Vaccine Stock Analysis during the COVID-19 Pandemic

May 19, 2022

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```
[41]: import sys
      !{sys.executable} -m pip install altair
```

WARNING: The directory '/home/jovyan/.cache/pip/http' or its parent
directory is not owned by the current user and the cache has been disabled.
Please check the permissions and owner of that directory. If executing pip with
sudo, you may want sudo's -H flag.
WARNING: The directory '/home/jovyan/.cache/pip' or its parent directory is
not owned by the current user and caching wheels has been disabled. check the
permissions and owner of that directory. If executing pip with sudo, you may
want sudo's -H flag.
Requirement already satisfied: altair in /opt/conda/lib/python3.7/site-packages
(4.2.0)
Requirement already satisfied: entrypoints in /opt/conda/lib/python3.7/site-
packages (from altair) (0.3)
Requirement already satisfied: jinja2 in /opt/conda/lib/python3.7/site-packages
(from altair) (2.10.1)
Requirement already satisfied: jsonschema>=3.0 in /opt/conda/lib/python3.7/site-
packages (from altair) (3.0.2)
Requirement already satisfied: toolz in /opt/conda/lib/python3.7/site-packages
(from altair) (0.10.0)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages
(from altair) (1.17.0)
Requirement already satisfied: pandas>=0.18 in /opt/conda/lib/python3.7/site-
packages (from altair) (0.25.0)
Requirement already satisfied: MarkupSafe>=0.23 in
/opt/conda/lib/python3.7/site-packages (from jinja2->altair) (1.1.1)
Requirement already satisfied: six>=1.11.0 in /opt/conda/lib/python3.7/site-
packages (from jsonschema>=3.0->altair) (1.12.0)
Requirement already satisfied: setuptools in /opt/conda/lib/python3.7/site-
packages (from jsonschema>=3.0->altair) (41.0.1)
Requirement already satisfied: pyrsistent>=0.14.0 in
/opt/conda/lib/python3.7/site-packages (from jsonschema>=3.0->altair) (0.15.4)
Requirement already satisfied: attrs>=17.4.0 in /opt/conda/lib/python3.7/site-
packages (from jsonschema>=3.0->altair) (19.1.0)

Requirement already satisfied: pytz>=2017.2 in /opt/conda/lib/python3.7/site-packages (from pandas>=0.18->altair) (2019.2)
Requirement already satisfied: python-dateutil>=2.6.1 in /opt/conda/lib/python3.7/site-packages (from pandas>=0.18->altair) (2.8.0)

```python
[42]: import numpy as np
      import pandas as pd
      import altair as alt

      from functools import reduce
```

Covid Dataset

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

```python
[44]: df.columns
```

```python
[44]: 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')
```

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

```python
[46]: covid_df.head()
```

```
[46]:        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
```

```
[47]: covid_df.dtypes
```

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

Stock Datasts

```
[48]: 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

```
[49]: 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']
```

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

```
[50]:          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
```

```
[51]: stock_merged.dtypes
```

```
[51]: 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
```

