Import Library

In [1]:
```
%matplotlib inline
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import yfinance as yf
from datetime import datetime, timedelta

import warnings
warnings.filterwarnings('ignore')
np.random.seed(42)
```

Load dataset

In [2]:
```
ticker = 'GC=F'
end_date = datetime.today().strftime('%Y-%m-%d')

gold_data = yf.download(ticker, start='2004-01-01', end=end_date)

goldDF = pd.DataFrame(gold_data).reset_index()

goldDF
```

```
[*********************100%%**********************]  1 of 1 completed
```

Out[2]:

	Date	Open	High	Low	Close	Adj Close	Volume
0	2004-01-05	415.700012	422.500000	422.500000	424.399994	424.399994	20
1	2004-01-06	424.399994	424.299988	424.299988	422.799988	422.799988	20
2	2004-01-07	423.000000	423.000000	423.000000	421.899994	421.899994	20
3	2004-01-08	421.899994	422.000000	422.000000	424.000000	424.000000	20
4	2004-01-09	424.000000	423.899994	423.899994	426.399994	426.399994	20
...	...	...	...	...	...	...	...
5033	2024-01-15	2051.699951	2054.800049	2051.699951	2054.800049	2054.800049	390
5034	2024-01-16	2051.699951	2054.800049	2026.000000	2026.000000	2026.000000	46
5035	2024-01-17	2026.500000	2026.500000	2002.599976	2002.599976	2002.599976	764
5036	2024-01-18	2012.800049	2018.599976	2009.500000	2018.599976	2018.599976	1474
5037	2024-01-19	2023.199951	2036.000000	2019.500000	2026.500000	2026.500000	1474

5038 rows × 7 columns

Exploratory Data Analysis (EDA)

In [3]:
```
# Display data types
goldDF.dtypes
```

Out[3]:
```
Date         datetime64[ns]
Open                float64
High                float64
Low                 float64
Close               float64
Adj Close           float64
Volume                int64
dtype: object
```

In [4]:
```
# Display information about the DataFrame
goldDF.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5038 entries, 0 to 5037
Data columns (total 7 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   Date       5038 non-null   datetime64[ns]
 1   Open       5038 non-null   float64
 2   High       5038 non-null   float64
 3   Low        5038 non-null   float64
 4   Close      5038 non-null   float64
 5   Adj Close  5038 non-null   float64
 6   Volume     5038 non-null   int64
dtypes: datetime64[ns](1), float64(5), int64(1)
memory usage: 275.6 KB
```

Data Cleaning

In [5]:
```
# Checking for missing values
missing_values = goldDF.isnull().sum()
print("Missing Values:\n", missing_values)
```

```
Missing Values:
 Date         0
Open         0
High         0
Low          0
Close        0
Adj Close    0
Volume       0
dtype: int64
```

In [6]:
```
# Handling missing values (if have)
goldDF = goldDF.dropna()
```

In [7]:
```
# Summary statistics
summary_stats = goldDF.describe()
print("Summary Statistics:\n", summary_stats)
```

```
Summary Statistics:
                                  Date         Open         High
Low  \
count                           5038  5038.000000  5038.000000  503
8.000000
mean   2014-01-14 13:22:01.953156096  1242.537277  1248.790294  123
5.903593
min              2004-01-05 00:00:00   375.799988   375.799988   37
5.799988
25%              2009-01-13 06:00:00   921.300003   926.600006   91
5.225006
50%              2014-01-14 12:00:00  1269.799988  1274.649963  126
4.750000
75%              2019-01-21 00:00:00  1629.174957  1641.125031  161
9.675049
max              2024-01-19 00:00:00  2081.600098  2130.199951  206
6.500000
std                              NaN   454.465985   456.898311   45
1.944020

             Close    Adj Close         Volume
count  5038.000000  5038.000000    5038.000000
mean   1242.398233  1242.398233    4802.149266
min     374.799988   374.799988       0.000000
25%     922.225006   922.225006      30.250000
50%    1270.400024  1270.400024     127.000000
75%    1628.100037  1628.100037     437.750000
max    2081.899902  2081.899902  386334.000000
std     454.423420   454.423420   26130.262789
```

In [8]:
```
goldDF.std()
```

Out[8]:
```
Date         2112 days 23:12:11.356896672
Open                           454.465985
High                           456.898311
Low                             451.94402
Close                           454.42342
Adj Close                       454.42342
Volume                       26130.262789
dtype: object
```

Statistical Analysis and Hypothesis Testing

In [9]:
```
# Calculate mean and standard deviation difference
mean_difference = (goldDF['Adj Close'] - goldDF['Close']).mean()
std_difference = (goldDF['Adj Close'] - goldDF['Close']).std()

print(f"Mean Difference: {mean_difference:.2f} USD")
print(f"Standard Deviation of Difference: {std_difference:.2f} USI
```

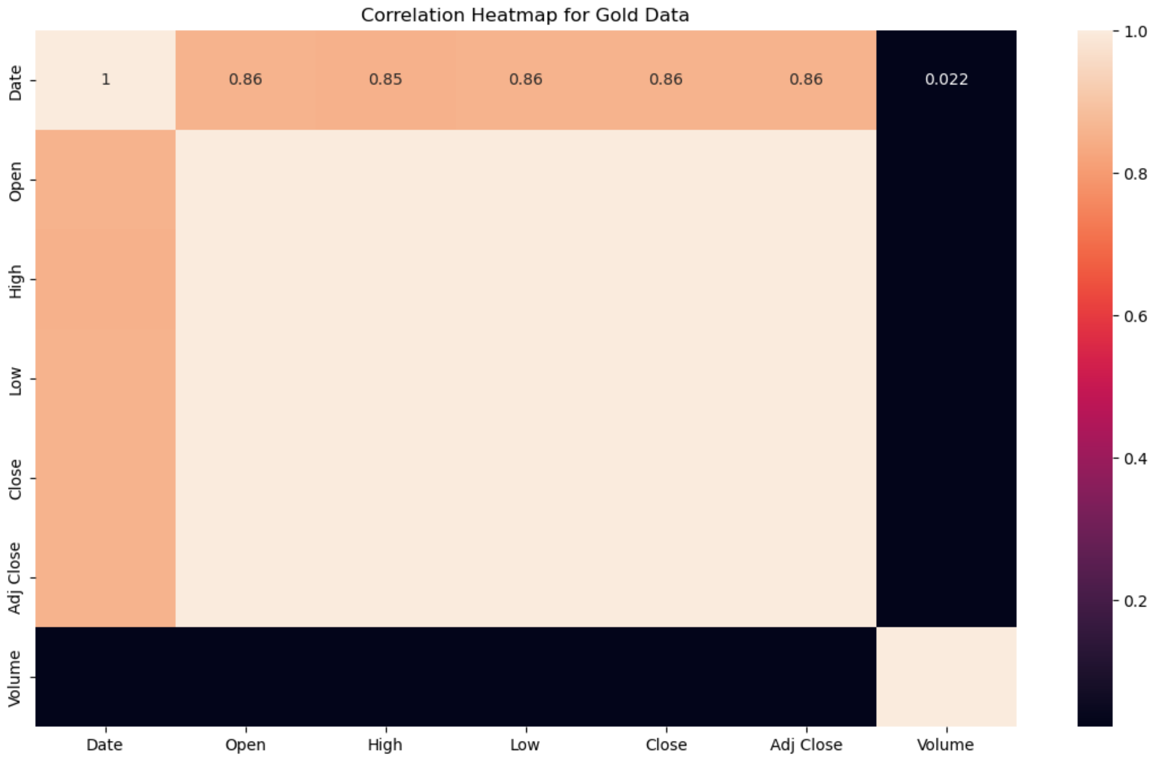
```
Mean Difference: 0.00 USD
Standard Deviation of Difference: 0.00 USD
```

In [10]:

```
goldDF_corr = goldDF.corr()
goldDF_corr

plt.figure(figsize=(14, 8))
sns.heatmap(goldDF_corr, annot=True)

plt.title('Correlation Heatmap for Gold Data')
plt.show()
```



Model Selection and Development

In [11]:

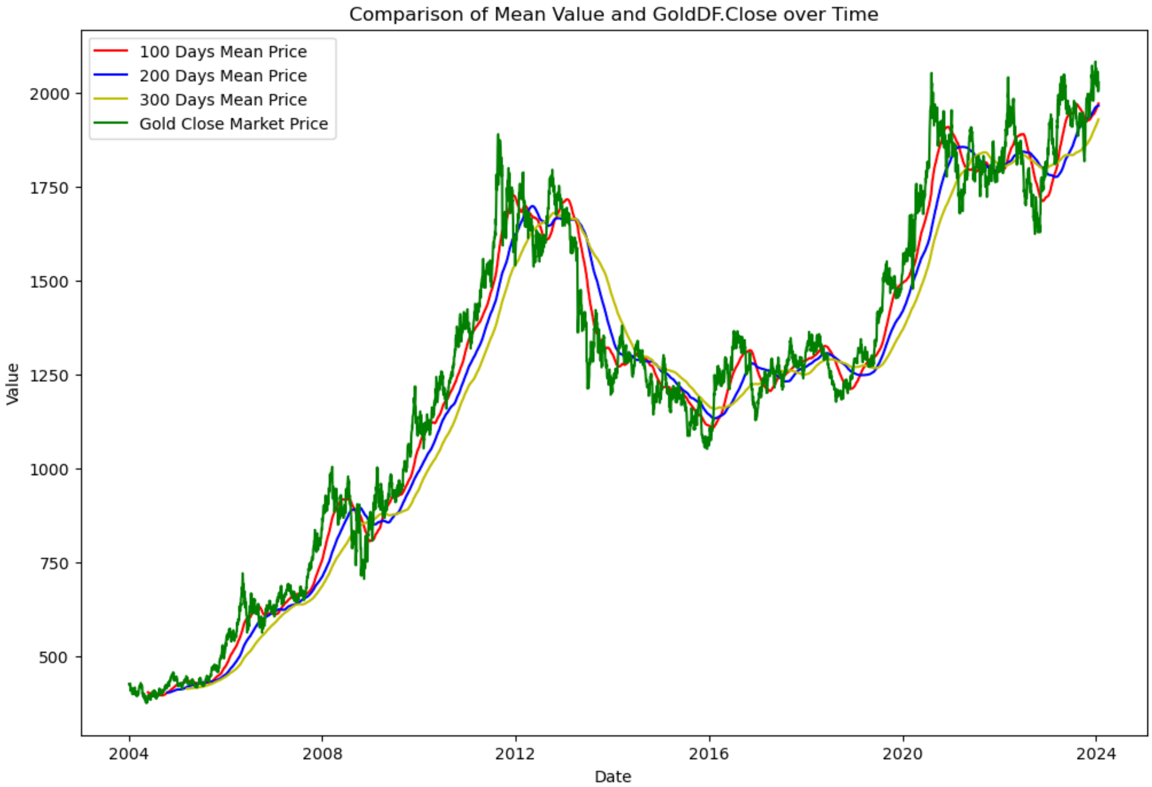
```
# Calculate moving averages
maen100Days = goldDF['Close'].rolling(100).mean()
maen200Days = goldDF['Close'].rolling(200).mean()
maen300Days = goldDF['Close'].rolling(300).mean()
```

In [12]:
```
# Plot mean values and gold close prices over time
plt.figure(figsize=(12, 8))

plt.plot(goldDF['Date'], maen100Days, 'r', label='100 Days Mean Pr
plt.plot(goldDF['Date'], maen200Days, 'b', label='200 Days Mean Pr
plt.plot(goldDF['Date'], maen300Days, 'y', label='300 Days Mean Pr

plt.plot(goldDF['Date'], goldDF['Close'], 'g', label='Gold Close M

plt.title('Comparison of Mean Value and GoldDF.Close over Time')
plt.xlabel('Date')
plt.ylabel('Value')
plt.legend()
plt.show()
```



In [13]:

```
# Check Adj Close Price with Close Price difference
plt.figure(figsize=(12, 8))

plt.plot(goldDF['Date'], goldDF['Adj Close'], label='Adjusted Clos
plt.plot(goldDF['Date'], goldDF['Close'], label='Close Price', lir

plt.legend()
plt.title('Adjusted Close Price vs. Closed Market Price')
plt.xlabel('Date')
plt.ylabel('Price (USD)')

plt.show()
```

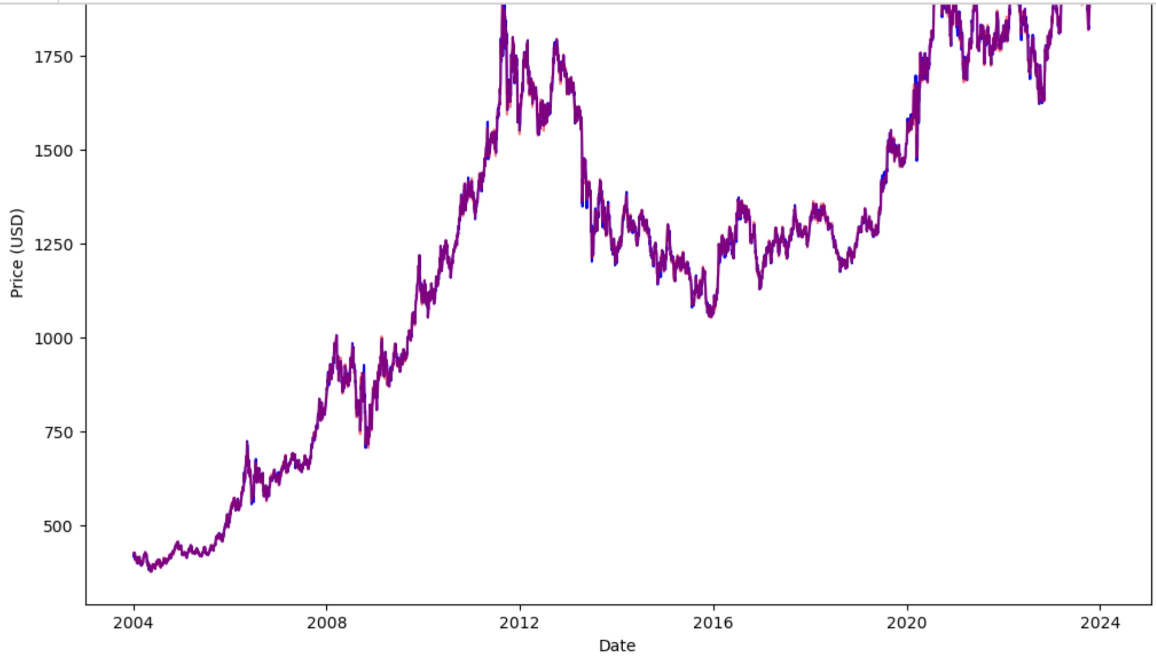
In [14]:

```
# Check Close Price with Open Price difference
plt.figure(figsize=(12, 8))

plt.plot(goldDF['Date'], goldDF['Open'], label='Open', linestyle='
plt.plot(goldDF['Date'], goldDF['Close'], label='Close', linestyle

plt.legend()
plt.title('Gold Price Open Market vs. Closed Market')
plt.xlabel('Date')
plt.ylabel('Price (USD)')

plt.show()
```



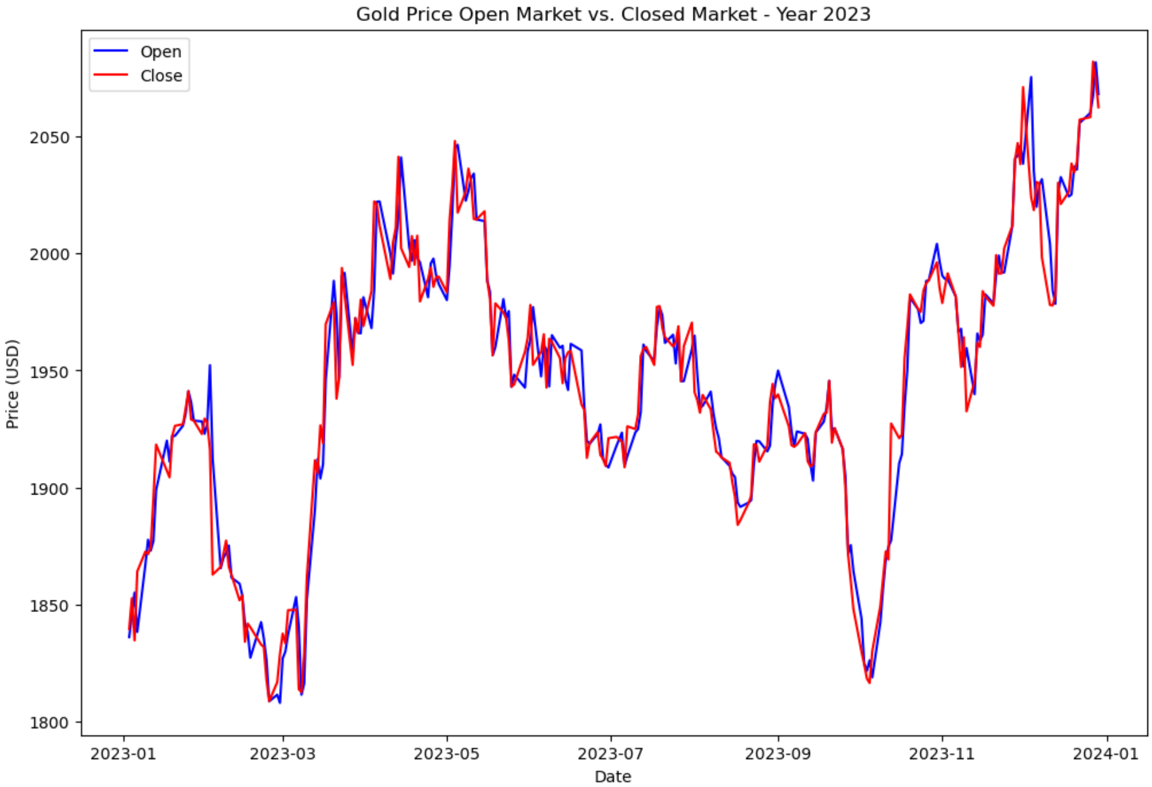
In [15]:
```
# Show Year 2023 plot
year2023 = goldDF[goldDF['Date'].dt.year == 2023]

plt.figure(figsize=(12, 8))

plt.plot(year2023['Date'], year2023['Open'], label='Open', linesty
plt.plot(year2023['Date'], year2023['Close'], label='Close', lines

plt.legend()
plt.title('Gold Price Open Market vs. Closed Market - Year 2023')
plt.xlabel('Date')
plt.ylabel('Price (USD)')

plt.show()
```



In [16]:

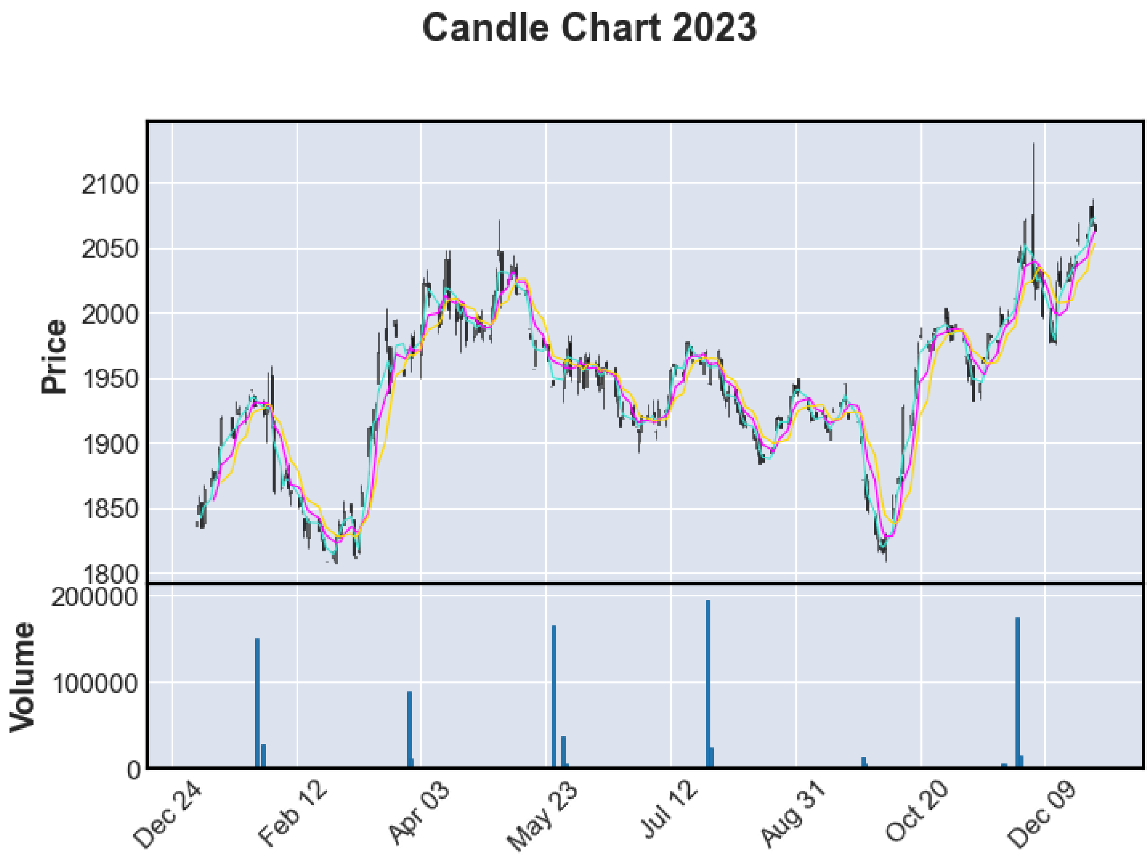
```python
import mplfinance as mpf

# Show the plot use Candlen Chart
Fdf = goldDF.copy()
Fdf.set_index('Date', inplace=True)

dec_2023 = Fdf.loc['2023-01-01':'2023-12-31']

mpf.plot(dec_2023, type='candle', mav=(3, 6, 9), figratio=(12, 8),
         title='Candle Chart 2023', show_nontrading=True)

mpf.show()
```



In [17]:
```python
# Find the Top 5 volume at December 2023
goldDF['Date'] = pd.to_datetime(goldDF['Date'])

dec_2023_data = goldDF[(goldDF['Date'].dt.year == 2023) & (goldDF[

top_5_volume_dec_2023 = dec_2023_data.sort_values(by='Volume', asc

print(top_5_volume_dec_2023)
```

