Time Series Forecasting

September 16, 2023

[37]:
```
import numpy as np
import pandas as pd
import seaborn as sns
from matplotlib import pyplot as plt
from statsmodels.tsa.api import ExponentialSmoothing, SimpleExpSmoothing, Holt
from sklearn.linear_model import LinearRegression
import warnings
warnings.filterwarnings('ignore')
```

[38]:
```
data=pd.read_csv("gold_monthly_csv.csv")
```

[39]:
```
data.head()
```

[39]:

	Date	Price
0	1950-01	34.73
1	1950-02	34.73
2	1950-03	34.73
3	1950-04	34.73
4	1950-05	34.73

[40]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 847 entries, 0 to 846
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   Date    847 non-null    object
 1   Price   847 non-null    float64
dtypes: float64(1), object(1)
memory usage: 13.4+ KB
```

[41]:
```
data.describe()
```

[41]:

	Price
count	847.000000
mean	416.556906
std	453.665313

```
min      34.490000
25%      35.190000
50%     319.622000
75%     447.029000
max    1840.807000
```

[42]:
```python
data.isnull().sum()
```

[42]:
```
Date     0
Price    0
dtype: int64
```

[43]:
```python
data.shape
```

[43]:
```
(847, 2)
```

[44]:
```python
# Date Range of Gold Prices
```

[45]:
```python
data.loc[:,"Date"][0] , data.loc[:,"Date"][len(data)-1]
```

[45]:
```
('1950-01', '2020-07')
```

[46]:
```python
date=pd.date_range(start='1/1/1950',end= '8/1/2020',freq='M')
```

[47]:
```python
date
```

[47]:
```
DatetimeIndex(['1950-01-31', '1950-02-28', '1950-03-31', '1950-04-30',
               '1950-05-31', '1950-06-30', '1950-07-31', '1950-08-31',
               '1950-09-30', '1950-10-31',
               …
               '2019-10-31', '2019-11-30', '2019-12-31', '2020-01-31',
               '2020-02-29', '2020-03-31', '2020-04-30', '2020-05-31',
               '2020-06-30', '2020-07-31'],
              dtype='datetime64[ns]', length=847, freq='M')
```

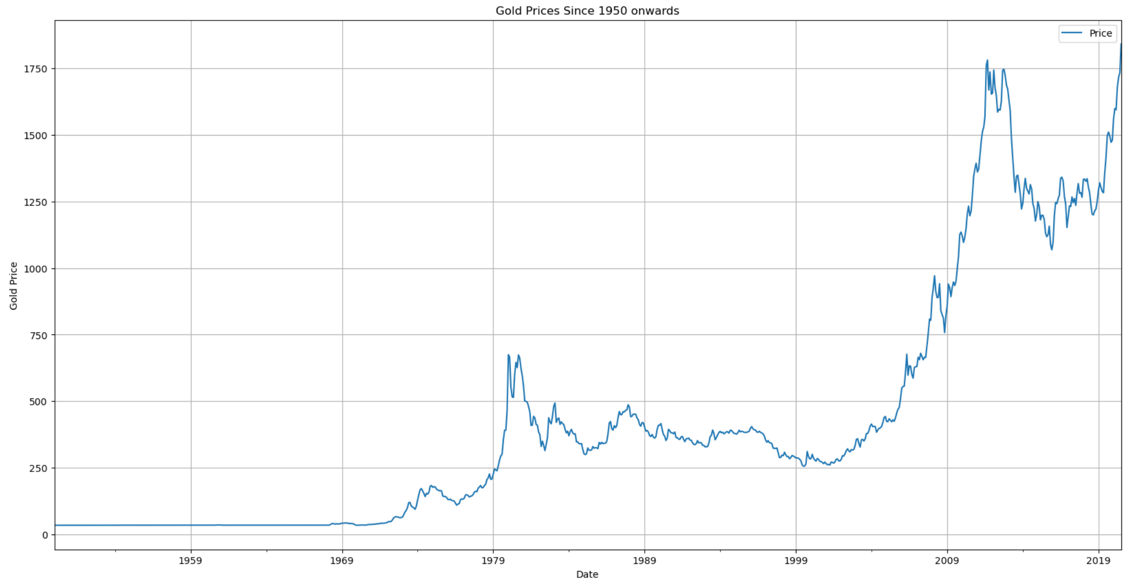
[48]:
```python
data['Month']=date
data.drop("Date",axis=1,inplace=True)
data=data.set_index('Month')
data.head()
```

[48]:

	Price
Month	
1950-01-31	34.73
1950-02-28	34.73
1950-03-31	34.73
1950-04-30	34.73
1950-05-31	34.73

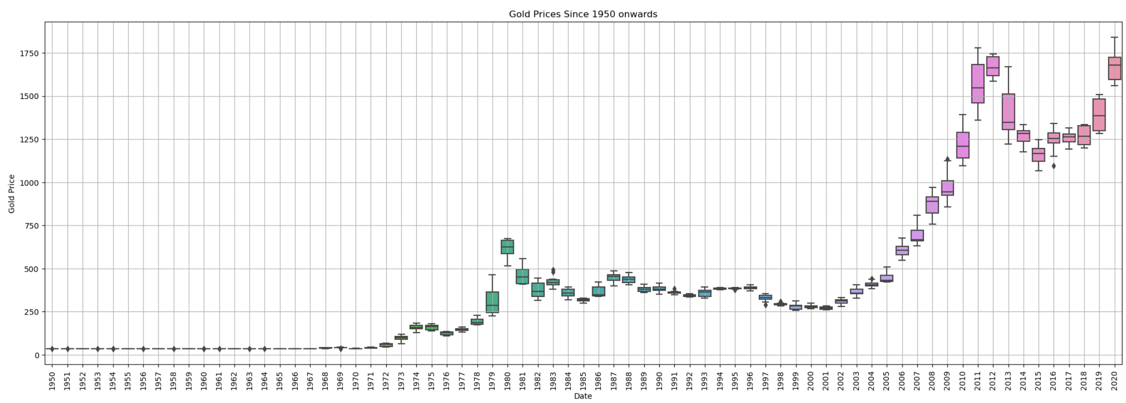
[50]:

```
data.plot(figsize=(20,10))
plt.title('Gold Prices Since 1950 onwards')
plt.xlabel('Date')
plt.ylabel('Gold Price')
plt.grid()
```

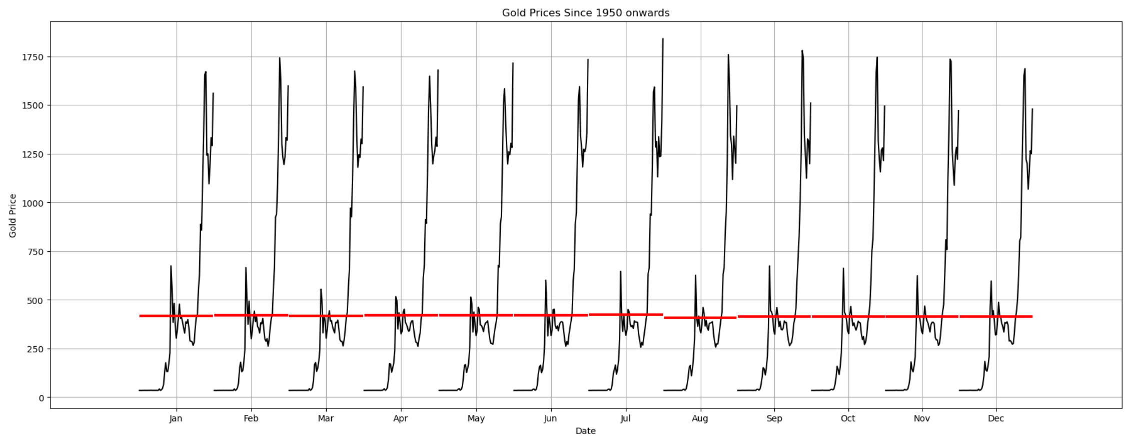


[53]:

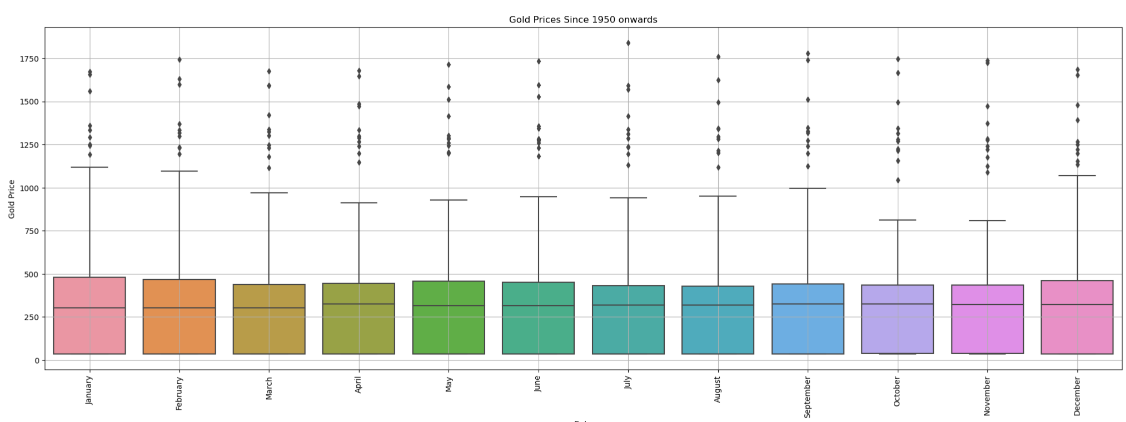
```
_,ax=plt.subplots(figsize=(25,8))
sns.boxplot(x=data.index.year,y=data.values[:,0],ax=ax)
plt.title('Gold Prices Since 1950 onwards')
plt.xlabel('Date')
plt.ylabel('Gold Price')
plt.xticks(rotation=90)
plt.grid()
```



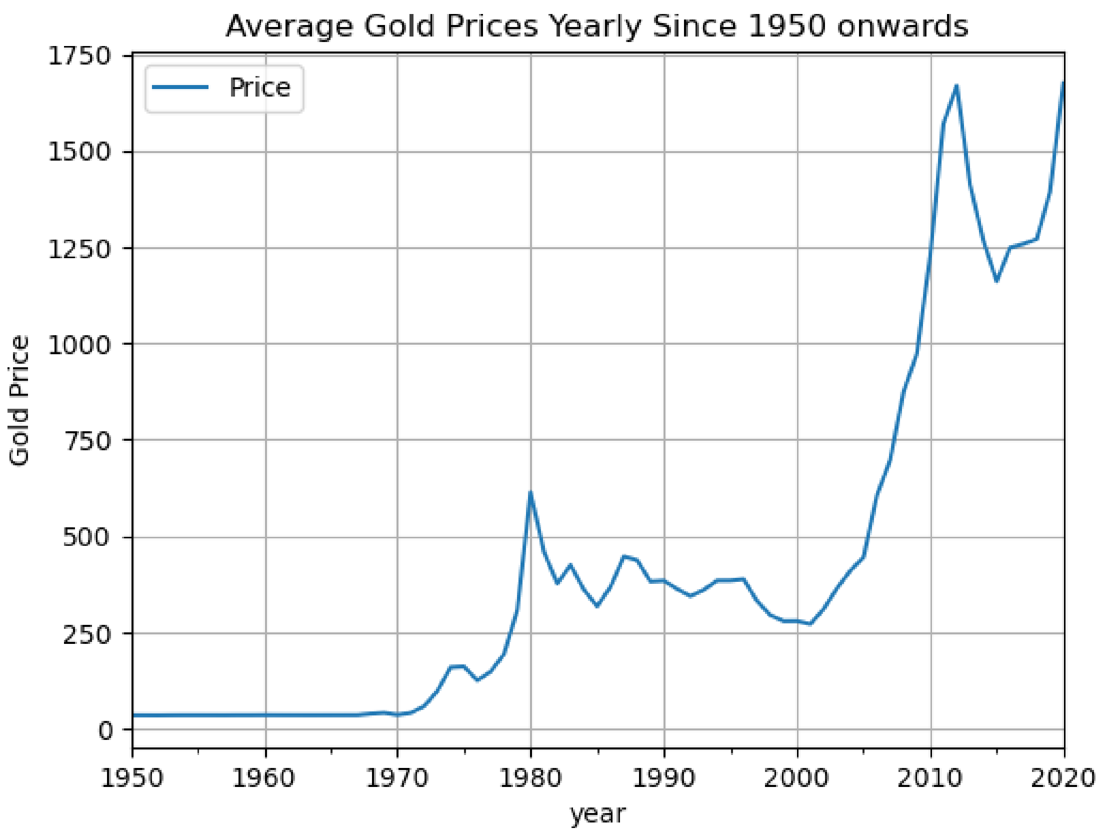
[54]:
```python
from statsmodels.graphics.tsaplots import month_plot
fig,ax=plt.subplots(figsize=(22,8))
month_plot(data,ylabel="Gold Price",ax=ax )
plt.title('Gold Prices Since 1950 onwards')
plt.xlabel('Date')
plt.ylabel('Gold Price')
plt.grid()
```



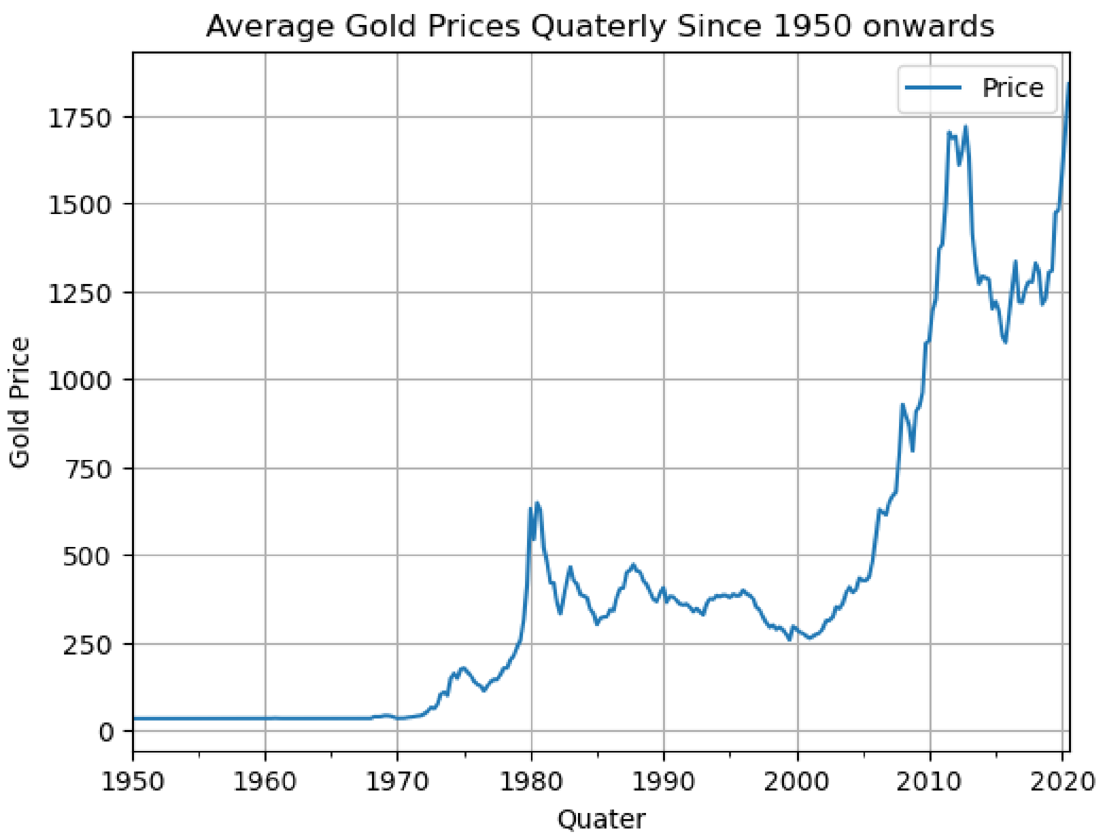
[55]:
```python
_,ax=plt.subplots(figsize=(25,8))
sns.boxplot(x=data.index.month_name(),y=data.values[:,0],ax=ax)
plt.title('Gold Prices Since 1950 onwards')
plt.xlabel('Date')
plt.ylabel('Gold Price')
plt.xticks(rotation=90)
plt.grid()
```



[56]:
```
data_yearly_sum=data.resample('A').mean()
data_yearly_sum.plot()
plt.title('Average Gold Prices Yearly Since 1950 onwards')
plt.xlabel('year')
plt.ylabel('Gold Price')
plt.grid()
```

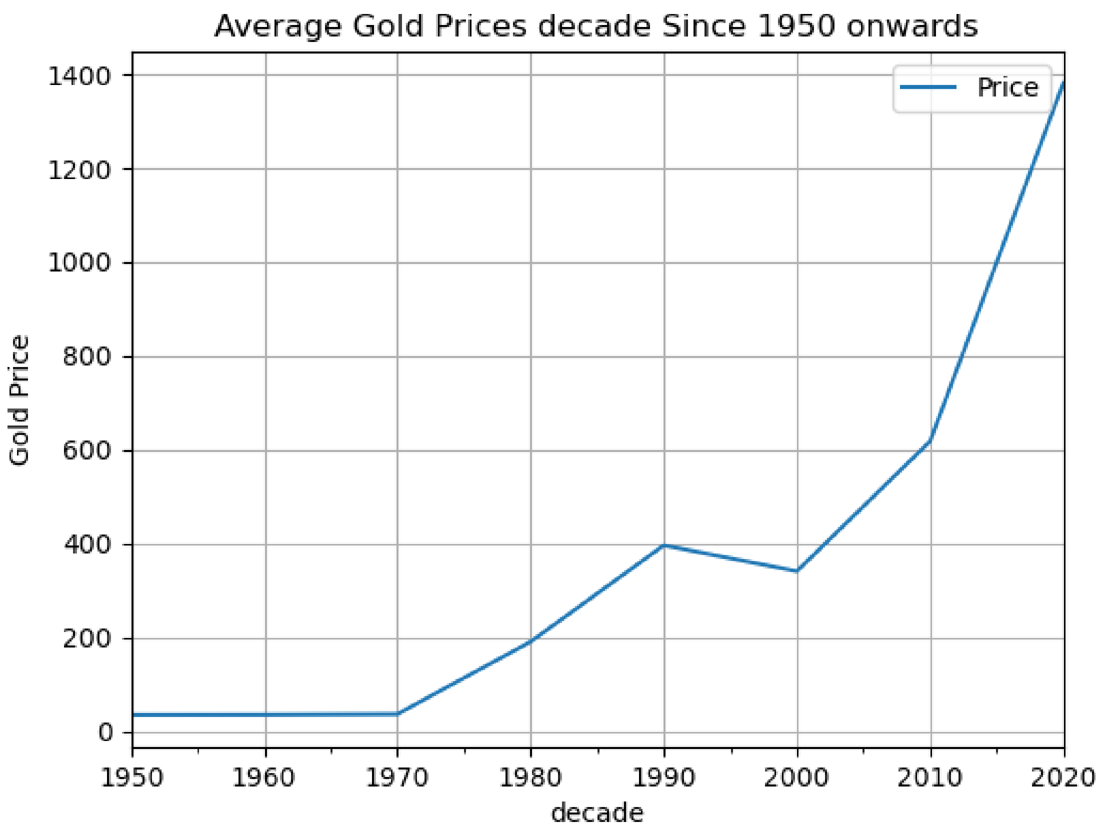


[58]:
```
data_quaterly_sum=data.resample('Q').mean()
data_quaterly_sum.plot()
plt.title('Average Gold Prices Quaterly Since 1950 onwards')
plt.xlabel('Quater')
plt.ylabel('Gold Price')
plt.grid()
```



[59]:

```
data_decade_sum=data.resample('10Y').mean()
data_decade_sum.plot()
plt.title('Average Gold Prices decade Since 1950 onwards')
plt.xlabel('decade')
plt.ylabel('Gold Price')
plt.grid()
```

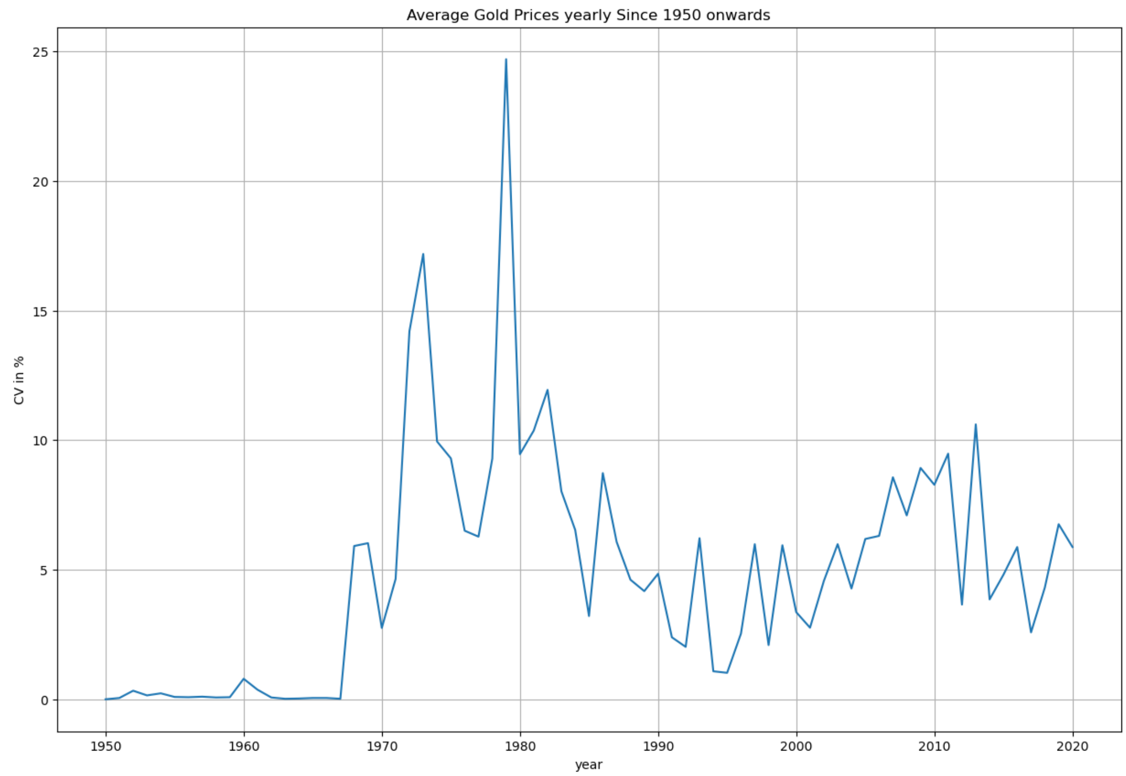


[64]:
```
df=data.groupby(data.index.year).mean().rename(columns={"Price":"Mean"})
df=df.merge(data.groupby(data.index.year).std().rename(columns={"Price":
↪"Std"}),left_index=True,right_index=True)
df["COV_PCT"]=((df['Std']/df["Mean"])*100).round(2)
df.head()
```

[64]:

Month	Mean	Std	COV_PCT
1950	34.729167	0.002887	0.01
1951	34.717500	0.020057	0.06
1952	34.628333	0.117538	0.34
1953	34.879167	0.056481	0.16
1954	35.020000	0.082792	0.24

[65]:
```
fig,ax=plt.subplots(figsize=(15,10))
df["COV_PCT"].plot()
plt.title('Average Gold Prices yearly Since 1950 onwards')
plt.xlabel('year')
plt.ylabel('CV in %')
plt.grid()
```



[66]:
```
train=data[data.index.year<=2015]
test=data[data.index.year>2015]
```

[67]:
```
train.shape
```

[67]: (792, 1)

[68]:
```
test.shape
```

[68]: (55, 1)

[70]:
```
train['Price'].plot(figsize=(15,5))
test['Price'].plot(figsize=(15,5))
plt.grid()
plt.legend(["Training Data","Test Data"])
plt.show()
```


```
[75]: # Fit the Model(Linear Regression)
```

```
[78]: train_time=[i+1 for i in range(len(train))]
      test_time=[1+len(train)+1 for i in range(len(test))]
```

```
[79]: LR_train=train.copy()
      LR_test=test.copy()
```

```
[80]: LR_train['time']=train_time
      LR_test['time']=test_time
```

```
[89]: model=LinearRegression()
      model.fit(LR_train[['time']],LR_train['Price'].values)
```

```
[89]: LinearRegression()
```

```
[91]: test_prediction=model.predict(LR_test[['time']])
```

```
[92]: test_prediction
```

```
[92]: array([896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016,
             896.8809016, 896.8809016, 896.8809016, 896.8809016, 896.8809016])
```

```
[93]: LR_test["forcast"]=test_prediction
```

[95]:

```
plt.figure(figsize=(14,6))
plt.plot(train["Price"],label="train")
plt.plot(test["Price"],label="test")
plt.plot(LR_test["forcast"],label="regression on time_test data")
plt.legend()
plt.grid()
```

[96]:

```
def mape(actual,pred):
    return round((np.mean(abs(actual-pred)/actual))*100,2)
```

[97]:

```
mape_model_test=mape(test['Price'].values,test_prediction)
```

[98]:

```
mape_model_test
```

[98]:

```
32.32
```

[99]:

```
Naive_train=train.copy()
Naive_test=test.copy()
```

[101]:

```
Naive_test['naive']=np.asarray(train["Price"])[len(np.
 ↪asarray(train["Price"]))-1]
Naive_test['naive'].head()
```

[101]:

```
Month
2016-01-31    1068.317
2016-02-29    1068.317
2016-03-31    1068.317
2016-04-30    1068.317
2016-05-31    1068.317
Name: naive, dtype: float64
```

[102]:
```
plt.figure(figsize=(14,6))
plt.plot(Naive_train["Price"],label="train")
plt.plot(test["Price"],label="test")
plt.plot(Naive_test["naive"],label="naive forcast on test data")
plt.legend()
plt.title('Naive Forecast')
plt.grid()
```

[103]:
```
mape_model_test_2=mape(test['Price'].values,Naive_test['naive'].values)
```

[104]:
```
mape_model_test_2
```

[104]: 19.38

[105]:
```
# Final Forecasting
```

[106]:
```
final_model=ExponentialSmoothing(data,trend="additive",seasonal="additive").
  ↪fit(smoothing_level=0.4,smoothing_trend=0.3,smoothing_seasonal=0.6)
```

[107]:
```
Mape_final_model=mape(data['Price'].values,final_model.fittedvalues)
```

[108]:
```
Mape_final_model
```

[108]: 17.24

[109]:
```
predictions=final_model.forecast(steps=len(test))
```

[111]:
```
pred_df=pd.DataFrame({'Lower_CI':predictions-1.96*np.std(final_model.
  ↪resid,ddof=1),
                      'Prediction':predictions,
```

```
                    'Upper_CI':predictions+1.96*np.std(final_model.
↪resid,ddof=1)
                   })
```

[115]:
```
pred_df.head(10)
```

[115]:

	Lower_CI	Prediction	Upper_CI
2020-08-31	1684.718274	1792.869246	1901.020219
2020-09-30	1615.301815	1723.452788	1831.603760
2020-10-31	1538.560879	1646.711851	1754.862823
2020-11-30	1476.748832	1584.899804	1693.050776
2020-12-31	1459.315210	1567.466182	1675.617154
2021-01-31	1514.403893	1622.554865	1730.705837
2021-02-28	1545.337867	1653.488839	1761.639811
2021-03-31	1556.749789	1664.900761	1773.051733
2021-04-30	1648.295729	1756.446701	1864.597673
2021-05-31	1694.212521	1802.363493	1910.514465

[121]:
```
axis=data.plot(label="Actual",figsize=(18,10))
pred_df['Prediction'].plot(ax=axis,label="Forecast",alpha=0.5)
axis.fill_between(pred_df.index,pred_df['Lower_CI'],pred_df['Upper_CI'],alpha=.
↪15)
axis.set_xlabel('year-month')
axis.set_ylabel('price')
plt.legend()
plt.grid()
```