EEP153 Project 0 - Team Greville

Table of Contents

Questions A, B, and C

Import necessary libraries

In [30]:
```
!pip install wbdata
import wbdata
import numpy as np
import pandas as pd
import cufflinks as cf
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
cf.go_offline()
```

```
Requirement already satisfied: wbdata in /opt/conda/lib/python3.8/site-packages (0.3.0)
Requirement already satisfied: appdirs<2.0,>=1.4 in /opt/conda/lib/python3.8/site-packages
(from wbdata) (1.4.4)
Requirement already satisfied: decorator>=4.0 in /opt/conda/lib/python3.8/site-packages (f
rom wbdata) (4.4.2)
Requirement already satisfied: requests>=2.0 in /opt/conda/lib/python3.8/site-packages (fr
om wbdata) (2.25.1)
Requirement already satisfied: tabulate>=0.8.5 in /opt/conda/lib/python3.8/site-packages
(from wbdata) (0.8.7)
Requirement already satisfied: chardet<5,>=3.0.2 in /opt/conda/lib/python3.8/site-packages
(from requests>=2.0->wbdata) (3.0.4)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.8/site-package
s (from requests>=2.0->wbdata) (2019.11.28)
Requirement already satisfied: idna<3,>=2.5 in /opt/conda/lib/python3.8/site-packages (fro
m requests>=2.0->wbdata) (2.8)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.8/site-pack
ages (from requests>=2.0->wbdata) (1.25.7)
```

Create population function

Takes in a given year, population parameter ("Male", "Female", "Everyone"), the minimum age, the maximum age, and the desired country (ex "USA" or "WLD" for world) an returns the counts of the given age groups aggregated in 5 year intervals

In [31]:
```
def population(year, population, low, high, location):
    age_ranges = []
    if high > 80:
        for i in range(low,80,5):
            age_ranges.append(f"{i:02d}"+f"{i+4:02d}")
        age_ranges.append("80UP")
    else:
        if high % 5 == 0:
            for i in range(low,high,5):
                age_ranges.append(f"{i:02d}"+f"{i+4:02d}")
        else:
            for i in range(low,high,5):
                age_ranges.append(f"{i:02d}"+f"{i+4:02d}")
```

```
    if population == "Male" or population == "Males":
        male_variables = {"SP.POP."+age_range+".MA":"Males "+age_range for age_range in ag
        variables = male_variables
    elif population == "Female" or population == "Females":
        female_variables = {"SP.POP."+age_range+".FE":"Females "+age_range for age_range i
        variables = female_variables
    else:
        male_variables = {"SP.POP."+age_range+".MA":"Males "+age_range for age_range in ag
        female_variables = {"SP.POP."+age_range+".FE":"Females "+age_range for age_range i
        variables = male_variables
        variables.update(female_variables)

    data = wbdata.get_dataframe(variables,country=location)
    data.reset_index(inplace=True)
    data['date'] = data['date'].astype(int)
    data.set_index(['date'],inplace=True)
    df = data.query("date=="+str(year))
    date_str = "date==" + str(year)
    print(df.query(date_str).sum(axis=0))

population(2008, "All", 15, 85, "GBR")
```

```
Males 1519      2055526.0
Males 2024      2107117.0
Males 2529      2029664.0
Males 3034      1993729.0
Males 3539      2167269.0
Males 4044      2329149.0
Males 4549      2183220.0
Males 5054      1877733.0
Males 5559      1834642.0
Males 6064      1764858.0
Males 6569      1353073.0
Males 7074      1132283.0
Males 7579       894554.0
Males 80UP      1020399.0
Females 1519    1972199.0
Females 2024    2067185.0
Females 2529    2028566.0
Females 3034    2011134.0
Females 3539    2207305.0
Females 4044    2382044.0
Females 4549    2228958.0
Females 5054    1909715.0
Females 5559    1879547.0
Females 6064    1830024.0
Females 6569    1448740.0
Females 7074    1276464.0
Females 7579    1108272.0
Females 80UP    1810474.0
dtype: float64
```

Create population_df function

Takes in a given year and the desired country (ex "USA" or "WLD" for world) and returns a one row dataframe of the counts of all ages aggreagted in 5 year groups

In [32]:

```
def population_df(year, location):
    age_ranges = []
    for i in range(0,80,5):
        age_ranges.append(f"{i:02d}"+f"{i+4:02d}")
    age_ranges.append("80UP")

    male_variables = {"SP.POP."+age_range+".MA":"Males "+age_range for age_range in age_ra
```

```
    female_variables = {"SP.POP."+age_range+".FE":"Females "+age_range for age_range in ag
    variables = male_variables
    variables.update(female_variables)

    df = wbdata.get_dataframe(variables,country="WLD")
    #final_df = pd.DataFrame(df, columns=["Population Age Range", "Population Count"])
    return df.loc[[str(year)],:]

population_df(2008, "GBR")
```

Out[32]:

date	Males 0004	Males 0509	Males 1014	Males 1519	Males 2024	Males 2529	Males 3034	Males 3539
2008	330870369.0	316287094.0	309906090.0	313386351.0	304771450.0	270286669.0	253155153.0	245625510.0

1 rows × 34 columns

Construct setup variables for population_pyramid

Creates a list of possible age ranges aggreagted at 5 year interval with the final group being 80 years and over, as well as creating the necessary male and female variables for the API

In [33]:

```
age_ranges = []
for i in range(0,80,5):
    age_ranges.append(f"{i:02d}"+f"{i+4:02d}")

age_ranges.append("80UP")

male_variables = {"SP.POP."+age_range+".MA":"Males "+age_range for age_range in age_ranges
female_variables = {"SP.POP."+age_range+".FE":"Females "+age_range for age_range in age_ra

variables = male_variables
variables.update(female_variables)

df = wbdata.get_dataframe(variables,country="GBR")
df
```

Out[33]:

date	Males 0004	Males 0509	Males 1014	Males 1519	Males 2024	Males 2529	Males 3034	Males 3539	Males 4044	Mal 45
2020	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	Na
2019	2002151.0	2083573.0	1964877.0	1860465.0	2074980.0	2261807.0	2319836.0	2222680.0	2107164.0	2131817
2018	2015968.0	2076882.0	1917793.0	1873417.0	2095259.0	2268214.0	2297014.0	2188332.0	2092905.0	216824(
2017	2031768.0	2060487.0	1867936.0	1894805.0	2112753.0	2270083.0	2269216.0	2154975.0	2085423.0	220968
2016	2049855.0	2030476.0	1824762.0	1915762.0	2127340.0	2265635.0	2237577.0	2124331.0	2087212.0	224648(
...	...	...	...	...	...	...	...	...	...	
1964	2424299.0	2038602.0	1975872.0	2135784.0	1756696.0	1674812.0	1673939.0	1751103.0	1828729.0	162969
1963	2388729.0	1967594.0	2043087.0	2073240.0	1724941.0	1661051.0	1678312.0	1793079.0	1780592.0	166576
1962	2333842.0	1916887.0	2115562.0	1984936.0	1696996.0	1653593.0	1682542.0	1834635.0	1719962.0	171572
1961	2240434.0	1902596.0	2165198.0	1898161.0	1667854.0	1653174.0	1692422.0	1860774.0	1673088.0	176175
1960	2107361.0	1928378.0	2183048.0	1831575.0	1641752.0	1660183.0	1715383.0	1866286.0	1658617.0	179663

61 rows × 34 columns

Create population_pyramid function

Creates a population pyramid using a dataframe corresponding to a given year and country or the world population

In [34]:

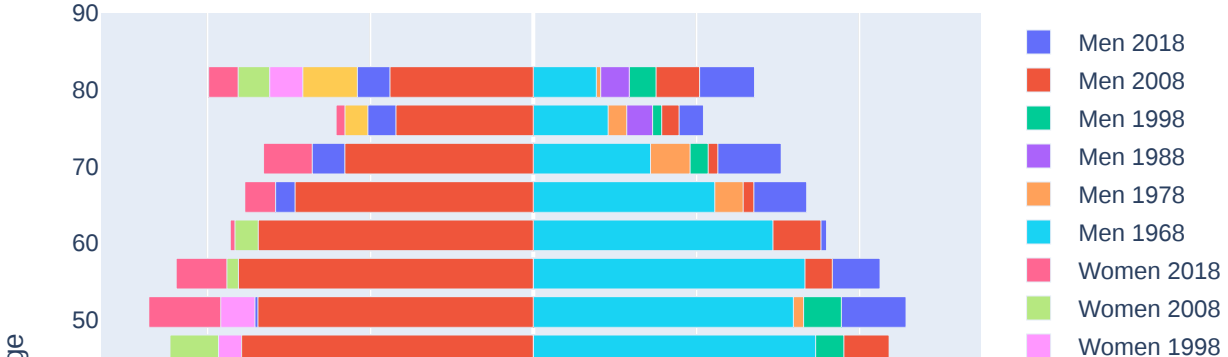
```
import plotly.offline as py
import plotly.graph_objs as go

py.init_notebook_mode(connected=True)


def population_pyramid(dataframe):
    layout = go.Layout(barmode='overlay',
                   yaxis=go.layout.YAxis(range=[0, 90], title='Age'),
                   xaxis=go.layout.XAxis(title='Number'))

    year = dataframe.index[0]

    bins = [go.Bar(x = dataframe.loc[str(year),:].filter(regex="Male").values,
                y = [int(s[:2])+1 for s in age_ranges],
                orientation='h',
                name='Men',
                marker=dict(color='purple'),
                hoverinfo='skip'
                ),

    go.Bar(x = -dataframe.loc[str(year),:].filter(regex="Female").values,
                y=[int(s[:2])+1 for s in age_ranges],
                orientation='h',
                name='Women',
                marker=dict(color='pink'),
                hoverinfo='skip',
                )
        ]
    py.iplot(dict(data=bins, layout=layout))

population_pyramid(population_df(2008, "GBR"))
```

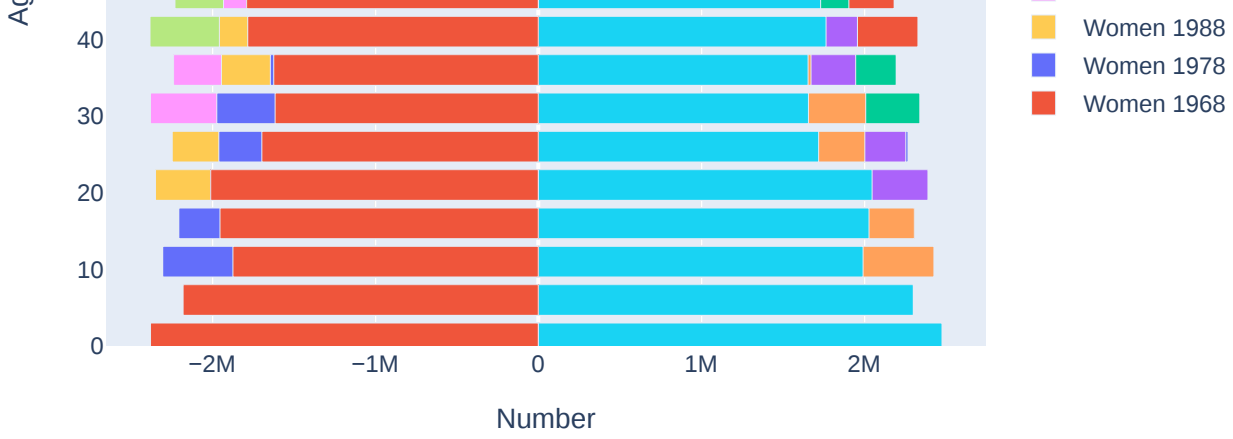
Construct animated_population_pyramid function

Takes in a dataframe and creates an animated population pyramid showing the change in population over time in each decade from 1960 to 2018

In [35]:

```
def animated_population_pyramid(dataframe):

    # Count down by increments of 20 years
    years = range(2018,1960,-10)

    layout = go.Layout(barmode='overlay',
                       yaxis=go.layout.YAxis(range=[0, 90], title='Age'),
                       xaxis=go.layout.XAxis(title='Number'))

    # This makes a list of graphs, year by year
    bins = [go.Bar(x = df.loc[str(year),:].filter(regex="Male").values,
                   y = [int(s[:2])+1 for s in age_ranges],
                   orientation='h',
                   name='Men {:d}'.format(year),
                   hoverinfo='skip'
                  )
            for year in years]

    bins += [go.Bar(x = -df.loc[str(year),:].filter(regex="Female").values,
                    y=[int(s[:2])+1 for s in age_ranges],
                    orientation='h',
                    name='Women {:d}'.format(year),
                    hoverinfo='skip',
                   )
             for year in years]

    return py.iplot(dict(data=bins, layout=layout))

animated_population_pyramid(df)
```



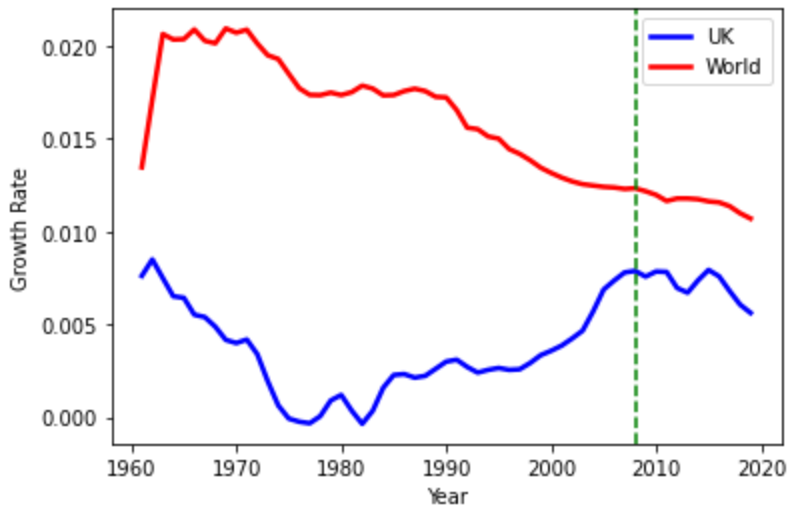


Presentation Graphs

Population Growth Rate Graph

In [36]:

```
variable_labels = {"SP.POP.TOTL":"Population"}

# Three letter codes come from wbdata.get_country()
countries = {"WLD":"World",
             "GBR":"United Kingdom"
            }

df = wbdata.get_dataframe(variable_labels, country = countries).squeeze()

df = df.unstack('country')
# Date index is of type string; change to integers
df.index = df.index.astype(int)

# Differences (over time) in logs give us growth rates
new_df = np.log(df).diff()

# Useful arguments to pass include xTitle, yTitle, Title
fig, ax = plt.subplots()
sns.lineplot(data=new_df, x="date", y="United Kingdom",
             label = 'UK', color='blue', linewidth=2.5, dashes=(5, 1), ax = ax)
sns.lineplot(data=new_df, x="date", y="World",
             label = 'World', color='red', linewidth=2.5, ax = ax)
plt.axvline(x = 2008, color = 'green', linestyle = '--')
ax.set(xlabel='Year', ylabel='Growth Rate');
```



Population Statistics gathering the data

In [37]:

```
wbdata.search_countries("World")
#WLD
wld_variable_labels = {"SP.DYN.LE00.IN":"World Life Expectancy at Birth",
                   "SP.POP.DPND":"World Dependency Ratio",
                   "SP.RUR.TOTL.ZG":"World Rural Population Growth (Annual %)",
                   "SP.URB.GROW":"World Urban Population Growth (Annual %)",
                    "NY.GDP.PCAP.CD": "GDP,Current US$"}
world = wbdata.get_dataframe(wld_variable_labels, country='WLD')
world.index = world.index.astype(int)
world = world.reset_index()
world = world.sort_values('date', ascending=True)
toPlot_world = world
toPlot_world

variable_labels = {"SP.DYN.LE00.IN":"Life Expectancy at Birth",
                   "SP.POP.DPND":"Dependency Ratio",
                   "SP.RUR.TOTL.ZG":"Rural Population Growth (Annual %)",
                   "SP.URB.GROW":"Urban Population Growth (Annual %)",
                   "NY.GDP.PCAP.CD": "GDP,Current US$"}
UK = wbdata.get_dataframe(variable_labels, country='GBR')
UK.index = UK.index.astype(int)

UK = UK.reset_index()
UK = UK.sort_values('date', ascending=True)
UK['Log GDP'] = np.log(UK['GDP,Current US$'])
toPlot_UK = UK.dropna(subset=['Log GDP'])
toPlot_UK.head()
```

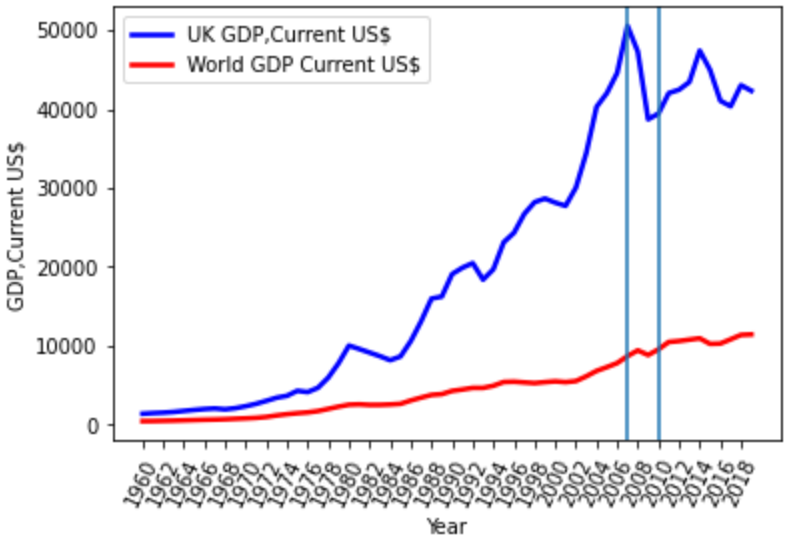
Out[37]:

	date	Life Expectancy at Birth	Dependency Ratio	Rural Population Growth (Annual %)	Urban Population Growth (Annual %)	GDP,Current US$	Log GDP
60	1960	71.126829	53.664141	NaN	NaN	1397.594803	7.242508
59	1961	70.878049	54.215750	1.084669	0.671184	1472.385714	7.294639
58	1962	70.926829	54.431065	1.480164	0.673704	1525.775853	7.330258
57	1963	70.826829	54.481651	1.380460	0.571826	1613.456884	7.386134
56	1964	71.624390	54.643298	1.282931	0.472119	1748.288118	7.466392

World vs UK GDP Graph

In [38]:

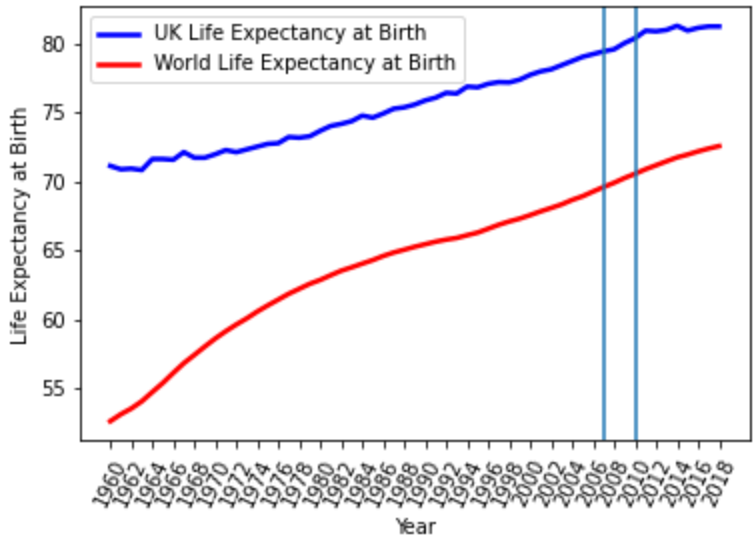
```
fig, ax = plt.subplots()
sns.lineplot(data=toPlot_UK, x='date', y ="GDP,Current US$",
             label = 'UK GDP,Current US$', color='blue', linewidth=2.5, dashes=(5, 1), ax
sns.lineplot(data= toPlot_world, x='date', y="GDP,Current US$",
            label='World GDP Current US$', color = 'red', linewidth = 2.5, dashes=(5,1), a

plt.xticks(np.arange(min(toPlot_UK['date']), max(toPlot_UK['date'])+1, 2), rotation = 65)
plt.axvline(x=2007)
plt.axvline(x=2010)
ax.set(xlabel='Year', ylabel='GDP,Current US$');
```



World vs UK Life Expectancy Graph

In [39]:

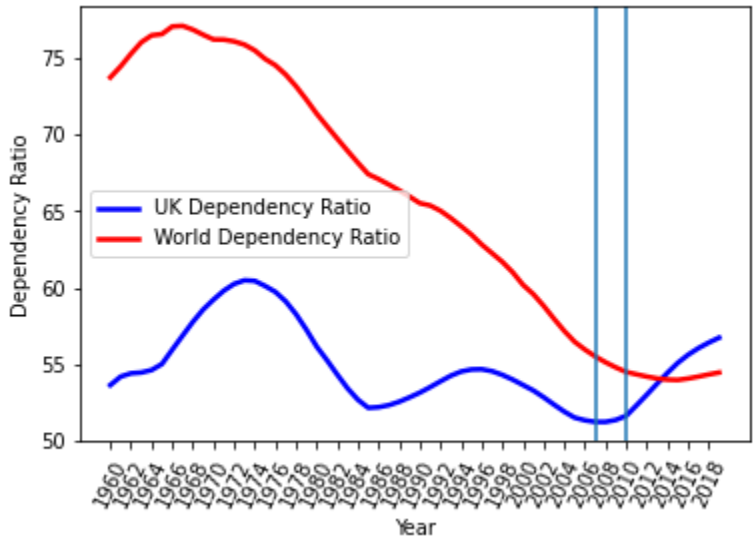
```
fig, ax = plt.subplots()
sns.lineplot(data=toPlot_UK,x='date', y = "Life Expectancy at Birth",
             label = "UK Life Expectancy at Birth", color='blue', linewidth=2.5, dashes=(5
sns.lineplot(data=toPlot_world, x='date',y='World Life Expectancy at Birth',
            label = 'World Life Expectancy at Birth', color ='red', linewidth = 2.5, dashe

plt.xticks(np.arange(min(toPlot_UK['date']), max(toPlot_UK['date'])+1, 2), rotation = 65)
plt.axvline(x=2007)
plt.axvline(x=2010)
ax.set(xlabel='Year', ylabel='Life Expectancy at Birth');
```



World vs UK Dependency Graph

In [40]:

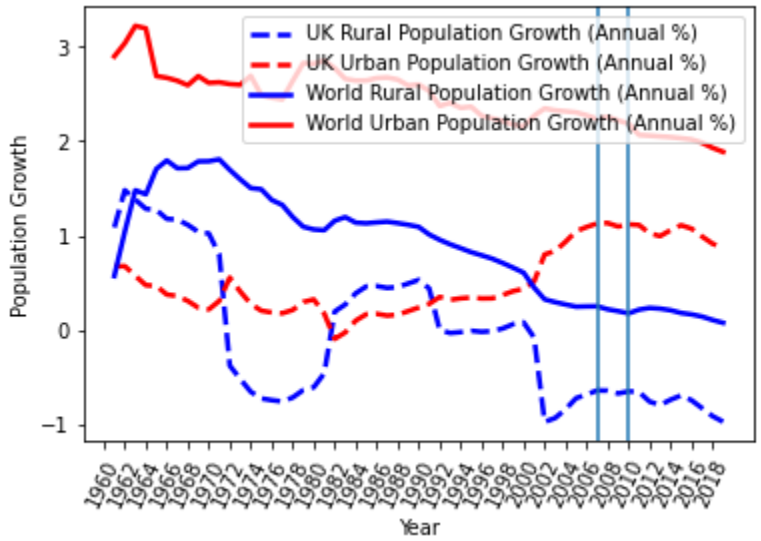
```
fig, ax = plt.subplots()
sns.lineplot(data=toPlot_UK, x= 'date', y = "Dependency Ratio",
             label = "UK Dependency Ratio", color='blue', linewidth=2.5, dashes=(5, 1), ax
sns.lineplot(data=toPlot_world, x='date', y = "World Dependency Ratio",
             label = "World Dependency Ratio", color='red', linewidth=2.5, dashes=(5, 1),

plt.xticks(np.arange(min(toPlot_UK['date']), max(toPlot_UK['date'])+1, 2), rotation = 65)
plt.axvline(x=2007)
plt.axvline(x=2010)
ax.set(xlabel='Year', ylabel='Dependency Ratio');
```



World vs UK Rural And Urban Population Growth Rates Graph

In [41]:

```
fig, ax = plt.subplots()
sns.lineplot(data=toPlot_UK, x="date", y="Rural Population Growth (Annual %)",
             label = "UK Rural Population Growth (Annual %)", color='blue', linewidth=2.5,
sns.lineplot(data=toPlot_UK, x="date", y="Urban Population Growth (Annual %)",
             label = "UK Urban Population Growth (Annual %)", color='red', linewidth=2.5,

sns.lineplot(data=toPlot_world, x="date", y="World Rural Population Growth (Annual %)",
             label = "World Rural Population Growth (Annual %)", color='blue', linewidth=2
sns.lineplot(data=toPlot_world, x="date", y="World Urban Population Growth (Annual %)",
             label = "World Urban Population Growth (Annual %)", color='red', linewidth=2.


plt.axvline(x=2007)
plt.axvline(x=2010)
plt.xticks(np.arange(min(toPlot_UK['date']), max(toPlot_UK['date'])+1, 2), rotation = 65)
ax.set(xlabel='Year', ylabel='Population Growth');
```



Construct Setup Variables for World vs UK Mortality Rates

In [42]:

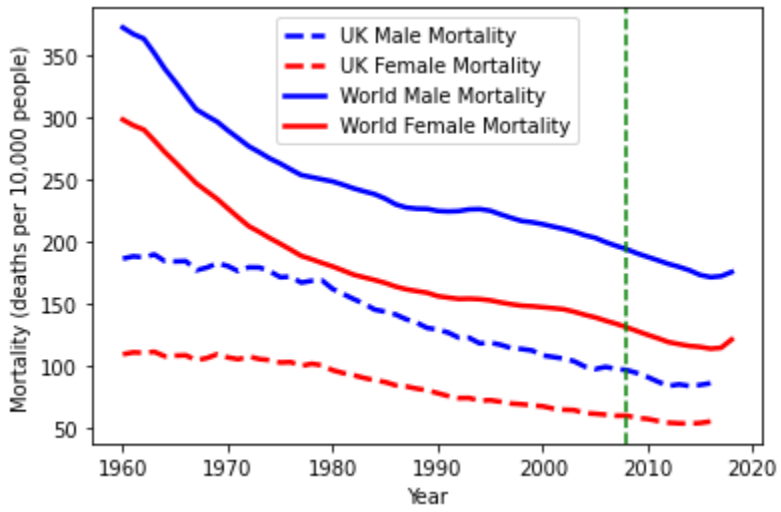
```
# get variable labels for world mortality rates
variable_labels = {"SP.DYN.AMRT.MA":"World Male Mortality",
                   "SP.DYN.AMRT.FE":"World Female Mortality",
                   "NY.GDP.PCAP.CD":'GDP'}
#create world mortality df
```

```
WLD_Mortality = wbdata.get_dataframe(variable_labels, country="WLD")

# get variable labels for uk male mortality rates
variable_labels = {"SP.DYN.AMRT.MA":"United Kingdom Male Mortality"}

GBR_MA = wbdata.get_dataframe(variable_labels, country="GBR")

GBR_Mortality=GBR_MA.reset_index().merge

# get variable labels for uk female mortality rates
variable_labels = {"SP.DYN.AMRT.FE":"United Kingdom Female Mortality",
                   "NY.GDP.PCAP.CD":'GDP'}

GBR_FE = wbdata.get_dataframe(variable_labels, country="GBR")

# merge uk female and male mortality rates
GBR_Mortality=GBR_MA.reset_index().merge(GBR_FE.reset_index(), left_on = 'date', right_on

WLD_Mortality = WLD_Mortality.reset_index()

# change data type of dates to integers
GBR_Mortality['date'] = (GBR_Mortality['date']).astype(int)
WLD_Mortality['date'] = (WLD_Mortality['date']).astype(int)
```

World vs UK Female/Male Mortality Rates Graph

In [43]:

```
fig, ax = plt.subplots()
sns.lineplot(data=GBR_Mortality, x="date", y="United Kingdom Male Mortality",
             label = 'UK Male Mortality', color='blue', linewidth=2.5, linestyle='--', das
sns.lineplot(data=GBR_Mortality, x="date", y="United Kingdom Female Mortality",
             label = 'UK Female Mortality', color='red', linewidth=2.5, linestyle='--', da
sns.lineplot(data=WLD_Mortality, x="date", y="World Male Mortality",
             label = 'World Male Mortality', color='blue', linewidth=2.5, ax = ax)
sns.lineplot(data=WLD_Mortality, x="date", y="World Female Mortality",
             label = 'World Female Mortality', color='red', linewidth=2.5, ax = ax)
plt.axvline(x = 2008, color = 'green', linestyle = '--')

plt.xticks(np.arange(min(GBR_Mortality['date']), max(GBR_Mortality['date'])+1, 10))
ax.set(xlabel='Year', ylabel='Mortality (deaths per 10,000 people)');
```



Construct Setup Variables for World vs UK Total Fertility Rates

In [44]:

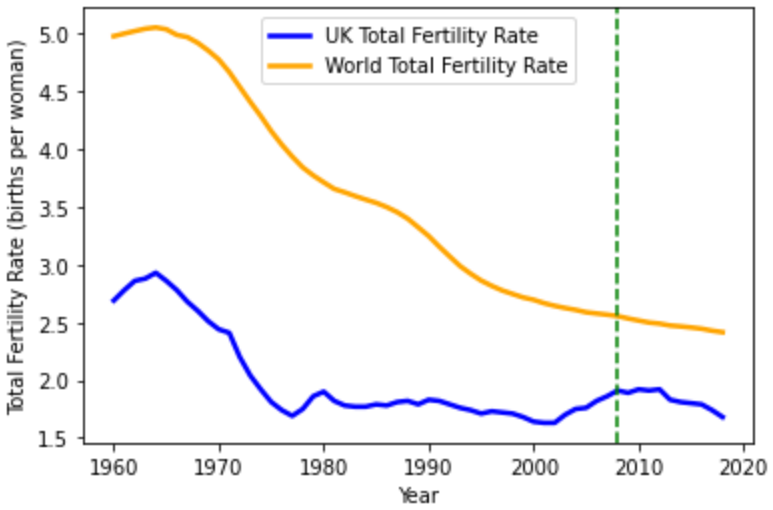
```
# get variable names for uk tfr
variable_labels = {"SP.DYN.TFRT.IN":"United Kingdom Total Fertility Rate"}
```

```
# get data frame for uk tfr
GBR_FR = wbdata.get_dataframe(variable_labels, country="GBR")
GBR_FR = GBR_FR.reset_index()
#change years to integer
GBR_FR['date'] = GBR_FR['date'].astype(int)

# get variable names for world tfr
variable_labels = {"SP.DYN.TFRT.IN":"World Total Fertility Rate"}
WLD_FR = wbdata.get_dataframe(variable_labels, country="WLD")
WLD_FR = WLD_FR.reset_index()
#change years to integer
WLD_FR['date'] = WLD_FR['date'].astype(int)
```

World vs UK Female/Male Total Fertility Rates Graph

In [45]:

```
fig, ax = plt.subplots()
sns.lineplot(data=GBR_FR, x="date", y="United Kingdom Total Fertility Rate",
             label = 'UK Total Fertility Rate', color='blue', linewidth=2.5, dashes=(5, 1)
sns.lineplot(data=WLD_FR, x="date", y="World Total Fertility Rate",
             label = 'World Total Fertility Rate', color='orange', linewidth=2.5, ax = ax)

plt.axvline(x = 2008, color = 'green', linestyle = '--')

plt.xticks(np.arange(min(GBR_FR['date']), max(GBR_FR['date'])+1, 10))
ax.set(xlabel='Year', ylabel='Total Fertility Rate (births per woman)');
```



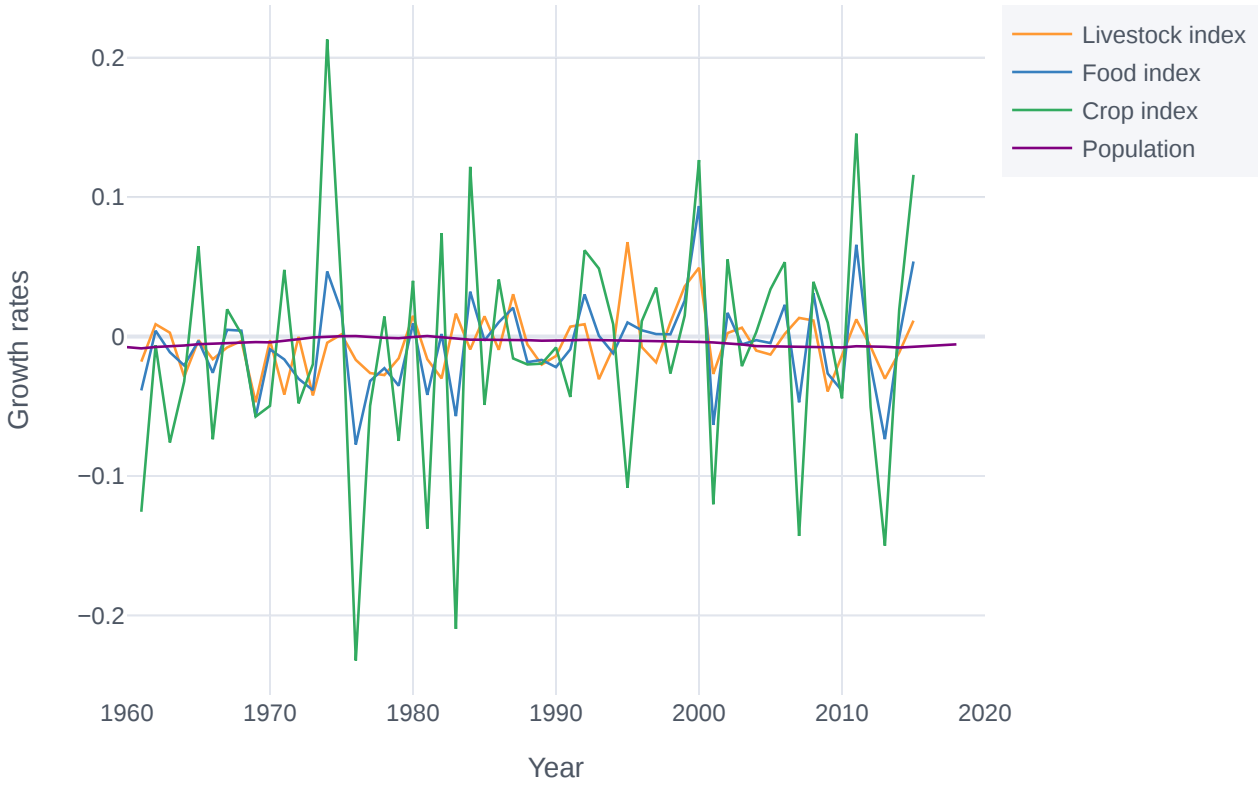
World vs UK Population, Livestock, Food, and Crop Rates Graph

In [46]:

```
from plotly.offline import init_notebook_mode, iplot
import numpy as np
from scipy.optimize import newton

init_notebook_mode(connected=True)

# Play with these constants
## for exponential
P0 = 1
r = 0.02

## for line
F0 = 10
m = 100

food_production = lambda t,m=m: F0+m*t
```

```
population = lambda t,r=r: P0*np.exp(r*t)

diff = lambda t,r=r,m=m: food_production(t,m) - population(t,r)

# Point where curves cross

def choose_xaxis(r,m,x0=10):
    """
    Find a range of x so that curves intersect
    """
    tstar = -1
    try:
        while tstar <= 0:
            tstar = newton(lambda t: diff(t,r,m),x0,maxiter=1000)
            x0 = x0*10
        return np.linspace(0,tstar*1.1,100)
    except RuntimeError: # Failed to find root
        return np.linspace(0,1000,100)

import plotly.graph_objs as go
from ipywidgets import interactive, HBox, VBox

T = choose_xaxis(r,m)

data = [dict(name='Food production',
             #visible = False,
             line=dict(color='blue', width=6),
             x = T,
             y = [food_production(t) for t in T]),
        dict(name='Population',
             #visible = False,
             line=dict(color='red', width=6),
             x = T,
             y = [population(t) for t in T])]

layout = dict()

#fig = dict(data=data, layout=layout)
#plot(fig)

f = go.FigureWidget(data=data,layout=layout)

def update_pop(r,m):
    T = choose_xaxis(r,m)
    f.data[1].y = [population(t,r) for t in T]
    f.data[0].x = T
    f.data[1].x = T

r_slider = interactive(update_pop,r=(-0.05,0.08,.01),m=(0,200,10))
vb = VBox((f, r_slider))
vb.layout.align_items = 'center'
vb


import numpy as np
import wbdata
import cufflinks as cf
cf.go_offline()

def fix_date_index(df):
    idx_vars = df.index.names
    new = df.reset_index()
    new.date = new.date.astype(int)
    return new.set_index(idx_vars)
```

```
#get variables for livestock/food/crop index and overall population
vars = {"AG.PRD.LVSK.XD":"Livestock index",
        "AG.PRD.FOOD.XD":"Food index",
        "AG.PRD.CROP.XD":"Crop index",
        "SP.POP.TOTL":"Population"}

food_GBR = fix_date_index(wbdata.get_dataframe(vars,country='GBR'))

food_GBR

# calculate and plot growth rates using diff and log
np.log(food_GBR).diff().iplot(xTitle="Year",yTitle="Growth rates")
```



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