Vaccine Stock Analysis during the COVID-19 Pandemic

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```
[28]: import numpy as np
      import pandas as pd

      from functools import reduce
```

Covid Dataset

```
[29]: df = pd.read_csv("us_covid19_cases.csv")
```

```
[30]: df.columns
```

```
[30]: Index(['iso_code', 'continent', 'location', 'date', 'total_cases', 'new_cases',
             'new_cases_smoothed', 'total_deaths', 'new_deaths',
             'new_deaths_smoothed', 'total_cases_per_million',
             'new_cases_per_million', 'new_cases_smoothed_per_million',
             'total_deaths_per_million', 'new_deaths_per_million',
             'new_deaths_smoothed_per_million', 'reproduction_rate', 'icu_patients',
             'icu_patients_per_million', 'hosp_patients',
             'hosp_patients_per_million', 'weekly_icu_admissions',
             'weekly_icu_admissions_per_million', 'weekly_hosp_admissions',
             'weekly_hosp_admissions_per_million', 'total_tests', 'new_tests',
             'total_tests_per_thousand', 'new_tests_per_thousand',
             'new_tests_smoothed', 'new_tests_smoothed_per_thousand',
             'positive_rate', 'tests_per_case', 'tests_units', 'total_vaccinations',
             'people_vaccinated', 'people_fully_vaccinated', 'total_boosters',
             'new_vaccinations', 'new_vaccinations_smoothed',
             'total_vaccinations_per_hundred', 'people_vaccinated_per_hundred',
             'people_fully_vaccinated_per_hundred', 'total_boosters_per_hundred',
             'new_vaccinations_smoothed_per_million',
             'new_people_vaccinated_smoothed',
             'new_people_vaccinated_smoothed_per_hundred', 'stringency_index',
             'population', 'population_density', 'median_age', 'aged_65_older',
             'aged_70_older', 'gdp_per_capita', 'extreme_poverty',
             'cardiovasc_death_rate', 'diabetes_prevalence', 'female_smokers',
             'male_smokers', 'handwashing_facilities', 'hospital_beds_per_thousand',
             'life_expectancy', 'human_development_index',
             'excess_mortality_cumulative_absolute', 'excess_mortality_cumulative',
             'excess_mortality', 'excess_mortality_cumulative_per_million'],
```

```
            dtype='object')
```

```
[31]: covid_df = df[['date', 'new_cases', 'new_deaths', 'new_tests',␣
      ↪'new_vaccinations']].dropna()
```

```
[32]: covid_df.head()
```

```
[32]:          date   new_cases   new_deaths   new_tests   new_vaccinations
      327   12/14/2020   209832.0       1656.0   1495007.0             4606.0
      328   12/15/2020   226317.0       2977.0   1946570.0            48023.0
      329   12/16/2020   234805.0       3726.0   2078071.0           159392.0
      330   12/17/2020   240248.0       3448.0   2053369.0           272612.0
      331   12/18/2020   247945.0       2936.0   2022827.0           416548.0
```

```
[33]: covid_df.dtypes
```

```
[33]: date                   object
      new_cases             float64
      new_deaths            float64
      new_tests             float64
      new_vaccinations      float64
      dtype: object
```

Stock Datasts

```
[34]: df2 = pd.read_csv("moderna.csv")
      moderna_df = df2[['date', 'close', 'volume', 'rsi']]

      df3 = pd.read_csv("jnj.csv")
      jnj_df = df3[['date', 'close', 'volume', 'rsi']]

      df4 = pd.read_csv("astra-zeneca.csv")
      astra_zeneca_df = df4[['date', 'close', 'volume', 'rsi']]

      df5 = pd.read_csv("biontech.csv")
      biontech_df = df5[['date', 'close', 'volume', 'rsi']]

      df6 = pd.read_csv("novavax.csv")
      novavax_df = df6[['date', 'close', 'volume', 'rsi']]

      df7 = pd.read_csv("pfizer.csv")
      pfizer_df = df7[['date', 'close', 'volume', 'rsi']]
```

Merge Datasets

```
[35]: stock_df = [moderna_df, jnj_df, astra_zeneca_df, biontech_df, novavax_df,␣
      ↪pfizer_df]

      stock_merged = reduce(lambda left, right: pd.merge(left, right, on=['date'],␣
      ↪how='outer'), stock_df)
```

```
stock_merged.columns = ['date', 'moderna_closing_price', 'moderna_volume',
 'moderna_rsi', 'jnj_closing_price', 'jnj_volume', 'jnj_rsi',
 'astra_zeneca_closing_price', 'astra_zeneca_volume', 'astra_zeneca_rsi',
 'biontech_closing_price', 'biontech_volume', 'biontech_rsi',
 'novavax_closing_price', 'novavax_volume', 'novavax_rsi',
 'pfizer_closing_price', 'pfizer_volume', 'pfizer_rsi']
```

[36]: `stock_merged.head()`

[36]:
```
        date  moderna_closing_price  moderna_volume  moderna_rsi  \
0  2022-04-08                 160.84       5454415.0    45.310068
1  2022-04-07                 159.00       5720873.0    45.059303
2  2022-04-06                 154.62       7401800.0    44.465273
3  2022-04-05                 162.05       6641095.0    45.279139
4  2022-04-04                 172.54       5908675.0    46.455614

   jnj_closing_price  jnj_volume    jnj_rsi  astra_zeneca_closing_price  \
0             182.12   7144703.0  58.007217                       71.14
1             181.76   7385291.0  57.800809                       71.01
2             182.23   9991790.0  58.166612                       69.07
3             177.61   7279617.0  55.450641                       67.05
4             176.47   6595724.0  54.740074                       66.67

   astra_zeneca_volume  astra_zeneca_rsi  biontech_closing_price  \
0            9082865.0         62.388493                  170.26
1            8310168.0         62.271561                  169.11
2            5596805.0         60.474451                  166.65
3            6953316.0         58.455160                  180.82
4            3987163.0         58.060152                  186.24

   biontech_volume  biontech_rsi  novavax_closing_price  novavax_volume  \
0         886206.0     47.024802                  60.63       3603222.0
1        1505572.0     46.875633                  59.50       4367650.0
2        2275843.0     46.560180                  62.44       5162016.0
3        1878969.0     48.174997                  65.23       6661778.0
4        2350714.0     48.809551                  75.29       2642969.0

   novavax_rsi  pfizer_closing_price  pfizer_volume  pfizer_rsi
0    41.168775                 55.17     23128622.0   55.231783
1    40.924147                 55.16     36292543.0   55.220421
2    41.362681                 52.87     31718155.0   52.515858
3    41.779037                 51.24     21027857.0   50.427343
4    43.319900                 50.94     20491602.0   50.030928
```

[37]: `stock_merged.dtypes`

[37]:
```
date                      object
moderna_closing_price    float64
moderna_volume           float64
```

```
moderna_rsi                    float64
jnj_closing_price              float64
jnj_volume                     float64
jnj_rsi                        float64
astra_zeneca_closing_price     float64
astra_zeneca_volume            float64
astra_zeneca_rsi               float64
biontech_closing_price         float64
biontech_volume                float64
biontech_rsi                   float64
novavax_closing_price          float64
novavax_volume                 float64
novavax_rsi                    float64
pfizer_closing_price           float64
pfizer_volume                  float64
pfizer_rsi                     float64
dtype: object
```

[38]:
```python
covid_df['date'] = pd.to_datetime(covid_df['date'])
stock_merged['date'] = pd.to_datetime(stock_merged['date'])
covid_df['new_vaccinations'] = covid_df['new_vaccinations'].fillna(0) # The NaN␣
 ↪value in this column cannot be simply dropped since we also need to analyze␣
 ↪the data before the vaccination process.
df_merged = pd.merge(covid_df, stock_merged, on='date').dropna()
```

[39]:
```python
float_cols = covid_df.columns[covid_df.dtypes.eq('float64')]
df_merged[float_cols] = df_merged[float_cols].apply(pd.to_numeric,␣
 ↪errors='ignore').astype(int)
```

```
Index(['new_cases', 'new_deaths', 'new_tests', 'new_vaccinations'],
dtype='object')
```

[40]:
```python
df_merged.head(10)
```

[40]:
```
        date  new_cases  new_deaths  new_tests  new_vaccinations  \
0 2020-12-14     209832        1656    1495007              4606
1 2020-12-15     226317        2977    1946570             48023
2 2020-12-16     234805        3726    2078071            159392
3 2020-12-17     240248        3448    2053369            272612
4 2020-12-18     247945        2936    2022827            416548
5 2020-12-21     196861        1798    1529532            384222
6 2020-12-22     205932        3298    1988775            448446
7 2020-12-23     221438        3382    2281090            574778
8 2020-12-24     212948        2922    1892175            196792
9 2020-12-28     173303        1872    1310126            593478

   moderna_closing_price  moderna_volume  moderna_rsi  jnj_closing_price  \
0                 155.07      22467742.0    66.453628         149.070007
1                 147.22      36451258.0    63.925455         150.570007
```

2	137.03	28476275.0	60.858631	149.669998
3	144.00	32404457.0	62.126807	153.619995
4	140.23	33157833.0	61.035348	154.509995
5	138.30	23921047.0	60.480298	153.020004
6	125.88	36126942.0	57.072189	152.720001
7	130.34	41905043.0	57.940648	151.940002
8	123.39	12720588.0	56.134859	152.470001
9	111.40	30712362.0	53.215229	153.190002

	jnj_volume	...	astra_zeneca_rsi	biontech_closing_price	biontech_volume \
0	8547300.0	...	45.104496	108.269997	10907900.0
1	7612600.0	...	46.192900	111.199997	5711800.0
2	8486100.0	...	46.328628	105.779999	4802600.0
3	9920300.0	...	46.162277	106.430000	3487800.0
4	17137200.0	...	45.472040	104.239998	3108200.0
5	7893400.0	...	44.846778	106.459999	2611000.0
6	4699500.0	...	43.746547	100.559998	5021000.0
7	4607300.0	...	43.805779	100.059998	3414000.0
8	2114900.0	...	43.513576	96.959999	1039100.0
9	3855500.0	...	44.805920	88.110001	4698900.0

	biontech_rsi	novavax_closing_price	novavax_volume	novavax_rsi \
0	54.754129	129.699997	4690300.0	55.615390
1	55.391848	126.220001	2721700.0	54.854471
2	53.956363	120.879997	4096600.0	53.703972
3	54.101921	131.750000	5070800.0	55.636655
4	53.520235	124.849998	4237400.0	54.171836
5	54.031468	124.059998	2763300.0	54.005719
6	52.466483	115.370003	6363600.0	52.208710
7	52.335398	127.650002	6681400.0	54.396768
8	51.521034	129.339996	3690600.0	54.688097
9	49.286893	116.849998	4840500.0	52.174493

	pfizer_closing_price	pfizer_volume	pfizer_rsi
0	39.209999	94809700.0	55.437718
1	38.709999	65712800.0	54.424993
2	37.840000	56515300.0	52.715195
3	38.029999	52036400.0	53.043929
4	37.680000	60259200.0	52.359688
5	37.380001	40891800.0	51.775536
6	36.740002	33634400.0	50.547914
7	37.439999	36182000.0	51.822803
8	37.270000	14790100.0	51.493825
9	36.820000	26993700.0	50.625749

[10 rows x 23 columns]

```
[41]: df_merged.dtypes
```

```
[41]: date                        datetime64[ns]
      new_cases                             int64
      new_deaths                            int64
      new_tests                             int64
      new_vaccinations                      int64
      moderna_closing_price               float64
      moderna_volume                      float64
      moderna_rsi                         float64
      jnj_closing_price                   float64
      jnj_volume                          float64
      jnj_rsi                             float64
      astra_zeneca_closing_price          float64
      astra_zeneca_volume                 float64
      astra_zeneca_rsi                    float64
      biontech_closing_price              float64
      biontech_volume                     float64
      biontech_rsi                        float64
      novavax_closing_price               float64
      novavax_volume                      float64
      novavax_rsi                         float64
      pfizer_closing_price                float64
      pfizer_volume                       float64
      pfizer_rsi                          float64
      dtype: object
```

Data Analysis

Q1: How did each pharmaceutical stock perform during the pandemic, and is there a trend between performance and COVID-19 cases?

```
[ ]:
```

Q2: Is there a positive or negative relationship between COVID-19 cases and pharmaceutical stock prices of the aforementioned companies? Could a rise in COVID-19 cases be used as a factor to predict a rise in pharmaceutical stock prices?

```
[ ]:
```

Q3: Assuming there is a pattern/relationship, what are the nuances that explain any breaks from the pattern between COVID-19 cases and stock prices?

```
[ ]:
```