[52]:
```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()
```

[53]:
```python
df_merged.head(10)
```

[53]:
```
         date  new_cases  new_deaths  new_tests  new_vaccinations  \
27 2020-03-02       23.0         5.0      515.0               0.0
28 2020-03-03       19.0         1.0      620.0               0.0
29 2020-03-04       33.0         4.0      891.0               0.0
30 2020-03-05       77.0         1.0     1203.0               0.0
31 2020-03-06       53.0         2.0     1523.0               0.0
32 2020-03-09       75.0         1.0     2399.0               0.0
33 2020-03-10      188.0         6.0     3481.0               0.0
34 2020-03-11      365.0         5.0     4833.0               0.0
35 2020-03-12      439.0        10.0     8891.0               0.0
36 2020-03-13      633.0         8.0    11732.0               0.0

    moderna_closing_price  moderna_volume  moderna_rsi  jnj_closing_price  \
27                  29.88      33084026.0    64.837624         140.020004
28                  27.91      17599114.0    61.075243         135.589996
29                  27.49      11817666.0    60.313849         143.479996
30                  28.01      14669976.0    60.929202         142.009995
31                  29.61      21097488.0    62.742982         142.029999
32                  24.29      14124076.0    54.205308         136.440002
33                  22.34      13019516.0    51.580159         141.639999
34                  23.61      14825434.0    53.089965         131.800003
35                  22.30      11305347.0    51.402919         125.410004
36                  21.30      11853052.0    50.161307         134.289993

    jnj_volume  ...  astra_zeneca_rsi  biontech_closing_price  \
27  11508200.0  ...         40.456508                   36.60
28  13662500.0  ...         39.738102                   38.48
```

```
29   10560500.0   ...              48.025686                    39.19
30   11339200.0   ...              47.549072                    37.12
31   12239100.0   ...              45.738435                    38.09
32   13848600.0   ...              41.449773                    33.48
33   12698100.0   ...              45.268621                    33.96
34   17763400.0   ...              41.437368                    32.17
35   21539200.0   ...              36.278622                    28.55
36   20084200.0   ...              39.344643                    30.93

      biontech_volume   biontech_rsi   novavax_closing_price   novavax_volume  \
27            185100.0      50.791524                   12.02       14261700.0
28            297900.0      52.850212                   10.78        9957300.0
29            127100.0      53.598311                   11.32       10977400.0
30             77000.0      51.182375                   12.87       14057100.0
31            279200.0      52.212347                   12.48       13250800.0
32            190200.0      47.365959                   10.02        8328800.0
33            327500.0      47.879960                   10.65       12365400.0
34            119000.0      46.164460                   10.51        9052100.0
35            184100.0      42.986160                    9.29        5488400.0
36            197600.0      45.503257                    8.41        6115400.0

      novavax_rsi   pfizer_closing_price   pfizer_volume   pfizer_rsi
27      62.899608              33.092979      42034469.0    37.171087
28      59.621290              32.542694      46174475.0    35.568345
29      60.535314              34.535103      38712155.0    44.422057
30      62.989154              33.643265      35096303.0    41.798627
31      61.999390              33.225807      40931036.0    40.651919
32      56.304878              32.030361      43183856.0    37.634936
33      57.329068              32.817837      40548329.0    40.598216
34      57.025971              30.521822      65350213.0    35.569873
35      54.465420              28.481974      62731445.0    31.979150
36      52.722981              31.034157      60553038.0    39.744867

[10 rows x 23 columns]
```

[54]: `df_merged.dtypes`

[54]:
```
date                     datetime64[ns]
new_cases                       float64
new_deaths                      float64
new_tests                       float64
new_vaccinations                float64
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
```

[55]:
```python
df_merged = df_merged[(df_merged['date']>='2020-03-01') &
 (df_merged['date']<'2022-04-01')]
df_merged.head()
```

[55]:
```
          date  new_cases  new_deaths  new_tests  new_vaccinations  \
27  2020-03-02       23.0         5.0      515.0               0.0
28  2020-03-03       19.0         1.0      620.0               0.0
29  2020-03-04       33.0         4.0      891.0               0.0
30  2020-03-05       77.0         1.0     1203.0               0.0
31  2020-03-06       53.0         2.0     1523.0               0.0

    moderna_closing_price  moderna_volume  moderna_rsi  jnj_closing_price  \
27                  29.88      33084026.0    64.837624         140.020004
28                  27.91      17599114.0    61.075243         135.589996
29                  27.49      11817666.0    60.313849         143.479996
30                  28.01      14669976.0    60.929202         142.009995
31                  29.61      21097488.0    62.742982         142.029999

     jnj_volume  ...  astra_zeneca_rsi  biontech_closing_price  \
27  11508200.0  ...         40.456508                   36.60
28  13662500.0  ...         39.738102                   38.48
29  10560500.0  ...         48.025686                   39.19
30  11339200.0  ...         47.549072                   37.12
31  12239100.0  ...         45.738435                   38.09

    biontech_volume  biontech_rsi  novavax_closing_price  novavax_volume  \
27         185100.0     50.791524                  12.02      14261700.0
28         297900.0     52.850212                  10.78       9957300.0
29         127100.0     53.598311                  11.32      10977400.0
30          77000.0     51.182375                  12.87      14057100.0
31         279200.0     52.212347                  12.48      13250800.0

    novavax_rsi  pfizer_closing_price  pfizer_volume  pfizer_rsi
27    62.899608             33.092979     42034469.0   37.171087
```

28	59.621290	32.542694	46174475.0	35.568345
29	60.535314	34.535103	38712155.0	44.422057
30	62.989154	33.643265	35096303.0	41.798627
31	61.999390	33.225807	40931036.0	40.651919

```
[5 rows x 23 columns]
```

Data Analysis

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

```python
[56]: df1 =␣
      →df_merged[["date","new_cases","new_deaths","new_vaccinations","moderna_closing_price","jnj_
                  "astra_zeneca_closing_price","biontech_closing_price",
                  "novavax_closing_price","pfizer_closing_price"]]

      #normalize values
      df1['cases'] = round(100*df1['new_cases']/df1['new_cases'].max())
      df1['deaths'] = round(100*df1['new_deaths']/df1['new_deaths'].max())
      df1['vaccinations'] = round(100*df1['new_vaccinations']/df1['new_vaccinations'].
       →max())
      df1['moderna'] = round(100*df1['moderna_closing_price']/
       →df1['moderna_closing_price'].max())
      df1['jnj'] = round(100*df1['jnj_closing_price']/df1['jnj_closing_price'].max())
      df1['astra_zeneca'] = round(100*df1['astra_zeneca_closing_price']/
       →df1['astra_zeneca_closing_price'].max())
      df1['biontech'] = round(100*df1['biontech_closing_price']/
       →df1['biontech_closing_price'].max())
      df1['novavax'] = round(100*df1['novavax_closing_price']/
       →df1['novavax_closing_price'].max())
      df1['pfizer'] = round(100*df1['pfizer_closing_price']/
       →df1['pfizer_closing_price'].max())

      #normalized df
      normalized_df =␣
       →df1[["date","cases","deaths","vaccinations","moderna","jnj","astra_zeneca","biontech","nova
```

```python
[57]: #melted_dfs for covid cases viz
      moderna_df = normalized_df[["date","cases","moderna"]]
      moderna = pd.melt(moderna_df, id_vars=["date"],value_vars=["cases","moderna"])
      jnj_df = normalized_df[["date","cases","jnj"]]
      jnj = pd.melt(jnj_df, id_vars=["date"],value_vars=["cases","jnj"])
      astra_zeneca_df = normalized_df[["date","cases","astra_zeneca"]]
      astra_zeneca = pd.melt(astra_zeneca_df,␣
       →id_vars=["date"],value_vars=["cases","astra_zeneca"])
      biontech_df = normalized_df[["date","cases","biontech"]]
      biontech = pd.melt(biontech_df,␣
       →id_vars=["date"],value_vars=["cases","biontech"])
```

```python
novavax_df = normalized_df[["date","cases","novavax"]]
novavax = pd.melt(novavax_df, id_vars=["date"],value_vars=["cases","novavax"])
pfizer_df = normalized_df[["date","cases","pfizer"]]
pfizer = pd.melt(pfizer_df, id_vars=["date"],value_vars=["cases","pfizer"])

dfs=[moderna,jnj,astra_zeneca,biontech,novavax,pfizer]

#create covid cases charts
charts=[]
for df in dfs:
    charts.append(
        alt.Chart(df,title=alt.TitleParams(str(df.iloc[-1,1]),fontSize=12)
                ).mark_line(
                ).transform_window(
                        rolling_30d_mean='mean(value)',
                        frame=[-15, 15],
                        groupby=['variable']
                ).encode(
                        x=alt.X('date',
                                axis=alt.Axis(labels=True),
                                title='date'),
                        y=alt.Y('rolling_30d_mean:Q',
                                scale=alt.Scale(domain=[0, 100]),
                                title='rolling mean'),
                        color=alt.Color('variable',legend=alt.
 ↪Legend(direction='vertical', titleAnchor='middle')),
                        tooltip=['variable:N',alt.Tooltip('rolling_30d_mean:Q',␣
 ↪format='.2f')]
                ).properties(
                        width=325,
                        height=100
                )
                )

x = alt.vconcat(charts[0], charts[1], charts[2])
y = alt.vconcat(charts[3], charts[4], charts[5])

(x|y).properties(title="30-day Rolling Average Covid Cases vs. Stocks"
                ).configure_title(fontSize=14,anchor='middle')
```

