

Vaccine Stock Analysis during the COVID-19 Pandemic

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

from functools import reduce
```

Covid Dataset

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

```
[111]: df.columns
```

```
[111]: 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')
```

```
[112]: covid_df = df[['date', 'new_cases', 'new_deaths', 'new_tests',  
    ↪ 'new_vaccinations']]
```

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

```
[113]:
```

	date	new_cases	new_deaths	new_tests	new_vaccinations
0	1/22/2020	NaN	NaN	NaN	NaN
1	1/23/2020	0.0	NaN	NaN	NaN
2	1/24/2020	1.0	NaN	NaN	NaN
3	1/25/2020	0.0	NaN	NaN	NaN
4	1/26/2020	3.0	NaN	NaN	NaN

```
[114]: covid_df.dtypes
```

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

Stock Datasets

```
[115]: 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

```
[116]: 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']
```

```
[117]: stock_merged.head()
```

```
[117]:      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
```

```
[118]: stock_merged.dtypes
```

```
[118]: 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

```

```

[119]: 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()

```

```

[120]: 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)

```

```

[121]: df_merged = df_merged[(df_merged['date'] >= '2020-03-01') &
    ↳ (df_merged['date'] < '2022-04-01')]
df_merged.reset_index(drop=True, inplace=True)

```

```

[122]: df_merged.head(10)

```

```

[122]:      date  new_cases  new_deaths  new_tests  new_vaccinations  \
0  2020-03-02         23           5        515             0
1  2020-03-03         19           1        620             0
2  2020-03-04         33           4        891             0
3  2020-03-05         77           1       1203             0
4  2020-03-06         53           2       1523             0
5  2020-03-09         75           1       2399             0
6  2020-03-10        188           6       3481             0
7  2020-03-11        365           5       4833             0
8  2020-03-12        439          10       8891             0
9  2020-03-13        633           8      11732             0

      moderna_closing_price  moderna_volume  moderna_rsi  jnj_closing_price  \
0              29.88      33084026.0      64.837624      140.020004

```

1	27.91	17599114.0	61.075243	135.589996
2	27.49	11817666.0	60.313849	143.479996
3	28.01	14669976.0	60.929202	142.009995
4	29.61	21097488.0	62.742982	142.029999
5	24.29	14124076.0	54.205308	136.440002
6	22.34	13019516.0	51.580159	141.639999
7	23.61	14825434.0	53.089965	131.800003
8	22.30	11305347.0	51.402919	125.410004
9	21.30	11853052.0	50.161307	134.289993

	jnj_volume	...	astra_zeneca_rsi	biontech_closing_price	biontech_volume	\
0	11508200.0	...	40.456508	36.60	185100.0	
1	13662500.0	...	39.738102	38.48	297900.0	
2	10560500.0	...	48.025686	39.19	127100.0	
3	11339200.0	...	47.549072	37.12	77000.0	
4	12239100.0	...	45.738435	38.09	279200.0	
5	13848600.0	...	41.449773	33.48	190200.0	
6	12698100.0	...	45.268621	33.96	327500.0	
7	17763400.0	...	41.437368	32.17	119000.0	
8	21539200.0	...	36.278622	28.55	184100.0	
9	20084200.0	...	39.344643	30.93	197600.0	

	biontech_rsi	novavax_closing_price	novavax_volume	novavax_rsi	\
0	50.791524	12.02	14261700.0	62.899608	
1	52.850212	10.78	9957300.0	59.621290	
2	53.598311	11.32	10977400.0	60.535314	
3	51.182375	12.87	14057100.0	62.989154	
4	52.212347	12.48	13250800.0	61.999390	
5	47.365959	10.02	8328800.0	56.304878	
6	47.879960	10.65	12365400.0	57.329068	
7	46.164460	10.51	9052100.0	57.025971	
8	42.986160	9.29	5488400.0	54.465420	
9	45.503257	8.41	6115400.0	52.722981	

	pfizer_closing_price	pfizer_volume	pfizer_rsi
0	33.092979	42034469.0	37.171087
1	32.542694	46174475.0	35.568345
2	34.535103	38712155.0	44.422057
3	33.643265	35096303.0	41.798627
4	33.225807	40931036.0	40.651919
5	32.030361	43183856.0	37.634936
6	32.817837	40548329.0	40.598216
7	30.521822	65350213.0	35.569873
8	28.481974	62731445.0	31.979150
9	31.034157	60553038.0	39.744867

[10 rows x 23 columns]

```
[123]: df_merged.dtypes
```

```
[123]: 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?

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[ ]:
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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?

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[ ]:
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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?

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[ ]:
```