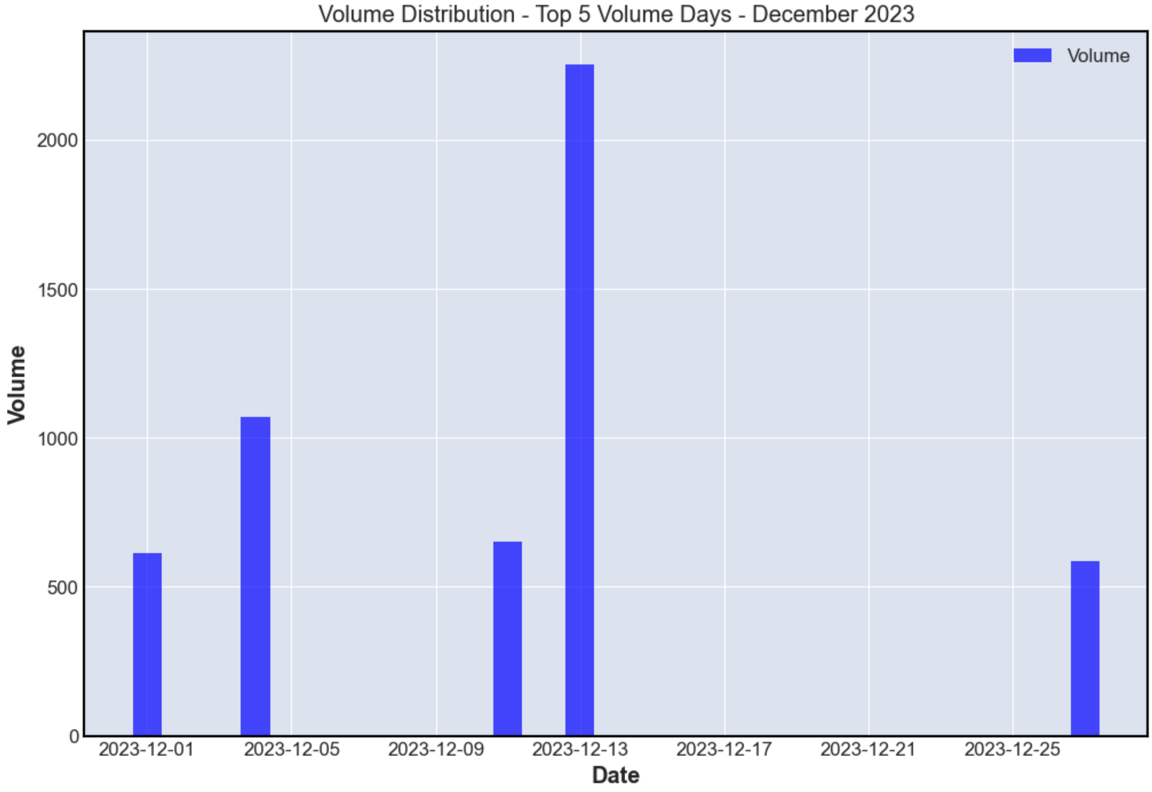
```
            Date         Open         High          Low        Close  \
5012 2023-12-13  1978.500000  2024.800049  1975.000000  1982.300049
5005 2023-12-04  2075.300049  2130.199951  2021.000000  2024.099976
5010 2023-12-11  2004.099976  2004.199951  1977.199951  1978.000000
5004 2023-12-01  2038.300049  2073.199951  2036.000000  2071.000000
5021 2023-12-27  2067.300049  2081.899902  2064.800049  2081.899902

        Adj Close  Volume
5012  1982.300049    2252
5005  2024.099976    1071
5010  1978.000000     651
5004  2071.000000     614
5021  2081.899902     586
```

In [18]:
```python
# Plotting the Top 5 Volume
plt.figure(figsize=(12, 8))
plt.bar(top_5_volume_dec_2023['Date'], top_5_volume_dec_2023['Volu

plt.legend(['Volume'])
plt.title('Volume Distribution - Top 5 Volume Days - December 202
plt.xlabel('Date')
plt.ylabel('Volume')

plt.show()
```



2023-12-13 - CPI report The U.S. CPI increased by 3.1% in November, and the market expects the Federal Reserve to continue to push interest rates higher on Wednesday. This report is bullish for gold, so traders will choose to enter the market at this time.

2023-12-22 - GDP report annualized growth rate is 4.9%, lower than the previous 5.2. This report is bullish for gold, so traders will choose to enter the market at this time.

The main reasons why gold rises and the US dollar falls

- Economic Uncertainty
- Inflation Hedge
- Currency Depreciation

Model Training and Validation

In [19]:
```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, MinMaxScaler
from sklearn.ensemble import RandomForestClassifier, GradientBoos
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score
from keras.models import Sequential, Model
from keras.layers import LSTM, Dense, Dropout, Input
from keras.optimizers import Nadam
from sklearn.metrics import mean_absolute_percentage_error

goldDF['Daily_Return'] = goldDF['Close'].pct_change()

goldDF['Price_Up'] = (goldDF['Daily_Return'] > 0).astype(int)

features = ['Open', 'High', 'Low', 'Volume', 'Close']
target = 'Price_Up'
X = goldDF[features]
y = goldDF[target]

X_train, X_test, y_train, y_test = train_test_split(X, y, test_si

# RandomForestClassifier
rf_classifier = RandomForestClassifier(random_state=42)
rf_classifier.fit(X_train, y_train)
rf_predictions = rf_classifier.predict(X_test)
rf_accuracy = accuracy_score(y_test, rf_predictions)

# Support Vector Machine (SVM)
svm_classifier = SVC(random_state=42)
svm_classifier.fit(X_train, y_train)
svm_predictions = svm_classifier.predict(X_test)
svm_accuracy = accuracy_score(y_test, svm_predictions)

# GradientBoostingClassifier
gb_classifier = GradientBoostingClassifier(random_state=42)
gb_classifier.fit(X_train, y_train)
gb_predictions = gb_classifier.predict(X_test)
gb_accuracy = accuracy_score(y_test, gb_predictions)

# Logistic Regression
logreg_classifier = LogisticRegression(random_state=42)
logreg_classifier.fit(X_train, y_train)
logreg_predictions = logreg_classifier.predict(X_test)
logreg_accuracy = accuracy_score(y_test, logreg_predictions)

# Feature Scaling for LSTM
scaler = MinMaxScaler()
scaler.fit(goldDF.Close.values.reshape(-1,1))

test_size = 365
test_data = goldDF[-test_size:]

window_size = 60

def prepare_lstm_data(data, window_size):
    X, y = [], []
    for i in range(window_size, len(data)):
        X.append(data[i - window_size:i, 0])
        y.append(data[i, 0])
    return np.array(X), np.array(y)
```

```python

train_data = goldDF['Close'][:-test_size]
train_data = scaler.transform(train_data.values.reshape(-1, 1))
X_train, y_train = prepare_lstm_data(train_data, window_size)

test_data = goldDF['Close'][-test_size - window_size:]
test_data = scaler.transform(test_data.values.reshape(-1, 1))
X_test, y_test = prepare_lstm_data(test_data, window_size)

X_train = np.reshape(X_train, (X_train.shape[0], X_train.shape[1]
X_test = np.reshape(X_test, (X_test.shape[0], X_test.shape[1], 1)
y_train = np.reshape(y_train, (-1, 1))
y_test = np.reshape(y_test, (-1, 1))

def define_model():
    model = Sequential()
    model.add(LSTM(units=64, return_sequences=True, input_shape=(
    model.add(Dropout(0.2))
    model.add(LSTM(units=64, return_sequences=True))
    model.add(Dropout(0.2))
    model.add(LSTM(units=64))
    model.add(Dropout(0.2))
    model.add(Dense(32, activation='softmax'))
    model.add(Dense(1))

    model.compile(loss='mean_squared_error', optimizer=Nadam())
    model.summary()

    return model

model = define_model()
history = model.fit(X_train, y_train, epochs=150, batch_size=32,
y_pred = model.predict(X_test)

MAPE = mean_absolute_percentage_error(y_test, y_pred)
lstm_accuracy = 1 - MAPE

print(f"Random Forest Accuracy: {rf_accuracy:.2%}")
print(f"SVM Accuracy: {svm_accuracy:.2%}")
print(f"Gradient Boosting Accuracy: {gb_accuracy:.2%}")
print(f"Logistic Regression Accuracy: {logreg_accuracy:.2%}")
print(f'LSTM model Accuracy: {lstm_accuracy:.2%}')
```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizer
s.Nadam` runs slowly on M1/M2 Macs, please use the legacy Keras opti
mizer instead, located at `tf.keras.optimizers.legacy.Nadam`.
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 lstm (LSTM)                 (None, 60, 64)            16896     
                                                                 
 dropout (Dropout)           (None, 60, 64)            0         
                                                                 
 lstm_1 (LSTM)               (None, 60, 64)            33024     
                                                                 
 dropout_1 (Dropout)         (None, 60, 64)            0         
                                                                 
 lstm_2 (LSTM)               (None, 64)                33024     
                                                                 
 dropout_2 (Dropout)         (None, 64)                0         
                                                                 
 dense (Dense)               (None, 32)                2080      
                                                                 
 dense_1 (Dense)             (None, 1)                 33        
                                                                 
=================================================================
Total params: 85057 (332.25 KB)
Trainable params: 85057 (332.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/150
130/130 [==============================] - 9s 48ms/step - loss: 0.06
87 - val_loss: 0.1403
Epoch 2/150
130/130 [==============================] - 6s 46ms/step - loss: 0.00
99 - val_loss: 0.0584
Epoch 3/150
130/130 [==============================] - 6s 47ms/step - loss: 0.00
41 - val_loss: 0.0297
Epoch 4/150
130/130 [==============================] - 6s 47ms/step - loss: 0.00
21 - val_loss: 0.0165
Epoch 5/150
130/130 [==============================] - 6s 47ms/step - loss: 0.00
14 - val_loss: 0.0104
Epoch 6/150
130/130 [==============================] - 6s 47ms/step - loss: 0.00
12 - val_loss: 0.0072
Epoch 7/150
130/130 [==============================] - 6s 48ms/step - loss: 9.93
34e-04 - val_loss: 0.0051
Epoch 8/150
130/130 [==============================] - 6s 48ms/step - loss: 8.66
94e-04 - val_loss: 0.0037
Epoch 9/150
130/130 [==============================] - 6s 48ms/step - loss: 8.14
08e-04 - val_loss: 0.0030
Epoch 10/150
130/130 [==============================] - 6s 47ms/step - loss: 7.99
01e-04 - val_loss: 0.0025
Epoch 11/150
130/130 [==============================] - 6s 47ms/step - loss: 7.20
77e-04 - val_loss: 0.0019
Epoch 12/150
130/130 [==============================] - 6s 47ms/step - loss: 6.80
42e-04 - val_loss: 0.0029
```

```
Epoch 13/150
130/130 [==============================] - 6s 47ms/step - loss: 6.09
63e-04 - val_loss: 0.0014
Epoch 14/150
130/130 [==============================] - 6s 48ms/step - loss: 5.80
43e-04 - val_loss: 9.6973e-04
Epoch 15/150
130/130 [==============================] - 6s 48ms/step - loss: 5.67
25e-04 - val_loss: 8.0587e-04
Epoch 16/150
130/130 [==============================] - 6s 48ms/step - loss: 5.31
61e-04 - val_loss: 7.9941e-04
Epoch 17/150
130/130 [==============================] - 6s 48ms/step - loss: 4.75
89e-04 - val_loss: 9.7697e-04
Epoch 18/150
130/130 [==============================] - 6s 49ms/step - loss: 4.98
34e-04 - val_loss: 5.8434e-04
Epoch 19/150
130/130 [==============================] - 6s 48ms/step - loss: 4.78
89e-04 - val_loss: 9.9430e-04
Epoch 20/150
130/130 [==============================] - 6s 49ms/step - loss: 4.50
72e-04 - val_loss: 6.8833e-04
Epoch 21/150
130/130 [==============================] - 6s 49ms/step - loss: 4.19
49e-04 - val_loss: 0.0014
Epoch 22/150
130/130 [==============================] - 6s 49ms/step - loss: 4.29
78e-04 - val_loss: 8.5701e-04
Epoch 23/150
130/130 [==============================] - 6s 49ms/step - loss: 4.11
54e-04 - val_loss: 8.7976e-04
Epoch 24/150
130/130 [==============================] - 7s 51ms/step - loss: 3.96
71e-04 - val_loss: 3.8765e-04
Epoch 25/150
130/130 [==============================] - 7s 51ms/step - loss: 3.77
12e-04 - val_loss: 8.9913e-04
Epoch 26/150
130/130 [==============================] - 7s 51ms/step - loss: 3.80
16e-04 - val_loss: 6.0120e-04
Epoch 27/150
130/130 [==============================] - 7s 52ms/step - loss: 3.55
81e-04 - val_loss: 0.0013
Epoch 28/150
130/130 [==============================] - 7s 53ms/step - loss: 3.55
31e-04 - val_loss: 0.0019
Epoch 29/150
130/130 [==============================] - 7s 51ms/step - loss: 3.25
08e-04 - val_loss: 6.9989e-04
Epoch 30/150
130/130 [==============================] - 7s 51ms/step - loss: 3.25
65e-04 - val_loss: 5.3913e-04
Epoch 31/150
130/130 [==============================] - 7s 53ms/step - loss: 3.04
25e-04 - val_loss: 6.4939e-04
Epoch 32/150
130/130 [==============================] - 7s 53ms/step - loss: 3.18
34e-04 - val_loss: 0.0058
Epoch 33/150
```

```
130/130 [==============================] - 7s 53ms/step - loss: 3.14
28e-04 - val_loss: 4.9159e-04
Epoch 34/150
130/130 [==============================] - 7s 54ms/step - loss: 2.87
75e-04 - val_loss: 0.0033
Epoch 35/150
130/130 [==============================] - 7s 53ms/step - loss: 2.81
36e-04 - val_loss: 3.2585e-04
Epoch 36/150
130/130 [==============================] - 7s 56ms/step - loss: 2.76
64e-04 - val_loss: 0.0011
Epoch 37/150
130/130 [==============================] - 7s 55ms/step - loss: 2.65
96e-04 - val_loss: 3.5432e-04
Epoch 38/150
130/130 [==============================] - 7s 55ms/step - loss: 2.59
08e-04 - val_loss: 0.0012
Epoch 39/150
130/130 [==============================] - 7s 55ms/step - loss: 2.54
65e-04 - val_loss: 0.0011
Epoch 40/150
130/130 [==============================] - 7s 55ms/step - loss: 2.36
42e-04 - val_loss: 3.0848e-04
Epoch 41/150
130/130 [==============================] - 7s 55ms/step - loss: 2.47
09e-04 - val_loss: 8.8270e-04
Epoch 42/150
130/130 [==============================] - 7s 56ms/step - loss: 2.47
71e-04 - val_loss: 8.5205e-04
Epoch 43/150
130/130 [==============================] - 7s 56ms/step - loss: 2.43
80e-04 - val_loss: 4.3493e-04
Epoch 44/150
130/130 [==============================] - 7s 57ms/step - loss: 2.13
39e-04 - val_loss: 9.8199e-04
Epoch 45/150
130/130 [==============================] - 7s 55ms/step - loss: 2.20
21e-04 - val_loss: 3.7605e-04
Epoch 46/150
130/130 [==============================] - 7s 55ms/step - loss: 2.10
67e-04 - val_loss: 3.1032e-04
Epoch 47/150
130/130 [==============================] - 7s 57ms/step - loss: 2.06
33e-04 - val_loss: 4.9096e-04
Epoch 48/150
130/130 [==============================] - 7s 52ms/step - loss: 2.14
60e-04 - val_loss: 2.9713e-04
Epoch 49/150
130/130 [==============================] - 7s 53ms/step - loss: 2.16
38e-04 - val_loss: 2.3370e-04
Epoch 50/150
130/130 [==============================] - 7s 53ms/step - loss: 2.02
93e-04 - val_loss: 2.0971e-04
Epoch 51/150
130/130 [==============================] - 7s 53ms/step - loss: 1.97
28e-04 - val_loss: 3.8455e-04
Epoch 52/150
130/130 [==============================] - 7s 55ms/step - loss: 1.98
11e-04 - val_loss: 3.3287e-04
Epoch 53/150
130/130 [==============================] - 7s 54ms/step - loss: 1.97
```

```
19e-04 - val_loss: 4.3932e-04
Epoch 54/150
130/130 [==============================] - 7s 55ms/step - loss: 1.92
20e-04 - val_loss: 3.1269e-04
Epoch 55/150
130/130 [==============================] - 7s 54ms/step - loss: 1.83
41e-04 - val_loss: 4.1792e-04
Epoch 56/150
130/130 [==============================] - 7s 55ms/step - loss: 1.85
36e-04 - val_loss: 2.5792e-04
Epoch 57/150
130/130 [==============================] - 7s 55ms/step - loss: 1.77
90e-04 - val_loss: 3.6777e-04
Epoch 58/150
130/130 [==============================] - 7s 56ms/step - loss: 1.77
57e-04 - val_loss: 4.2625e-04
Epoch 59/150
130/130 [==============================] - 7s 55ms/step - loss: 1.68
74e-04 - val_loss: 3.2402e-04
Epoch 60/150
130/130 [==============================] - 7s 56ms/step - loss: 1.71
91e-04 - val_loss: 2.9569e-04
Epoch 61/150
130/130 [==============================] - 7s 55ms/step - loss: 1.81
48e-04 - val_loss: 3.5007e-04
Epoch 62/150
```

```
130/130 [==============================] - 7s 54ms/step - loss: 1.78
03e-04 - val_loss: 2.9365e-04
Epoch 63/150
130/130 [==============================] - 7s 54ms/step - loss: 1.69
99e-04 - val_loss: 2.3240e-04
Epoch 64/150
130/130 [==============================] - 6s 50ms/step - loss: 1.74
52e-04 - val_loss: 2.8314e-04
Epoch 65/150
130/130 [==============================] - 7s 50ms/step - loss: 1.67
21e-04 - val_loss: 5.7346e-04
Epoch 66/150
130/130 [==============================] - 6s 49ms/step - loss: 1.67
20e-04 - val_loss: 1.9001e-04
Epoch 67/150
130/130 [==============================] - 6s 50ms/step - loss: 1.61
77e-04 - val_loss: 2.4671e-04
Epoch 68/150
130/130 [==============================] - 7s 51ms/step - loss: 1.62
54e-04 - val_loss: 2.2924e-04
Epoch 69/150
130/130 [==============================] - 7s 51ms/step - loss: 1.63
60e-04 - val_loss: 0.0020
Epoch 70/150
130/130 [==============================] - 7s 51ms/step - loss: 1.63
88e-04 - val_loss: 3.7957e-04
Epoch 71/150
130/130 [==============================] - 6s 50ms/step - loss: 1.61
52e-04 - val_loss: 3.7433e-04
Epoch 72/150
130/130 [==============================] - 6s 50ms/step - loss: 1.51
04e-04 - val_loss: 2.6918e-04
Epoch 73/150
130/130 [==============================] - 7s 50ms/step - loss: 1.62
53e-04 - val_loss: 2.5127e-04
Epoch 74/150
130/130 [==============================] - 6s 50ms/step - loss: 1.47
83e-04 - val_loss: 1.7861e-04
Epoch 75/150
130/130 [==============================] - 7s 50ms/step - loss: 1.52
62e-04 - val_loss: 2.3398e-04
Epoch 76/150
130/130 [==============================] - 7s 51ms/step - loss: 1.57
99e-04 - val_loss: 2.3907e-04
Epoch 77/150
130/130 [==============================] - 7s 51ms/step - loss: 1.52
88e-04 - val_loss: 7.0411e-04
Epoch 78/150
130/130 [==============================] - 7s 52ms/step - loss: 1.53
56e-04 - val_loss: 5.7625e-04
Epoch 79/150
130/130 [==============================] - 7s 53ms/step - loss: 1.45
55e-04 - val_loss: 0.0011
Epoch 80/150
130/130 [==============================] - 7s 52ms/step - loss: 1.52
66e-04 - val_loss: 2.5387e-04
Epoch 81/150
130/130 [==============================] - 7s 51ms/step - loss: 1.53
59e-04 - val_loss: 3.6928e-04
Epoch 82/150
130/130 [==============================] - 7s 52ms/step - loss: 1.49
```

```
63e-04 - val_loss: 2.2111e-04
Epoch 83/150
130/130 [==============================] - 7s 52ms/step - loss: 1.43
32e-04 - val_loss: 7.7345e-04
Epoch 84/150
130/130 [==============================] - 7s 52ms/step - loss: 1.41
79e-04 - val_loss: 2.1163e-04
Epoch 85/150
130/130 [==============================] - 7s 55ms/step - loss: 1.49
57e-04 - val_loss: 2.1290e-04
Epoch 86/150
130/130 [==============================] - 7s 53ms/step - loss: 1.38
96e-04 - val_loss: 2.5912e-04
Epoch 87/150
130/130 [==============================] - 7s 54ms/step - loss: 1.43
64e-04 - val_loss: 2.7561e-04
Epoch 88/150
130/130 [==============================] - 7s 53ms/step - loss: 1.39
98e-04 - val_loss: 1.7825e-04
Epoch 89/150
130/130 [==============================] - 7s 54ms/step - loss: 1.37
00e-04 - val_loss: 1.9892e-04
Epoch 90/150
130/130 [==============================] - 7s 53ms/step - loss: 1.39
66e-04 - val_loss: 4.1500e-04
Epoch 91/150
130/130 [==============================] - 7s 53ms/step - loss: 1.34
09e-04 - val_loss: 4.8989e-04
Epoch 92/150
130/130 [==============================] - 7s 53ms/step - loss: 1.41
24e-04 - val_loss: 2.5452e-04
Epoch 93/150
130/130 [==============================] - 7s 55ms/step - loss: 1.36
36e-04 - val_loss: 4.4774e-04
Epoch 94/150
130/130 [==============================] - 7s 57ms/step - loss: 1.38
97e-04 - val_loss: 4.6326e-04
Epoch 95/150
130/130 [==============================] - 7s 55ms/step - loss: 1.42
39e-04 - val_loss: 1.6627e-04
Epoch 96/150
130/130 [==============================] - 7s 54ms/step - loss: 1.40
89e-04 - val_loss: 2.7423e-04
Epoch 97/150
130/130 [==============================] - 8s 58ms/step - loss: 1.33
42e-04 - val_loss: 6.4664e-04
Epoch 98/150
130/130 [==============================] - 7s 57ms/step - loss: 1.39
87e-04 - val_loss: 1.8653e-04
Epoch 99/150
130/130 [==============================] - 7s 57ms/step - loss: 1.33
33e-04 - val_loss: 3.9297e-04
Epoch 100/150
130/130 [==============================] - 7s 56ms/step - loss: 1.34
52e-04 - val_loss: 1.9901e-04
Epoch 101/150
130/130 [==============================] - 7s 56ms/step - loss: 1.35
28e-04 - val_loss: 2.7606e-04
Epoch 102/150
130/130 [==============================] - 7s 54ms/step - loss: 1.29
05e-04 - val_loss: 3.5310e-04
```

```
Epoch 103/150
130/130 [==============================] - 7s 56ms/step - loss: 1.32
22e-04 - val_loss: 2.6192e-04
Epoch 104/150
130/130 [==============================] - 7s 55ms/step - loss: 1.32
21e-04 - val_loss: 3.0489e-04
Epoch 105/150
130/130 [==============================] - 7s 56ms/step - loss: 1.31
44e-04 - val_loss: 2.1116e-04
Epoch 106/150
130/130 [==============================] - 8s 59ms/step - loss: 1.26
17e-04 - val_loss: 2.5846e-04
Epoch 107/150
130/130 [==============================] - 7s 57ms/step - loss: 1.35
19e-04 - val_loss: 2.2094e-04
Epoch 108/150
130/130 [==============================] - 7s 56ms/step - loss: 1.36
75e-04 - val_loss: 3.8278e-04
Epoch 109/150
130/130 [==============================] - 7s 56ms/step - loss: 1.24
22e-04 - val_loss: 4.8913e-04
Epoch 110/150
130/130 [==============================] - 8s 58ms/step - loss: 1.30
51e-04 - val_loss: 2.4594e-04
Epoch 111/150
130/130 [==============================] - 7s 56ms/step - loss: 1.27
72e-04 - val_loss: 5.7276e-04
Epoch 112/150
130/130 [==============================] - 7s 57ms/step - loss: 1.26
83e-04 - val_loss: 2.0813e-04
Epoch 113/150
130/130 [==============================] - 7s 56ms/step - loss: 1.27
31e-04 - val_loss: 2.7574e-04
Epoch 114/150
130/130 [==============================] - 7s 55ms/step - loss: 1.21
81e-04 - val_loss: 1.6884e-04
Epoch 115/150
130/130 [==============================] - 7s 55ms/step - loss: 1.18
90e-04 - val_loss: 2.8837e-04
Epoch 116/150
130/130 [==============================] - 7s 57ms/step - loss: 1.22
31e-04 - val_loss: 2.7094e-04
Epoch 117/150
130/130 [==============================] - 8s 59ms/step - loss: 1.42
31e-04 - val_loss: 1.9579e-04
Epoch 118/150
130/130 [==============================] - 8s 59ms/step - loss: 1.29
52e-04 - val_loss: 2.3072e-04
Epoch 119/150
130/130 [==============================] - 7s 58ms/step - loss: 1.27
69e-04 - val_loss: 2.1149e-04
Epoch 120/150
130/130 [==============================] - 8s 60ms/step - loss: 1.21
47e-04 - val_loss: 4.5995e-04
Epoch 121/150
130/130 [==============================] - 7s 56ms/step - loss: 1.24
69e-04 - val_loss: 6.2655e-04
Epoch 122/150
130/130 [==============================] - 8s 59ms/step - loss: 1.28
85e-04 - val_loss: 2.8194e-04
Epoch 123/150
```

```
130/130 [==============================] - 7s 57ms/step - loss: 1.25
93e-04 - val_loss: 3.6366e-04
Epoch 124/150
130/130 [==============================] - 7s 53ms/step - loss: 1.23
81e-04 - val_loss: 4.4767e-04
Epoch 125/150
130/130 [==============================] - 7s 55ms/step - loss: 1.21
79e-04 - val_loss: 2.6016e-04
Epoch 126/150
130/130 [==============================] - 7s 53ms/step - loss: 1.18
81e-04 - val_loss: 1.7591e-04
Epoch 127/150
130/130 [==============================] - 7s 51ms/step - loss: 1.17
62e-04 - val_loss: 5.7084e-04
Epoch 128/150
130/130 [==============================] - 7s 51ms/step - loss: 1.18
45e-04 - val_loss: 2.8367e-04
Epoch 129/150
130/130 [==============================] - 7s 51ms/step - loss: 1.22
79e-04 - val_loss: 2.2399e-04
Epoch 130/150
130/130 [==============================] - 7s 52ms/step - loss: 1.30
17e-04 - val_loss: 2.0285e-04
Epoch 131/150
130/130 [==============================] - 7s 53ms/step - loss: 1.19
57e-04 - val_loss: 2.3243e-04
Epoch 132/150
130/130 [==============================] - 6s 50ms/step - loss: 1.20
49e-04 - val_loss: 2.7375e-04
Epoch 133/150
130/130 [==============================] - 7s 51ms/step - loss: 1.25
48e-04 - val_loss: 5.9574e-04
Epoch 134/150
130/130 [==============================] - 7s 51ms/step - loss: 1.19
01e-04 - val_loss: 4.9511e-04
Epoch 135/150
```

```
130/130 [==============================] - 7s 52ms/step - loss: 1.17
08e-04 - val_loss: 1.8648e-04
Epoch 136/150
130/130 [==============================] - 7s 52ms/step - loss: 1.18
64e-04 - val_loss: 3.8469e-04
Epoch 137/150
130/130 [==============================] - 7s 51ms/step - loss: 1.13
67e-04 - val_loss: 2.1262e-04
Epoch 138/150
130/130 [==============================] - 7s 51ms/step - loss: 1.20
62e-04 - val_loss: 1.7391e-04
Epoch 139/150
130/130 [==============================] - 7s 52ms/step - loss: 1.14
90e-04 - val_loss: 2.3241e-04
Epoch 140/150
130/130 [==============================] - 7s 51ms/step - loss: 1.18
25e-04 - val_loss: 2.7959e-04
Epoch 141/150
130/130 [==============================] - 7s 51ms/step - loss: 1.18
18e-04 - val_loss: 3.8640e-04
Epoch 142/150
130/130 [==============================] - 7s 51ms/step - loss: 1.19
23e-04 - val_loss: 2.3734e-04
Epoch 143/150
130/130 [==============================] - 7s 51ms/step - loss: 1.14
12e-04 - val_loss: 3.1466e-04
Epoch 144/150
130/130 [==============================] - 7s 51ms/step - loss: 1.17
84e-04 - val_loss: 5.8081e-04
Epoch 145/150
130/130 [==============================] - 7s 52ms/step - loss: 1.22
56e-04 - val_loss: 2.5801e-04
Epoch 146/150
130/130 [==============================] - 7s 51ms/step - loss: 1.15
61e-04 - val_loss: 3.1902e-04
Epoch 147/150
130/130 [==============================] - 7s 53ms/step - loss: 1.16
19e-04 - val_loss: 2.2802e-04
Epoch 148/150
130/130 [==============================] - 7s 54ms/step - loss: 1.15
65e-04 - val_loss: 4.6153e-04
Epoch 149/150
130/130 [==============================] - 7s 54ms/step - loss: 1.19
45e-04 - val_loss: 3.3898e-04
Epoch 150/150
130/130 [==============================] - 7s 53ms/step - loss: 1.10
51e-04 - val_loss: 1.7987e-04
12/12 [==============================] - 1s 12ms/step
Random Forest Accuracy: 66.27%
SVM Accuracy: 52.58%
Gradient Boosting Accuracy: 63.69%
Logistic Regression Accuracy: 78.87%
LSTM model Accuracy: 98.09%
```

In [20]:
```
# Save LSTM model
model.save('gold_price_prediction_model.h5')

print("Best Model saved successfully.")
```

```
Best Model saved successfully.
```

In [21]:
```
best_model = None
best_accuracy = 0.0

if rf_accuracy > best_accuracy:
    best_accuracy = rf_accuracy
    best_model = rf_classifier

if svm_accuracy > best_accuracy:
    best_accuracy = svm_accuracy
    best_model = svm_classifier

if gb_accuracy > best_accuracy:
    best_accuracy = gb_accuracy
    best_model = gb_classifier

if logreg_accuracy > best_accuracy:
    best_accuracy = logreg_accuracy
    best_model = logreg_classifier

if lstm_accuracy > best_accuracy:
    best_accuracy = lstm_accuracy
    best_model = model

print(f"The best model is {type(best_model).__name__} with an accu
```

```
The best model is Sequential with an accuracy of 98.09%
```

In [25]:

```
import numpy as np
import pandas as pd
from datetime import datetime, timedelta
import yfinance as yf
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import load_model
import matplotlib.pyplot as plt

# Define the calculate_rsi function
def calculate_rsi(data, window=14):
    close_price = data['Close']
    delta = close_price.diff()

    gain = delta.where(delta > 0, 0)
    loss = -delta.where(delta < 0, 0)

    avg_gain = gain.rolling(window=window, min_periods=1).mean()
    avg_loss = loss.rolling(window=window, min_periods=1).mean()

    rs = avg_gain / avg_loss
    rsi = 100 - (100 / (1 + rs))

    return rsi

# Define the market_status function
def market_status(rsi_value):
    if rsi_value > 70:
        return 'Overbought'
    elif rsi_value < 30:
        return 'Oversold'
    else:
        return 'Neutral'


model = load_model('gold_price_prediction_model.h5')

input_date = pd.to_datetime(input("\nEnter the date to visualize

days_ranges = [180, 365]
days_before = max(days_ranges) // 2
days_after = days_before

window_size = 60
for days_range in days_ranges:
    plot_start_date = input_date - pd.Timedelta(days=days_range /
    plot_end_date = input_date + pd.Timedelta(days=days_range //

    try:
        plot_data = yf.download('GC=F', start=plot_start_date, en

        if len(plot_data) >= window_size:
            input_data = plot_data['Close'][-window_size:].values

            scaler = MinMaxScaler()
            scaler.fit(plot_data['Close'].values.reshape(-1, 1))

            def predict_gold_price(input_data):
                input_data = scaler.transform(input_data.reshape(
                input_data = np.reshape(input_data, (1, window_si
                predicted_price = model.predict(input_data)
                predicted_price = scaler.inverse_transform(predic
```

```
                return predicted_price[0, 0]

            predictions = []
            future_dates = [input_date + timedelta(days=i) for i
            for i in range(days_after + 1):
                predictions.append(predict_gold_price(input_data)
                input_data = np.append(input_data[1:], prediction

            last_day_difference = ((predictions[-1] - plot_data['
                                    plot_data['Close'].iloc[-1]) *

            last_day_direction = 'Up' if last_day_difference > 0

            last_day_date = plot_data.index[-1]

            # Calculate close_price here
            close_price = plot_data['Close'].iloc[-1]

            print(f"The price is expected to go {last_day_directi
            print(f"Predicted price on {last_day_date.strftime('%
            print(f"Predicted price after {days_range} days on {f

            plt.figure(figsize=(10, 6))

            plt.subplot(2, 1, 1)
            plt.plot(plot_data.index, plot_data['Close'], label='
            plt.plot(future_dates, predictions, color='orange', l
            plt.axvline(x=input_date, color='red', linestyle='--'

            plt.scatter(input_date, predictions[0], color='green'
            plt.text(input_date, predictions[0], f'USD {predictio
                     va='bottom', color='green')
            plt.scatter(input_date, plot_data['Close'].iloc[-1],
            plt.axvline(x=input_date, color='red', linestyle='-')
            plt.text(input_date, close_price, f'USD {close_price:
                     va='bottom', color='red')

            last_day_annotation = f'{future_dates[-1].strftime("%
            plt.scatter(future_dates[-1], predictions[-1], color=
            plt.text(future_dates[-1], predictions[-1], last_day_
                     va='bottom', color='purple')

            plt.title(f'Gold Price Data Around {input_date.strfti
            plt.xlabel('Date')
            plt.ylabel('Gold Price')
            plt.legend()
            plt.grid(True)

            # Plotting RSI
            plt.subplot(2, 1, 2)
            rsi_data = calculate_rsi(plot_data)
            plt.plot(plot_data.index, rsi_data, label='RSI', line
            plt.axhline(y=70, color='red', linestyle='--', label=
            plt.axhline(y=30, color='green', linestyle='--', labe

            # Add red vertical line for input date
            plt.axvline(x=input_date, color='red', linestyle='-')

            market_status_value = market_status(rsi_data.iloc[-1]
            plt.title(f'Market Status: {market_status_value}')
            plt.xlabel('Date')
```

```
            plt.ylabel('RSI')
            plt.legend()
            plt.grid(True)

            plt.tight_layout()
            plt.show()

        else:
            print(f"Insufficient historical data for scaling in t

    except Exception as e:
        print(f"Failed to download data for the {days_range}-day

```

```
WARNING:absl:At this time, the v2.11+ optimizer `tf.keras.optimizer
s.Nadam` runs slowly on M1/M2 Macs, please use the legacy Keras opti
mizer instead, located at `tf.keras.optimizers.legacy.Nadam`.
```

```
Enter the date to visualize (YYYY-MM-DD): 2023-12-05
[*********************100%%**********************]  1 of 1 completed
1/1 [==============================] - 0s 462ms/step
1/1 [==============================] - 0s 15ms/step
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1/1 [==============================] - 0s 15ms/step
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The price is expected to go Down by 0.88%
Predicted price on 2024-01-22: USD 2006.80
Predicted price after 180 days on 2024-06-04 is USD 2024.70
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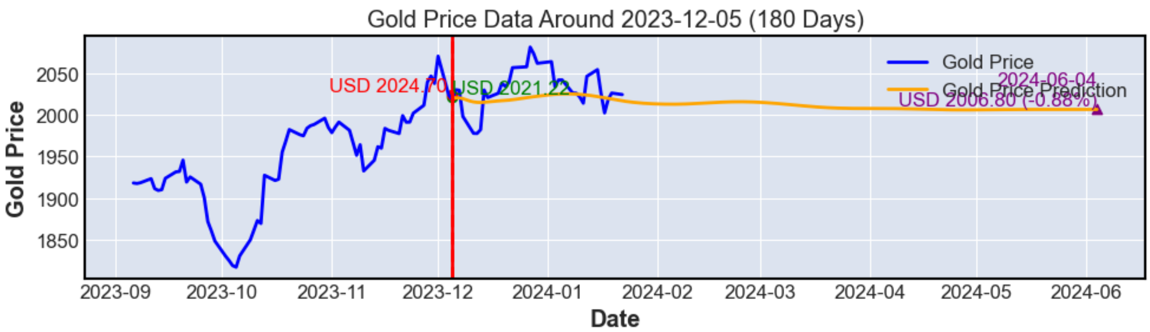

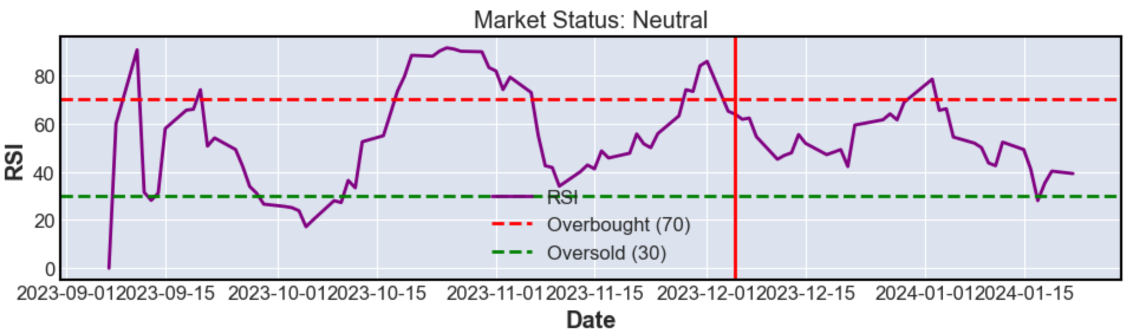

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The price is expected to go Down by 0.88%
Predicted price on 2024-01-22: USD 2006.80
Predicted price after 365 days on 2024-06-04 is USD 2024.60
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