

United States

Unused Doses Methodology

To calculate unused doses by a certain date, we take the following steps:

1. Estimate how many doses the country has received (and/or will) by a specific date
2. Estimate how many doses have been used (and/or will) by a specific date, should vaccinations continue at the same rate as now (latest 14-day period)
3. Estimate how many doses the country has donated (and/or will, based actual or projected deliveries) by a specific date.
4. Estimate how many unused or excess doses there would be by a specific date, calculated as:

$$Unused_{doses} = Supply - Demand - Donations$$

Prep

Before starting the analysis, the necessary libraries and functions need to be imported. To keep this section clean, most of the scripts are stored in a file called `utils.py`

```
In [1]: import os
import sys
project_path = os.path.dirname(os.path.abspath(os.path.join('')))
scripts_path = os.path.dirname(os.path.abspath(os.path.join('/jupyter_notebooks/')))

if project_path not in sys.path:
    sys.path.append(project_path)

#Import pandas and the utilities
import pandas as pd
from jupyter_notebooks import utils

#Format the display of numbers
from IPython.display import display
pd.options.display.float_format = '{:,.0f}'.format

def show(title=None, data=None):
    if title is not None:
        title = "\033[1m" + title + "\033[0m"
        print('\n',title)
        display(data)

def number(number):
    return "{:,.0f}".format(number)
```

Step 1: Supply

```
In [2]: #US Received Supply Data
supply_received = utils.get_supply(filename='us_received_airfinity')

#US Forecast Supply Data.
vaccines = ['Johnson&Johnson', 'Pfizer/BioNTech', 'Moderna']
supply_forecast = utils.get_supply_forecast(filename='us_supply_forecast',
                                             vaccines = vaccines)

#Add supply change to forecast
supply_forecast = utils.add_supply_change_to_forecast(supply_forecast)

#Forecast summary
supply_forecast_summary = utils.additional_supply_by_month(supply_forecast)

#Store key numbers for further analysis
current_supply_delivered = supply_received.delivered_supply.sum()
supply_forecast_year_end = supply_forecast_summary['Total'].sum()

#Show summary
supply_forecast_short = supply_forecast_summary.query("date == 'August' or date== 'December'")
supply_received_short = supply_received.query('delivered_supply > 0')

print(f'The US has received {number(current_supply_delivered)} doses')
print(f'It will have received {number(supply_forecast_year_end)} doses by the end of the year.')
```

The US has received 390,090,255 doses
It will have received 948,506,615 doses by the end of the year.

Supply Forecast (additional doses per month)						
	country	date	Johnson&Johnson	Moderna	Pfizer/BioNTech	Total
9	United States	August	15,152,287	33,803,191	30,249,422	79,204,900
13	United States	December	21,258,183	32,712,766	60,402,315	114,373,264

Supply received to date					
	country	vaccine	delivered_supply	confirmed_supply	supply_date
0	United States	Johnson&Johnson	21,484,400	200,000,000	2021-07-18
1	United States	Moderna	161,006,080	410,000,000	2021-07-18
4	United States	Pfizer/BioNTech	207,599,775	500,000,000	2021-07-18

Step 2: Demand

This demand analysis is based on current trends up to 18-July, based on the demand of the previous 14 days period. It assumes a linear trend that continues indefinitely.

Data is available for the US in order to calculate the demand by vaccine type.

```
In [3]: #Get demand data (from OWID), clean and add linear projections with 14-day window

demand = (utils.get_used_doses_by_manufacturer(vaccines)
          .pipe(utils.clean_used_doses_by_manufacturer)
          .pipe(utils.linear_projection_by_manufacturer, observed_max_date='2021-07-27',days_window=14)
          .pipe(utils.add_change, 'cumulative_doses','additional_doses')
          )

#Filter the demand data for the US
us_demand = demand.query("iso_code == 'USA'")

#Show a summary of the forecast demand data
demand_summary = utils.additional_used_by_month(us_demand, vaccines)

show('Observed/forecast Demand by month', demand_summary)

print(f'Total expected demand this year: {number(demand_summary.Total.sum())} doses')
```

	iso_code	date	Johnson&Johnson	Pfizer/BioNTech	Moderna	Total
0	USA	January	0	16,775,916	14,246,089	31,022,005
1	USA	February	0	21,650,651	22,448,325	44,098,976
2	USA	March	3,307,113	38,465,345	33,236,542	75,009,000
3	USA	April	4,924,026	50,241,487	34,682,937	89,848,450
4	USA	May	2,545,478	32,278,632	19,907,021	54,731,131
5	USA	June	1,629,129	20,932,966	8,993,954	31,556,049
6	USA	July	975,405	12,211,590	5,105,944	18,292,939
7	USA	August	865,204	11,758,182	4,463,667	17,087,053
8	USA	September	837,295	11,378,886	4,319,677	16,535,858
9	USA	October	865,204	11,758,182	4,463,667	17,087,053
10	USA	November	837,295	11,378,886	4,319,677	16,535,857
11	USA	December	865,204	11,758,182	4,463,667	17,087,053

Total expected demand this year: 428,891,423 doses

```
In [4]: #The analysis also requires estimates on full vaccinations per month
full_vaccinations = (utils.get_owid_vaccination()
                    .pipe(utils.full_vaccination_forecast, observed_max_date='2021-07-27'))

#Filter for US only
us_full_vaccinations = full_vaccinations.query("iso_code == 'USA'")

us_full_vaccinations_summary = utils.additional_vax_by_month(us_full_vaccinations)
us_full_vaccinations_summary['Fully_vaccinated_cumulative'] = us_full_vaccinations_summary.additional_fully_vax

#Show key numbers
show('Observed / Forecast Full Vaccinations (additional per month)', us_full_vaccinations_summary)
print(f'An average of {number(us_full_vaccinations_summary.iloc[7:,2].mean())} full vaccinations per month (Aug-Dec)')
```

Observed / Forecast Full Vaccinations (additional per month)				
	iso_code	date	additional_fully_vaxxed	Fully_vaccinated_cumulative
0	USA	January	5,657,142	5,657,142
1	USA	February	19,122,778	24,779,920
2	USA	March	29,827,121	54,607,041
3	USA	April	46,800,277	101,407,318
4	USA	May	33,680,001	135,087,319
5	USA	June	19,797,367	154,884,686
6	USA	July	9,593,427	164,478,113
7	USA	August	7,928,734	172,406,847
8	USA	September	7,672,968	180,079,815
9	USA	October	7,928,734	188,008,549
10	USA	November	7,672,968	195,681,517
11	USA	December	7,928,734	203,610,251

An average of 7,826,428 full vaccinations per month (Aug-Dec)

Step 3: Donations

This section contains donations committed and delivered as of 18 July, according to Airfinity's data. It is possible that it does not include all doses effectively delivered in July.

Our forecast for August assumes that all the remaining doses committed (outside the 500m doses of Pfizer) are delivered that month.

```
In [5]: #Load the US donations to date

us_donations = utils.get_donations_data(filename='us_donations_airfinity')
us_donations_summary = utils.donations_to_date_summary(us_donations)

donations_to_date =us_donations_summary.copy()
donations_to_date['date']='July'
donations_to_date = donations_to_date.groupby('date').sum().reset_index(drop=False)
donations_to_date.rename(columns={'delivered':'Total_Donations'}, inplace=True)

us_donations_summary['Cumulative_delivered'] = us_donations_summary.delivered.cumsum()

#Donations forecast
doses = {'Pfizer/BioNTech': {'August': 3.5*1e6,'September': 50*1e6,'October': 50*1e6,'November': 50*1e6,'December': 50*1e6},
        'Moderna': {'August': 2168000,'September': 0,'October': 0,'November': 0,'December': 0},
        'Johnson&Johnson': {'August': 1.5*1e6,'September': 0,'October': 0,'November': 0,'December': 0},
        'Oxford/AstraZeneca': {'August': 0, 'September': 0,'October': 0,'November': 0,'December': 0},
        }

us_forecast_donations = utils.us_donation_schedule(doses)
us_forecast_donations_summary = utils.donations_forecast_summary(us_forecast_donations)
us_forecast_donations_summary.rename(columns={'Total': 'Total_Donations'}, inplace=True)

#Show key figures
show('US Donations Summary (observed)', us_donations_summary)
show('US Donations Forecast', us_forecast_donations_summary)

total_donations_2021 = us_donations_summary.delivered.sum() + us_forecast_donations_summary.Total_Donations.sum()
print(f'A total of {number(total_donations_2021)} (delivered + forecasted) donated doses in 2021')
```

```
print(f'A total of {number(total_donations_2021)} (delivered + for
```

US Donations Summary (observed)					
	vaccine	donated	delivered	delivery_date_last	Cumulative_delivered
0	Johnson&Johnson	7,518,000	5,350,000	2021-07-12	5,350,000
1	Moderna	13,500,000	12,000,000	2021-07-18	17,350,000
2	Pfizer/BioNTech	207,500,480	4,000,480	2021-07-15	21,350,480

US Donations Forecast							
	date	Johnson&Johnson	Moderna	Oxford/AstraZeneca	Pfizer/BioNTech	Total_Donations	Cumulative
0	August	1,500,000	2,168,000	0	3,500,000	7,168,000	7,168,000
1	September	0	0	0	50,000,000	50,000,000	57,168,000
2	October	0	0	0	50,000,000	50,000,000	107,168,000
3	November	0	0	0	50,000,000	50,000,000	157,168,000
4	December	0	0	0	50,000,000	50,000,000	207,168,000

A total of 228,518,480 (delivered + forecasted) donated doses in 2021

Step 4: Unused doses

```
In [6]: #At any point, unused is supply minus demand minus donations
#Create table with all aggregate numbers

df = (supply_forecast_summary[['country','date','Total']]
      .merge(demand_summary[['date','Total']], on=['date'], how='left', suffixes=('_Supply','_Demand'))
      .merge(donations_to_date.append(us_forecast_donations_summary[['date','Total_Donations']],ignore_index=True,
                                     on=['date'], how='left')
      )

df['Unused'] = df.Total_Supply - df.Total_Demand.fillna(0) - df.Total_Donations.fillna(0)

df_summary = df.groupby('country').sum().reset_index(drop=False)

df['Unused Cumulative'] = df.Unused.cumsum()

df_short = df.query("date=='August" or date == "December'")

show('Unused doses analysis for the US', df_short.fillna(0))

show('As a result, by the end of the year, the situation will look like this',df_summary)
```

9	United States	August	79,204,900	17,087,053	7,168,000	54,949,848	149,395,585
13	United States	December	114,373,264	17,087,053	50,000,000	47,286,211	291,096,712
As a result, by the end of the year, the situation will look like this							
	country	Total Supply	Total Demand	Total Donations	Unused		

As a result, by the end of the year, the situation will look like this

	country	Total_Supply	Total_Demand	Total_Donations	Unused
0	United States	948,506,615	428,891,423	228,518,480	291,096,712

Export analysis

```
In [7]: #Export
data_to_export = {'Supply Forecast': supply_forecast_summary,
                  'Demand Summary': demand_summary,
                  'Observed/Forecast Full Vaccinations (Additional per month)': us_full_vaccinations_summary,
                  'US donations forecast': us_forecast_donations_summary,
                  'US Unused Doses Analysis': df}

utils.export_excel(file_name= 'US_Supply and Demand analysis',
                  worksheet_name = 'US_analysis',
                  dataframes_dict = data_to_export)
```