[57]: `alt.HConcatChart(...)`

```python
[58]: #melted_dfs for covid deaths
moderna_df = normalized_df[["date","deaths","moderna"]]
moderna = pd.melt(moderna_df, id_vars=["date"],value_vars=["deaths","moderna"])
jnj_df = normalized_df[["date","deaths","jnj"]]
jnj = pd.melt(jnj_df, id_vars=["date"],value_vars=["deaths","jnj"])
astra_zeneca_df = normalized_df[["date","deaths","astra_zeneca"]]
```

```python
astra_zeneca = pd.melt(astra_zeneca_df,␣
 ↪id_vars=["date"],value_vars=["deaths","astra_zeneca"])
biontech_df = normalized_df[["date","deaths","biontech"]]
biontech = pd.melt(biontech_df,␣
 ↪id_vars=["date"],value_vars=["deaths","biontech"])
novavax_df = normalized_df[["date","deaths","novavax"]]
novavax = pd.melt(novavax_df, id_vars=["date"],value_vars=["deaths","novavax"])
pfizer_df = normalized_df[["date","deaths","pfizer"]]
pfizer = pd.melt(pfizer_df, id_vars=["date"],value_vars=["deaths","pfizer"])

dfs=[moderna,jnj,astra_zeneca,biontech,novavax,pfizer]

#create covid deaths charts
charts=[]
for df in dfs:
    charts.append(
        alt.Chart(df,title=alt.TitleParams(str(df.iloc[-1,1]),fontSize=12)
                ).mark_line(
                ).transform_window(
                        rolling_30d_mean='mean(value)',
                        frame=[-15, 15],
                        groupby=['variable']
                ).encode(
                        x=alt.X('date',
                                axis=alt.Axis(labels=True),
                                title='date'),
                        y=alt.Y('rolling_30d_mean:Q',
                                scale=alt.Scale(domain=[0, 100]),
                                title='rolling mean'),
                        color=alt.Color('variable',legend=alt.
 ↪Legend(direction='vertical', titleAnchor='middle')),
                        tooltip=['variable:N',alt.Tooltip('rolling_30d_mean:Q',␣
 ↪format='.2f')]
                ).properties(
                        width=325,
                        height=100
                )
                )

x = alt.vconcat(charts[0], charts[1], charts[2])
y = alt.vconcat(charts[3], charts[4], charts[5])

(x|y).properties(title="30-day Rolling Average Covid Deaths vs. Stocks"
                ).configure_title(fontSize=14,anchor='middle')
```

[58]: alt.HConcatChart(...)

```python
[59]: #melted_dfs for covid vaccinations
      moderna_df = normalized_df[["date","vaccinations","moderna"]]
      moderna = pd.melt(moderna_df,
       ↪id_vars=["date"],value_vars=["vaccinations","moderna"])
      jnj_df = normalized_df[["date","vaccinations","jnj"]]
      jnj = pd.melt(jnj_df, id_vars=["date"],value_vars=["vaccinations","jnj"])
      astra_zeneca_df = normalized_df[["date","vaccinations","astra_zeneca"]]
      astra_zeneca = pd.melt(astra_zeneca_df,
       ↪id_vars=["date"],value_vars=["vaccinations","astra_zeneca"])
      biontech_df = normalized_df[["date","vaccinations","biontech"]]
      biontech = pd.melt(biontech_df,
       ↪id_vars=["date"],value_vars=["vaccinations","biontech"])
      novavax_df = normalized_df[["date","vaccinations","novavax"]]
      novavax = pd.melt(novavax_df,
       ↪id_vars=["date"],value_vars=["vaccinations","novavax"])
      pfizer_df = normalized_df[["date","vaccinations","pfizer"]]
      pfizer = pd.melt(pfizer_df,
       ↪id_vars=["date"],value_vars=["vaccinations","pfizer"])

      dfs=[moderna,jnj,astra_zeneca,biontech,novavax,pfizer]

      #create covid vaccinations charts
      charts=[]
      for df in dfs:
          charts.append(
              alt.Chart(df,title=alt.TitleParams(str(df.iloc[-1,1]),fontSize=12)
                      ).mark_line(
                      ).transform_window(
                              rolling_30d_mean='mean(value)',
                              frame=[-15, 15],
                              groupby=['variable']
                      ).encode(
                              x=alt.X('date',
                                      axis=alt.Axis(labels=True),
                                      title='date'),
                              y=alt.Y('rolling_30d_mean:Q',
                                      scale=alt.Scale(domain=[0, 100]),
                                      title='rolling_mean'),
                              color=alt.Color('variable', legend=alt.
       ↪Legend(direction='vertical', titleAnchor='middle')
                                              ),
                              tooltip=['variable:N',alt.Tooltip('rolling_30d_mean:Q',
       ↪format='.2f')]
                      ).properties(
                              width=325,
                              height=100
```

```
                    )
                    )

x = alt.vconcat(charts[0], charts[1], charts[2])
y = alt.vconcat(charts[3], charts[4], charts[5])

(x|y).properties(title="30-day Rolling Average Covid Vaccinations vs. Stocks"
                ).configure_title(fontSize=14,anchor='middle')
```

[59]: alt.HConcatChart(...)

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?

[ ]: