0.01	0.00	-0.03	-0.03	-0.03	-0.04	-0.05	-0.07	-0.07
2017-12-28	-0.05	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.00
2017-12-29	0.00	-0.01	0.00	-0.02	-0.02	-0.03	-0.03	-0.03	-0.02	-0.01

3500 rows × 10 columns

```
In [63]: #d.Compute correlations and volatilities among the series (using level data)
rates_corr=df.corr()
rates_vol=df.std()
```

Correlations of level data

```
In [64]: rates_corr

Out[64]:
```

	3 Mo	6 Mo	1 Yr	2 Yr	3 Yr	5 Yr	7 Yr	10 Yr	20 Yr	30 Yr
3 Mo	1.000000	0.998193	0.993822	0.977428	0.958402	0.913623	0.871034	0.821496	0.716080	0.776434
6 Mo	0.998193	1.000000	0.997762	0.983143	0.964393	0.919051	0.875304	0.825408	0.717972	0.775367
1 Yr	0.993822	0.997762	1.000000	0.991906	0.977042	0.936206	0.894355	0.845618	0.739919	0.783584
2 Yr	0.977428	0.983143	0.991906	1.000000	0.995436	0.968371	0.934688	0.889895	0.791746	0.816350
3 Yr	0.958402	0.964393	0.977042	0.995436	1.000000	0.986713	0.961466	0.922396	0.833411	0.843809
5 Yr	0.913623	0.919051	0.936206	0.968371	0.986713	1.000000	0.992642	0.969447	0.903283	0.899069
7 Yr	0.871034	0.875304	0.894355	0.934688	0.961466	0.992642	1.000000	0.990357	0.944619	0.937393
10 Yr	0.821496	0.825408	0.845618	0.889895	0.922396	0.969447	0.990357	1.000000	0.978850	0.972313
20 Yr	0.716080	0.717972	0.739919	0.791746	0.833411	0.903283	0.944619	0.978850	1.000000	0.994330
30 Yr	0.776434	0.775367	0.783584	0.816350	0.843809	0.899069	0.937393	0.972313	0.994330	1.000000

Volatilities of level data

```
In [65]: rates_vol

Out[65]:
```

3 Mo	1.917301
6 Mo	1.940245
1 Yr	1.879415
2 Yr	1.798570
3 Yr	1.701489
5 Yr	1.524441
7 Yr	1.397518
10 Yr	1.256276
20 Yr	1.218747
30 Yr	1.063210

dtype: float64

```
In [66]: #e.Compute correlations and volatilities among the series (using daily differences)
diff_corr=daily_diff.corr()
diff_vol=daily_diff.std()
```

Correlations of daily differences

```
In [67]: diff_corr

Out[67]:
```

	3 Mo	6 Mo	1 Yr	2 Yr	3 Yr	5 Yr	7 Yr	10 Yr	20 Yr	30 Yr
3 Mo	1.000000	0.775412	0.623168	0.377613	0.335919	0.268021	0.221039	0.184743	0.133107	0.121938
6 Mo	0.775412	1.000000	0.830927	0.570569	0.528115	0.439022	0.376131	0.330519	0.259068	0.236106
1 Yr	0.623168	0.830927	1.000000	0.785212	0.736831	0.636053	0.561373	0.502508	0.407699	0.375561
2 Yr	0.377613	0.570569	0.785212	1.000000	0.946121	0.870382	0.795645	0.729032	0.609920	0.564717
3 Yr	0.335919	0.528115	0.736831	0.946121	1.000000	0.938203	0.877756	0.818493	0.703717	0.659206
5 Yr	0.268021	0.439022	0.636053	0.870382	0.938203	1.000000	0.965835	0.926011	0.833637	0.791164
7 Yr	0.221039	0.376131	0.561373	0.795645	0.877756	0.965835	1.000000	0.969638	0.903453	0.866880
10 Yr	0.184743	0.330519	0.502508	0.729032	0.818493	0.926011	0.969638	1.000000	0.948822	0.921200
20 Yr	0.133107	0.259068	0.407699	0.609920	0.703717	0.833637	0.903453	0.948822	1.000000	0.978462
30 Yr	0.121938	0.236106	0.375561	0.564717	0.659206	0.791164	0.866880	0.921200	0.978462	1.000000

Volatilities of daily differences

```
In [68]: diff_vol

Out[68]:
```

3 Mo	0.054991
6 Mo	0.042518
1 Yr	0.040324
2 Yr	0.050989
3 Yr	0.055203
5 Yr	0.060343
7 Yr	0.061513
10 Yr	0.058616
20 Yr	0.056003
30 Yr	0.054553

dtype: float64

```
In [75]: #f. Plot the volatility curves computed in 2d & 2e
ax=rates_vol.plot(title='volatility curves',label='Level Data',legend=True, figsize=(9,6))
ax.set_ylabel("Volatility of Level Data")
ax2=diff_vol.plot(secondary_y=True, label='Difference Data',legend=True)
ax2.set_ylabel("Volatility of Difference Data")
plt.show()
```

