Exchange Rate Forecasting

In [43]:
```
import statsmodels
import pandas as pd
```

In [44]:
```
from statsmodels.tsa.arima.model import ARIMA
```

In [45]:
```
data = pd.read_csv("/Users/snehilshandilya/Desktop/A1_JPYUSD.csv",
```

In [46]:
```
train_data = data.iloc[:int(0.8*len(data))]
test_data = data.iloc[int(0.8*len(data)):]
```

In [47]:
```
test_data
```

Out[47]:

Date	Japan
01/05/15	0.008081
01/06/15	0.008167
01/07/15	0.008066
01/08/15	0.008251
01/09/15	0.008337
...	...
01/07/22	0.007519
01/08/22	0.007214
01/09/22	0.006909
01/10/22	0.006746
01/11/22	0.007205

91 rows × 1 columns

In [48]:
```
pip install pmdarima
```

```
Requirement already satisfied: pmdarima in ./opt/anaconda3/lib/pyt
hon3.9/site-packages (2.0.2)
Requirement already satisfied: urllib3 in ./opt/anaconda3/lib/pyth
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a3/lib/python3.9/site-packages (from pmdarima) (1.0.2)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in
./opt/anaconda3/lib/python3.9/site-packages (from pmdarima) (0.29.
28)
Requirement already satisfied: pandas>=0.19 in ./opt/anaconda3/lib
/python3.9/site-packages (from pmdarima) (1.4.2)
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t/anaconda3/lib/python3.9/site-packages (from pmdarima) (61.2.0)
Requirement already satisfied: python-dateutil>=2.8.1 in ./opt/ana
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2.8.2)
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Requirement already satisfied: six>=1.5 in ./opt/anaconda3/lib/pyt
hon3.9/site-packages (from python-dateutil>=2.8.1->pandas>=0.19->p
mdarima) (1.16.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in ./opt/anaco
nda3/lib/python3.9/site-packages (from scikit-learn>=0.22->pmdarim
a) (2.2.0)
Requirement already satisfied: packaging>=21.3 in ./opt/anaconda3/
lib/python3.9/site-packages (from statsmodels>=0.13.2->pmdarima) (
21.3)
Requirement already satisfied: patsy>=0.5.2 in ./opt/anaconda3/lib
/python3.9/site-packages (from statsmodels>=0.13.2->pmdarima) (0.5
.2)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in ./opt/a
naconda3/lib/python3.9/site-packages (from packaging>=21.3->statsm
odels>=0.13.2->pmdarima) (3.0.4)
Note: you may need to restart the kernel to use updated packages.
```

In [49]:
```
import pmdarima as pm
arima = pm.auto_arima(data["Japan"].diff().dropna(), start_p = 0, s
                      suppress_warnings=True)
arima.summary()
```

```
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
tatsmodels/tsa/statespace/sarimax.py:1899: RuntimeWarning: invalid
value encountered in reciprocal
```

```
  return np.roots(self.polynomial_reduced_ar)**-1
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```

Out[49]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	454
Model:	SARIMAX(2, 0, 0)	**Log Likelihood**	3100.045
Date:	Fri, 27 Jan 2023	**AIC**	-6194.090
Time:	19:08:07	**BIC**	-6181.736
Sample:	0	**HQIC**	-6189.223
	- 454		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.0858	0.039	2.174	0.030	0.008	0.163
ar.L2	0.0916	0.044	2.091	0.037	0.006	0.177
sigma2	6.857e-08	3.37e-09	20.331	0.000	6.2e-08	7.52e-08

Ljung-Box (L1) (Q):	0.00	**Jarque-Bera (JB):**	59.70
Prob(Q):	0.98	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.79	**Skew:**	-0.07
Prob(H) (two-sided):	0.14	**Kurtosis:**	4.77

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

B

In [50]:
```
model = ARIMA(test_data["Japan"].dropna(), order=(2,0,0)).fit()
model.forecast(12)
```

```
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
tatsmodels/tsa/base/tsa_model.py:471: ValueWarning: A date index h
as been provided, but it has no associated frequency information a
nd so will be ignored when e.g. forecasting.
  self._init_dates(dates, freq)
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
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/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
tatsmodels/base/model.py:604: ConvergenceWarning: Maximum Likeliho
od optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
tatsmodels/tsa/base/tsa_model.py:834: ValueWarning: No supported i
ndex is available. Prediction results will be given with an intege
r index beginning at `start`.
  return get_prediction_index(
```

Out[50]:
```
91     0.007323
92     0.007396
93     0.007461
94     0.007522
95     0.007580
96     0.007636
97     0.007690
98     0.007741
99     0.007790
100    0.007837
101    0.007882
102    0.007925
Name: predicted_mean, dtype: float64
```

In [51]:
```
forecast = model.get_forecast(12)
yhat_conf_int = forecast.conf_int(alpha=0.1)
yhat_conf_int["mean"] = forecast.predicted_mean
yhat_conf_int
```

