FX Value strategy

Model to determine Fair value

Assume we use 100 USD to buy GBP with the exchange rate FX_1 (GBP/USD). This yields $100FX_1$ GBP.

With this $100FX_1$ GBP we invest in the UK market at a return r_{UK}. This yields $100FX_1(1 + r_{UK})$ GBP at the end of the period.

If instead, we invest the original 100 USD in the US market, we will get $100(1 + r_{US})$ USD at the end of the period.

Now if we use this amount of USD to buy GBP with exchange rate FX_2 (GBP/USD), we will have $100FX_2(1 + r_{US})$ GBP.

Assumming equilibrium, the two amount should be the same; otherwise investors will make use of the rate differences to earn profit. In other words,

$$FX_1(1 + r_{UK}) = FX_2(1 + r_{US})$$

And we can get:

$$FX_2 = FX_1 \frac{1 + r_{UK}}{1 + r_{US}}$$

This will be our model to estimate the Fair value of current exchange rate FX_2

Approach to obtain required variables

The market return for each country is computed by finding the percentage change of its Stock market index over a chosen period. We choose 1 month for our strategy.

The past exchange rate FX_1 is found by computing the rolling average of spot exchange rate, one period before the current exchange rate. It is the same period as above, 1 month.

Strategy

If **spot exchange rate < estimated fair value**, we **buy now** and enter a forward contract to **sell in the future** (long position)

If **spot exchange rate > estimated fair value**, we **sell now** and enter a forward contract to **buy in the future** (short position)

All forward contracts are for delivery in **1 month**.

Note that we have a *threshold* to decide whether we will proceed with entering the future contract. The purpose of this threshold is to reject insignificant deviations from the fair value.

Limitation

Due to limited resources and time constraint, we only test our strategy against GBP/USD exchange rate.

Set up

Import packages and define helper functions

In [1]:
```
# Import necessary packages
import pandas as pd
import numpy as np
import datetime
import matplotlib
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.stats import stats
import requests
import json

%matplotlib inline
plt.style.use('seaborn')
```

In [2]:
```
# Define a function to query data

def get_data_request(url, access_token, requestData):
    '''make HTTP GET request'''
    dResp = requests.get(url, headers = {'X-api-key': access_token}, params = request
Data);


    if dResp.status_code != 200:
        print("Unable to get data. Code %s, Message: %s" % (dResp.status_code, dResp.
text));
    else:
        print("Data access successful")
        jResp = json.loads(dResp.text);
        return jResp
```

In [3]:
```
# Define a function to retrieve data from Refinitiv Data Science Accelerator
# Default window time period is from 2016-11-01 to 2018-01-01

def query_refinitiv_data(ric,start_date='2016-11-01',end_date='2018-01-01'):
  access_token = 'Jjxmy4OMWB5t5osGMF5Ut7qkRipRRhPa4Ns86iiW'  # your personal key for
 Data Science Accelerator access to Pricing Data
  RESOURCE_ENDPOINT = "https://dsa-stg-edp-api.fr-nonprod.aws.thomsonreuters.com/dat
a/historical-pricing/beta1/views/summaries/" + ric

  requestData = {
      "interval": "P1D",
      "start": start_date,
      "end": end_date,
      "fields": 'TRDPRC_1' #BID,ASK,OPEN_PRC,HIGH_1,LOW_1,TRDPRC_1,NUM_MOVES,TRNOVR_U
NS
  };

  # Get the data from Refinitiv server
  jResp = get_data_request(RESOURCE_ENDPOINT, access_token, requestData)

  # Create a DataFrame from the retrieved data
  if jResp is not None:
      data = jResp[0]['data']
      headers = jResp[0]['headers']
      names = [headers[x]['name'] for x in range(len(headers))]
      df = pd.DataFrame(data, columns=names )

      # Make DATE into DateTime object and make it the Index of df
      df.DATE = pd.to_datetime(df.DATE)
      df = df.set_index('DATE')

      df = df.rename(columns={'TRDPRC_1': 'Price'})
      df = df.sort_index()

      return df
```

Query spot FX data

In [4]:
```
# Query spot FX data and create a DataFrame from the data
GBP_USD_df = query_refinitiv_data('=GBP')
GBP_USD_df = GBP_USD_df.rename(columns={'Price':'GBP/USD'})
GBP_USD_df.tail()
```

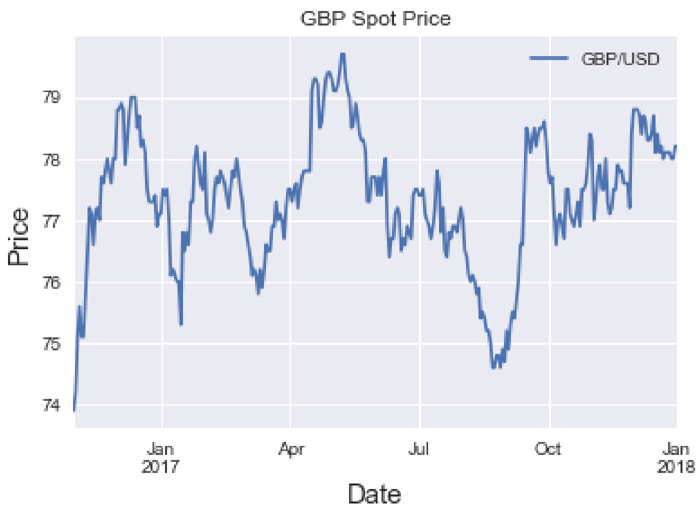
```
Data access successful
```

Out[4]:

DATE	GBP/USD
2017-12-26	78.1
2017-12-27	78.0
2017-12-28	78.0
2017-12-29	78.2
2018-01-01	78.2

In [5]:
```
GBP_USD_df.plot(title= 'GBP Spot Price')
plt.xlabel('Date', fontsize=15)
plt.ylabel('Price', fontsize=15)
```

Out[5]:
```
Text(0, 0.5, 'Price')
```



Query Stock market indices

We choose the following Stock market index for US and UK

Country	Index
US	SPX
GBP	FTSE

In [6]:
```
SPX_df = query_refinitiv_data('.SPX')
SPX_df = SPX_df.rename(columns={'Price': 'SPX'})
SPX_df.tail()
```

```
Data access successful
```

Out[6]:

	SPX
DATE	
2017-12-22	2683.34
2017-12-26	2680.50
2017-12-27	2682.62
2017-12-28	2687.54
2017-12-29	2673.61

In [7]:
```
FTSE_df = query_refinitiv_data('.FTSE')
FTSE_df = FTSE_df.rename(columns={'Price': 'FTSE'})
FTSE_df.tail()
```

```
Data access successful
```

Out[7]:

	FTSE
DATE	
2017-12-21	7603.98
2017-12-22	7592.66
2017-12-27	7620.68
2017-12-28	7622.88
2017-12-29	7687.77

Prepare data for GBP/USD

Combine GBP/USD, SPX and FTSE into 1 DataFrame

In [8]:
```
GBP_USD_df = pd.merge(GBP_USD_df,SPX_df,how='outer',left_index=True,right_index=True)
GBP_USD_df = pd.merge(GBP_USD_df,FTSE_df,how='outer',left_index=True,right_index=True
)
GBP_USD_df.fillna(method='ffill',inplace=True)
GBP_USD_df.tail()
```

Out[8]:

	GBP/USD	SPX	FTSE
DATE			
2017-12-26	78.1	2680.50	7592.66
2017-12-27	78.0	2682.62	7620.68
2017-12-28	78.0	2687.54	7622.88
2017-12-29	78.2	2673.61	7687.77
2018-01-01	78.2	2673.61	7687.77

Calculate moving average of the indices, which provide a better estimate for the Intrinsic value of those indices

In [9]:
```
GBP_USD_df['GBP/USD 5D'] = GBP_USD_df['GBP/USD'].rolling(5).mean()
GBP_USD_df['SPX MA 5D'] = GBP_USD_df['SPX'].rolling(5).mean()
GBP_USD_df['FTSE MA 5D'] = GBP_USD_df['FTSE'].rolling(5).mean()
GBP_USD_df.tail()
```

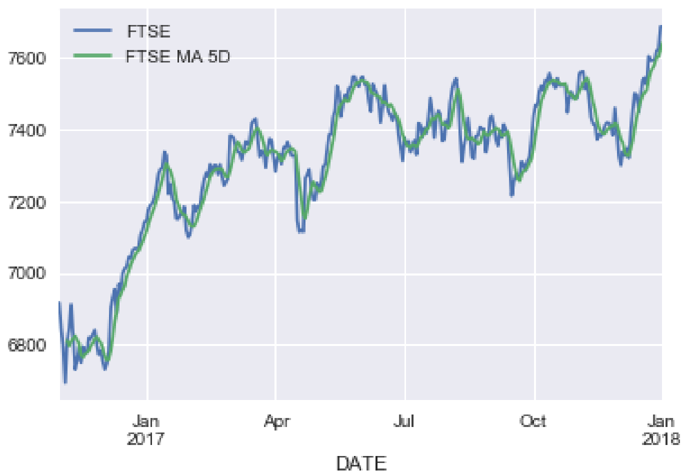
Out[9]:

DATE	GBP/USD	SPX	FTSE	GBP/USD 5D	SPX MA 5D	FTSE MA 5D
2017-12-26	78.1	2680.50	7592.66	78.10	2682.200	7581.436
2017-12-27	78.0	2682.62	7620.68	78.06	2682.874	7600.528
2017-12-28	78.0	2687.54	7622.88	78.06	2683.468	7604.308
2017-12-29	78.2	2673.61	7687.77	78.08	2681.522	7623.330
2018-01-01	78.2	2673.61	7687.77	78.10	2679.576	7642.352

Plot for visualization

In [10]:
```
GBP_USD_df.loc[:,['SPX','SPX MA 5D']].plot()
GBP_USD_df.loc[:,['FTSE','FTSE MA 5D']].plot()
```

Out[10]: <matplotlib.axes._subplots.AxesSubplot at 0x18427dd0b88>



Calculating market return for 1 period

There are on average 30 days of in a month. We take 30 days to be our period duration for calculation

In [11]:
```
duration = 30
```

In [12]:
```
GBP_USD_df['SPX Returns 1M'] = GBP_USD_df['SPX MA 5D'].pct_change(duration)
GBP_USD_df['FTSE Returns 1M'] = GBP_USD_df['FTSE MA 5D'].pct_change(duration)
GBP_USD_df.tail()
```

Out[12]:

	GBP/USD	SPX	FTSE	GBP/USD 5D	SPX MA 5D	FTSE MA 5D	SPX Returns 1M	FTSE Returns 1M
DATE								
2017-12-26	78.1	2680.50	7592.66	78.10	2682.200	7581.436	0.037601	0.016921
2017-12-27	78.0	2682.62	7620.68	78.06	2682.874	7600.528	0.040257	0.023797
2017-12-28	78.0	2687.54	7622.88	78.06	2683.468	7604.308	0.040405	0.026995
2017-12-29	78.2	2673.61	7687.77	78.08	2681.522	7623.330	0.039928	0.031020
2018-01-01	78.2	2673.61	7687.77	78.10	2679.576	7642.352	0.039391	0.034313

In [13]:
```
GBP_USD_df.reset_index(inplace=True)
GBP_USD_df.tail()
```

Out[13]:

	DATE	GBP/USD	SPX	FTSE	GBP/USD 5D	SPX MA 5D	FTSE MA 5D	SPX Returns 1M	FTSE Returns 1M
300	2017-12-26	78.1	2680.50	7592.66	78.10	2682.200	7581.436	0.037601	0.016921
301	2017-12-27	78.0	2682.62	7620.68	78.06	2682.874	7600.528	0.040257	0.023797
302	2017-12-28	78.0	2687.54	7622.88	78.06	2683.468	7604.308	0.040405	0.026995
303	2017-12-29	78.2	2673.61	7687.77	78.08	2681.522	7623.330	0.039928	0.031020
304	2018-01-01	78.2	2673.61	7687.77	78.10	2679.576	7642.352	0.039391	0.034313

Calculating Fair value of exchange rate using the proposed model

$$FX_2 = FX_1 \frac{1 + r_{UK}}{1 + r_{US}}$$

In [14]:
```
GBP_USD_df['GBP/USD Fair value'] = np.nan
for i in np.arange(duration,len(GBP_USD_df)):
    GBP_USD_df.loc[i,'GBP/USD Fair value'] = GBP_USD_df.loc[i-duration,'GBP/USD 5D']
* (1 + GBP_USD_df.loc[i,'FTSE Returns 1M']) / (1 + GBP_USD_df.loc[i,'SPX Returns 1M'
])
```

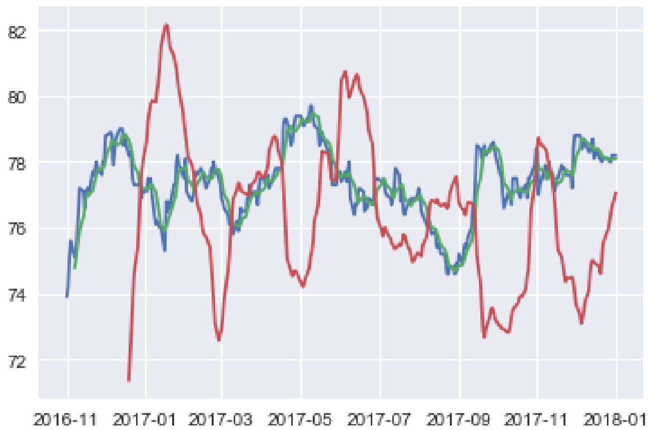
In [15]:
```
GBP_USD_df.tail()
```

Out[15]:

	DATE	GBP/USD	SPX	FTSE	GBP/USD 5D	SPX MA 5D	FTSE MA 5D	SPX Returns 1M	FTSE Returns 1M	GBP/USD Fair value
300	2017-12-26	78.1	2680.50	7592.66	78.10	2682.200	7581.436	0.037601	0.016921	75.935828
301	2017-12-27	78.0	2682.62	7620.68	78.06	2682.874	7600.528	0.040257	0.023797	76.195030
302	2017-12-28	78.0	2687.54	7622.88	78.06	2683.468	7604.308	0.040405	0.026995	76.422113
303	2017-12-29	78.2	2673.61	7687.77	78.08	2681.522	7623.330	0.039928	0.031020	76.657679
304	2018-01-01	78.2	2673.61	7687.77	78.10	2679.576	7642.352	0.039391	0.034313	77.061606

In [16]:
```
plt.plot(GBP_USD_df['DATE'],GBP_USD_df['GBP/USD'])
plt.plot(GBP_USD_df['DATE'],GBP_USD_df['GBP/USD 5D'])
plt.plot(GBP_USD_df['DATE'],GBP_USD_df['GBP/USD Fair value'])
```

Out[16]: [<matplotlib.lines.Line2D at 0x18427eee608>]



Sharpe ratio and Backtesting

Take the risk free rate to be 1.4% and constant throughout our analysis.

We enter forward contracts for delivery in 1 month time. Thus, our **realized return** will be computed using *current spot exchange rate* and *spot exchange rate in 1 month later*.

In [17]:
```
Ra = np.array([])
threshold = 1
```

In [18]:
```
for i in np.arange(len(GBP_USD_df)-duration):
    if GBP_USD_df.loc[i,'GBP/USD'] - GBP_USD_df.loc[i,'GBP/USD Fair value'] > thresho
ld:             # long position
        Ra = np.append(Ra, 1 - GBP_USD_df.loc[i+duration,'GBP/USD'] / GBP_USD_df.loc[
i,'GBP/USD'])    # realized return

    elif GBP_USD_df.loc[i,'GBP/USD'] - GBP_USD_df.loc[i,'GBP/USD Fair value'] < -thre
shold:          # short position
        Ra = np.append(Ra, GBP_USD_df.loc[i+duration,'GBP/USD'] / GBP_USD_df.loc[i,'G
BP/USD'] - 1)    # realized return
```

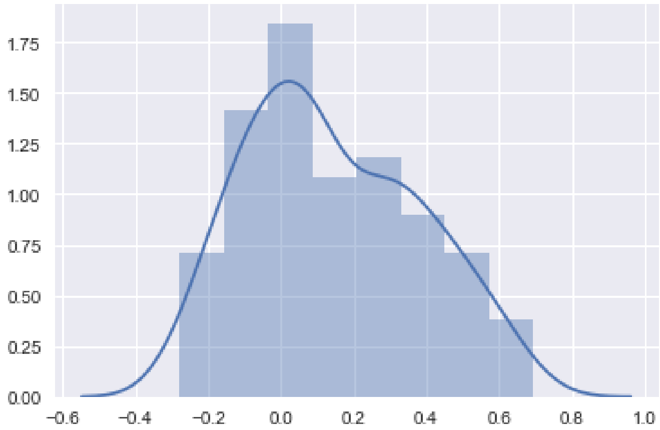
In [19]:
```python
# convert to annual rate, compound the rate by 12 periods (there are 12 months in a y
ear)
Ra = (Ra + 1)**12 - 1
```

In [20]:
```python
Ra.mean()
```

Out[20]: 0.14337656172005883

In [21]:
```python
sns.distplot(Ra)
```

Out[21]: <matplotlib.axes._subplots.AxesSubplot at 0x18427f44448>



In [22]:
```python
Sharpe_ratio = (Ra.mean() - 0.014) / Ra.std()
Sharpe_ratio
```

Out[22]: 0.5466553040687679

Export estimated Fair value

For submission purpose

In [23]:
```python
FV_df = GBP_USD_df.loc[:,['DATE','GBP/USD Fair value']]
FV_df.tail()
```

Out[23]:

	DATE	GBP/USD Fair value
300	2017-12-26	75.935828
301	2017-12-27	76.195030
302	2017-12-28	76.422113
303	2017-12-29	76.657679
304	2018-01-01	77.061606

In [24]:
```python
FV_df.to_csv('Fair_value.csv',index=False)
```