EEP 153 Project 1: Group Kitagawa

Countries of Investigation: The Baltic States (Estonia, Latvia, and Lithuania)

Description: Originally we wanted to see if there was convergence in population trends for countries who joined the EU in 2004 (mostly post-soviet states). What stood out to us most was a very similar pattern in the three Baltic states: their populations were steadily increasing until 1994, after which they experienced a steep decline. Interested in this abnormal trend, we decided to narrow our countries of interest down to Estonia, Latvia, and Lithuania, and see what exactly caused this pattern after the fall of the USSR. Preliminary research revealed that after the USSR collapsed, these countries' healthcare systems rapidly deteriorated while poverty spiked (along with poverty, homelessness, and drug use). The combined effect was a major Tuberculosis (and HIV) epidemic around 1994. Since we only have more comprehensive data on these states starting in 1995, we decided to see how economic indicators have determined population growth and TB incidence since then. Although GDPPC is a poor measure of poverty (doesn't account for distribution), it's the most accurate indicator of poverty we have for these countries. Evidence suggests that GDPPC is strongly correlated with population, and we maintain that public health is one intermediary through which national income determines population trends.

Objectives:

1. Explain the impact of the dissolution of the USSR on the Baltic States
2. Analyze and create corresponding visualizations on population and socioeconomic trends relative to the fall of the USSR and the TB epidemic in the early 1990s
3. Capture any trends during the early 2000s using TB data from the World Bank python packages

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Import All Data Libraries

In [1]:

```
## uncomment lines below if installation is needed
!pip install wbdata
!pip install cufflinks
!pip install iso3166

import wbdata
import numpy as np
```

```
import plotly.offline as py
import plotly.graph_objs as go
import pandas as pd
from iso3166 import countries
import cufflinks as cf
cf.go_offline()
```

```
Requirement already satisfied: wbdata in /opt/conda/lib/python3.9/site-packages (0.3.0)
Requirement already satisfied: requests>=2.0 in /opt/conda/lib/python3.9/site-packages
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Requirement already satisfied: tabulate>=0.8.5 in /opt/conda/lib/python3.9/site-packages
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Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.9/site-pa
ckages (from requests>=2.0->wbdata) (1.25.7)
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7.3)
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t/conda/lib/python3.9/site-packages (from ipywidgets>=7.0.0->cufflinks) (1.0.2)
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a/lib/python3.9/site-packages (from ipython>=5.3.0->cufflinks) (3.0.26)
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Requirement already satisfied: executing in /opt/conda/lib/python3.9/site-packages (from
stack-data->ipython>=5.3.0->cufflinks) (0.8.2)
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1)
Requirement already satisfied: nbconvert in /opt/conda/lib/python3.9/site-packages (from notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (6.4.0)
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Requirement already satisfied: MarkupSafe>=2.0 in /opt/conda/lib/python3.9/site-packages (from jinja2->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (2.0.1)
Requirement already satisfied: pandocfilters>=1.4.1 in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (1.5.0)
Requirement already satisfied: testpath in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (0.5.0)
Requirement already satisfied: defusedxml in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (0.7.1)
Requirement already satisfied: mistune<2,>=0.8.1 in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (0.8.4)
Requirement already satisfied: jupyterlab-pygments in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (0.1.2)
Requirement already satisfied: bleach in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (4.1.0)
Requirement already satisfied: nbclient<0.6.0,>=0.5.0 in /opt/conda/lib/python3.9/site-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (0.5.10)
Requirement already satisfied: cffi>=1.0.1 in /opt/conda/lib/python3.9/site-packages (from argon2-cffi-bindings->argon2-cffi->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (1.14.6)
Requirement already satisfied: packaging in /opt/conda/lib/python3.9/site-packages (from bleach->nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (21.3)
Requirement already satisfied: webencodings in /opt/conda/lib/python3.9/site-packages (from bleach->nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (0.5.1)
Requirement already satisfied: pycparser in /opt/conda/lib/python3.9/site-packages (from cffi>=1.0.1->argon2-cffi-bindings->argon2-cffi->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (2.20)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /opt/conda/lib/python3.9/site-packages (from packaging->bleach->nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets>=7.0.0->cufflinks) (3.0.7)
Requirement already satisfied: iso3166 in /opt/conda/lib/python3.9/site-packages (2.0.2)
/opt/conda/lib/python3.9/site-packages/geopandas/_compat.py:111: UserWarning:

The Shapely GEOS version (3.10.2-CAPI-1.16.0) is incompatible with the GEOS version PyGEOS was compiled with (3.10.1-CAPI-1.16.0). Conversions between both will be slow.
```

In [2]:

```
#if need be, use the comand below to get ISO alpha-3 country code
#example:
countries.get('estonia').alpha3
countries.get('latvia').alpha3
countries.get('lithuania').alpha3
```

Out[2]:

```
'LTU'
```

In [3]:

```
#Or, use the following command to get the country name, given its ISO3 code
#example
```

```
countries.get('EST').name
```

Out[3]:

```
'Estonia'
```

For the following statistical exploration, we are using **source 40: Population estimates and projections** and a few indicators within this database. To see all possible datasets, use `wbdata.get_source()` ; to see all indicators in a dataset, use `wbdata.get_indicator(source=SOURCE_id)` .

[#A] Population DataFrames

A function that returns a `pandas` DataFrame for a particular country indexed by year, with columns giving counts of people in different age-sex groups.

Input Parameters:

- **sex**: a str ('Female','Male', or 'All')
- **age_range**: a tuple with a lower bound and a higher bound, between 0 to 100
- **place**: a str (the ISO 3166-1 alpha-3 code of a country or region)
- **year** (optional): an int between 1960 to 2020; if no year is specified, the returned dataframe contains statistics from 1960 to 2020

In [4]:

```
def population_df(sex, age_range, place, year = None):

    def age_generate(age_range):
        lower = 5* round(age_range[0] / 5)
        upper = 5* round(age_range[1] / 5)
        age_code = []
        while lower < upper and lower < 80:
            age_code.append(f"{lower:02d}{lower+4:02d}")
            lower += 5
        if upper > 79:
            age_code.append('80UP')
        return age_code

    age_list = age_generate(age_range)

    def label_generate(sex, age_ls):
        prefix = sex[:2].upper()
        indicators = {}
        for i in range(len(age_ls)):
            indicators[f"SP.POP.{age_ls[i]}.{prefix}"] = f"{sex} ages {age_ls[i][:2]}-{a
        return indicators

    if sex != "All":
        indicator_labels = label_generate(sex, age_list)
    else:
        male_labels = label_generate("Male", age_list)
        female_labels = label_generate("Female", age_list)

        male_labels.update(female_labels)
        indicator_labels = male_labels

    pdf = wbdata.get_dataframe(indicator_labels, country = place)

    def clean_df(df, year = None):
        df.reset_index(inplace=True)
        df['date'] = df['date'].astype(int)
        df.set_index('date', inplace = True)
        df['Total Population in Given Range'] = df.loc[:].sum(axis=1)
        if year != None:
```

```
            df.query(f'date=={year}', inplace = True)

    clean_df(pdf, year)
    return pdf
```

One testing example:

In [5]:

```
world_female = population_df("Female", (47,100), "WLD", year = 2002)
world_female
```

Out[5]:

	Female ages 45-49	Female ages 50-54	Female ages 55-59	Female ages 60-64	Female ages 65-69	Female ages 70-74	Female ages 75-79	Female ages 80-UP	Po
date									
2002	172436167.0	144642454.0	111974477.0	96861604.0	83341490.0	66225590.0	48357921.0	50298053.0	774

1.Population Tabulation for Estonia

In [6]:

```
estonia = population_df("All", (1,100), "EST")
estonia
```

Out[6]:

	Male ages 00-04	Male ages 05-09	Male ages 10-14	Male ages 15-19	Male ages 20-24	Male ages 25-29	Male ages 30-34	Male ages 35-39	Male ages 40-44	Male ages 45-49	...	Female ages 40-44	F
date													
2021	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	
2020	35955.0	38207.0	38866.0	32086.0	29666.0	46429.0	53894.0	47694.0	45834.0	49185.0	...	43041.0	47
2019	35743.0	38648.0	38094.0	30917.0	31675.0	47720.0	53040.0	46754.0	46441.0	47285.0	...	43813.0	46
2018	34999.0	39377.0	36908.0	29869.0	34090.0	48714.0	51707.0	46136.0	47221.0	44763.0	...	44849.0	44
2017	34419.0	39930.0	35509.0	29256.0	36343.0	49672.0	50112.0	45845.0	47711.0	42507.0	...	45701.0	42
...	...	...	...	...	...	...	...	...	...	...	...	...	
1964	50217.0	49909.0	50254.0	48789.0	44629.0	52926.0	49113.0	45928.0	30396.0	24949.0	...	47361.0	34
1963	49920.0	49550.0	49847.0	46057.0	45889.0	51739.0	48961.0	42656.0	27900.0	26256.0	...	43257.0	36
1962	49498.0	49221.0	49164.0	43385.0	47756.0	50167.0	48892.0	38997.0	25979.0	28080.0	...	39105.0	40
1961	48955.0	48885.0	47977.0	41537.0	49332.0	48848.0	48271.0	35489.0	24835.0	29788.0	...	36018.0	42
1960	48637.0	48536.0	46365.0	40944.0	50195.0	48177.0	46848.0	32526.0	24598.0	31043.0	...	34720.0	44

62 rows × 35 columns

2.Population Tabulation for Latvia

In [7]:

```
latvia = population_df("All", (1,100), "LVA")
latvia
```

Out[7]:

	Male ages 00-04	Male ages 05-09	Male ages 10-14	Male ages 15-19	Male ages 20-24	Male ages 25-29	Male ages 30-34	Male ages 35-39	Male ages 40-44	Male ages 45-49	...	Female ages 40-44	F
date													
2021	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	
2020	59925.0	49127.0	52985.0	44197.0	36453.0	61794.0	73341.0	61917.0	60104.0	65153.0	...	61626.0	69
2019	58850.0	50228.0	52323.0	42416.0	40800.0	65950.0	72516.0	61746.0	61515.0	64440.0	...	63369.0	68
2018	55814.0	52010.0	51139.0	41015.0	46700.0	69232.0	71254.0	62184.0	63329.0	63244.0	...	65426.0	67
2017	52243.0	53552.0	49810.0	40618.0	53107.0	71707.0	70146.0	62868.0	65176.0	62350.0	...	67425.0	66
...	...	...	...	...	...	...	...	...	...	...	...	...	
1964	88837.0	86560.0	82018.0	78943.0	86033.0	91040.0	86198.0	77874.0	51448.0	41289.0	...	85169.0	58
1963	88274.0	85297.0	79586.0	78689.0	86497.0	89092.0	85364.0	72389.0	46610.0	44442.0	...	76476.0	63
1962	87265.0	83712.0	77203.0	79005.0	86663.0	87172.0	84378.0	66355.0	42679.0	48802.0	...	67559.0	70
1961	86263.0	81744.0	75230.0	79594.0	86367.0	85676.0	82473.0	60438.0	40319.0	53053.0	...	60940.0	76
1960	85321.0	79341.0	73783.0	80035.0	85581.0	84506.0	79206.0	55001.0	39842.0	56251.0	...	57987.0	79

62 rows × 35 columns

3.Population Tabulation for Lithuania

In [8]:

```
lithuania = population_df("All", (1,100), "LTU")
lithuania
```

Out[8]:

	Male ages 00-04	Male ages 05-09	Male ages 10-14	Male ages 15-19	Male ages 20-24	Male ages 25-29	Male ages 30-34	Male ages 35-39	Male ages 40-44	Male ages 45-49	...	Fe 4
date												
2021	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	
2020	76730.0	82275.0	63163.0	64723.0	70274.0	98520.0	99409.0	80264.0	82258.0	96679.0	...	832
2019	76760.0	77629.0	62751.0	66162.0	77620.0	101721.0	95743.0	80006.0	85182.0	95768.0	...	876
2018	76790.0	73484.0	63697.0	68381.0	85933.0	102728.0	92092.0	80930.0	88342.0	94190.0	...	923
2017	77383.0	70874.0	65379.0	72512.0	94239.0	102309.0	89762.0	82844.0	91505.0	93784.0	...	969
...	...	...	...	...	...	...	...	...	...	...	...	
1964	146762.0	139478.0	121031.0	112532.0	114613.0	113025.0	111993.0	99662.0	70751.0	48724.0	...	983
1963	146367.0	135523.0	118956.0	113720.0	114455.0	112854.0	111100.0	94795.0	64604.0	48656.0	...	894
1962	145534.0	131777.0	117513.0	115215.0	113574.0	112956.0	109658.0	89288.0	58905.0	50022.0	...	805
1961	144014.0	128372.0	116527.0	116229.0	112255.0	112925.0	107188.0	83276.0	54268.0	52679.0	...	735
1960	140974.0	125472.0	116052.0	116368.0	111033.0	112479.0	103640.0	77065.0	51175.0	56512.0	...	698

62 rows × 35 columns

[#A] Population Statistics

Using the previously defined `population_df` function, a `python` function named `population` is created to return the population in a particular country in a given age range for a given year.

Input Parameters:

- **year**: a int between 1960 to 2020
- **sex**: a str ('Female','Male', or 'All')
- **age_range**: a tuple with a lower bound and a higher bound, between 0 to 100
- **place**: a str (the ISO 3166-1 alpha-3 code of a country or region)

In [9]:
```
def population(year_defined, sex, age_range, place):
    df = population_df(sex, age_range, place, year = year_defined)
    population = df['Total Population in Given Range'].loc[year_defined]
    return population
```

One testing examples:

In [10]:
```
population(2002, "Female", (47,100), "WLD")
```

Out[10]:
```
774137756.0
```

1.Population of Estonia in 1990

In [11]:
```
population(1990,"All", (1,100), "EST")
```

Out[11]:
```
1569173.0
```

2.Population of Latvia in 1990

In [12]:
```
population(1990,"All", (1,100), "LVA")
```

Out[12]:
```
2663151.0
```

3.Population of Lithuania in 1990

In [13]:
```
population(1990,"All", (1,100), "LTU")
```

Out[13]:
```
3697836.0
```

In [ ]:
```

```

Additional Statement Function

In additin, a `python` function named `population_statement` is created to return a string with population statistics in the following form:

- In [year], there are [number] of [people/males/females] aged [low] to [high] living in [the world/region/country].

Input Parameters:

- **year**: a int between 1960 to 2020
- **sex**: a str ('Female','Male', or 'All')
- **age_range**: a tuple with a lower bound and a higher bound, between 0 to 100
- **place**: a str (the ISO 3166-1 alpha-3 code of a country or region)

In [14]:
```
def population_statement(year_defined, sex, age_range, place):
    df = population_df(sex, age_range, place, year = year_defined)
    if sex == "All":
        ppl = 'people'
    else:
        ppl = f"{sex.lower()}s"
    lower = age_range[0]
    higher = age_range[1]
    if place == 'WLD':
        country_name = 'the world'
    else:
        country_name = countries.get(place).name
    population = df['Total Population in Given Range'].loc[year_defined]

    answer = f"In {year_defined}, there are {population} {ppl} aged {lower} to {higher}

    return answer
```

One testing examples:

In [15]:
```
population_statement(2002, "Female", (47,100), "WLD")
```

Out[15]:
```
'In 2002, there are 774137756.0 females aged 47 to 100 living in the world by approximat
ion.'
```

In [ ]:
```

```

[#B&C] Population Pyramids

Static Population Pyramid Function

The `pop_pyramid` function returns a static population pyramid for either the population of a single year or the populations between a year range with a specified increment of years.

Input Parameters:

- **dataframe**: the name of the established dataframe for a specific country
- **country_name**: A string (e.g. "Estonia")
- **year**: a list
    - for a single year, it's in the form [year]
    - for multiple years, it's in the form [end_year, start_year, year_increments]

In [16]:
```
def pop_pyramid(dataframe, country_name, year):
    py.init_notebook_mode(connected=True)

    #create titles for the two different forms of population pyramid
    def title_creator(country_name, year):
        if len(year) == 1:
            title = f"Population Pyramid of {country_name}, {year[0]}"
        else:
            "Population Pyramid of Estonia, 1990-2010"
```

```
            title = f"Population Pyramid of {country_name}, {year[1]}-{year[0]} ({year[2
        return title
    title_ = title_creator(country_name, year)

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

    #create the age labels
    age_ranges = []
    for i in range(0,80,5):
        age_ranges.append(f"{i:02d}"+f"{i+4:02d}")
    age_ranges.append("80UP")

    #bins for one year
    if len(year) == 1:
        bins = [go.Bar(x = dataframe.loc[year[0],:].filter(regex="Male").values,
                       y = [int(s[:2])+1 for s in age_ranges],
                       orientation='h',
                       name='Men',
                       marker=dict(color='blue'),
                       hoverinfo=['x','y']
                       ),
                    go.Bar(x = -dataframe.loc[year[0],:].filter(regex="Female").values,
                       y=[int(s[:2])+1 for s in age_ranges],
                       orientation='h',
                       name='Women',
                       marker=dict(color='red'),
                       hoverinfo=['x','y']
                          )
                   ]
    #bins for multiple years
    else:
        years = range(year[0],year[1], -year[2])
        bins = [go.Bar(x = dataframe.loc[year,:].filter(regex="Male").values,
                   y = [int(s[:2])+1 for s in age_ranges],
                   orientation='h',
                   name='Men {:d}'.format(year),
                   hoverinfo=['x','y'],
                     opacity=0.5,
                     marker=dict(color='green')
                  )
        for year in years]

        bins += [go.Bar(x = -dataframe.loc[year,:].filter(regex="Female").values,
                    y=[int(s[:2])+1 for s in age_ranges],
                    orientation='h',
                    name='Women {:d}'.format(year),
                    hoverinfo=['x','y'],
                      opacity=0.5,
                      marker=dict(color='orange')
                   )
         for year in years]


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

Animated Population Pyramid Function

The `animate_pyramid` function returns an interactive population pyramid for the chosen country to illustrate the change of population over years.

Input Parameters:

- **df**: the name of the established dataframe for a specific country
- **country_name**: A string (e.g. "Estonia")
- **year**: a tuple
  - in the form (star_year, end_year, year_increments)

In [17]:

```
#import data libraries
import ipywidgets
from ipywidgets import interactive, fixed

def animate_pyramid(df, country_name, year):
    def animate_helper(df, country_name, year):
            py.init_notebook_mode(connected=True)

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

            layout = go.Layout(barmode='overlay',
                               yaxis=go.layout.YAxis(range=[0, 90], title='Age'),
                               xaxis=go.layout.XAxis(title='Population'),
                               title = f"Population Pyramid of {country_name}, {year}")
            bins = [go.Bar(x = df.loc[year,:].filter(regex="Male").values,
                           y = [int(s[:2])+1 for s in age_ranges],
                           orientation='h',
                           name='Men',
                           marker=dict(color='yellow'),
                           hoverinfo=['x','y']
                          ),
                    go.Bar(x = -df.loc[year,:].filter(regex="Female").values,
                           y=[int(s[:2])+1 for s in age_ranges],
                           orientation='h',
                           name='Women',
                           marker=dict(color='pink'),
                           hoverinfo=['x','y'])
                   ]
            py.iplot(dict(data=bins, layout=layout))
    return ipywidgets.interactive(animate_helper, df = fixed(df), year = year, country_r
```

1. Estonia

In [18]:

```
pop_pyramid(estonia, "Estonia", [2010])
pop_pyramid(estonia, "Estonia", [2020,1960,20])
animate_pyramid(estonia, "Estonia", (1960, 2020, 1))
```

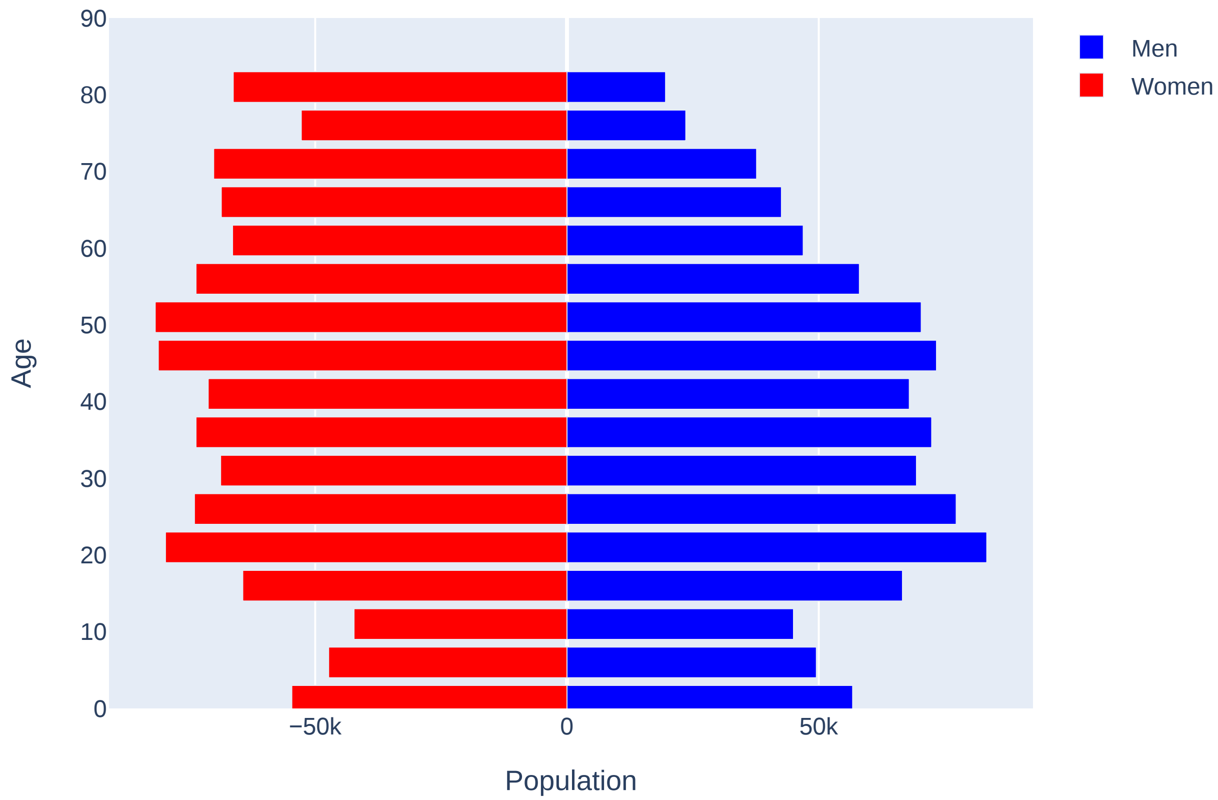
```
interactive(children=(Text(value='Estonia', description='country_name'), IntSlider(value
=1990, description='ye…
```

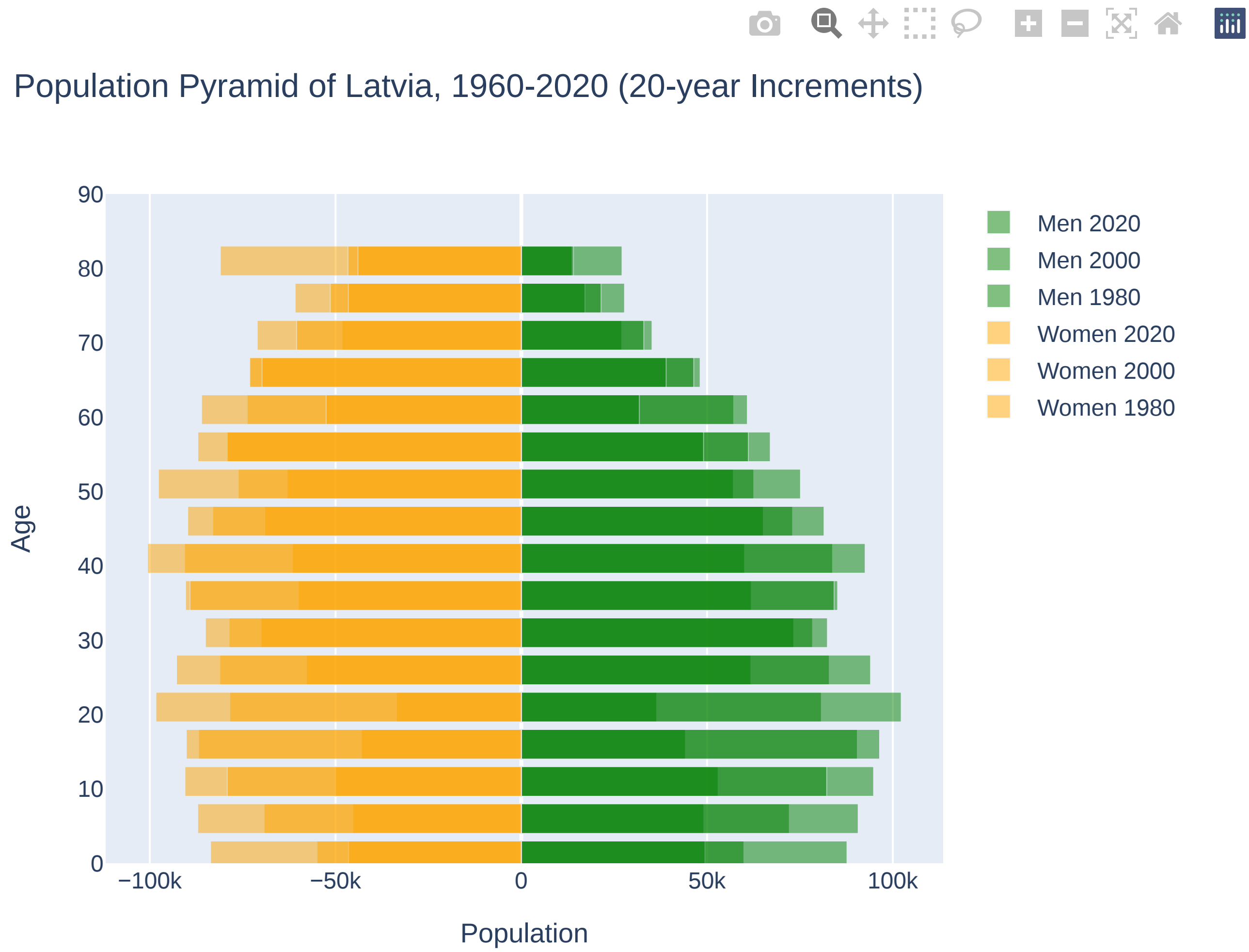
2. Latvia

In [19]:

```
pop_pyramid(latvia, "Latvia", [2010])
pop_pyramid(latvia, "Latvia", [2020,1960,20])
animate_pyramid(latvia, "Latvia", (1960, 2020, 1))
```

Population Pyramid of Latvia, 2010





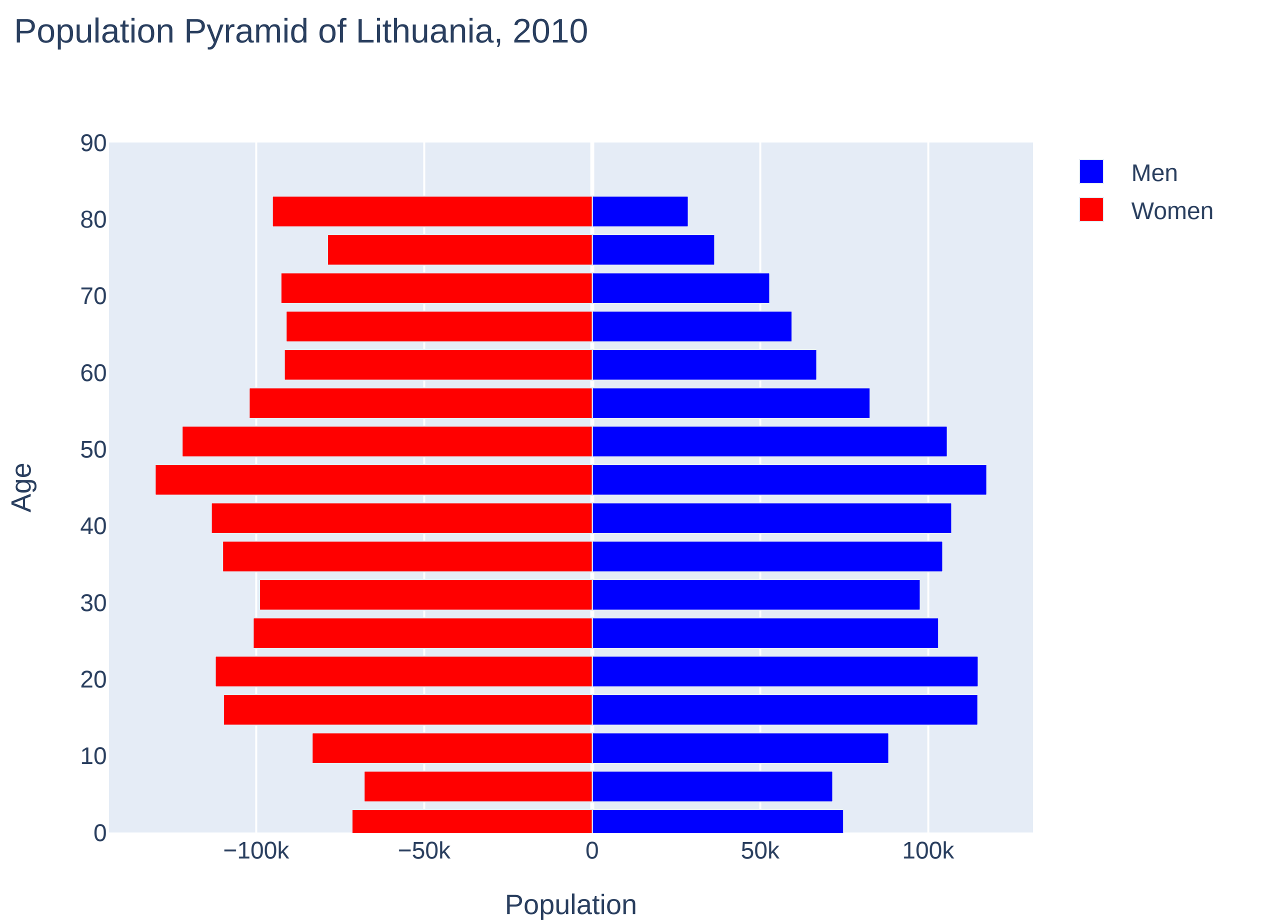

```
interactive(children=(Text(value='Latvia', description='country_name'), IntSlider(value=
1990, description='yea…
```

3. Lithuania

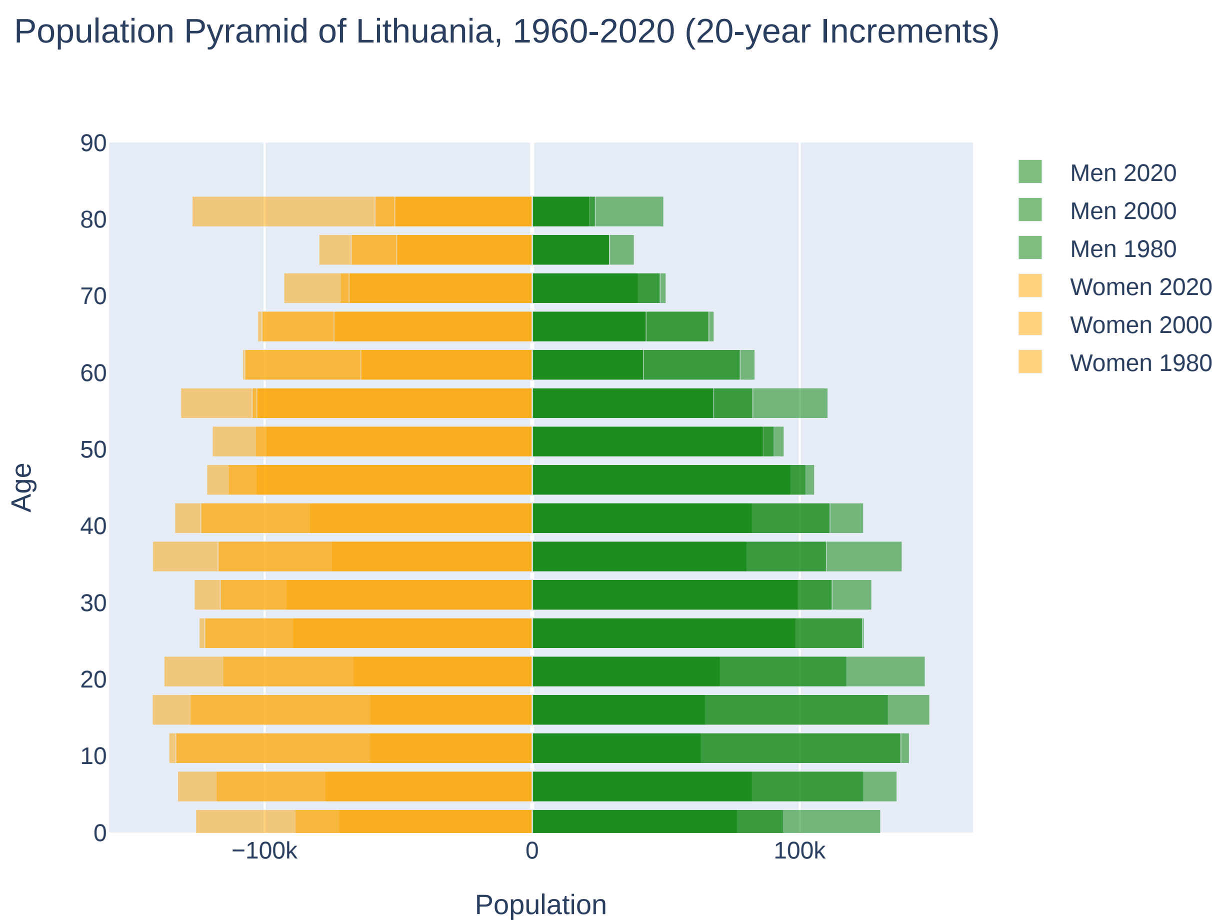
Population Pyramid from 1990 to 2010 (5-year Increments)

In [20]:

```
pop_pyramid(lithuania, "Lithuania", [2010])
pop_pyramid(lithuania, "Lithuania", [2020,1960,20])
animate_pyramid(lithuania, "Lithuania", (1960, 2020, 1))
```



Population Pyramid of Lithuania, 2010
Men
Women
Age
Population
90
80
70
60
50
40
30
20
10
0
−100k
−50k
0
50k
100k




```
interactive(children=(Text(value='Lithuania', description='country_name'), IntSlider(val
ue=1990, description='…
```

In [ ]:

[#C] Population Maps of the Baltic States

In [21]:

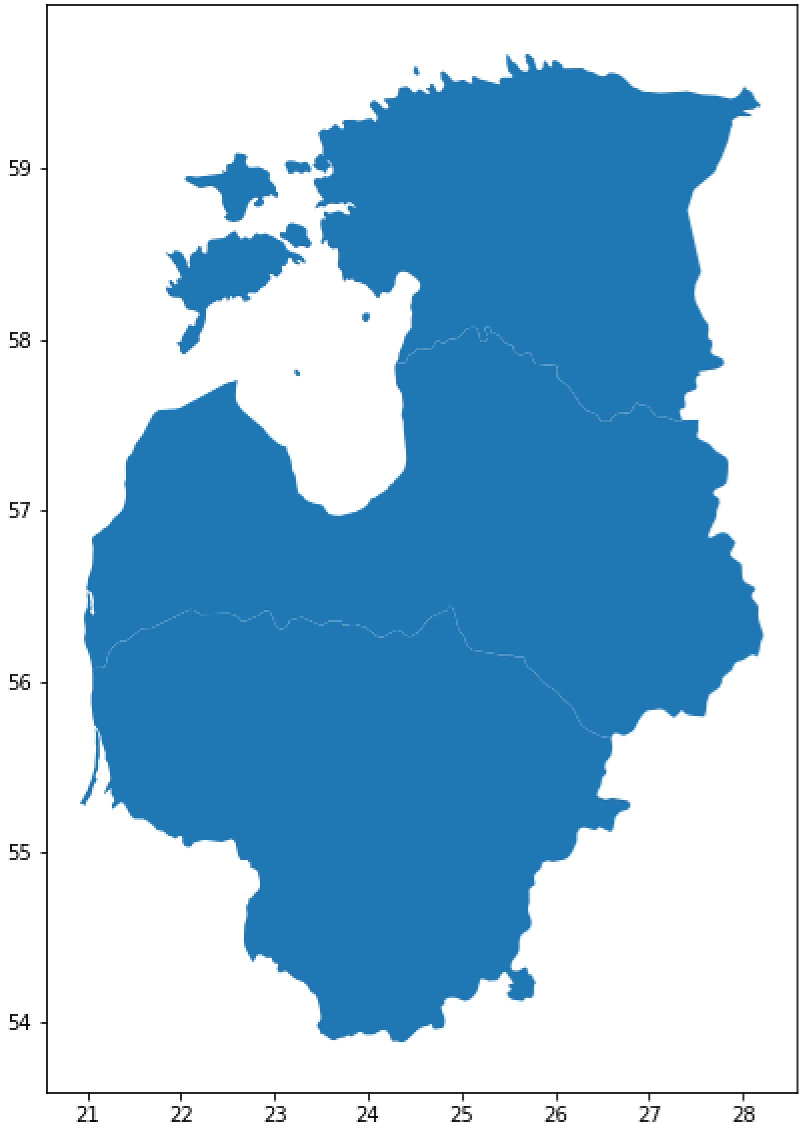
```
# Install & import new data libraries
!pip install geopandas
!pip install pyshp


import matplotlib.pyplot as plt
import geopandas as gpd
import shapefile as shp
import seaborn as sns
```

```
Requirement already satisfied: geopandas in /opt/conda/lib/python3.9/site-packages (0.1
0.2)
Requirement already satisfied: pandas>=0.25.0 in /opt/conda/lib/python3.9/site-packages
(from geopandas) (1.3.5)
Requirement already satisfied: fiona>=1.8 in /opt/conda/lib/python3.9/site-packages (fro
m geopandas) (1.8.20)
Requirement already satisfied: pyproj>=2.2.0 in /opt/conda/lib/python3.9/site-packages
(from geopandas) (3.3.0)
Requirement already satisfied: shapely>=1.6 in /opt/conda/lib/python3.9/site-packages (f
rom geopandas) (1.8.0)
Requirement already satisfied: python-dateutil>=2.7.3 in /opt/conda/lib/python3.9/site-p
ackages (from pandas>=0.25.0->geopandas) (2.8.0)
Requirement already satisfied: pytz>=2017.3 in /opt/conda/lib/python3.9/site-packages (f
rom pandas>=0.25.0->geopandas) (2021.1)
Requirement already satisfied: numpy>=1.17.3 in /opt/conda/lib/python3.9/site-packages
(from pandas>=0.25.0->geopandas) (1.21.5)
Requirement already satisfied: click-plugins>=1.0 in /opt/conda/lib/python3.9/site-packa
ges (from fiona>=1.8->geopandas) (1.1.1)
Requirement already satisfied: attrs>=17 in /opt/conda/lib/python3.9/site-packages (from
fiona>=1.8->geopandas) (19.3.0)
Requirement already satisfied: six>=1.7 in /opt/conda/lib/python3.9/site-packages (from
fiona>=1.8->geopandas) (1.16.0)
Requirement already satisfied: cligj>=0.5 in /opt/conda/lib/python3.9/site-packages (fro
m fiona>=1.8->geopandas) (0.7.2)
Requirement already satisfied: munch in /opt/conda/lib/python3.9/site-packages (from fio
na>=1.8->geopandas) (2.5.0)
Requirement already satisfied: certifi in /opt/conda/lib/python3.9/site-packages (from f
iona>=1.8->geopandas) (2019.11.28)
Requirement already satisfied: click>=4.0 in /opt/conda/lib/python3.9/site-packages (fro
m fiona>=1.8->geopandas) (8.0.3)
Requirement already satisfied: setuptools in /opt/conda/lib/python3.9/site-packages (fro
m fiona>=1.8->geopandas) (58.2.0)
Requirement already satisfied: pyshp in /opt/conda/lib/python3.9/site-packages (2.1.3)
```

We now import the shapefiles for the Baltic States and create a dataframe with the shapefile information. We extracted the shapefiles for Estonia, Lithuania, and Latvia from a large European map in QGIS.

In [22]:

```
baltics_path = "/home/jovyan//EEP153_Exercises/Baltics Shapefiles"
map_df = gpd.read_file(baltics_path)
plt.rcParams['figure.figsize'] = [30,10]
map_df.plot();
```



We plan on creating a population density map so we will create a dataframe using the wbdata package for population for the three Baltic States.

In [23]:

```
population = {"SP.POP.TOTL":"Population"}
baltic = {"EST":"Estonia",
            "LVA":"Latvia",
            "LTU":"Lithuania"}

# The following creates a dataframe for population in the Baltic States
baltic_pop_df = wbdata.get_dataframe(population, country=baltic).squeeze()
baltic_pop_df = baltic_pop_df.unstack('country')
baltic_pop_df.index = baltic_pop_df.index.astype(int)
baltic_pop_df = baltic_pop_df.transpose()
baltic_pop_df.index.name
map_df.index.name
# Now we merge the population dataframe with the map dataframe.
pop_map_df = map_df.merge(baltic_pop_df, left_on="NAME_ID", right_on="country", how='out
pop_map_df
```

Out[23]:

	featurecla	scalerank	LABELRANK	SOVEREIGNT	SOV_A3	ADM0_DIF	LEVEL	TYPE	ADMIN	ADM0_
0	Admin-0 map unit	0.0	5.0	Lithuania	LTU	0.0	2.0	Sovereign country	Lithuania	L
1	Admin-0 map unit	0.0	6.0	Estonia	EST	0.0	2.0	Sovereign country	Estonia	E
2	Admin-0 map unit	0.0	5.0	Latvia	LVA	0.0	2.0	Sovereign country	Latvia	L
3	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	N

4 rows × 223 columns

Now we make a new dataframe extracting only the information we want to use from the shapefiles dataframe for clean and easy manipulation before merging the new shapefiles dataframe with the population dataframe.

In [24]:

```
shape_columns = map_df[['SOVEREIGNT', 'ADMIN', 'geometry']]
merged = shape_columns.merge(baltic_pop_df, left_on="SOVEREIGNT", right_on="country", hc
merged
```

Out[24]:

	SOVEREIGNT	ADMIN	geometry	1960	1961	1962	1963	1964	1965
0	Lithuania	Lithuania	MULTIPOLYGON (((26.59453 55.66699, 26.60383 55...	2778550.0	2823550.0	2863350.0	2898950.0	2935200.0	2971450.0
1	Estonia	Estonia	MULTIPOLYGON (((24.30616 57.86819, 24.31666 57...	1211537.0	1225077.0	1241623.0	1258857.0	1277086.0	1294566.0
2	Latvia	Latvia	POLYGON ((27.35293 57.52760, 27.52817 57.52848...	2120979.0	2152681.0	2181586.0	2210919.0	2240623.0	2265919.0

3 rows × 64 columns

In [25]:

```
# Set a common index to match series
merged = merged.set_index('SOVEREIGNT')
```

In [26]:

```
# Create a series with the land areas (km^2) of the Baltic States.
landareas = pd.Series([25212, 17505, 24938], index = ['Lithuania', 'Estonia', 'Latvia']
landareas
```

Out[26]:

```
Lithuania    25212
Estonia      17505
Latvia       24938
dtype: int64
```

Next, we are dividing the population columns in the dataframe by the land areas of the Baltic states to create an interactive population density map.

In [27]:

```
for n in range(1960,2021,1):
    merged[n] = merged[n] / landareas
merged
```

Out[27]:

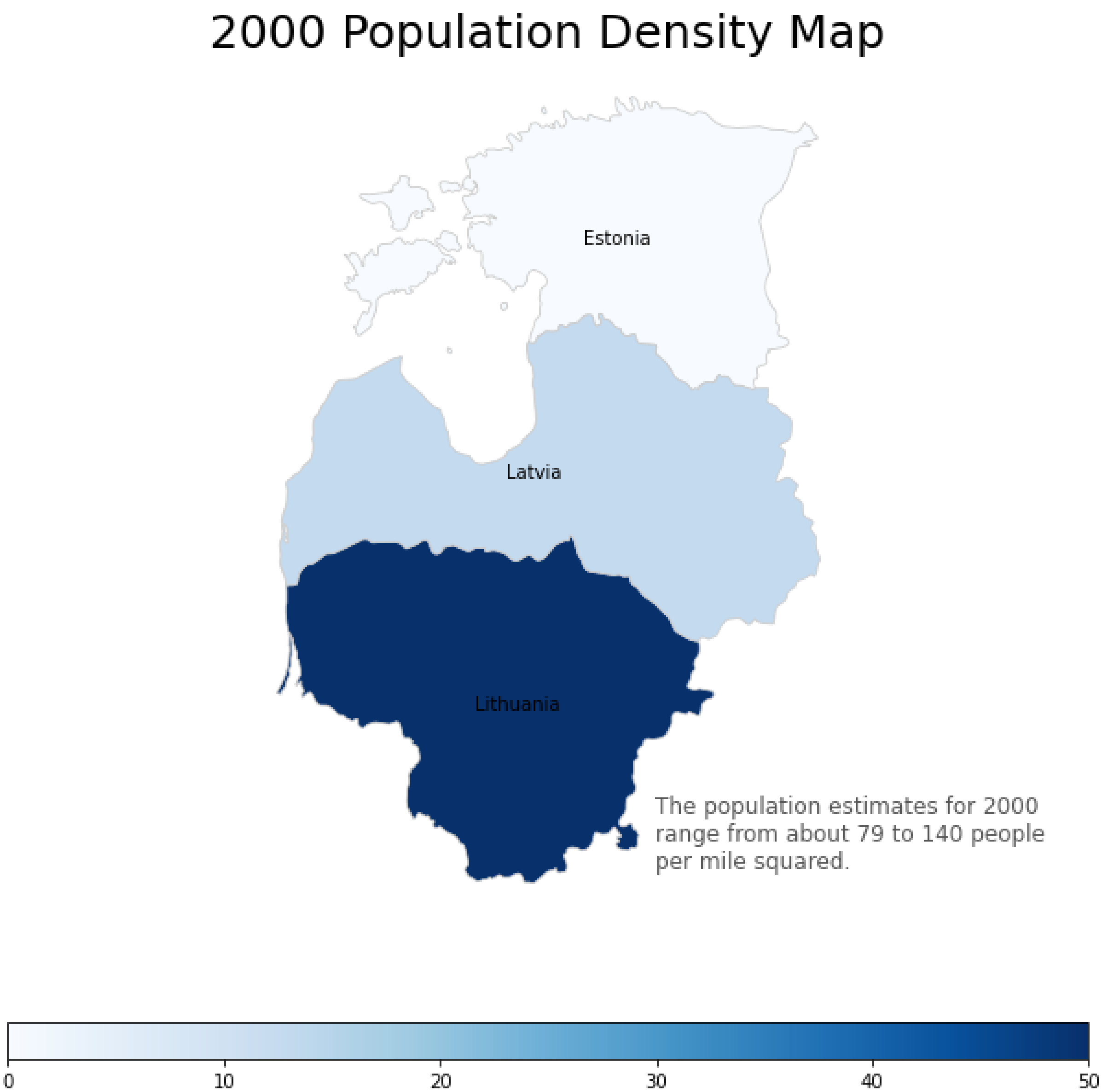
	ADMIN	geometry	1960	1961	1962	1963	1964	19
SOVEREIGNT								
Lithuania	Lithuania	MULTIPOLYGON (((26.59453 55.66699, 26.60383 55...	110.207441	111.992305	113.570919	114.982945	116.420752	117.8585
Estonia	Estonia	MULTIPOLYGON (((24.30616 57.86819, 24.31666 57...	69.210911	69.984404	70.929620	71.914139	72.955498	73.9540
Latvia	Latvia	POLYGON ((27.35293 57.52760, 27.52817 57.52848...	85.050084	86.321317	87.480391	88.656628	89.847742	90.8620

3 rows × 63 columns

Now we can graph the population density in the Baltic countries by specifying the year we want to see.

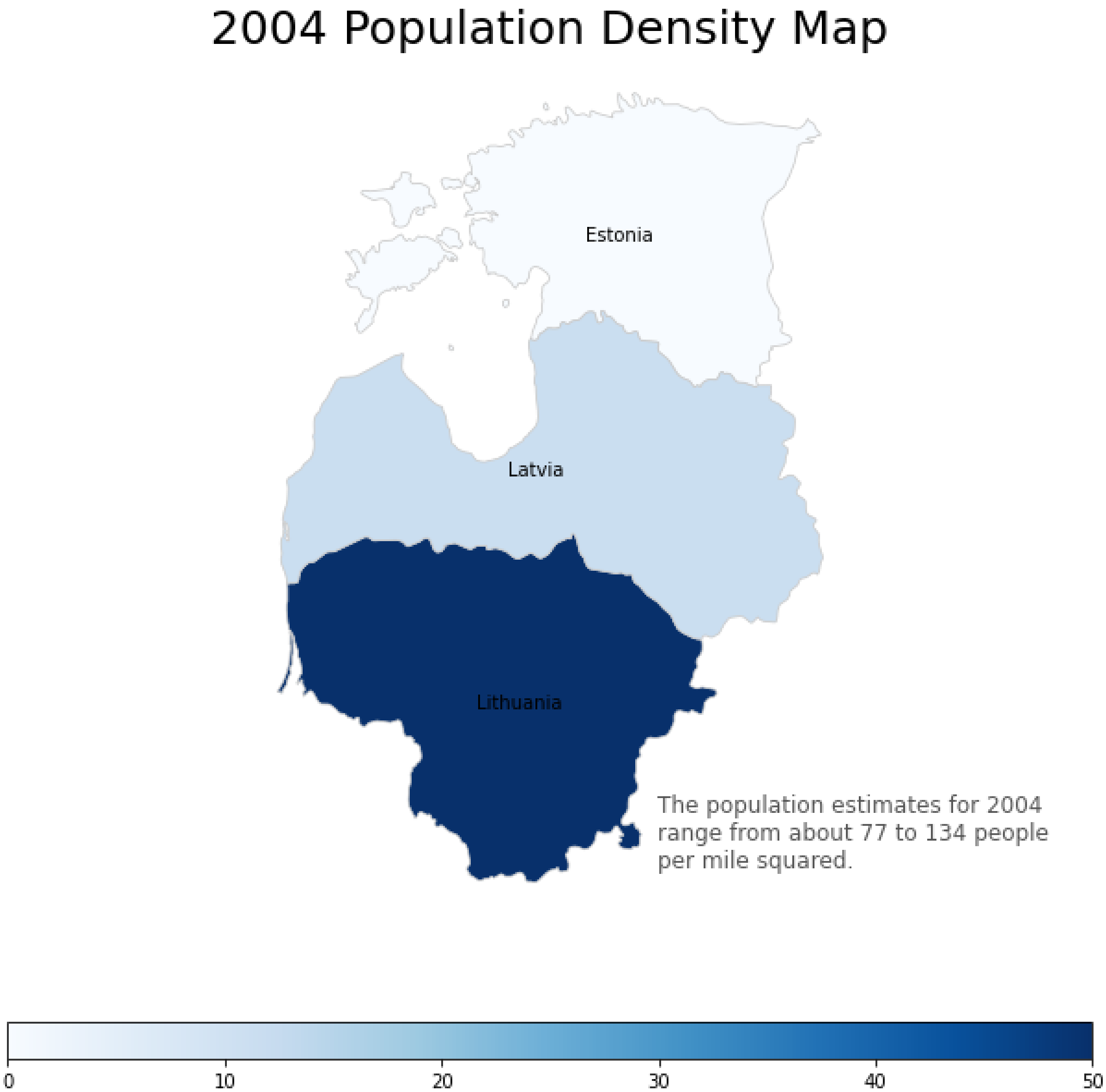
In [28]:

```
variable = 2000
vmin, vmax = 0, 50
fig, ax = plt.subplots(1, figsize=(30,10))
ax.axis('off')
ax.set_title('2000 Population Density Map', fontdict={'fontsize': '25', 'fontweight' :
ax.annotate('The population estimates for 2000 \nrange from about 79 to 140 people \nper
            xycoords='data', fontsize=12,
            color='#555555')
sm = plt.cm.ScalarMappable(cmap='Blues', norm=plt.Normalize(vmin=vmin, vmax=vmax))
sm.set_array([])
fig.colorbar(sm, orientation="horizontal", fraction=0.036, pad=0.1, aspect = 30)
merged.plot(column=variable, cmap='Blues', linewidth=0.8, ax=ax, edgecolor='0.8')
merged['coords'] = merged['geometry'].apply(lambda x: x.representative_point().coords[:]
merged['coords'] = [coords[0] for coords in merged['coords']]
for idx, row in merged.iterrows():
    plt.annotate(text=row['ADMIN'], xy=row['coords'],horizontalalignment='center')
```



In [29]:

```
variable = 2004
vmin, vmax = 0, 50
fig, ax = plt.subplots(1, figsize=(30,10))
ax.axis('off')
ax.set_title('2004 Population Density Map', fontdict={'fontsize': '25', 'fontweight' :
ax.annotate('The population estimates for 2004 \nrange from about 77 to 134 people \npe
            xycoords='data', fontsize=12,
            color='#555555')
sm = plt.cm.ScalarMappable(cmap='Blues', norm=plt.Normalize(vmin=vmin, vmax=vmax))
sm.set_array([])
fig.colorbar(sm, orientation="horizontal", fraction=0.036, pad=0.1, aspect = 30)
merged.plot(column=variable, cmap='Blues', linewidth=0.8, ax=ax, edgecolor='0.8')
merged['coords'] = merged['geometry'].apply(lambda x: x.representative_point().coords[:]
merged['coords'] = [coords[0] for coords in merged['coords']]
for idx, row in merged.iterrows():
    plt.annotate(text=row['ADMIN'], xy=row['coords'],horizontalalignment='center')
```



We also want to visualize TB rates on the density map so we will create a dataframe for TB Incidence using the World Bank Data package.

In [30]:

```
#TB Rates
tb_incidence_df = wbdata.get_dataframe({"SH.TBS.INCD":"Incidence of tuberculosis (per 10
tb_incidence_df = tb_incidence_df.squeeze().T.unstack('country').dropna(axis=0, how='any
tb_incidence_df.index = tb_incidence_df.index.astype(int)
tb_incidence_df = tb_incidence_df.T
tb_incidence_df = shape_columns.merge(tb_incidence_df, left_on="SOVEREIGNT", right_on="c
tb_incidence_df
```

Out[30]:

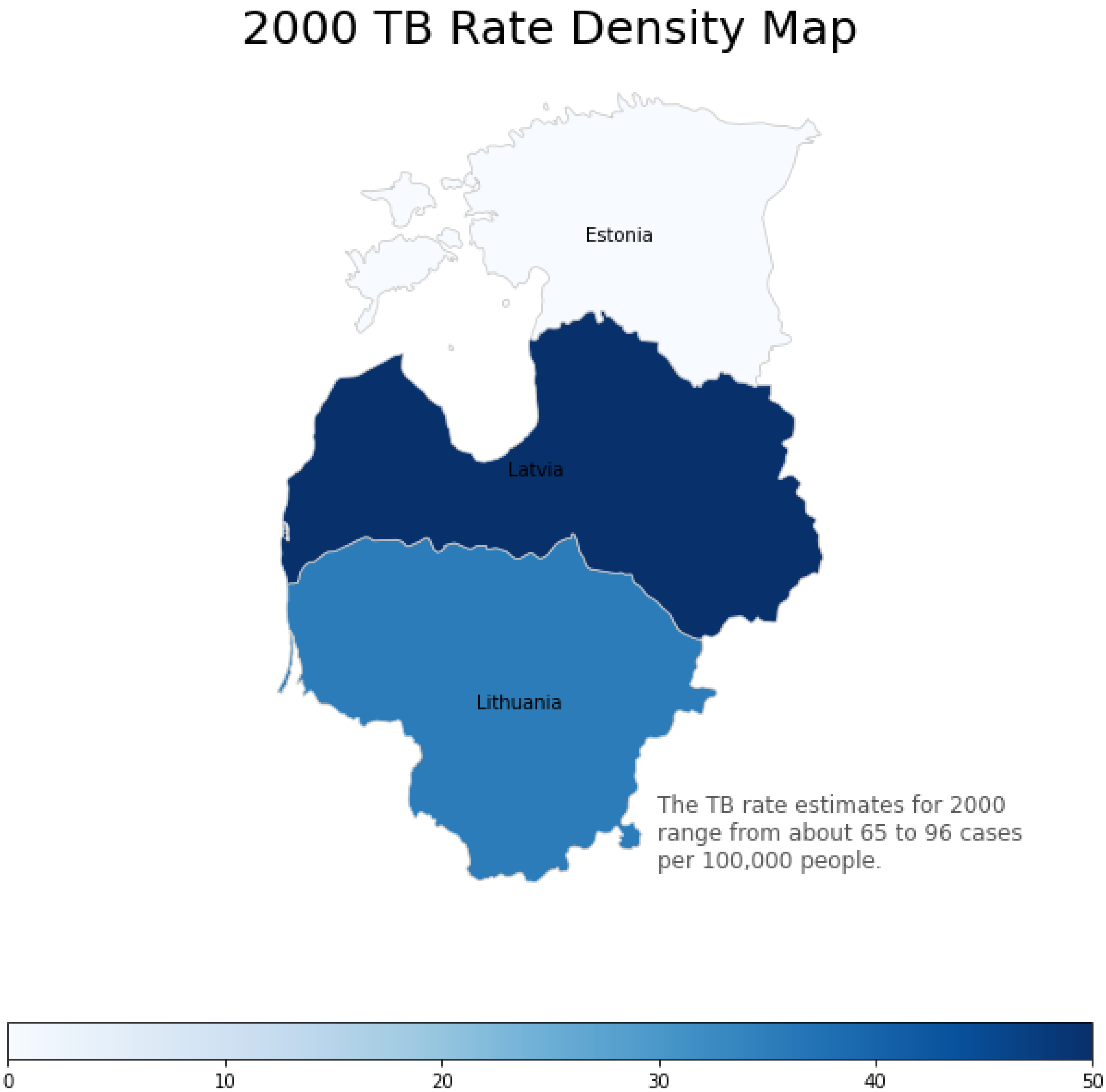
	SOVEREIGNT	ADMIN	geometry	2000	2001	2002	2003	2004	2005	2006	...	2011	2012	2013
0	Lithuania	Lithuania	MULTIPOLYGON (((26.59453 55.66699, 26.60383 55...	87.0	86.0	81.0	88.0	69.0	73.0	82.0	...	65.0	62.0	60.0
1	Estonia	Estonia	MULTIPOLYGON (((24.30616 57.86819, 24.31666 57...	65.0	59.0	52.0	49.0	45.0	41.0	36.0	...	25.0	23.0	23.0
2	Latvia	Latvia	POLYGON ((27.35293 57.52760, 27.52817 57.52848...	96.0	98.0	89.0	84.0	80.0	72.0	67.0	...	47.0	53.0	49.0

3 rows × 24 columns

We can now create the density maps with the TB dataframe.

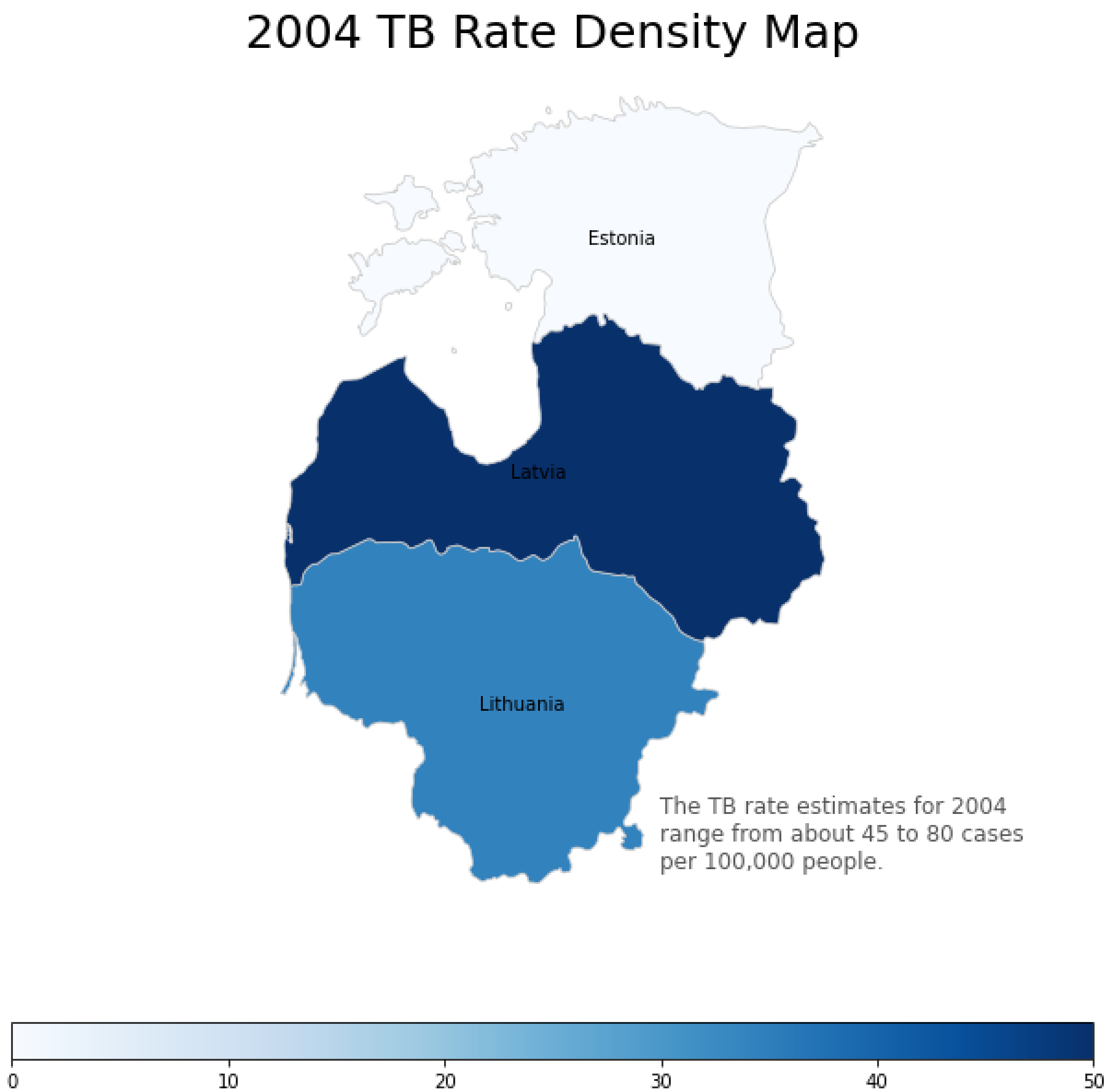
In [31]:

```
variable = 2000
vmin, vmax = 0, 50
fig, ax = plt.subplots(1, figsize=(30,10))
ax.axis('off')
ax.set_title('2000 TB Rate Density Map', fontdict={'fontsize': '25', 'fontweight' : '3'}
ax.annotate('The TB rate estimates for 2000 \nrange from about 65 to 96 cases \nper 100,
            xycoords='data', fontsize=12,
            color='#555555')
sm = plt.cm.ScalarMappable(cmap='Blues', norm=plt.Normalize(vmin=vmin, vmax=vmax))
sm.set_array([])
fig.colorbar(sm, orientation="horizontal", fraction=0.036, pad=0.1, aspect = 30)
tb_incidence_df.plot(column=variable, cmap='Blues', linewidth=0.8, ax=ax, edgecolor='0.8
tb_incidence_df['coords'] = tb_incidence_df['geometry'].apply(lambda x: x.representative
tb_incidence_df['coords'] = [coords[0] for coords in tb_incidence_df['coords']]
for idx, row in merged.iterrows():
    plt.annotate(text=row['ADMIN'], xy=row['coords'],horizontalalignment='center')
```



In [32]:

```
variable = 2004
vmin, vmax = 0, 50
fig, ax = plt.subplots(1, figsize=(30,10))
ax.axis('off')
ax.set_title('2004 TB Rate Density Map', fontdict={'fontsize': '25', 'fontweight' : '3'}
ax.annotate('The TB rate estimates for 2004 \nrange from about 45 to 80 cases \nper 100,
            xycoords='data', fontsize=12,
            color='#555555')
sm = plt.cm.ScalarMappable(cmap='Blues', norm=plt.Normalize(vmin=vmin, vmax=vmax))
sm.set_array([])
fig.colorbar(sm, orientation="horizontal", fraction=0.036, pad=0.1, aspect = 30)
tb_incidence_df.plot(column=variable, cmap='Blues', linewidth=0.8, ax=ax, edgecolor='0.8
tb_incidence_df['coords'] = tb_incidence_df['geometry'].apply(lambda x: x.representative
tb_incidence_df['coords'] = [coords[0] for coords in tb_incidence_df['coords']]
for idx, row in merged.iterrows():
    plt.annotate(text=row['ADMIN'], xy=row['coords'],horizontalalignment='center')
```



[#C] Other Indicators

The following cell creates dictionaries for the members of the Baltics, the original EU members in 1995 before the other 12 countries joined to form the entire EU which is also listed below.

In [33]:
```
baltic = {"EST":"Estonia",
                "LVA":"Latvia",
                "LTU":"Lithuania"
         }

original_15 = {"ESP":"Spain",
                "AUT":"Austria",
                "FIN":"Finland",
                "GRC":"Greece",
                "PRT":"Portugal",
                "IRL":"Ireland",
                "DNK":"Denmark",
                "SWE":"Sweden",
                "BEL":"Belgium",
                "FRA":"France",
                "DEU":"Germany",
                "ITA":"Italy",
                "LUX":"Luxembourg",
                "NLD":"The Netherlands",
                "GBR":"United Kingdom"
```

```
                    }

eumembers = {"ESP":"Spain",
                "AUT":"Austria",
                "EST":"Estonia",
                "FIN":"Finland",
                "GRC":"Greece",
                "LVA":"Latvia",
                "LTU":"Lithuania",
                "MLT":"Malta",
                "POL":"Poland",
                "PRT":"Portugal",
                "SVK":"Slovakia",
                "SVN":"Slovenia",
                "IRL":"Ireland",
                "BGR":"Bulgaria",
                "HRV":"Croatia",
                "ROU":"Romania",
                "CZE":"Czech Republic",
                "DNK":"Denmark",
                "HUN":"Hungary",
                "POL":"Poland",
                "SWE":"Sweden",
                "BEL":"Belgium",
                "CYP":"Cyprus",
                "FRA":"France",
                "DEU":"Germany",
                "ITA":"Italy",
                "LUX":"Luxembourg",
                "NLD":"The Netherlands"
                 }
```

We created 4 functions for graphing hte different indicators. The first one graphs a given indicator for certain countries. The second one graphs the log of a given indicator for certain countries. The last 2 graph either the indicator or the log of the indicator, but also graph 2 more lines for EU15 (the original 15 members of the EU) and one for EU27 (all current members of the EU) which contain the average in all of those countries combined.

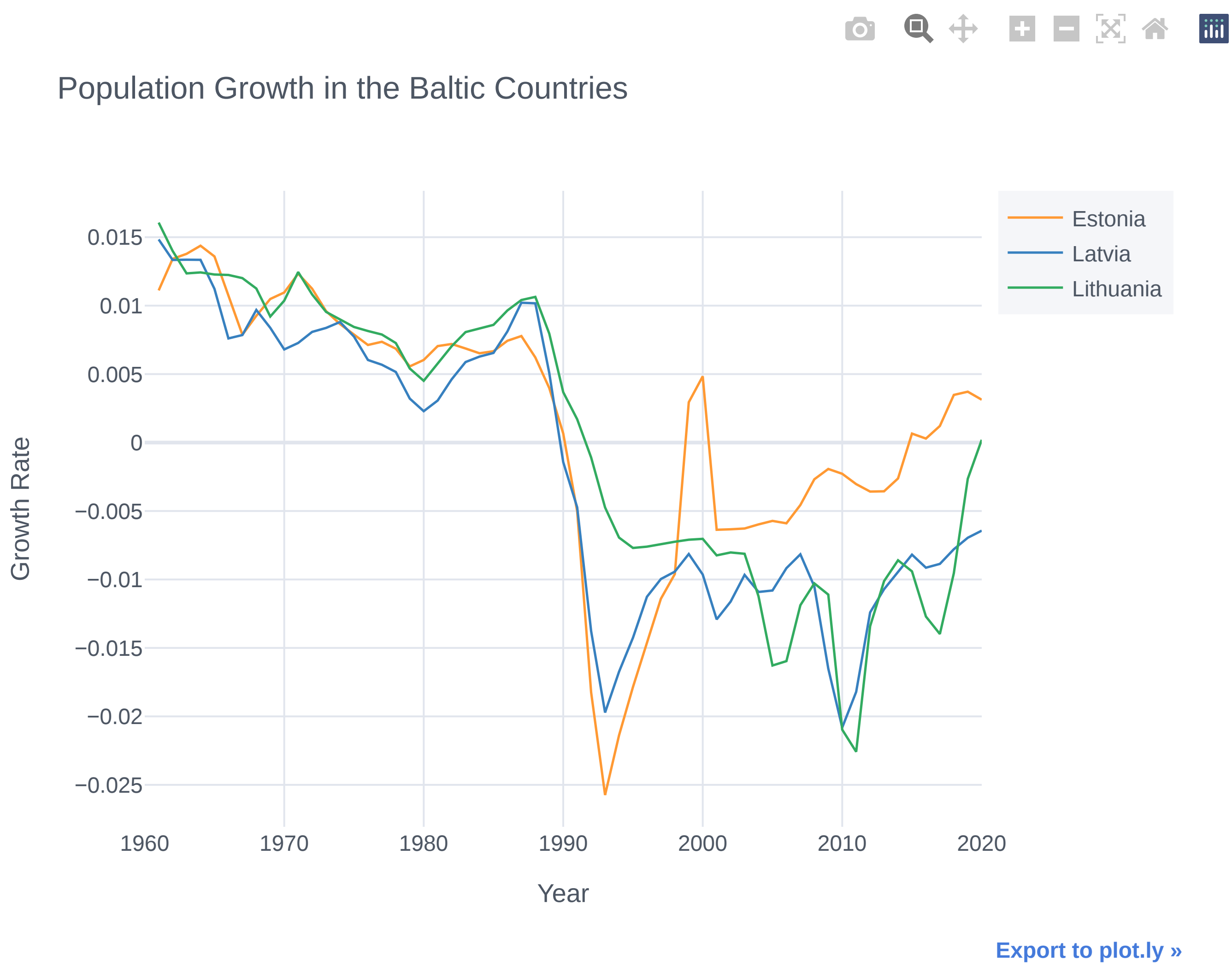
In [34]:

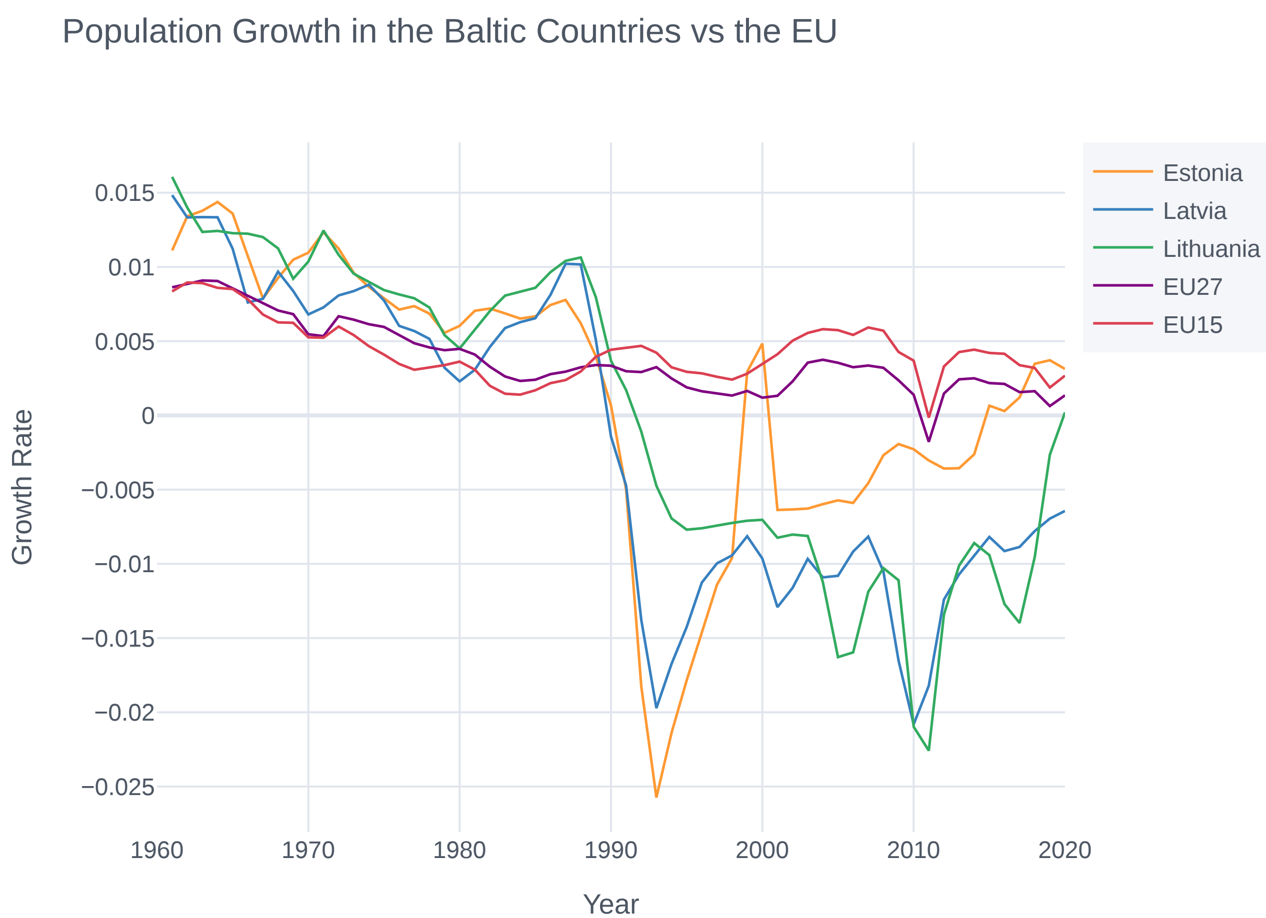
```
import plotly.graph_objs as go

def graph_indicator(indicator_dict, country_dict, graph_title, y_title):
    data = wbdata.get_dataframe(indicator_dict, country = country_dict).squeeze().T
    data = data.unstack('country').dropna(axis=0, how='any')
    data.index = data.index.astype(int)
    data.iplot(title = graph_title,
                        yTitle = y_title, xTitle = 'Year')

def graph_log(indicator_dict, country_dict, graph_title, y_title):
    data = wbdata.get_dataframe(indicator_dict, country = country_dict).squeeze().T
    data = data.unstack('country').dropna(axis=0, how='any')
    data.index = data.index.astype(int)
    np.log(data).diff().iplot(title = graph_title,
                        yTitle = y_title, xTitle = 'Year')

def eu_comparison_graph(indicator_dict, graph_title, y_title):
    all_eu = wbdata.get_dataframe(indicator_dict, country = eumembers)
    all_eu = all_eu.unstack('country').dropna(axis=0, how='any').droplevel(level=0, axis
    all_eu['EU27'] = all_eu.sum(axis=1) / 27

    originals = wbdata.get_dataframe(indicator_dict, country = original_15)
    originals = originals.unstack('country').dropna(axis=0, how='any').droplevel(level=0
    all_eu['EU15'] = originals.sum(axis=1) / 15
    all_eu.index = all_eu.index.astype(int)
```

```
    comparison = all_eu[['Estonia', 'Latvia', 'Lithuania', 'EU27', 'EU15']]
    comparison.iplot(title = graph_title,
                        yTitle = y_title, xTitle = 'Year')

def eu_log_comparison_graph(indicator_dict, graph_title, y_title):
    all_eu = wbdata.get_dataframe(indicator_dict, country = eumembers)
    all_eu = all_eu.unstack('country').dropna(axis=0, how='any').droplevel(level=0, axis
    all_eu['EU27'] = all_eu.sum(axis=1) / 27

    originals = wbdata.get_dataframe(indicator_dict, country = original_15)
    originals = originals.unstack('country').dropna(axis=0, how='any').droplevel(level=0
    all_eu['EU15'] = originals.sum(axis=1) / 15
    all_eu.index = all_eu.index.astype(int)

    comparison = all_eu[['Estonia', 'Latvia', 'Lithuania', 'EU27', 'EU15']]
    np.log(comparison).diff().iplot(title = graph_title,
                        yTitle = y_title, xTitle = 'Year')
```

The following cells use these functions in order to visualize the different indicators.

In [46]:
```
graph_log({"SP.POP.TOTL":"Population"}, baltic, "Population Growth in the Baltic Countri
eu_log_comparison_graph({"SP.POP.TOTL":"Population"}, "Population Growth in the Baltic C
```



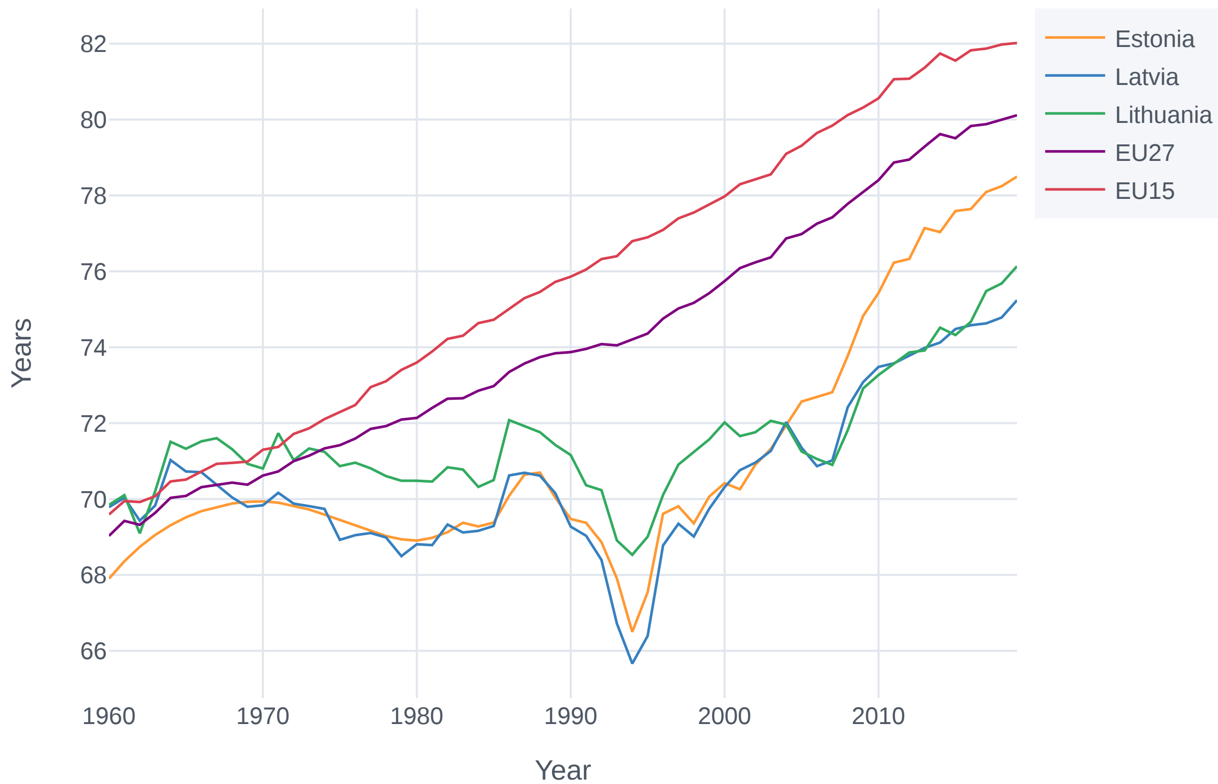


Export to plot.ly »

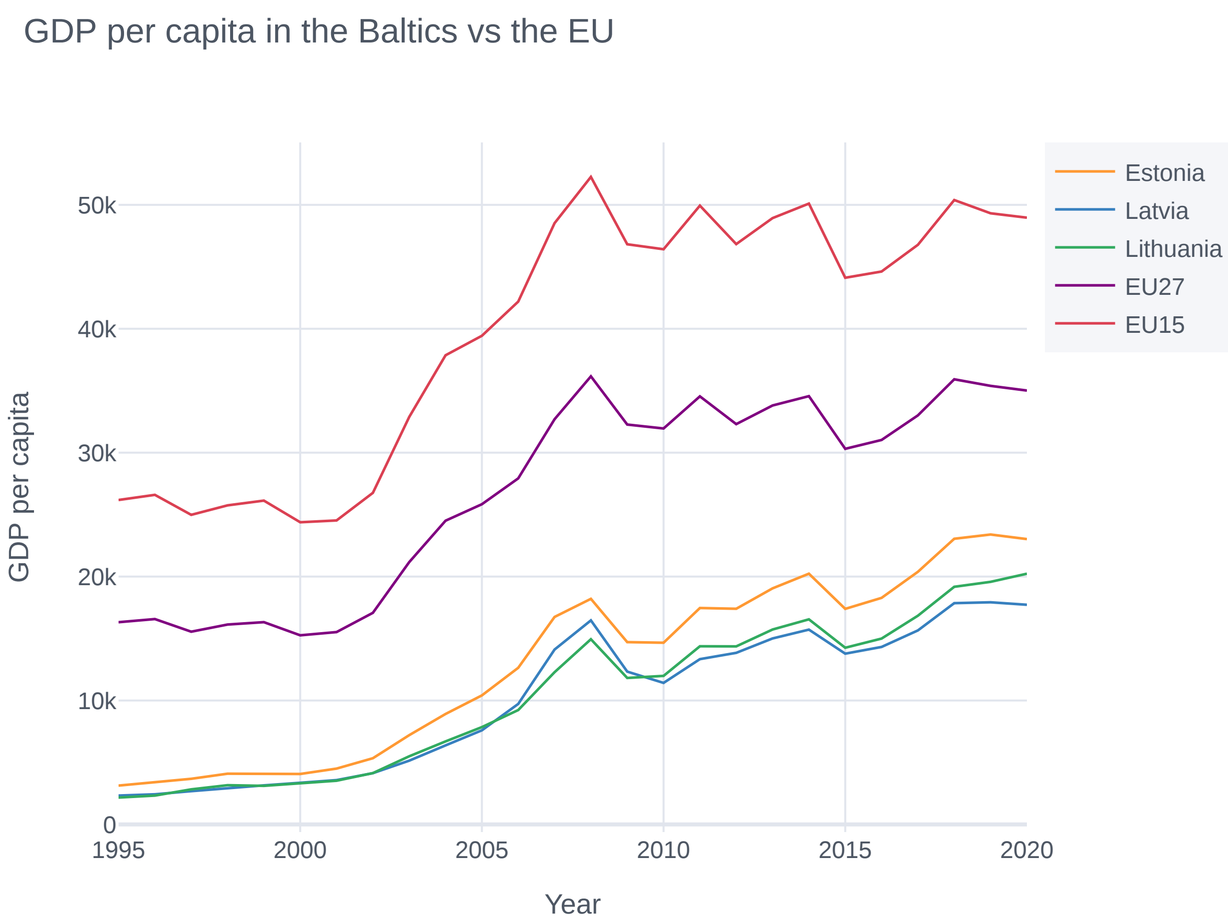
In [49]:

```
eu_comparison_graph({'SP.DYN.LE00.IN':'Life Expectancy'}, 'Life Expectancy in the Baltic
eu_comparison_graph({"NY.GDP.PCAP.CD":"GDP per capita"}, "GDP per capita in the Baltics
graph_indicator({"NY.GDP.PCAP.CD":"GDP per capita"}, baltic, "GDP per capita in the Balt
eu_comparison_graph({"NY.GDP.MKTP.CD":"GDP (current US dollars)"}, "GDP in the Baltics v
graph_indicator({"NY.GDP.MKTP.CD":"GDP (current US dollars)"}, baltic, "GDP in the Balti
```

Life Expectancy in the Baltics vs th EU

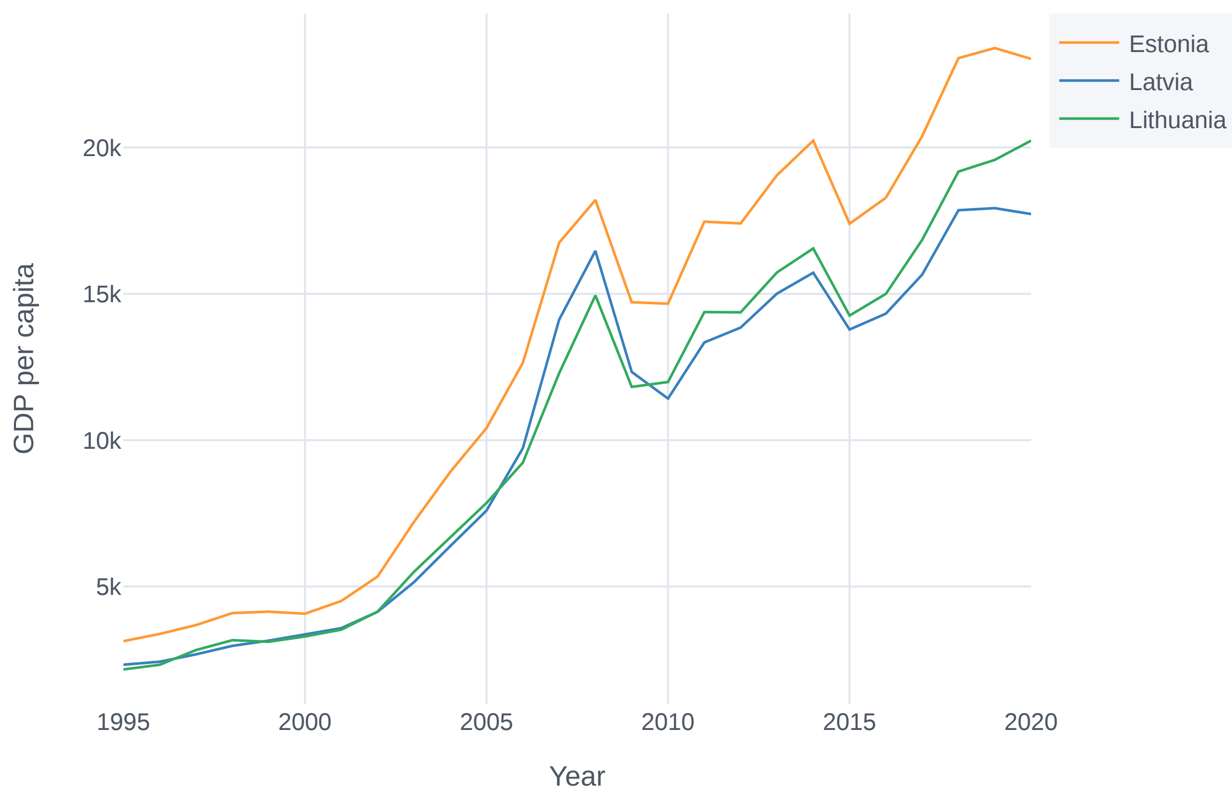


Export to plot.ly »

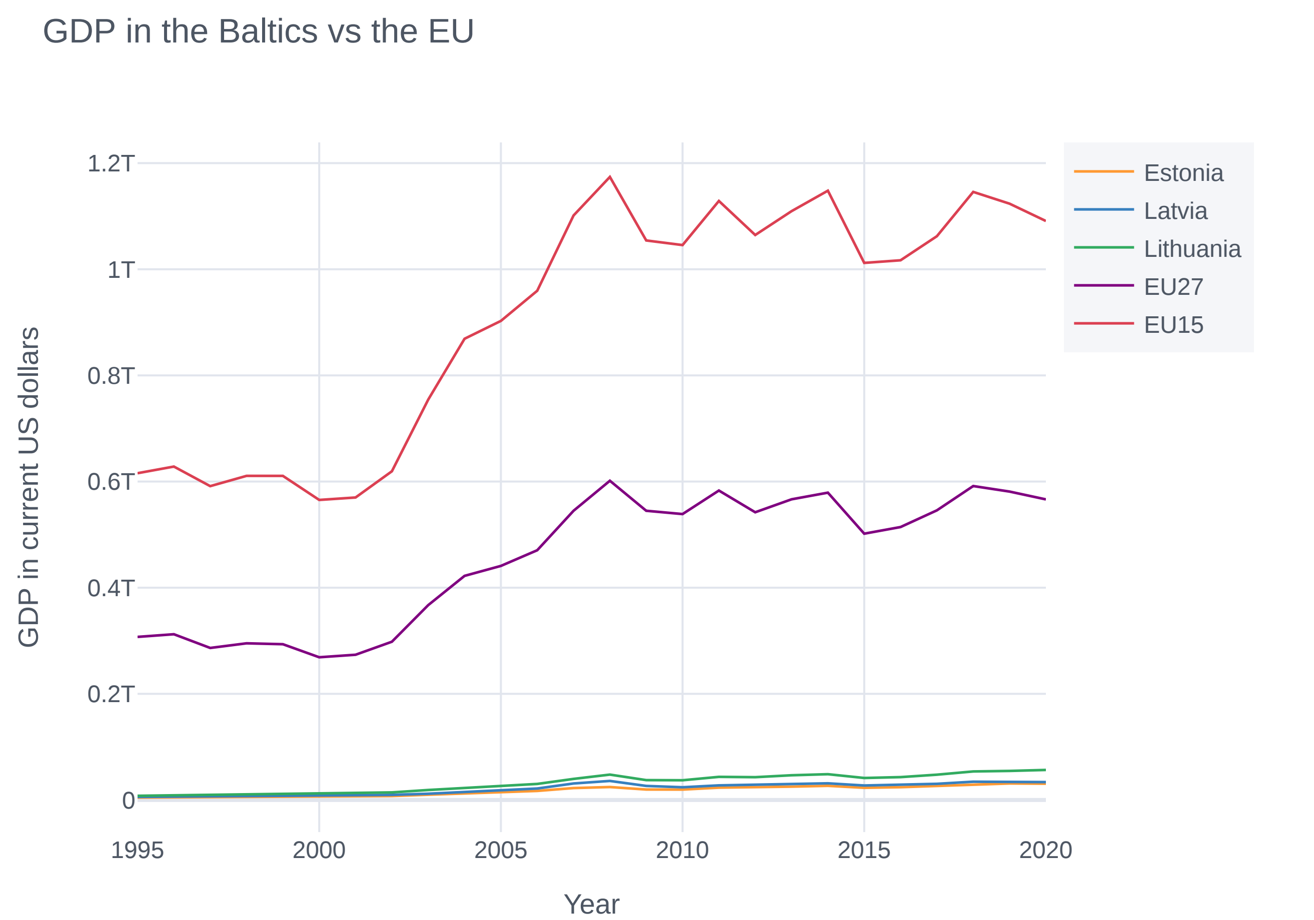


Export to plot.ly »

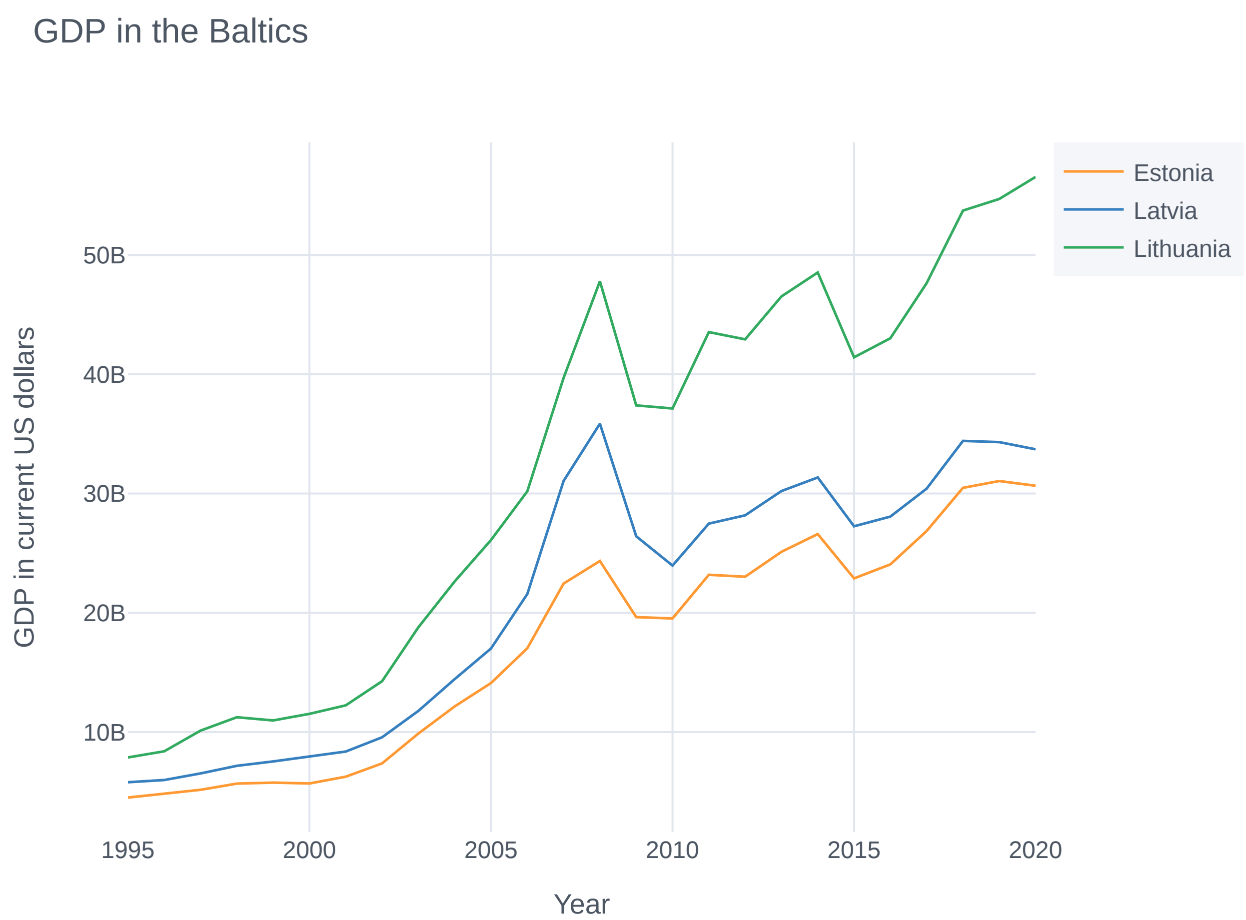
GDP per capita in the Baltics



Export to plot.ly »



Export to plot.ly »

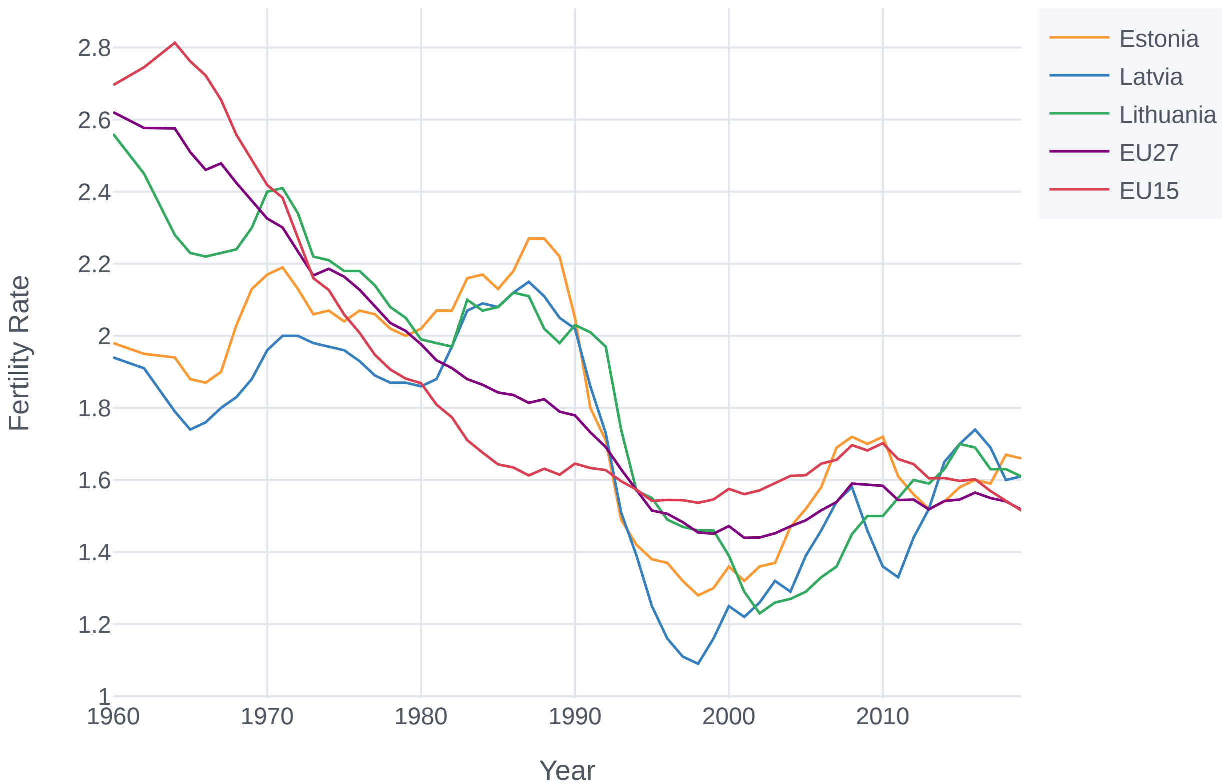


Export to plot.ly »

In [43]:

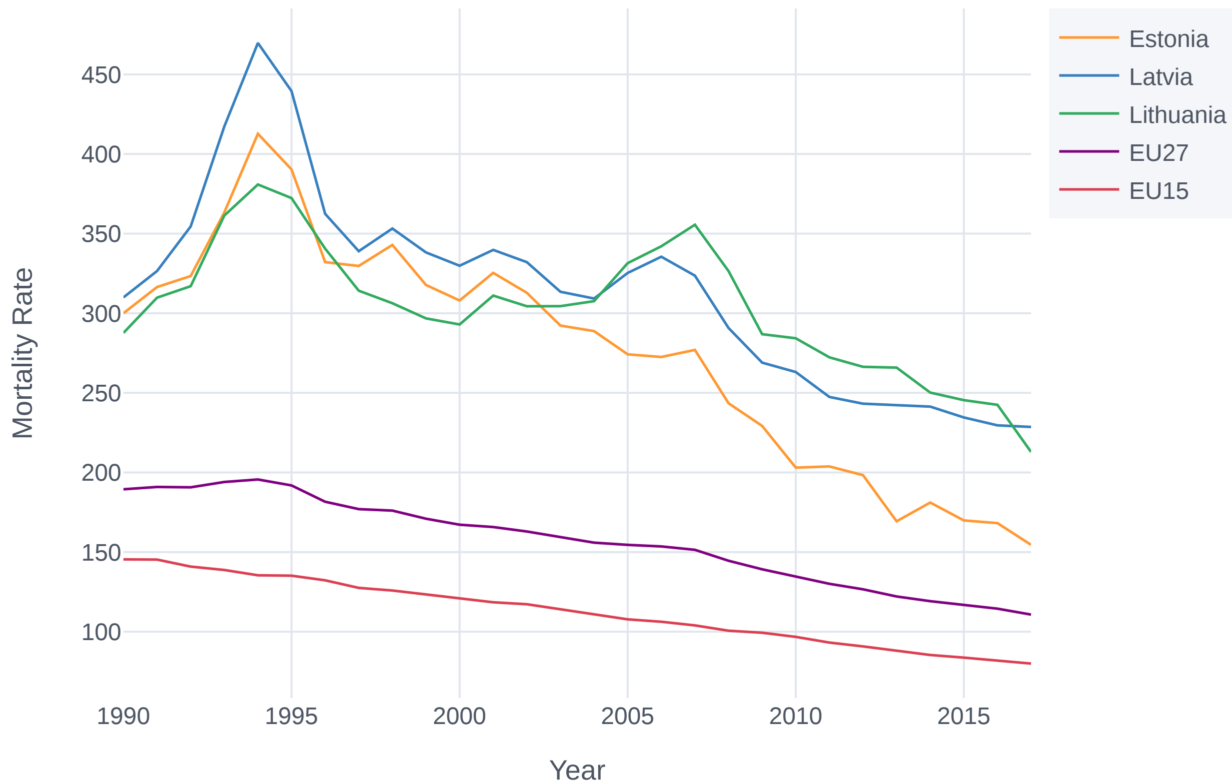
```
eu_comparison_graph({"SP.DYN.TFRT.IN":"Total Fertility Rate"}, "Fertility Rates", "Ferti
eu_comparison_graph({"SP.DYN.AMRT.MA":"Male Mortality"}, "Male Mortality Rates", "Mortal
eu_comparison_graph({"SP.DYN.AMRT.FE":"Female Mortality"}, "Female Mortality Rates", "Mo
```

Fertility Rates

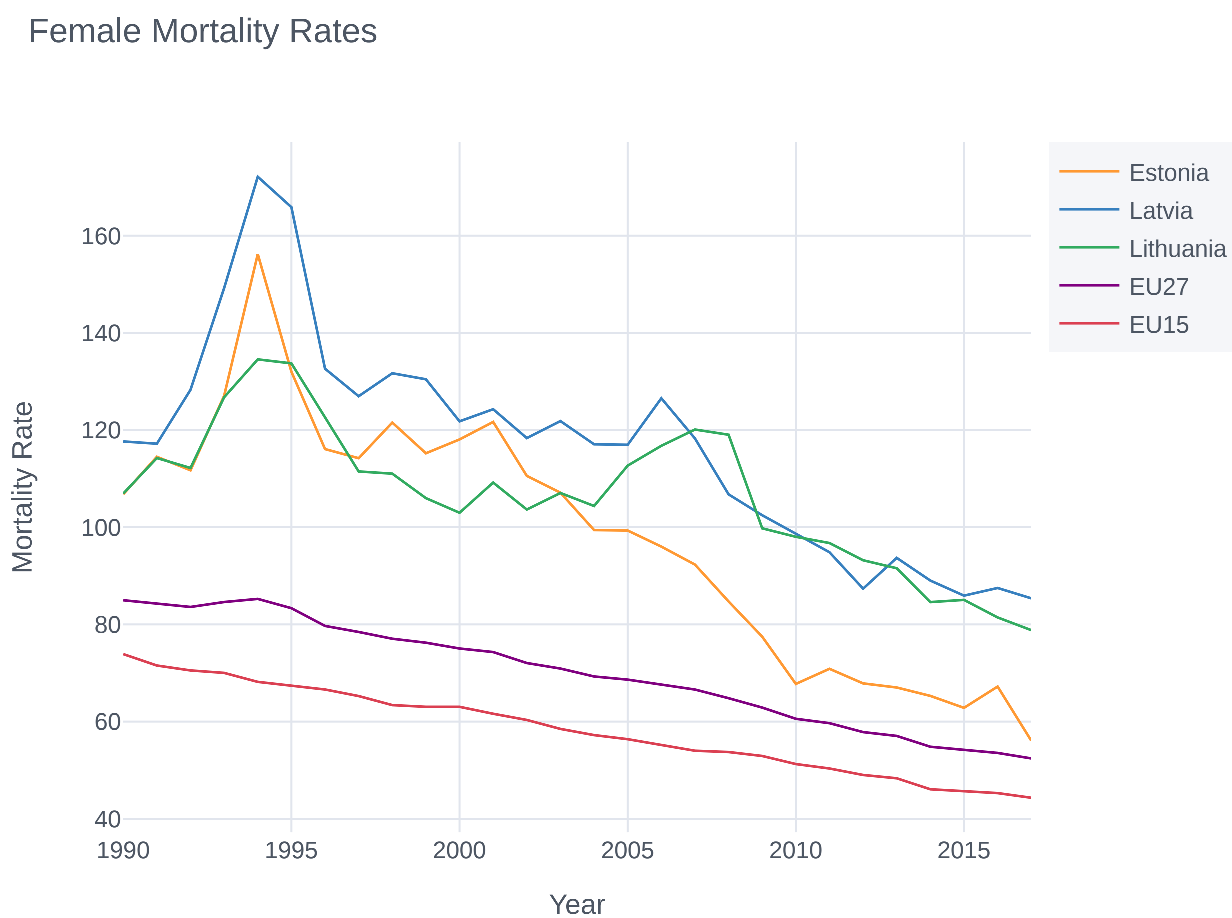


Export to plot.ly »

Male Mortality Rates



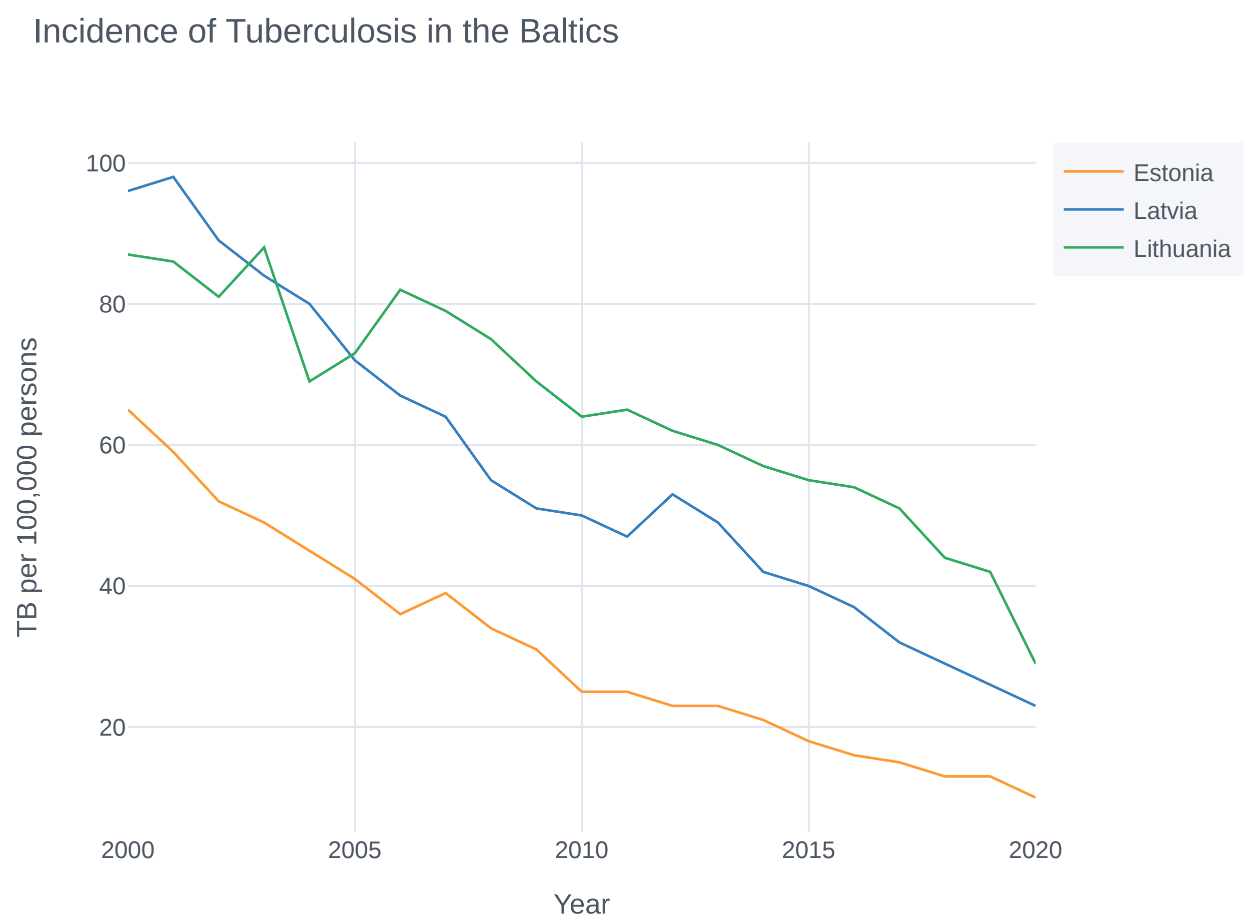
Export to plot.ly »



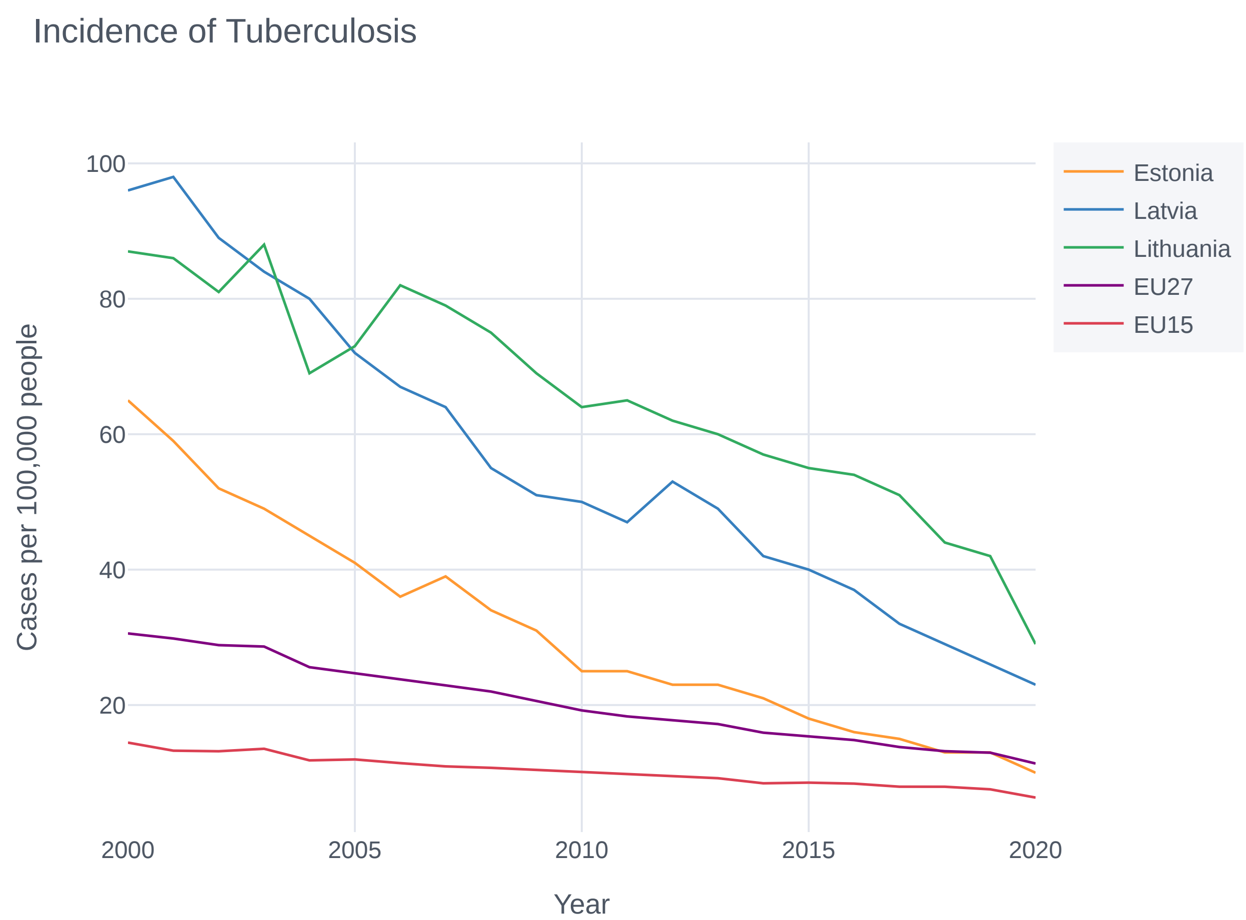
Export to plot.ly »

In [44]:

```
graph_indicator({"SH.TBS.INCD":"Incidence of tuberculosis (per 100,000 people)"}, baltic
eu_comparison_graph({"SH.TBS.INCD":"Incidence of tuberculosis (per 100,000 people)"}, "I
```



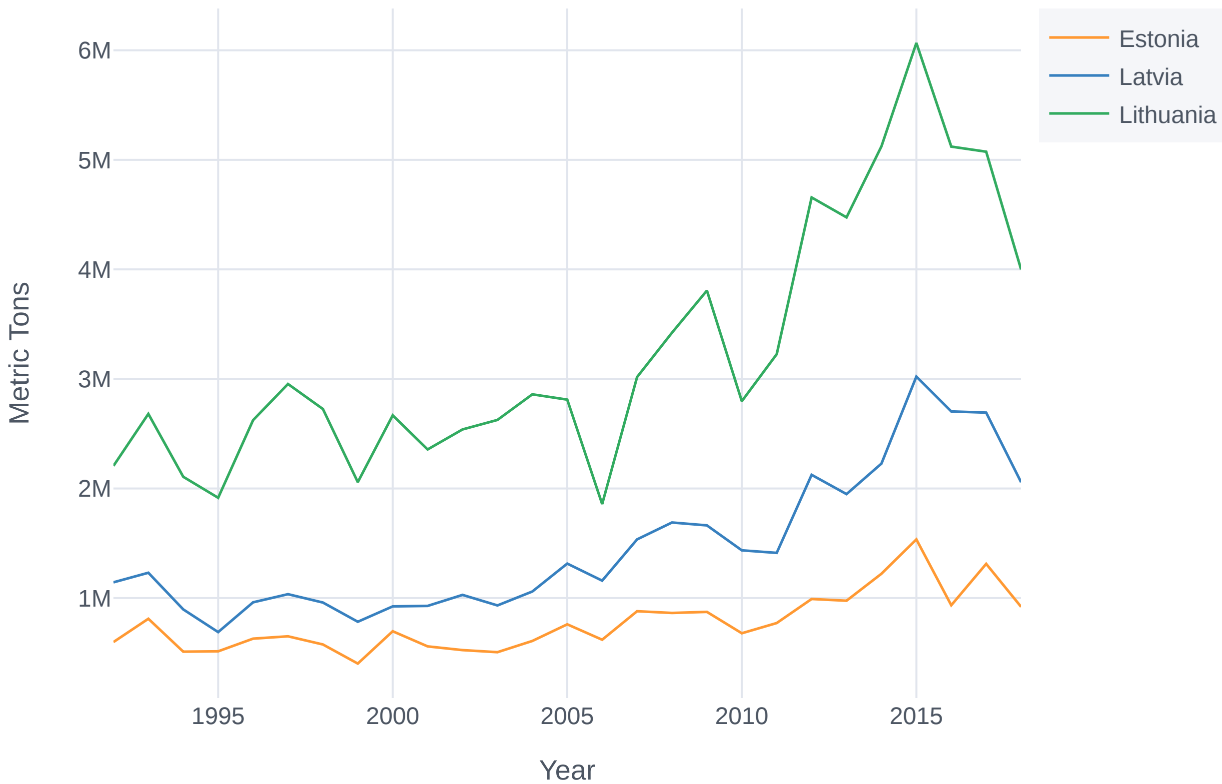
Export to plot.ly »



Export to plot.ly »

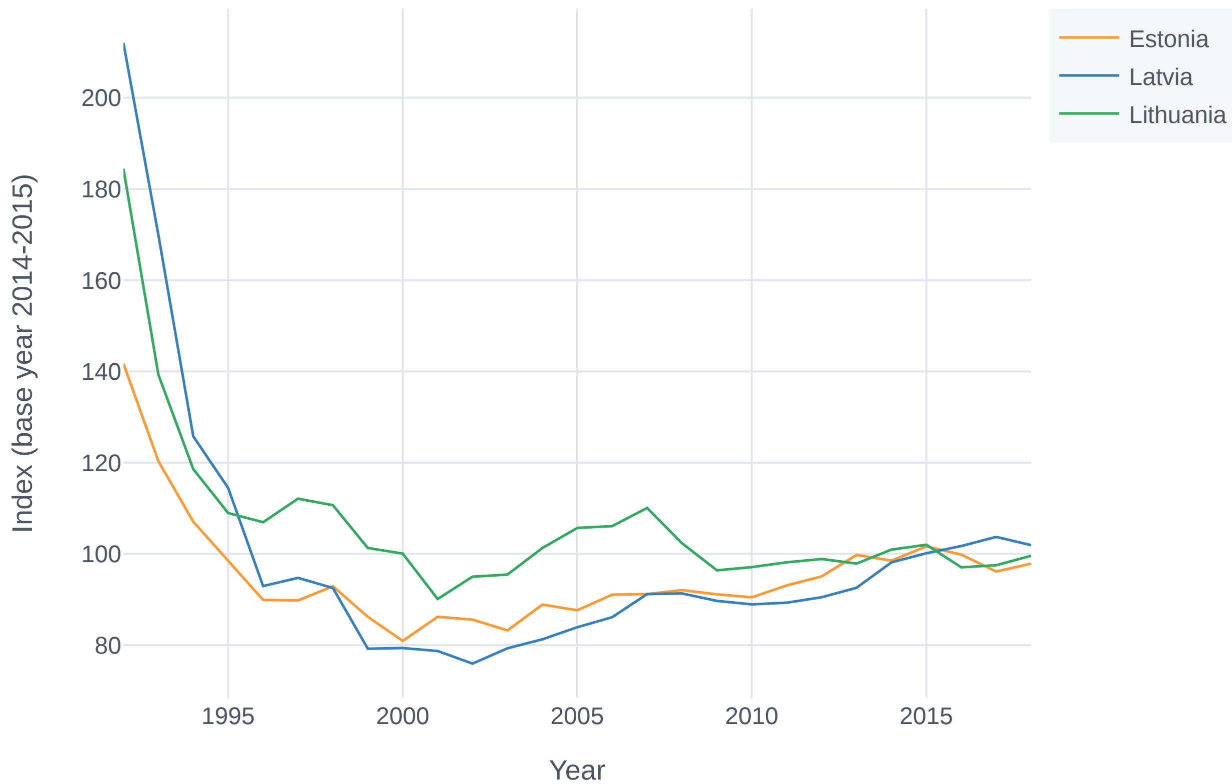
In [45]:
```
graph_indicator({"AG.PRD.CREL.MT":"Cereal production"}, baltic, "Cereal Production in th
graph_indicator({"AG.PRD.LVSK.XD":"Livestock index"}, baltic, "Livestock Indices in the
graph_indicator({"AG.PRD.FOOD.XD":"Food index"}, baltic, "Food Indices in the Baltics",
```

Cereal Production in the Baltics



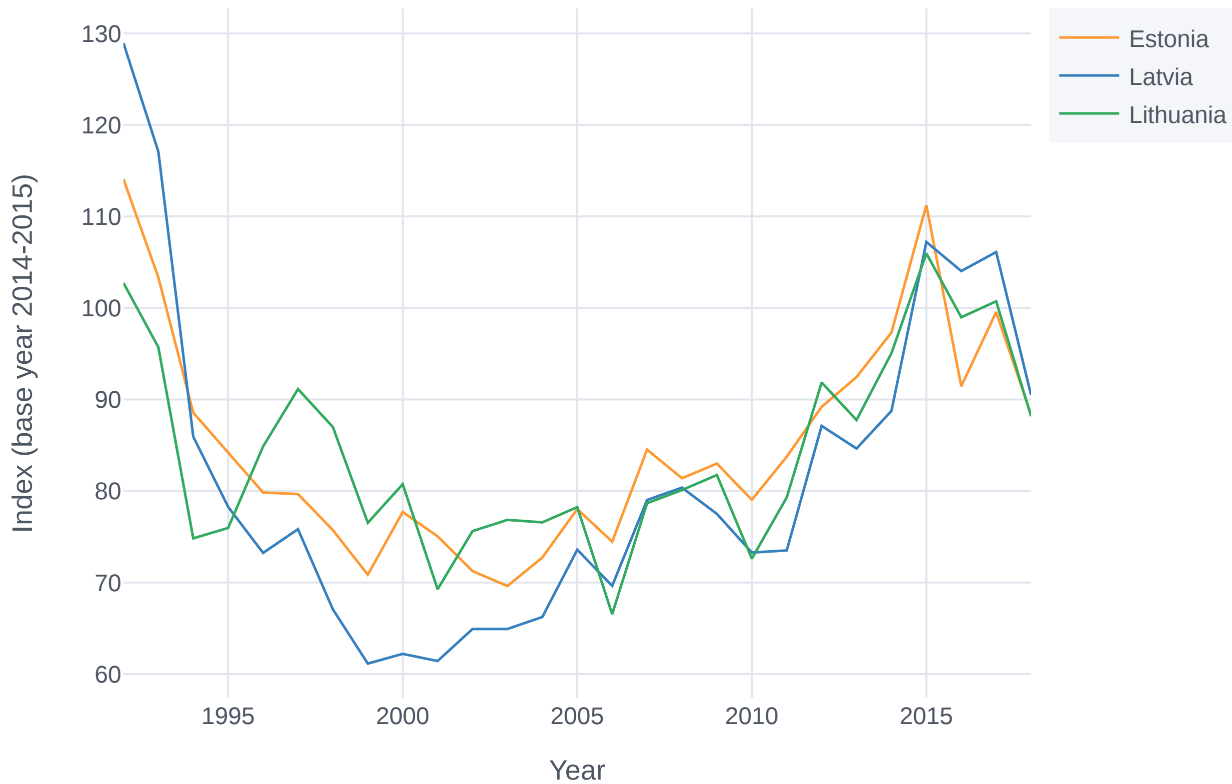
Export to plot.ly »

Livestock Indices in the Baltics



Export to plot.ly »

Food Indices in the Baltics



Export to plot.ly »

In [ ]:

[#C] Regression: Tuberculosis and Poverty

In [50]:

```
import statsmodels.api as sm
import plotly.express as px
```

Population growth depends on mortality, fertility, and the share of the population that can bear children.

From the accounting equation given in class, we know population in the next period $t+1$ will be given by

$$N_{t+1} = (1 - \text{mortality rate})N_t + \text{TFR} \cdot \phi_t N_t, \qquad \text{where...}$$

N_t: total population in year t

N_{t+1}: total population in year $t+1$

ϕ_t: share of the population at time t that are women of child-bearing age (here, 15–49)

Are the demographic trends we've witnessed due to changes in **mortality, fertility, or ϕ_t?**

In [51]:

```
adults = {"SP.POP.TOTL":"Total pop",
          "SP.DYN.AMRT.MA":"Male mortality",
          "SP.DYN.AMRT.FE":"Female mortality",
          "NY.GDP.PCAP.CD":"GDP pc",
          "SP.DYN.TFRT.IN":"TFR",
```

```
          "SP.DYN.CDRT.IN": "Death rate",
          "SP.POP.1564.FE.IN": "Population ages 15-64, female",
          "SP.POP.6064.FE":    "Population ages 60-64, female",
          "SP.POP.TOTL.FE.IN":  "Population, female"
         }

baltic = {"EST":"estonia",
             "LVA":"latvia",
             "LTU":"lithuania"
            }

peqn = wbdata.get_dataframe(adults, country = baltic)
peqn['Mom pop'] = peqn['Population ages 15-64, female']-peqn['Population ages 60-64, fer

peqn.reset_index(inplace=True)
peqn['date'] = peqn['date'].astype(int)
peqn.set_index(['date', 'country'],inplace=True)
peqn = peqn.dropna(axis=0, how='any')

peqn = peqn.drop(columns = ['Population ages 15-64, female', 'Population ages 60-64, fer
peqn['Est births'] = peqn['Mom pop'] * peqn['TFR']

peqn_log = peqn
peqn_log['Log total pop'] = np.log(peqn_log['Total pop'])
peqn_log['Log male mortality'] = np.log(peqn_log['Male mortality'])
peqn_log['Log female mortality'] = np.log(peqn_log['Female mortality'])
peqn_log['Log female mortality'] = np.log(peqn_log['Female mortality'])
peqn_log['Log GDP pc'] = np.log(peqn_log['GDP pc'])
peqn_log['Log TFR'] = np.log(peqn_log['TFR'])
peqn_log['Log death rate'] = np.log(peqn_log['Death rate'])
peqn_log['Log est births'] = np.log(peqn_log['Est births'])
peqn_log['Log mom pop'] = np.log(peqn_log['Mom pop'])
peqn_log = peqn_log.drop(columns = ['Total pop','Male mortality', 'Female mortality', '(
peqn_log
```

Out[51]:

date	country	Mom pop	Log total pop	Log male mortality	Log female mortality	Log GDP pc	Log TFR	Log death rate	Log est births	Log mom pop
1995	**Estonia**	447311.0	14.177813	5.966936	4.882878	8.050190	0.322083	2.674149	13.333093	13.011009
1996	**Estonia**	442208.0	14.163060	5.805466	4.754271	8.125905	0.314811	2.595255	13.314346	12.999536
1997	**Estonia**	437348.0	14.151651	5.798141	4.737934	8.211470	0.277632	2.587764	13.266116	12.988484
1998	**Estonia**	432662.0	14.142045	5.837451	4.800186	8.317129	0.246860	2.639057	13.224572	12.977712
1999	**Estonia**	433831.0	14.144990	5.761268	4.746809	8.328677	0.262364	2.595255	13.242775	12.980410
...	**...**	...	...	...	...	...	...	...	...	...
2015	**Lithuania**	901910.0	14.881913	5.502963	4.443216	9.565090	0.530628	2.667228	14.242898	13.712270
2016	**Lithuania**	878890.0	14.869206	5.490886	4.399781	9.615680	0.524729	2.660260	14.211144	13.686415
2017	**Lithuania**	854187.0	14.855223	5.360752	4.367179	9.731732	0.488580	2.653242	14.146485	13.657905
2018	**Lithuania**	833138.0	14.845681	5.332381	4.332048	9.861457	0.488580	2.646175	14.121535	13.632955
2019	**Lithuania**	817016.0	14.843034	5.302932	4.294274	9.882048	0.476234	2.617396	14.089648	13.613414

71 rows × 9 columns

In [52]:

```
y_1a = peqn_log['Log total pop']
X_1a = sm.add_constant(peqn_log[['Log death rate', 'Log est births', 'Log GDP pc']])
model_1a = sm.OLS(y_1a, X_1a)
```

```
results_1a = model_1a.fit(cov_type='HAC', cov_kwds={'maxlags':1})
results_1a.summary()
```

```
/opt/conda/lib/python3.9/site-packages/statsmodels/tsa/tsatools.py:142: FutureWarning:

In a future version of pandas all arguments of concat except for the argument 'objs' wil
l be keyword-only
```

Out[52]:

OLS Regression Results

Dep. Variable:	Log total pop	**R-squared:**	0.962
Model:	OLS	**Adj. R-squared:**	0.960
Method:	Least Squares	**F-statistic:**	348.5
Date:	Mon, 14 Feb 2022	**Prob (F-statistic):**	8.50e-41
Time:	13:13:37	**Log-Likelihood:**	87.402
No. Observations:	71	**AIC:**	-166.8
Df Residuals:	67	**BIC:**	-157.8
Df Model:	3		
Covariance Type:	HAC		

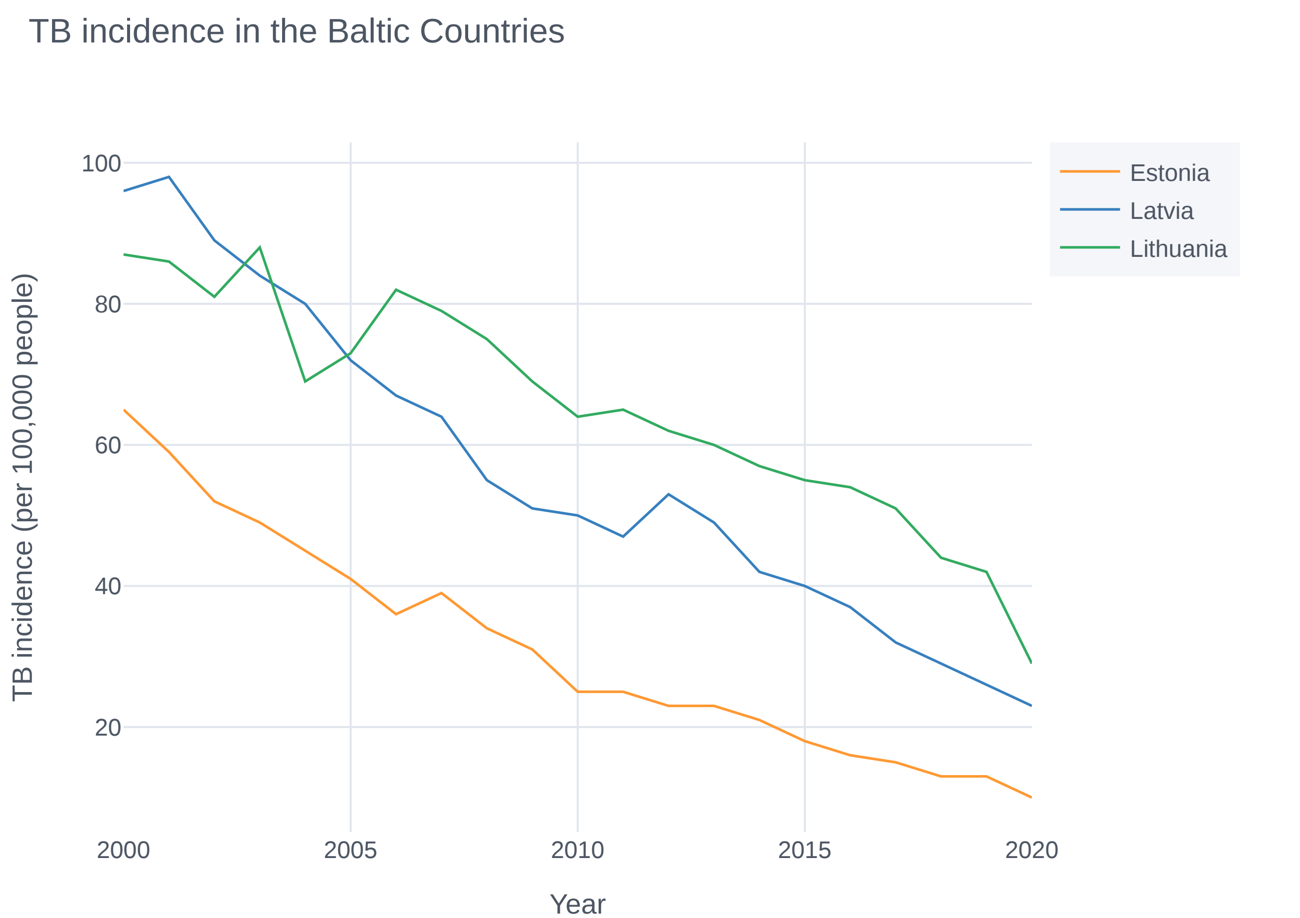
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
const	2.2475	0.441	5.093	0.000	1.383	3.112
Log death rate	0.1533	0.129	1.187	0.235	-0.100	0.406
Log est births	0.9399	0.031	30.392	0.000	0.879	1.000
Log GDP pc	-0.1131	0.017	-6.631	0.000	-0.147	-0.080

Omnibus:	2.461	**Durbin-Watson:**	0.365
Prob(Omnibus):	0.292	**Jarque-Bera (JB):**	1.539
Skew:	0.056	**Prob(JB):**	0.463
Kurtosis:	2.287	**Cond. No.**	831.

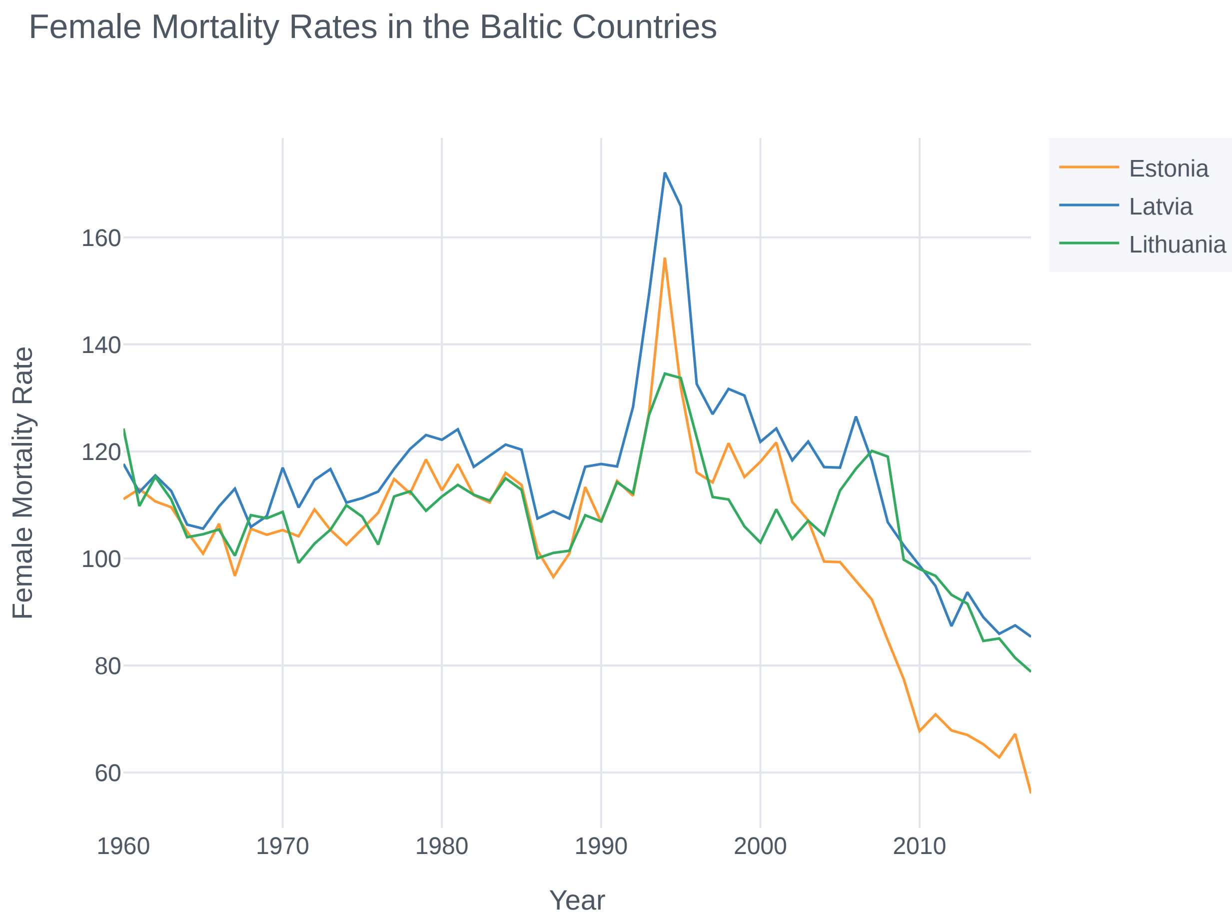
Notes:
[1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

In [53]:

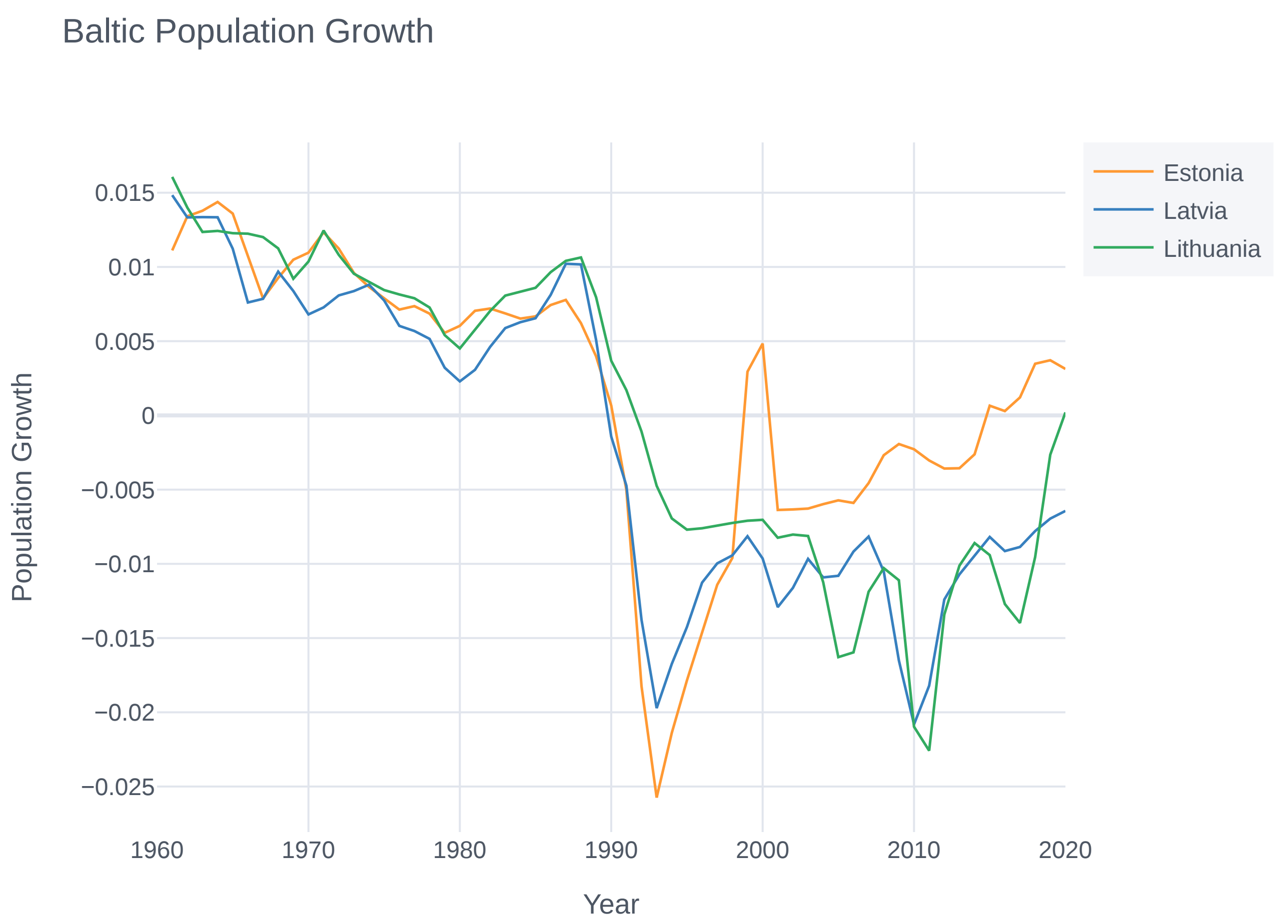
```
graph_indicator({"SH.TBS.INCD" : "Incidence of tuberculosis (per 100,000 people)"}, balt
graph_indicator({"SP.DYN.AMRT.FE":"Female Mortality"}, baltic, "Female Mortality Rates i
graph_log({"SP.POP.TOTL":"Population"}, baltic, "Baltic Population Growth", "Population
```



Export to plot.ly »

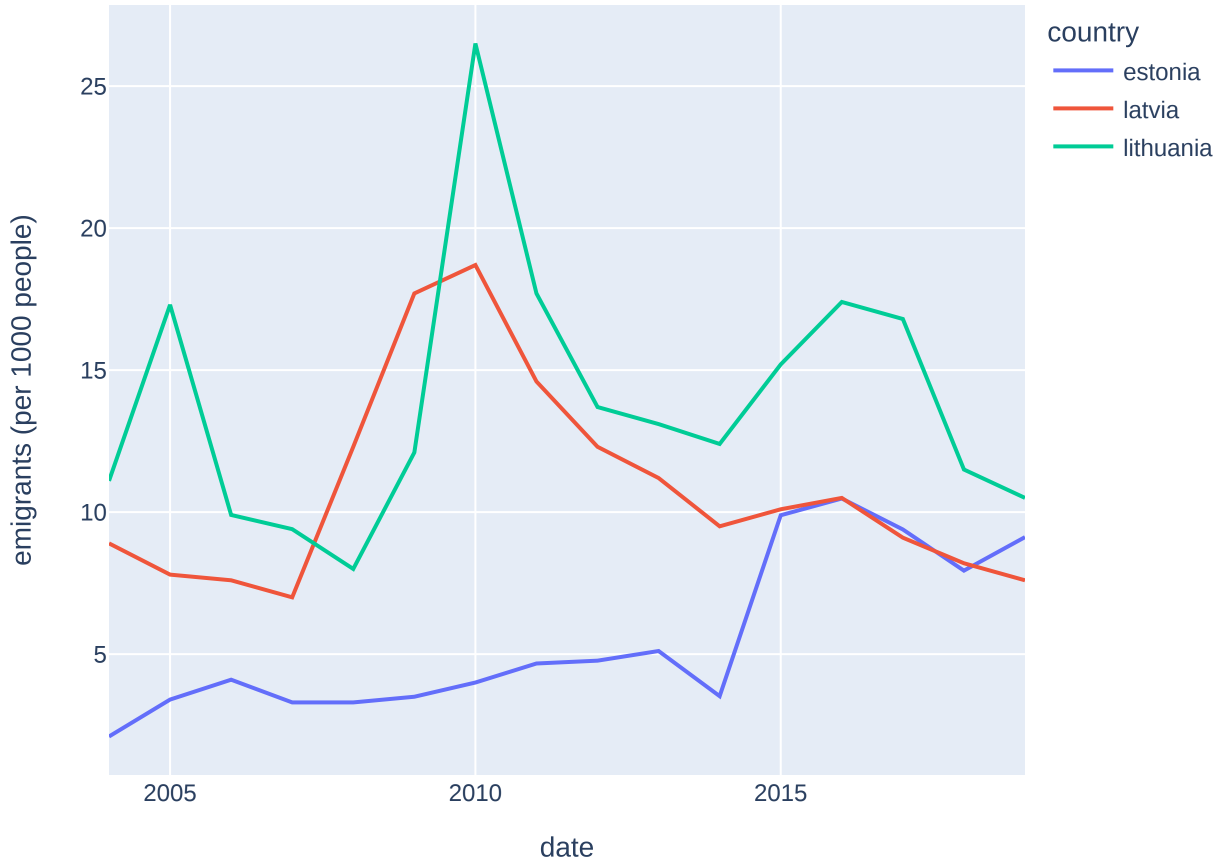


Export to plot.ly »



Export to plot.ly »

In [54]:
```
emigration = pd.read_csv('emigration.csv')
emigration = emigration.rename(columns = {'year': 'date'})
emigration.reset_index(inplace=True)
emigration['date'] = emigration['date'].astype(int)
emigration = emigration.drop(columns = 'index')

emigration.reset_index(inplace=True)
emigration['date'] = emigration['date'].astype(int)
emigration.set_index(['date', 'country'],inplace=True)
emigration.reset_index(inplace = True)
emigration = emigration.drop(columns = 'index')

fig = px.line(emigration, x='date', y='emigrants (per 1000 people)' , color='country')
fig.update_traces(textposition="bottom right")
fig.show()

emi_est = emigration[emigration['country']=='estonia']
emi_lva = emigration[emigration['country']=='latvia']
emi_ltu = emigration[emigration['country']=='lithuania']
emi_ltu
```



Out[54]:

	date	country	emigrants (per 1000 people)
32	2004	lithuania	11.1
33	2005	lithuania	17.3
34	2006	lithuania	9.9
35	2007	lithuania	9.4
36	2008	lithuania	8.0
37	2009	lithuania	12.1
38	2010	lithuania	26.5
39	2011	lithuania	17.7
40	2012	lithuania	13.7
41	2013	lithuania	13.1
42	2014	lithuania	12.4
43	2015	lithuania	15.2
44	2016	lithuania	17.4
45	2017	lithuania	16.8
46	2018	lithuania	11.5
47	2019	lithuania	10.5

In [55]:

```
ind = {"SH.TBS.INCD" : "Incidence of tuberculosis (per 100,000 people)",
       "NY.GDP.PCAP.CD":"GDP per capita",
```

```
        "SI.POV.LMIC": "Poverty headcount ratio at $3.20 a day (2011 PPP) (% of populat
       "SP.POP.TOTL":"Total population",
       "SP.POP.GROW":"Population Growth Rate",
       "SP.DYN.AMRT.FE":"Female Mortality"}
data = wbdata.get_dataframe(ind, country = baltic)

# Make years ints instead of strings
data.reset_index(inplace=True)
data['date'] = data['date'].astype(int)
data = data.dropna(axis=0, how='any')

data['Log GDP per capita'] = np.log(data['GDP per capita'])
data['Log TB incidence'] = np.log(data['Incidence of tuberculosis (per 100,000 people)']
```

In [56]:

```
#simple linear regression of log TB incidence on log gdppc, for all three baltic states
y_2a = data['Log TB incidence']
X_2a = sm.add_constant(data[['Log GDP per capita']])
model_2a = sm.OLS(y_2a, X_2a)
results_2a = model_2a.fit(cov_type='HAC', cov_kwds={'maxlags':1})
results_2a.summary()
```

```
/opt/conda/lib/python3.9/site-packages/statsmodels/tsa/tsatools.py:142: FutureWarning:

In a future version of pandas all arguments of concat except for the argument 'objs' wil
l be keyword-only
```

Out[56]:

OLS Regression Results

Dep. Variable:	Log TB incidence	**R-squared:**	0.386
Model:	OLS	**Adj. R-squared:**	0.371
Method:	Least Squares	**F-statistic:**	18.23
Date:	Mon, 14 Feb 2022	**Prob (F-statistic):**	0.000109
Time:	13:13:39	**Log-Likelihood:**	-16.367
No. Observations:	44	**AIC:**	36.73
Df Residuals:	42	**BIC:**	40.30
Df Model:	1		
Covariance Type:	HAC		

	coef	std err	z	P>|z|	[0.025	0.975]
const	12.6698	2.048	6.185	0.000	8.655	16.684
Log GDP per capita	-0.9337	0.219	-4.270	0.000	-1.362	-0.505

Omnibus:	3.423	**Durbin-Watson:**	0.321
Prob(Omnibus):	0.181	**Jarque-Bera (JB):**	2.058
Skew:	-0.295	**Prob(JB):**	0.357
Kurtosis:	2.121	**Cond. No.**	307.

Notes:
[1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

In [57]:
```
#now, want to see how gdppc well predicts tb incidence in each individual country, start
est = data[data['country']=='Estonia']

y_2b = est['Log TB incidence']
X_2b = sm.add_constant(est[['Log GDP per capita']])
model_2b = sm.OLS(y_2b, X_2b)
results_2b = model_2b.fit(cov_type='HAC', cov_kwds={'maxlags':1})
results_2b.summary()
```

```
/opt/conda/lib/python3.9/site-packages/statsmodels/tsa/tsatools.py:142: FutureWarning:

In a future version of pandas all arguments of concat except for the argument 'objs' wil
l be keyword-only

/opt/conda/lib/python3.9/site-packages/scipy/stats/stats.py:1541: UserWarning:

kurtosistest only valid for n>=20 ... continuing anyway, n=15
```

Out[57]:

OLS Regression Results

Dep. Variable:	Log TB incidence	**R-squared:**	0.634
Model:	OLS	**Adj. R-squared:**	0.606
Method:	Least Squares	**F-statistic:**	36.57
Date:	Mon, 14 Feb 2022	**Prob (F-statistic):**	4.12e-05
Time:	13:13:39	**Log-Likelihood:**	1.4315
No. Observations:	15	**AIC:**	1.137
Df Residuals:	13	**BIC:**	2.553
Df Model:	1		
Covariance Type:	HAC		

	coef	std err	z	P>|z|	[0.025	0.975]
const	12.5353	1.470	8.527	0.000	9.654	15.417
Log GDP per capita	-0.9590	0.159	-6.047	0.000	-1.270	-0.648

Omnibus:	0.836	**Durbin-Watson:**	0.581
Prob(Omnibus):	0.659	**Jarque-Bera (JB):**	0.374
Skew:	0.378	**Prob(JB):**	0.829
Kurtosis:	2.840	**Cond. No.**	310.

Notes:
[1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

In [58]:
```
lva = data[data['country']=='Latvia']

y_2c = lva['Log TB incidence']
X_2c = sm.add_constant(lva[['Log GDP per capita']])
model_2c = sm.OLS(y_2c, X_2c)
results_2c = model_2c.fit(cov_type='HAC', cov_kwds={'maxlags':1})
results_2c.summary()
```

```
/opt/conda/lib/python3.9/site-packages/statsmodels/tsa/tsatools.py:142: FutureWarning:

In a future version of pandas all arguments of concat except for the argument 'objs' wil
l be keyword-only

/opt/conda/lib/python3.9/site-packages/scipy/stats/stats.py:1541: UserWarning:

kurtosistest only valid for n>=20 ... continuing anyway, n=14
```

Out[58]:

OLS Regression Results

Dep. Variable:	Log TB incidence	**R-squared:**	0.563
Model:	OLS	**Adj. R-squared:**	0.526
Method:	Least Squares	**F-statistic:**	25.69
Date:	Mon, 14 Feb 2022	**Prob (F-statistic):**	0.000276
Time:	13:13:39	**Log-Likelihood:**	5.2893
No. Observations:	14	**AIC:**	-6.579
Df Residuals:	12	**BIC:**	-5.300
Df Model:	1		
Covariance Type:	HAC		

	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
const	10.4343	1.233	8.466	0.000	8.019	12.850
Log GDP per capita	-0.6894	0.136	-5.068	0.000	-0.956	-0.423

Omnibus:	0.083	**Durbin-Watson:**	0.533
Prob(Omnibus):	0.959	**Jarque-Bera (JB):**	0.106
Skew:	0.085	**Prob(JB):**	0.948
Kurtosis:	2.608	**Cond. No.**	330.

Notes:
[1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

In [59]:

```
ltu = data[data['country']=='Lithuania']

y_2b = ltu['Log TB incidence']
X_2b = sm.add_constant(ltu[['Log GDP per capita']])
model_2b = sm.OLS(y_2b, X_2b)
results_2b = model_2b.fit(cov_type='HAC', cov_kwds={'maxlags':1})
results_2b.summary()
```

```
/opt/conda/lib/python3.9/site-packages/statsmodels/tsa/tsatools.py:142: FutureWarning:

In a future version of pandas all arguments of concat except for the argument 'objs' wil
l be keyword-only

/opt/conda/lib/python3.9/site-packages/scipy/stats/stats.py:1541: UserWarning:

kurtosistest only valid for n>=20 ... continuing anyway, n=15
```

Out[59]:

OLS Regression Results

Dep. Variable:	Log TB incidence	**R-squared:**	0.462
Model:	OLS	**Adj. R-squared:**	0.420
Method:	Least Squares	**F-statistic:**	8.111
Date:	Mon, 14 Feb 2022	**Prob (F-statistic):**	0.0137
Time:	13:13:39	**Log-Likelihood:**	10.200
No. Observations:	15	**AIC:**	-16.40
Df Residuals:	13	**BIC:**	-14.98
Df Model:	1		
Covariance Type:	HAC		

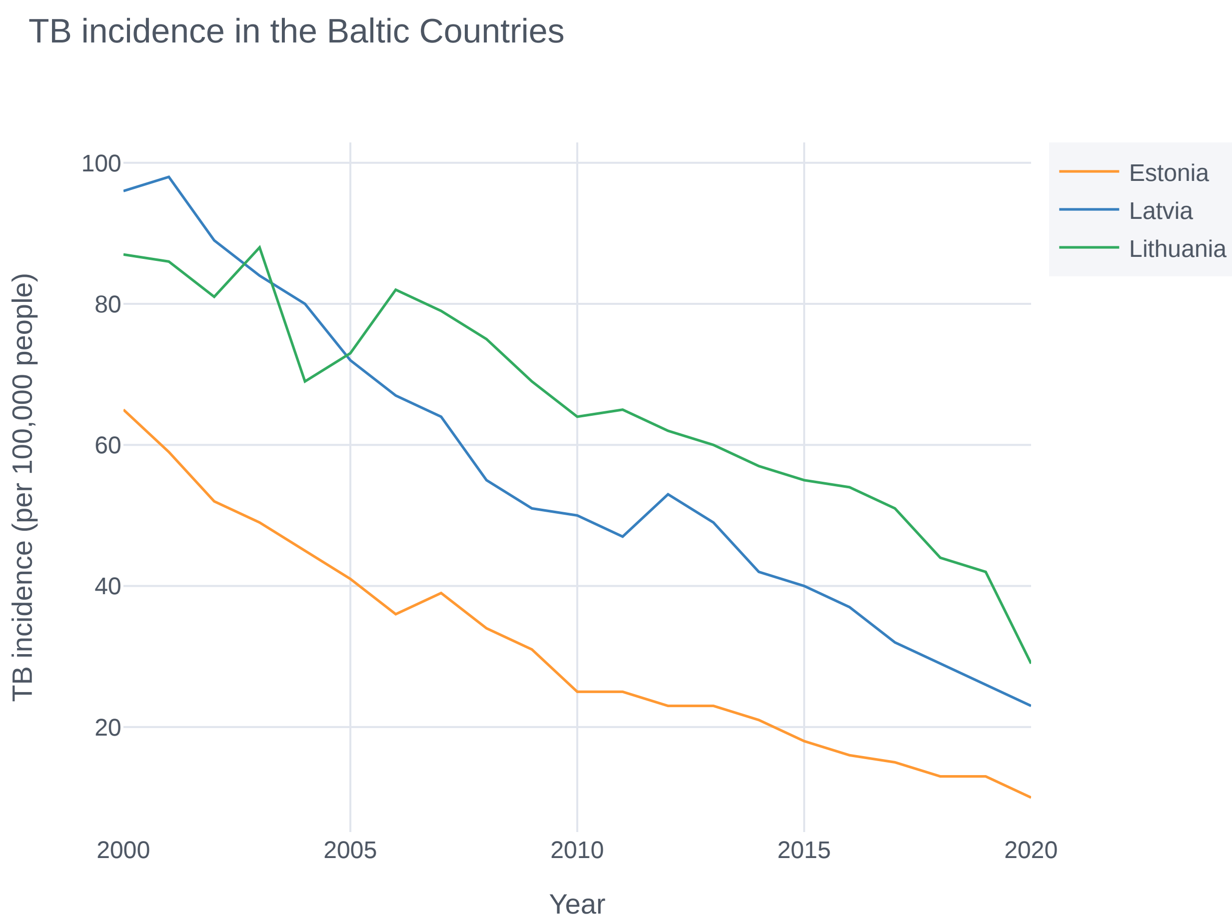
	coef	**std err**	**z**	**P>|z|**	**[0.025**	**0.975]**
const	7.9296	1.327	5.975	0.000	5.329	10.531
Log GDP per capita	-0.3999	0.140	-2.848	0.004	-0.675	-0.125

Omnibus:	0.340	**Durbin-Watson:**	0.529
Prob(Omnibus):	0.844	**Jarque-Bera (JB):**	0.465
Skew:	0.256	**Prob(JB):**	0.792
Kurtosis:	2.306	**Cond. No.**	319.

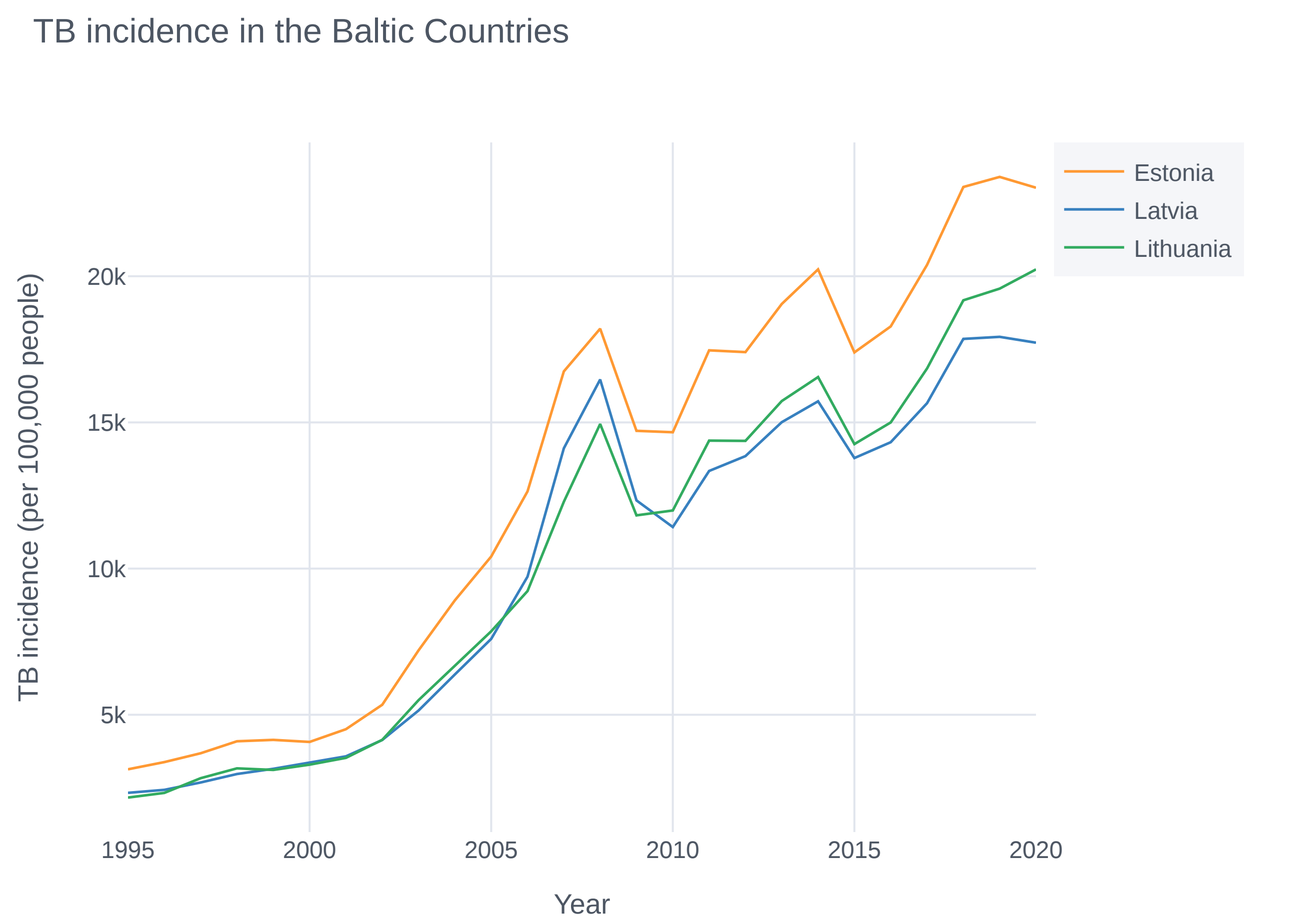
Notes:
[1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

In [60]:

```
graph_indicator({"SH.TBS.INCD" : "Incidence of tuberculosis (per 100,000 people)"}, balt
graph_indicator({"NY.GDP.PCAP.CD":"GDP per capita"}, baltic, "TB incidence in the Baltic
```



Export to plot.ly »



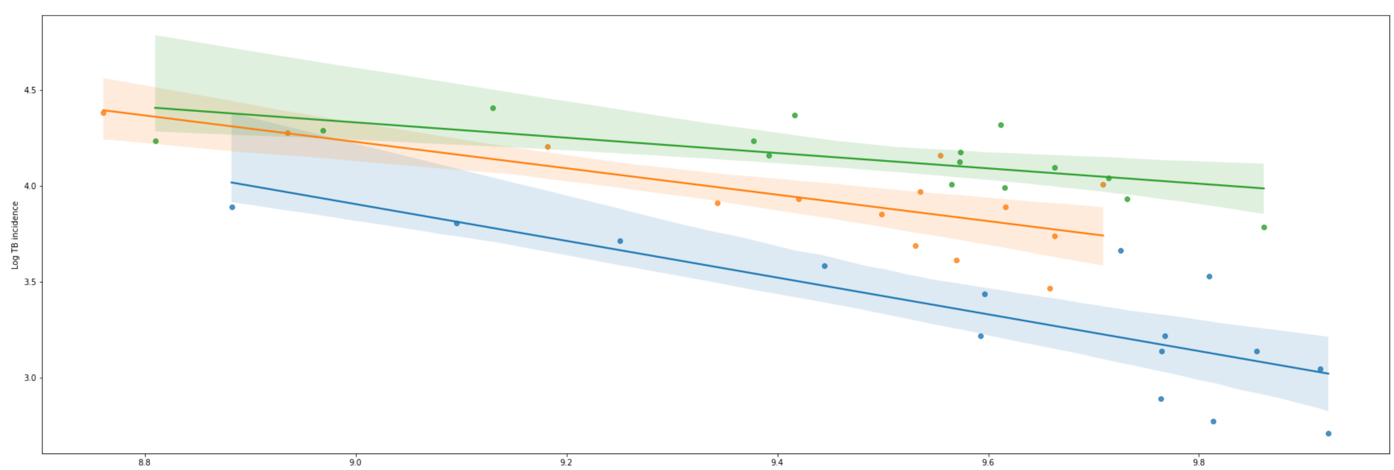
Export to plot.ly »

In [61]:

```
sns.regplot(x='Log GDP per capita', y='Log TB incidence', data=est)
sns.regplot(x='Log GDP per capita', y='Log TB incidence', data=lva)
sns.regplot(x='Log GDP per capita', y='Log TB incidence', data=ltu)
```

Out[61]:

```
<AxesSubplot:xlabel='Log GDP per capita', ylabel='Log TB incidence'>
```



In [62]:

```
est[['Log GDP per capita',"Log TB incidence"]].corr()
lva[['Log GDP per capita',"Log TB incidence"]].corr()
ltu[['Log GDP per capita',"Log TB incidence"]].corr()
```

Out[62]:

	Log GDP per capita	Log TB incidence
Log GDP per capita	1.000000	-0.679619
Log TB incidence	-0.679619	1.000000

In [ ]:

Conclusion

Estonia, Latvia, and Lithuania experienced significant population demographic impacts as a result of the dissolution of the USSR. The effects were further exacerbated by the 1990s TB epidemic that swept the region. We were able to confirm the effects through observation and analysis using multiple socio-economic and population indicators.

- Population growth, life expectancy, and fertility rates observe a dramatic dip, as expected, in the years following the dissolution of the USSR and the TB epidemic
  - Population growth, otherwise, is constant and follows a trend similar to the EU
  - Life expectancy in the Baltic countries does not recover nearly enough to catch up to the EU
- The Baltic countries follow a very similar GDP and GDP per capita trend, however the Baltics are consistently poorer relative to the EU
  - Compared to the Baltics, EU GDP is on average 20 times higher in 2020