```
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/statsmodels/tsa/base/tsa_model.py:834: ValueWarning: No supported index is available. Prediction results will be given with an integer index beginning at `start`.
  return get_prediction_index(
```

Out[51]:

	lower Japan	upper Japan	mean
91	0.006987	0.007660	0.007323
92	0.006900	0.007892	0.007396
93	0.006852	0.008070	0.007461
94	0.006825	0.008219	0.007522
95	0.006811	0.008350	0.007580
96	0.006807	0.008466	0.007636
97	0.006809	0.008571	0.007690
98	0.006815	0.008667	0.007741
99	0.006825	0.008755	0.007790
100	0.006838	0.008836	0.007837
101	0.006852	0.008911	0.007882
102	0.006868	0.008981	0.007925

In [52]:
```
def evaluate_arima_model(X, arima_order):
    history = [x for x in train_data['Japan']]
    # make predictions
    predictions = []
    conf_int = []
    for t in range(len(test_data['Japan'])):
        model = ARIMA(history, order=arima_order)
        model_fit = model.fit()
        yhat = model_fit.forecast()[0]
        conf_ints = model_fit.get_forecast(1).conf_int(alpha = 0.1)
        conf_int.append(conf_ints)
        predictions.append(yhat)
        history.append(test_data['Japan'][t])
    # calculate out of sample error
    test = pd.DataFrame(test_data['Japan'])
    test["predictions"] = predictions
    test['Confidence Intervals'] = conf_int
    return test
```

In [53]:
```
y = evaluate_arima_model(data['Japan'], (2,1,0))
```

```
od optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
tatsmodels/base/model.py:604: ConvergenceWarning: Maximum Likeliho
od optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
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  warnings.warn("Maximum Likelihood optimization failed to "
/Users/snehilshandilya/opt/anaconda3/lib/python3.9/site-packages/s
tatsmodels/base/model.py:604: ConvergenceWarning: Maximum Likeliho
```

In [54]:
```
y
```

Out[54]:

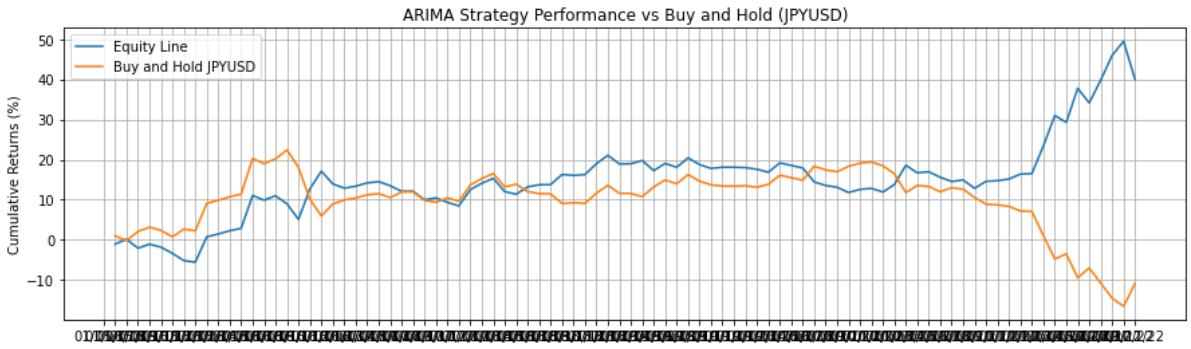
	Japan	predictions	Confidence Intervals
Date			
01/05/15	0.008081	0.008443	[[0.007992341461312715, 0.008892869691392429]]
01/06/15	0.008167	0.008060	[[0.0076094961882690005, 0.008510404333867207]]
01/07/15	0.008066	0.008140	[[0.007689501980427222, 0.008589894780856986]]
01/08/15	0.008251	0.008066	[[0.00761649872566448, 0.008515742104754552]]
01/09/15	0.008337	0.008257	[[0.007807860119050416, 0.008705910645826631]]
...	...	...	...
01/07/22	0.007519	0.007285	[[0.006855720102475713, 0.007714676518059566]]
01/08/22	0.007214	0.007491	[[0.007061843064463195, 0.007920614833733887]]
01/09/22	0.006909	0.007208	[[0.006779001472044709, 0.007637859064129535]]
01/10/22	0.006746	0.006853	[[0.006423527494985584, 0.007283192578697927]]
01/11/22	0.007205	0.006702	[[0.006272879527716987, 0.007131251338487316]]

91 rows × 3 columns

In [55]:
```
import numpy as np
# compute whether we are going long or short
y["Signals"] = np.where(y['predictions']>y['Japan'].shift(), 1,-1)

# get the series of log returns
y["returns"] = np.log(y["Japan"]/y["Japan"].shift())

y["strategy returns"] = y["Signals"]*y["returns"]

# convert to simple returns
y["Cumulative Returns"] = (np.exp(y["strategy returns"].cumsum())-1
```

In [56]:
```
import matplotlib
from matplotlib import pyplot as plt
```

In [57]:
```
plt.figure(figsize = (15, 4))
plt.plot(y["Cumulative Returns"])
plt.plot((np.exp(y["returns"].cumsum())-1)*100)
plt.ylabel("Cumulative Returns (%)")
plt.title("ARIMA Strategy Performance vs Buy and Hold (JPYUSD)")
plt.legend(["Equity Line", "Buy and Hold JPYUSD"])
plt.grid()
```



D

In [58]:
```
P = 1000000
A = (((y["Cumulative Returns"]/100)+1)*P)[-1]
t = (len(y)/12)
CCROR = np.log(A/P)/t
print(CCROR*100)
```

```
4.433704686010043
```

In [59]:
```
((A/P)**(1/t)-1)*100
```

Out[59]:
```
4.533462227199214
```

In [60]:
```
CCROR*100
```

Out[60]:
```
4.433704686010043
```

Performing DMW and CW Test

In [61]:
```
y['s_current'] = y['Japan']
y['s_future'] = y['s_current'].shift(+1)
y['s_change'] = y['s_future'] - y['s_current']
y['s_change_fitted'] = y['predictions'] - y['predictions'].shift()
y['error'] = ((y['Japan'].shift(-1) - y['Japan']) - (y['predictions
```

In [62]:
```
y
```

Out[62]:

Date	Japan	predictions	Confidence Intervals	Signals	returns	strategy returns	Cu
01/05/15	0.008081	0.008443	[[0.007992341461312715, 0.008892869691392429]]	-1	NaN	NaN	
01/06/15	0.008167	0.008060	[[0.007609496188269005, 0.008510404333867207]]	-1	0.010561	-0.010561	-
01/07/15	0.008066	0.008140	[[0.007689501980427222, 0.008589894780856986]]	-1	-0.012337	0.012337	
01/08/15	0.008251	0.008066	[[0.00761649872566448, 0.008515742104754552]]	-1	0.022597	-0.022597	-:
01/09/15	0.008337	0.008257	[[0.007807860119050416, 0.00870591064582663]]	1	0.010367	0.010367	-
...	...	...	...	...	...	...	
01/07/22	0.007519	0.007285	[[0.006855720102475713, 0.007714676518059566]]	-1	0.026927	-0.026927	3
01/08/22	0.007214	0.007491	[[0.007061843064463195, 0.007920614833733887]]	-1	-0.041315	0.041315	3
01/09/22	0.006909	0.007208	[[0.006779001472044709, 0.007637859064129535]]	-1	-0.043275	0.043275	4
01/10/22	0.006746	0.006853	[[0.006423527494985584, 0.007283192578697927]]	-1	-0.023893	0.023893	4
01/11/22	0.007205	0.006702	[[0.006272879527716987, 0.007131251338487316]]	-1	0.065798	-0.065798	3

91 rows × 12 columns

In [63]:
```
P = len(y['error'])
MSE_T = np.sum(np.square(y['error']))/P
MSE_T
```

Out[63]: 4.215419660252756e-08

In [64]:
```
MSE_R = np.sum(np.square(y['s_change']))/P
MSE_R
```

Out[64]: 4.2298706938516495e-08

DMW Test

In [65]:
```
import scipy.stats as st
```

In [66]:
```
error_R = y['s_change'].reset_index(drop=True)
error_T = y['error'].reset_index(drop=True)
tmp = np.square(error_R) - np.square(error_T) - (MSE_R - MSE_T)
V_hat = np.sum(np.square(tmp))/P

## Statistic
DMW = (MSE_R - MSE_T)/np.sqrt(V_hat/P)

print('Since the DMW statitsic is equal to ' + str(DMW) + ',' + ' w
print('we fail to reject the null hypothesis that the MP model does
```

```
Since the DMW statitsic is equal to 0.012124352779876712, which is
less than the critical value (1.64),
we fail to reject the null hypothesis that the MP model does not o
utperform the random walk model, hence our model does outperform t
he random walk model.
```

CW Test

In [67]:
```
y['s_change_pred'] = y['predictions']-y['Japan'].shift()
```

In [69]:
```
tmp2 = np.sum(np.square(y['s_change_pred']))/P
CW = (MSE_R - MSE_T + tmp2)/np.sqrt(V_hat/P)

print('Since the CW statitsic is equal to ' + str(CW) + ',' + ' whi
print('we fail to reject the null hypothesis that the MP model does
```

```
Since the CW statitsic is equal to 0.07494334582115675, which is l
esser than the critical value (1.64),
we fail to reject the null hypothesis that the MP model does not o
utperforms the random walk model. Hence, the Random Walk outperfor
ms the MP model
```

In [ ]: