Area-Plots-Histograms-and-Bar-Charts

May 8, 2020

Area Plots, Histograms, and Bar Plots

0.1 Table of Contents

1 Exploring Datasets with *pandas* and Matplotlib

Toolkits: The course heavily relies on *pandas* and **Numpy** for data wrangling, analysis, and visualization. The primary plotting library that we are exploring in the course is Matplotlib.

Dataset: Immigration to Canada from 1980 to 2013 - International migration flows to and from selected countries - The 2015 revision from United Nation's website.

The dataset contains annual data on the flows of international migrants as recorded by the countries of destination. The data presents both inflows and outflows according to the place of birth, citizenship or place of previous / next residence both for foreigners and nationals. For this lesson, we will focus on the Canadian Immigration data.

2 Downloading and Prepping Data

Import Primary Modules. The first thing we'll do is import two key data analysis modules: *pandas* and **Numpy**.

[1]:
```
import numpy as np  # useful for many scientific computing in Python
import pandas as pd # primary data structure library
```

Let's download and import our primary Canadian Immigration dataset using *pandas* `read_excel()` method. Normally, before we can do that, we would need to download a module which *pandas* requires to read in excel files. This module is **xlrd**. For your convenience, we have pre-installed this module, so you would not have to worry about that. Otherwise, you would need to run the following line of code to install the **xlrd** module:

```
!conda install -c anaconda xlrd --yes
```

Download the dataset and read it into a *pandas* dataframe.

[2]:
```
df_can = pd.read_excel('https://s3-api.us-geo.objectstorage.softlayer.net/
↪cf-courses-data/CognitiveClass/DV0101EN/labs/Data_Files/Canada.xlsx',
                       sheet_name='Canada by Citizenship',
                       skiprows=range(20),
                       skipfooter=2
                      )

print('Data downloaded and read into a dataframe!')
```

```
Data downloaded and read into a dataframe!
```

Let's take a look at the first five items in our dataset.

[5]:
```
df_can.head()
```

[5]:

	Type	Coverage	OdName	AREA	AreaName	REG	\
0	Immigrants	Foreigners	Afghanistan	935	Asia	5501	
1	Immigrants	Foreigners	Albania	908	Europe	925	
2	Immigrants	Foreigners	Algeria	903	Africa	912	
3	Immigrants	Foreigners	American Samoa	909	Oceania	957	
4	Immigrants	Foreigners	Andorra	908	Europe	925	

	RegName	DEV	DevName	1980	…	2004	2005	2006	\
0	Southern Asia	902	Developing regions	16	…	2978	3436	3009	
1	Southern Europe	901	Developed regions	1	…	1450	1223	856	
2	Northern Africa	902	Developing regions	80	…	3616	3626	4807	
3	Polynesia	902	Developing regions	0	…	0	0	1	
4	Southern Europe	901	Developed regions	0	…	0	0	1	

	2007	2008	2009	2010	2011	2012	2013
0	2652	2111	1746	1758	2203	2635	2004
1	702	560	716	561	539	620	603
2	3623	4005	5393	4752	4325	3774	4331
3	0	0	0	0	0	0	0
4	1	0	0	0	0	1	1

[5 rows x 43 columns]

Let's find out how many entries there are in our dataset.

[6]:
```
# print the dimensions of the dataframe
print(df_can.shape)
```

```
(195, 43)
```

Clean up data. We will make some modifications to the original dataset to make it easier to create our visualizations. Refer to `Introduction to Matplotlib and Line Plots` lab for the rational and detailed description of the changes.

1. Clean up the dataset to remove columns that are not informative to us for visualization (eg. Type, AREA, REG).

[7]:
```
df_can.drop(['AREA', 'REG', 'DEV', 'Type', 'Coverage'], axis=1, inplace=True)

# let's view the first five elements and see how the dataframe was changed
df_can.head()
```

[7]:
```
           OdName AreaName          RegName             DevName  1980  1981  \
0     Afghanistan     Asia    Southern Asia  Developing regions    16    39
1         Albania   Europe  Southern Europe   Developed regions     1     0
2         Algeria   Africa  Northern Africa  Developing regions    80    67
3  American Samoa  Oceania        Polynesia  Developing regions     0     1
4         Andorra   Europe  Southern Europe   Developed regions     0     0

   1982  1983  1984  1985  …  2004  2005  2006  2007  2008  2009  2010  \
0    39    47    71   340  …  2978  3436  3009  2652  2111  1746  1758
1     0     0     0     0  …  1450  1223   856   702   560   716   561
2    71    69    63    44  …  3616  3626  4807  3623  4005  5393  4752
3     0     0     0     0  …     0     0     1     0     0     0     0
4     0     0     0     0  …     0     0     1     1     0     0     0

   2011  2012  2013
0  2203  2635  2004
1   539   620   603
2  4325  3774  4331
3     0     0     0
4     0     1     1

[5 rows x 38 columns]
```

Notice how the columns Type, Coverage, AREA, REG, and DEV got removed from the dataframe.

2. Rename some of the columns so that they make sense.

[8]:
```
df_can.rename(columns={'OdName':'Country', 'AreaName':'Continent','RegName':
 ↪'Region'}, inplace=True)

# let's view the first five elements and see how the dataframe was changed
df_can.head()
```

[8]:
```
           Country Continent          Region             DevName  1980  1981  \
0     Afghanistan      Asia    Southern Asia  Developing regions    16    39
1         Albania    Europe  Southern Europe   Developed regions     1     0
2         Algeria    Africa  Northern Africa  Developing regions    80    67
3  American Samoa   Oceania        Polynesia  Developing regions     0     1
4         Andorra    Europe  Southern Europe   Developed regions     0     0

   1982  1983  1984  1985  …  2004  2005  2006  2007  2008  2009  2010  \
```

```
0    39    47    71   340  …  2978  3436  3009  2652  2111  1746  1758
1     0     0     0     0  …  1450  1223   856   702   560   716   561
2    71    69    63    44  …  3616  3626  4807  3623  4005  5393  4752
3     0     0     0     0  …     0     0     1     0     0     0     0
4     0     0     0     0  …     0     0     1     1     0     0     0

   2011  2012  2013
0  2203  2635  2004
1   539   620   603
2  4325  3774  4331
3     0     0     0
4     0     1     1

[5 rows x 38 columns]
```

Notice how the column names now make much more sense, even to an outsider.

3. For consistency, ensure that all column labels of type string.

[9]:
```
# let's examine the types of the column labels
all(isinstance(column, str) for column in df_can.columns)
```

[9]:
```
False
```

Notice how the above line of code returned *False* when we tested if all the column labels are of type **string**. So let's change them all to **string** type.

[10]:
```
df_can.columns = list(map(str, df_can.columns))

# let's check the column labels types now
all(isinstance(column, str) for column in df_can.columns)
```

[10]:
```
True
```

4. Set the country name as index - useful for quickly looking up countries using .loc method.

[11]:
```
df_can.set_index('Country', inplace=True)

# let's view the first five elements and see how the dataframe was changed
df_can.head()
```

[11]:
```
               Continent           Region             DevName  1980  1981  \
Country
Afghanistan         Asia    Southern Asia  Developing regions    16    39
Albania           Europe  Southern Europe   Developed regions     1     0
Algeria           Africa  Northern Africa  Developing regions    80    67
American Samoa   Oceania        Polynesia  Developing regions     0     1
Andorra           Europe  Southern Europe   Developed regions     0     0
```

```
                1982  1983  1984  1985  1986  …  2004  2005  2006  2007  \
Country                                       …
Afghanistan       39    47    71   340   496  …  2978  3436  3009  2652
Albania            0     0     0     0     1  …  1450  1223   856   702
Algeria           71    69    63    44    69  …  3616  3626  4807  3623
American Samoa     0     0     0     0     0  …     0     0     1     0
Andorra            0     0     0     0     2  …     0     0     1     1

                2008  2009  2010  2011  2012  2013
Country
Afghanistan     2111  1746  1758  2203  2635  2004
Albania          560   716   561   539   620   603
Algeria         4005  5393  4752  4325  3774  4331
American Samoa     0     0     0     0     0     0
Andorra            0     0     0     0     1     1

[5 rows x 37 columns]
```

Notice how the country names now serve as indices.

5. Add total column.

[12]:
```
df_can['Total'] = df_can.sum(axis=1)

# let's view the first five elements and see how the dataframe was changed
df_can.head()
```

[12]:
```
               Continent           Region             DevName  1980  1981  \
Country
Afghanistan         Asia    Southern Asia  Developing regions    16    39
Albania           Europe  Southern Europe   Developed regions     1     0
Algeria           Africa  Northern Africa  Developing regions    80    67
American Samoa   Oceania        Polynesia  Developing regions     0     1
Andorra           Europe  Southern Europe   Developed regions     0     0

                1982  1983  1984  1985  1986  …  2005  2006  2007  2008  \
Country                                       …
Afghanistan       39    47    71   340   496  …  3436  3009  2652  2111
Albania            0     0     0     0     1  …  1223   856   702   560
Algeria           71    69    63    44    69  …  3626  4807  3623  4005
American Samoa     0     0     0     0     0  …     0     1     0     0
Andorra            0     0     0     0     2  …     0     1     1     0

                2009  2010  2011  2012  2013  Total
Country
Afghanistan     1746  1758  2203  2635  2004  58639
Albania          716   561   539   620   603  15699
```

```
Algeria          5393  4752  4325  3774  4331  69439
American Samoa      0     0     0     0     0      6
Andorra             0     0     0     1     1     15

[5 rows x 38 columns]
```

Now the dataframe has an extra column that presents the total number of immigrants from each country in the dataset from 1980 - 2013. So if we print the dimension of the data, we get:

[13]:
```
print ('data dimensions:', df_can.shape)
```

```
data dimensions: (195, 38)
```

So now our dataframe has 38 columns instead of 37 columns that we had before.

[14]:
```
# finally, let's create a list of years from 1980 - 2013
# this will come in handy when we start plotting the data
years = list(map(str, range(1980, 2014)))

years
```

[14]:
```
['1980',
 '1981',
 '1982',
 '1983',
 '1984',
 '1985',
 '1986',
 '1987',
 '1988',
 '1989',
 '1990',
 '1991',
 '1992',
 '1993',
 '1994',
 '1995',
 '1996',
 '1997',
 '1998',
 '1999',
 '2000',
 '2001',
 '2002',
 '2003',
 '2004',
 '2005',
 '2006',
```

```
 '2007',
 '2008',
 '2009',
 '2010',
 '2011',
 '2012',
 '2013']
```

3 Visualizing Data using Matplotlib

Import `Matplotlib` and **Numpy**.

[15]:
```
# use the inline backend to generate the plots within the browser
%matplotlib inline

import matplotlib as mpl
import matplotlib.pyplot as plt

mpl.style.use('ggplot') # optional: for ggplot-like style

# check for latest version of Matplotlib
print ('Matplotlib version: ', mpl.__version__) # >= 2.0.0
```

```
Matplotlib version:  3.1.1
```

4 Area Plots

In the last module, we created a line plot that visualized the top 5 countries that contribued the most immigrants to Canada from 1980 to 2013. With a little modification to the code, we can visualize this plot as a cumulative plot, also knows as a **Stacked Line Plot** or **Area plot**.

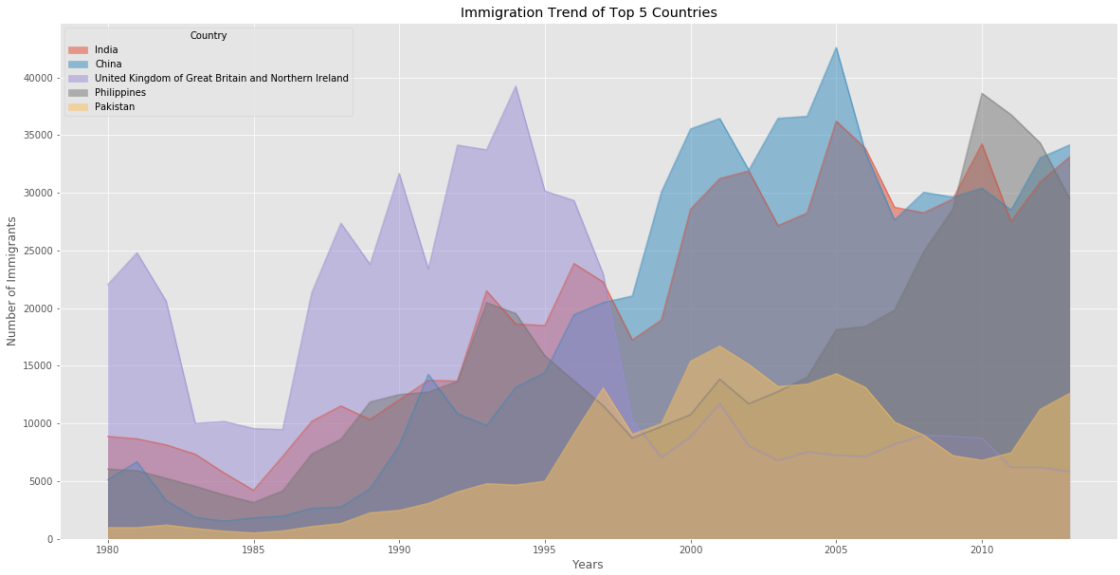
[16]:
```
df_can.sort_values(['Total'], ascending=False, axis=0, inplace=True)

# get the top 5 entries
df_top5 = df_can.head()

# transpose the dataframe
df_top5 = df_top5[years].transpose()

df_top5.head()
```

[16]:
```
Country  India  China  United Kingdom of Great Britain and Northern Ireland  \
1980      8880   5123                                                22045
1981      8670   6682                                                24796
1982      8147   3308                                                20620
1983      7338   1863                                                10015
1984      5704   1527                                                10170
```

Country	Philippines	Pakistan
1980	6051	978
1981	5921	972
1982	5249	1201
1983	4562	900
1984	3801	668

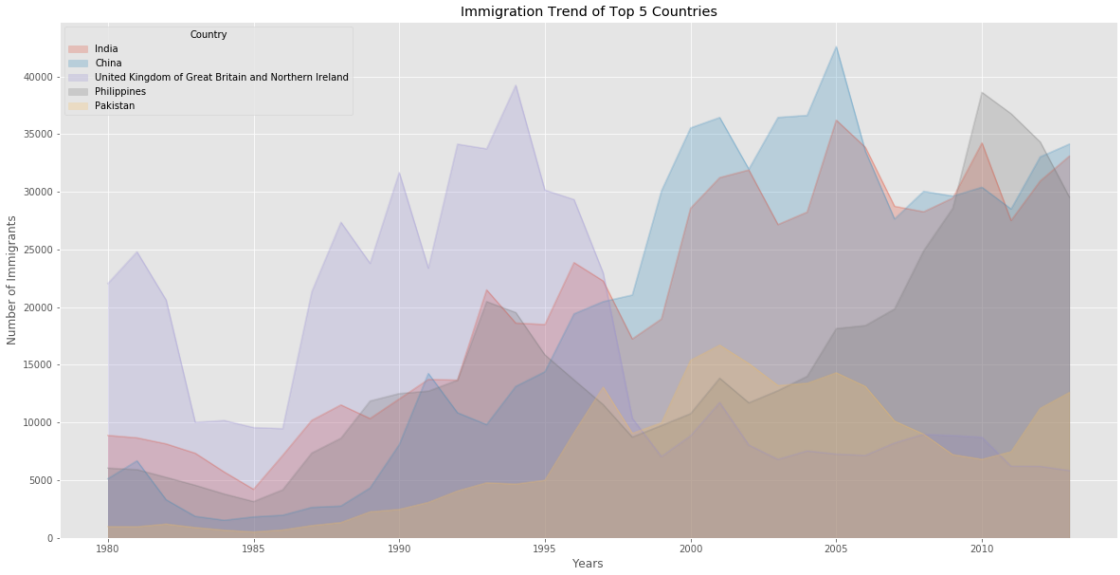
Area plots are stacked by default. And to produce a stacked area plot, each column must be either all positive or all negative values (any NaN values will defaulted to 0). To produce an unstacked plot, pass `stacked=False`.

[17]:
```
df_top5.index = df_top5.index.map(int) # let's change the index values of␣
↪df_top5 to type integer for plotting
df_top5.plot(kind='area',
             stacked=False,
             figsize=(20, 10), # pass a tuple (x, y) size
             )

plt.title('Immigration Trend of Top 5 Countries')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

plt.show()
```



The unstacked plot has a default transparency (alpha value) at 0.5. We can modify this value by passing in the `alpha` parameter.

[18]:
```
df_top5.plot(kind='area',
             alpha=0.25, # 0-1, default value a= 0.5
             stacked=False,
             figsize=(20, 10),
            )

plt.title('Immigration Trend of Top 5 Countries')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

plt.show()
```



4.0.1 Two types of plotting

As we discussed in the video lectures, there are two styles/options of ploting with `matplotlib`. Plotting using the Artist layer and plotting using the scripting layer.

Option 1: Scripting layer (procedural method) - using matplotlib.pyplot as 'plt'

You can use `plt` i.e. `matplotlib.pyplot` and add more elements by calling different methods procedurally; for example, `plt.title(...)` to add title or `plt.xlabel(...)` to add label to the x-axis.

```
# Option 1: This is what we have been using so far
df_top5.plot(kind='area', alpha=0.35, figsize=(20, 10))
plt.title('Immigration trend of top 5 countries')
plt.ylabel('Number of immigrants')
plt.xlabel('Years')
```

Option 2: Artist layer (Object oriented method) - using an `Axes` instance from Mat-

plotlib (preferred)

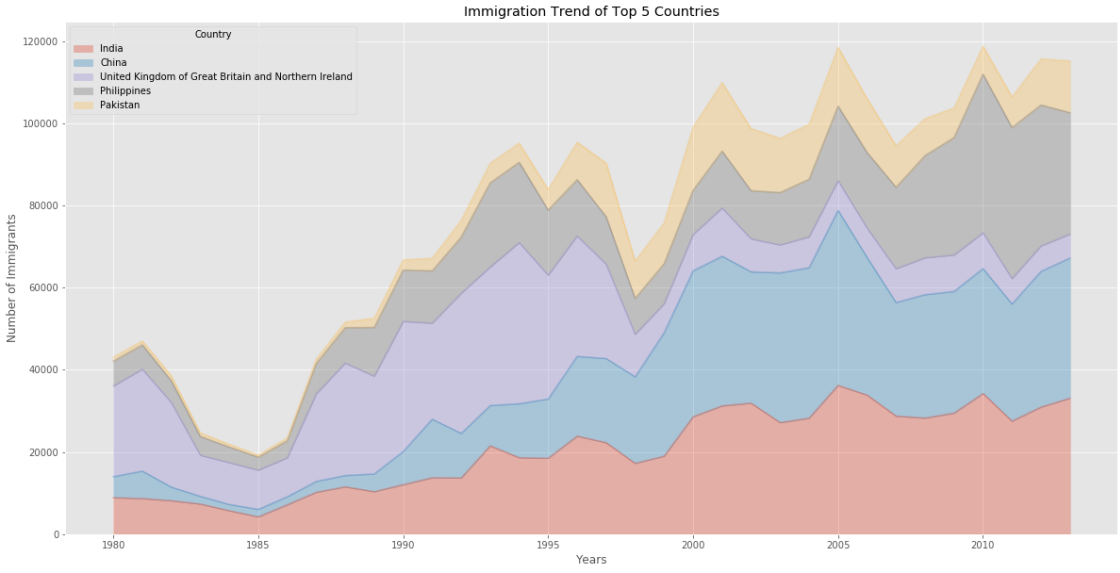
You can use an `Axes` instance of your current plot and store it in a variable (eg. `ax`). You can add more elements by calling methods with a little change in syntax (by adding "*set_*" to the previous methods). For example, use `ax.set_title()` instead of `plt.title()` to add title, or `ax.set_xlabel()` instead of `plt.xlabel()` to add label to the x-axis.

This option sometimes is more transparent and flexible to use for advanced plots (in particular when having multiple plots, as you will see later).

In this course, we will stick to the **scripting layer**, except for some advanced visualizations where we will need to use the **artist layer** to manipulate advanced aspects of the plots.

[19]:
```
# option 2: preferred option with more flexibility
ax = df_top5.plot(kind='area', alpha=0.35, figsize=(20, 10))

ax.set_title('Immigration Trend of Top 5 Countries')
ax.set_ylabel('Number of Immigrants')
ax.set_xlabel('Years')
```

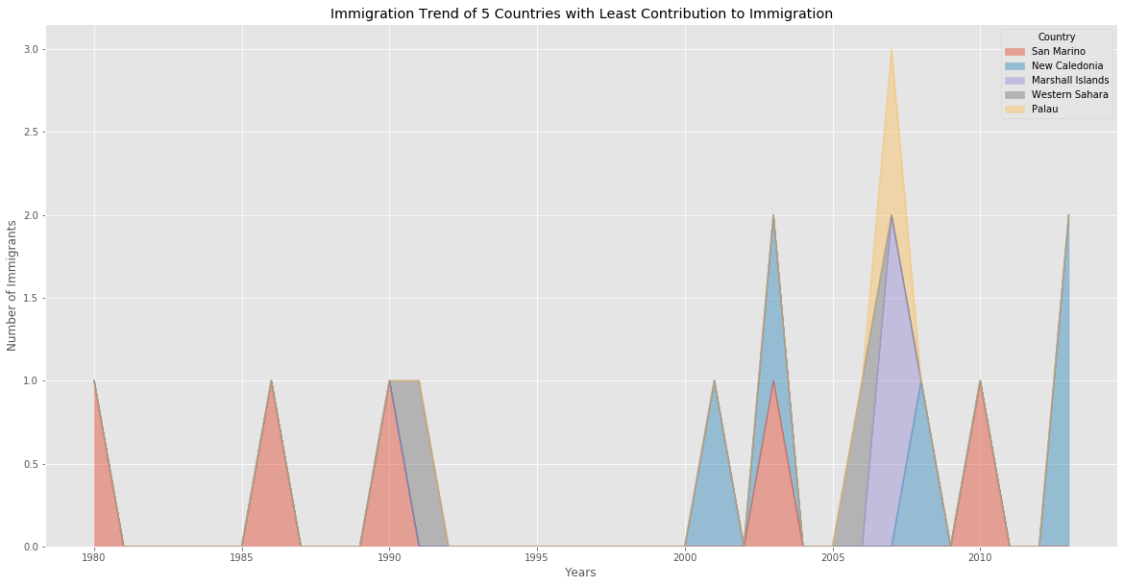
[19]:
```
Text(0.5, 0, 'Years')
```



Question: Use the scripting layer to create a stacked area plot of the 5 countries that contributed the least to immigration to Canada **from** 1980 to 2013. Use a transparency value of 0.45.

[20]:
```
df_least5 = df_can.tail(5)
df_least5 = df_least5[years].transpose()
df_least5.index = df_least5.index.map(int)
df_least5.plot(kind='area', alpha=0.45, figsize=(20, 10))
```

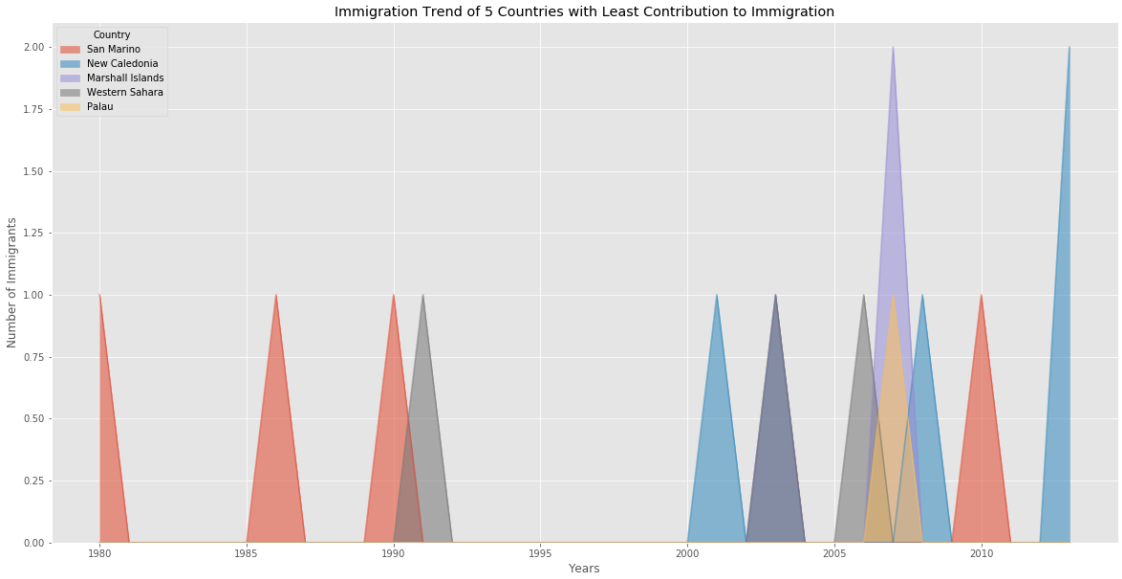
```
plt.title('Immigration Trend of 5 Countries with Least Contribution to␣
 ↪Immigration')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')
plt.show()
```



Question: Use the artist layer to create an unstacked area plot of the 5 countries that contributed the least to immigration to Canada **from** 1980 to 2013. Use a transparency value of 0.55.

[21]:
```
df_least5 = df_can.tail(5)
df_least5 = df_least5[years].transpose()
df_least5.index = df_least5.index.map(int)
ax = df_least5.plot(kind='area', alpha=0.55, stacked=False, figsize=(20, 10))
ax.set_title('Immigration Trend of 5 Countries with Least Contribution to␣
 ↪Immigration')
ax.set_ylabel('Number of Immigrants')
ax.set_xlabel('Years')
```

[21]:
```
Text(0.5, 0, 'Years')
```



5 Histograms

A histogram is a way of representing the *frequency* distribution of numeric dataset. The way it works is it partitions the x-axis into *bins*, assigns each data point in our dataset to a bin, and then counts the number of data points that have been assigned to each bin. So the y-axis is the frequency or the number of data points in each bin. Note that we can change the bin size and usually one needs to tweak it so that the distribution is displayed nicely.

Question: What is the frequency distribution of the number (population) of new immigrants from the various countries to Canada in 2013?

Before we proceed with creating the histogram plot, let's first examine the data split into intervals. To do this, we will us **Numpy**'s `histrogram` method to get the bin ranges and frequency counts as follows:

[22]:
```
# let's quickly view the 2013 data
df_can['2013'].head()
```

[22]:
```
Country
India                                                33087
China                                                34129
United Kingdom of Great Britain and Northern Ireland     5827
Philippines                                          29544
Pakistan                                             12603
Name: 2013, dtype: int64
```

[23]:
```
# np.histogram returns 2 values
count, bin_edges = np.histogram(df_can['2013'])
```

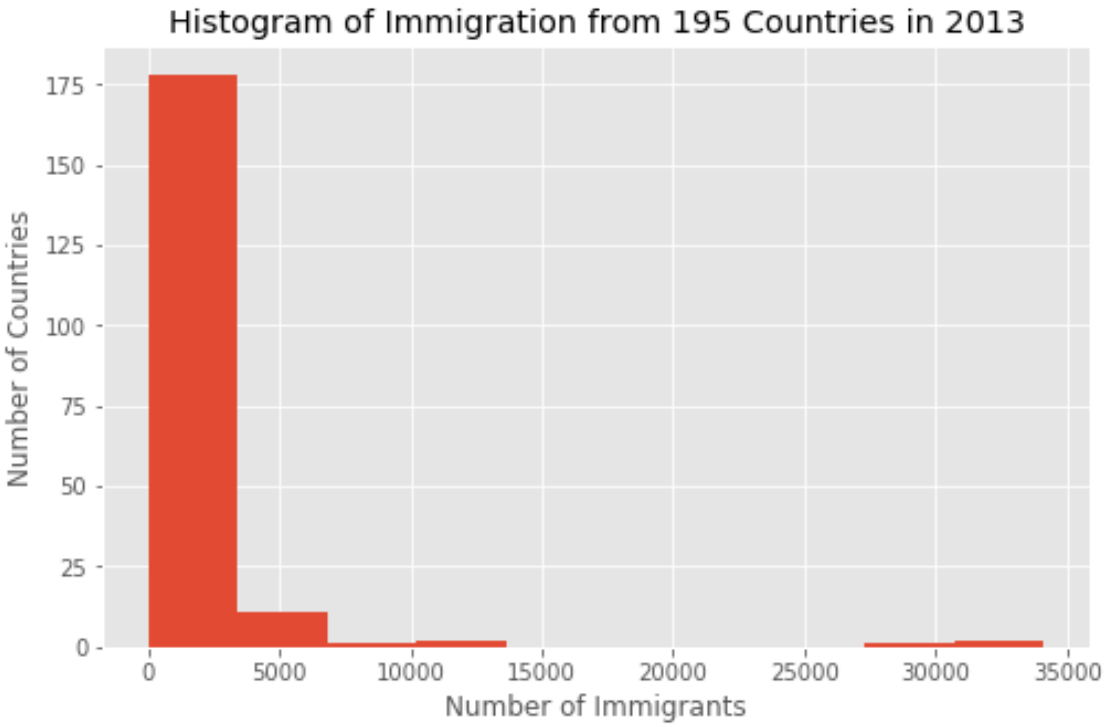
```
print(count) # frequency count
print(bin_edges) # bin ranges, default = 10 bins
```

```
[178  11   1   2   0   0   0   0   1   2]
[    0.   3412.9  6825.8 10238.7 13651.6 17064.5 20477.4 23890.3 27303.2
 30716.1 34129. ]
```

By default, the `histrogram` method breaks up the dataset into 10 bins. The figure below summarizes the bin ranges and the frequency distribution of immigration in 2013. We can see that in 2013: * 178 countries contributed between 0 to 3412.9 immigrants * 11 countries contributed between 3412.9 to 6825.8 immigrants * 1 country contributed between 6285.8 to 10238.7 immigrants, and so on..

We can easily graph this distribution by passing `kind=hist` to `plot()`.

[24]:
```
df_can['2013'].plot(kind='hist', figsize=(8, 5))

plt.title('Histogram of Immigration from 195 Countries in 2013') # add a title␣
 ↪to the histogram
plt.ylabel('Number of Countries') # add y-label
plt.xlabel('Number of Immigrants') # add x-label

plt.show()
```

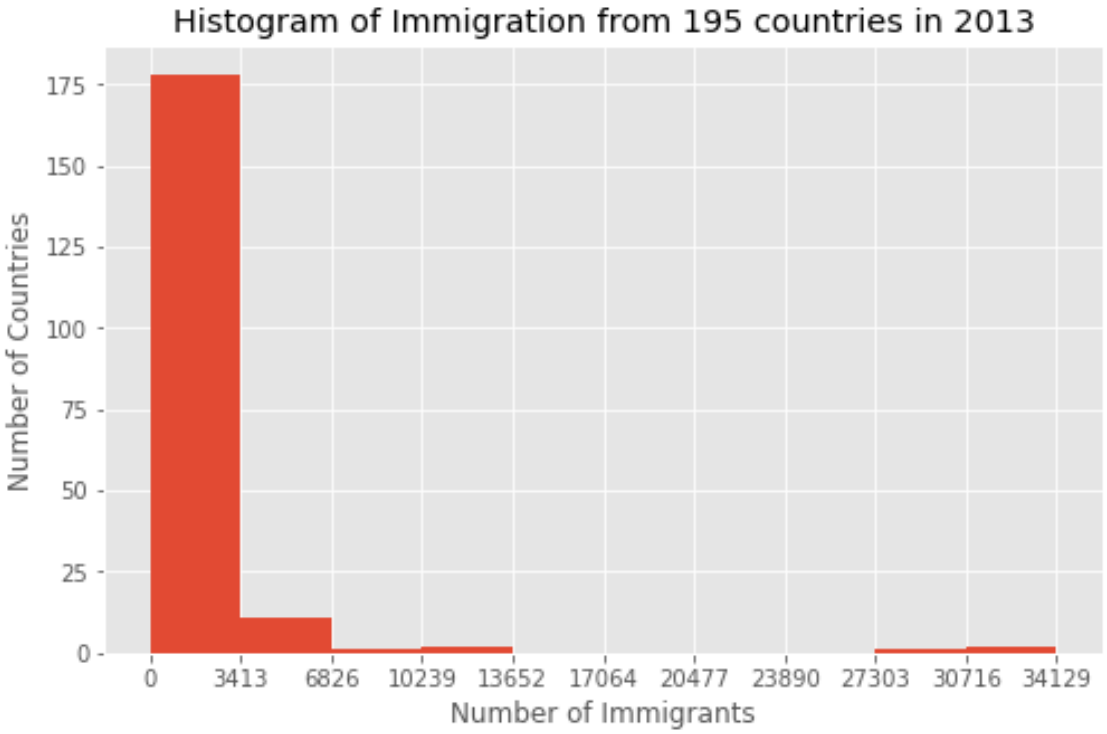


In the above plot, the x-axis represents the population range of immigrants in intervals of 3412.9.

The y-axis represents the number of countries that contributed to the aforementioned population.

Notice that the x-axis labels do not match with the bin size. This can be fixed by passing in a `xticks` keyword that contains the list of the bin sizes, as follows:

[25]:
```
# 'bin_edges' is a list of bin intervals
count, bin_edges = np.histogram(df_can['2013'])

df_can['2013'].plot(kind='hist', figsize=(8, 5), xticks=bin_edges)

plt.title('Histogram of Immigration from 195 countries in 2013') # add a title␣
 ↪to the histogram
plt.ylabel('Number of Countries') # add y-label
plt.xlabel('Number of Immigrants') # add x-label

plt.show()
```



Side Note: We could use `df_can['2013'].plot.hist()`, instead. In fact, throughout this lesson, using `some_data.plot(kind='type_plot', ...)` is equivalent to `some_data.plot.type_plot(...)`. That is, passing the type of the plot as argument or method behaves the same.

See the *pandas* documentation for more info http://pandas.pydata.org/pandas-docs/stable/generated/pandas.Series.plot.html.

We can also plot multiple histograms on the same plot. For example, let's try to answer the following questions using a histogram.

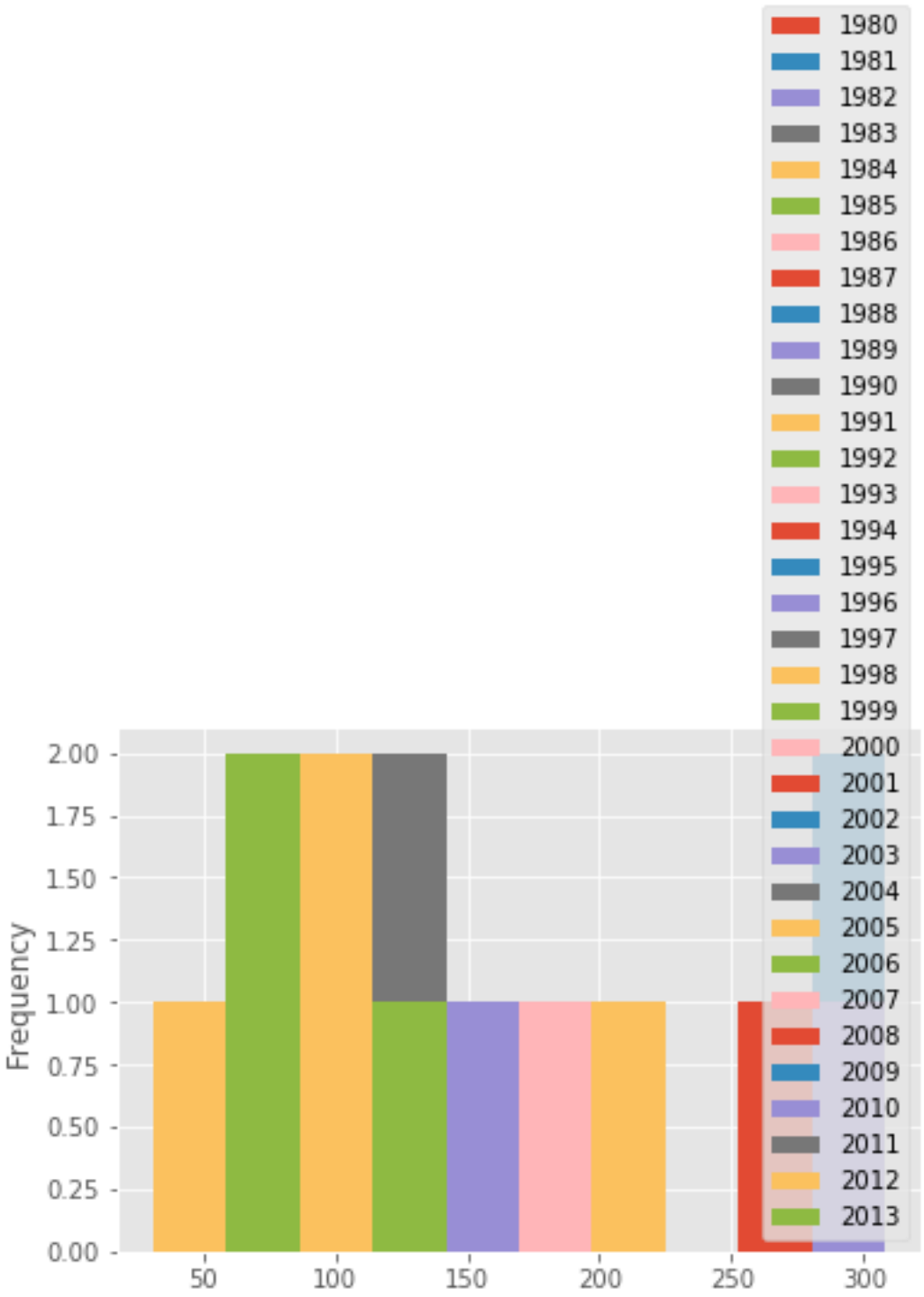
Question: What is the immigration distribution for Denmark, Norway, and Sweden for years 1980 - 2013?

[26]:
```
# let's quickly view the dataset
df_can.loc[['Denmark', 'Norway', 'Sweden'], years]
```

[26]:
```
         1980  1981  1982  1983  1984  1985  1986  1987  1988  1989  … \
Country                                                              …
Denmark   272   293   299   106    93    73    93   109   129   129  …
Norway    116    77   106    51    31    54    56    80    73    76  …
Sweden    281   308   222   176   128   158   187   198   171   182  …

         2004  2005  2006  2007  2008  2009  2010  2011  2012  2013
Country
Denmark    89    62   101    97   108    81    92    93    94    81
Norway     73    57    53    73    66    75    46    49    53    59
Sweden    129   205   139   193   165   167   159   134   140   140

[3 rows x 34 columns]
```

[27]:
```
# generate histogram
df_can.loc[['Denmark', 'Norway', 'Sweden'], years].plot.hist()
```

[27]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fbbe1535240>
```



That does not look right!

Don't worry, you'll often come across situations like this when creating plots. The solution often lies in how the underlying dataset is structured.

Instead of plotting the population frequency distribution of the population for the 3 countries, *pandas* instead plotted the population frequency distribution for the `years`.

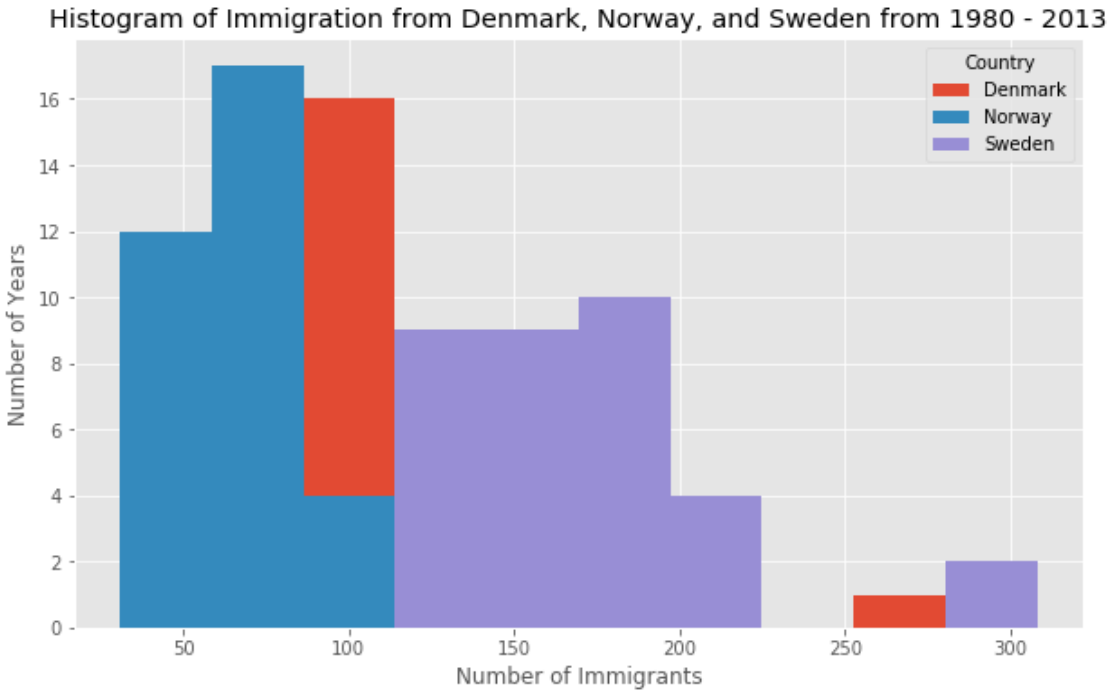
This can be easily fixed by first transposing the dataset, and then plotting as shown below.

[28]:
```
# transpose dataframe
df_t = df_can.loc[['Denmark', 'Norway', 'Sweden'], years].transpose()
df_t.head()
```

[28]:

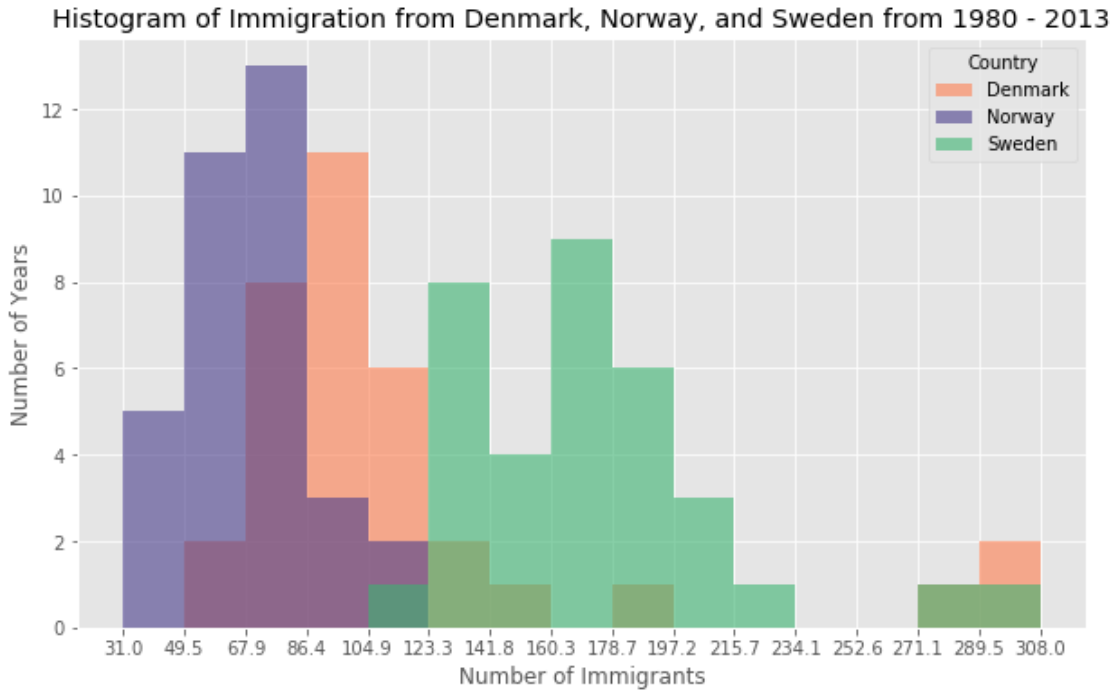
Country	Denmark	Norway	Sweden
1980	272	116	281
1981	293	77	308
1982	299	106	222
1983	106	51	176
1984	93	31	128

[29]:
```
# generate histogram
df_t.plot(kind='hist', figsize=(10, 6))

plt.title('Histogram of Immigration from Denmark, Norway, and Sweden from 1980␣
 ↪- 2013')
plt.ylabel('Number of Years')
plt.xlabel('Number of Immigrants')

plt.show()
```



Let's make a few modifications to improve the impact and aesthetics of the previous plot: * increase the bin size to 15 by passing in `bins` parameter * set transparency to 60% by passing in `alpha` paramemter * label the x-axis by passing in `x-label` paramater * change the colors of the plots by passing in `color` parameter

[30]:
```
# let's get the x-tick values
count, bin_edges = np.histogram(df_t, 15)

# un-stacked histogram
df_t.plot(kind ='hist',
          figsize=(10, 6),
          bins=15,
          alpha=0.6,
          xticks=bin_edges,
          color=['coral', 'darkslateblue', 'mediumseagreen']
         )

plt.title('Histogram of Immigration from Denmark, Norway, and Sweden from 1980␣
 ↪- 2013')
plt.ylabel('Number of Years')
plt.xlabel('Number of Immigrants')

plt.show()
```

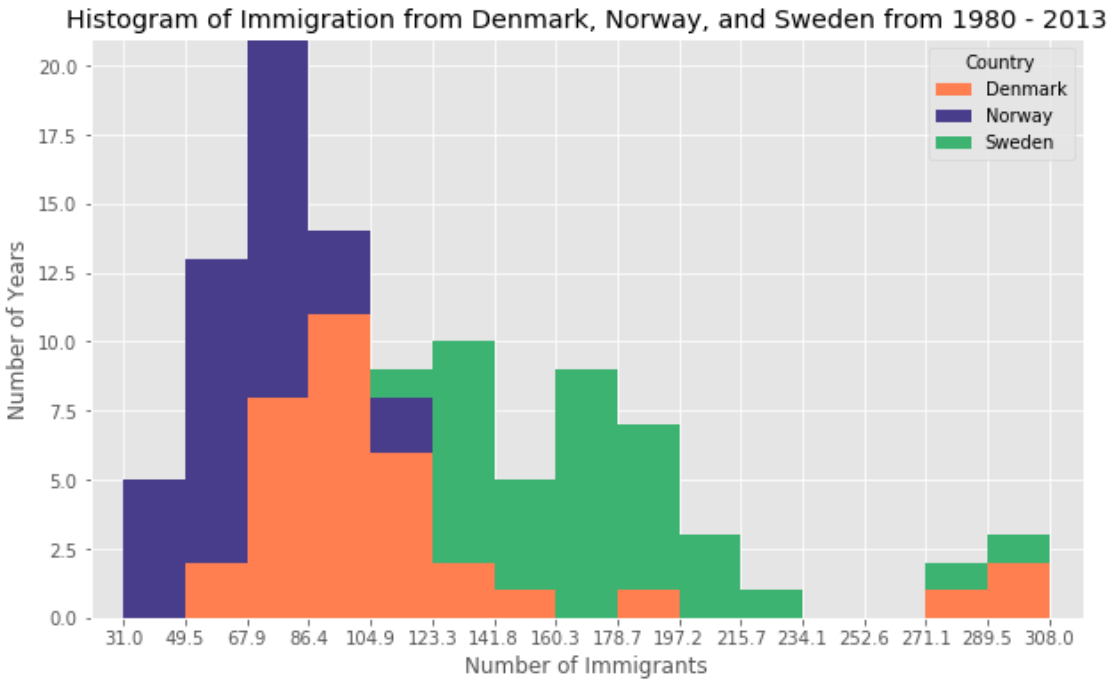


Tip: For a full listing of colors available in Matplotlib, run the following code in your python shell:

```
import matplotlib
for name, hex in matplotlib.colors.cnames.items():
    print(name, hex)
```

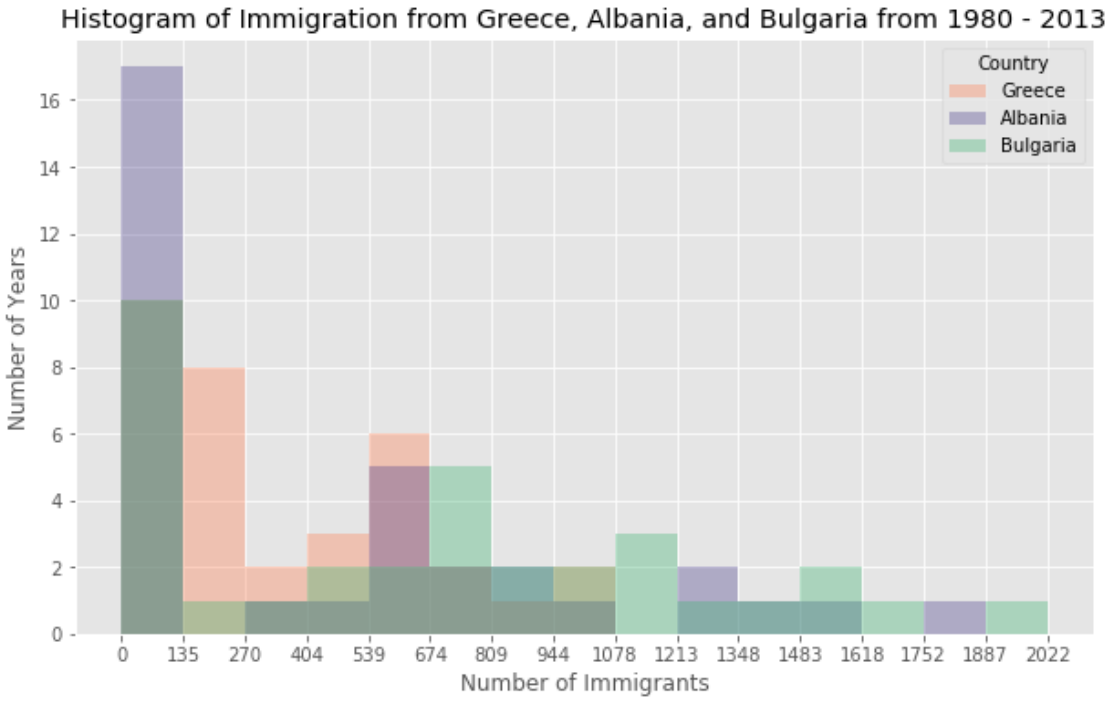
If we do no want the plots to overlap each other, we can stack them using the `stacked` paramemter. Let's also adjust the min and max x-axis labels to remove the extra gap on the edges of the plot. We can pass a tuple (min,max) using the `xlim` paramater, as show below.

[31]:
```
count, bin_edges = np.histogram(df_t, 15)
xmin = bin_edges[0] - 10   #  first bin value is 31.0, adding buffer of 10 for␣
 ↪aesthetic purposes
xmax = bin_edges[-1] + 10  #  last bin value is 308.0, adding buffer of 10 for␣
 ↪aesthetic purposes

# stacked Histogram
df_t.plot(kind='hist',
          figsize=(10, 6),
          bins=15,
          xticks=bin_edges,
          color=['coral', 'darkslateblue', 'mediumseagreen'],
          stacked=True,
          xlim=(xmin, xmax)
         )

plt.title('Histogram of Immigration from Denmark, Norway, and Sweden from 1980␣
 ↪- 2013')
plt.ylabel('Number of Years')
plt.xlabel('Number of Immigrants')

plt.show()
```



Question: Use the scripting layer to display the immigration distribution for Greece, Albania, and Bulgaria for years 1980 - 2013? Use an overlapping plot with 15 bins and a transparency value of 0.35.

[32]:
```
df_cof = df_can.loc[['Greece', 'Albania', 'Bulgaria'], years]
df_cof = df_cof.transpose()
count, bin_edges = np.histogram(df_cof, 15)

df_cof.plot(kind ='hist',
            figsize=(10, 6),
            bins=15,
            alpha=0.35,
            xticks=bin_edges,
            color=['coral', 'darkslateblue', 'mediumseagreen']
            )

plt.title('Histogram of Immigration from Greece, Albania, and Bulgaria from␣
 ↪1980 - 2013')
plt.ylabel('Number of Years')
plt.xlabel('Number of Immigrants')
plt.show()
```



6 Bar Charts (Dataframe)

A bar plot is a way of representing data where the *length* of the bars represents the magnitude/size of the feature/variable. Bar graphs usually represent numerical and categorical variables grouped in intervals.

To create a bar plot, we can pass one of two arguments via `kind` parameter in `plot()`:

- `kind=bar` creates a *vertical* bar plot
- `kind=barh` creates a *horizontal* bar plot

Vertical bar plot

In vertical bar graphs, the x-axis is used for labelling, and the length of bars on the y-axis corresponds to the magnitude of the variable being measured. Vertical bar graphs are particuarly useful in analyzing time series data. One disadvantage is that they lack space for text labelling at the foot of each bar.

Let's start off by analyzing the effect of Iceland's Financial Crisis:

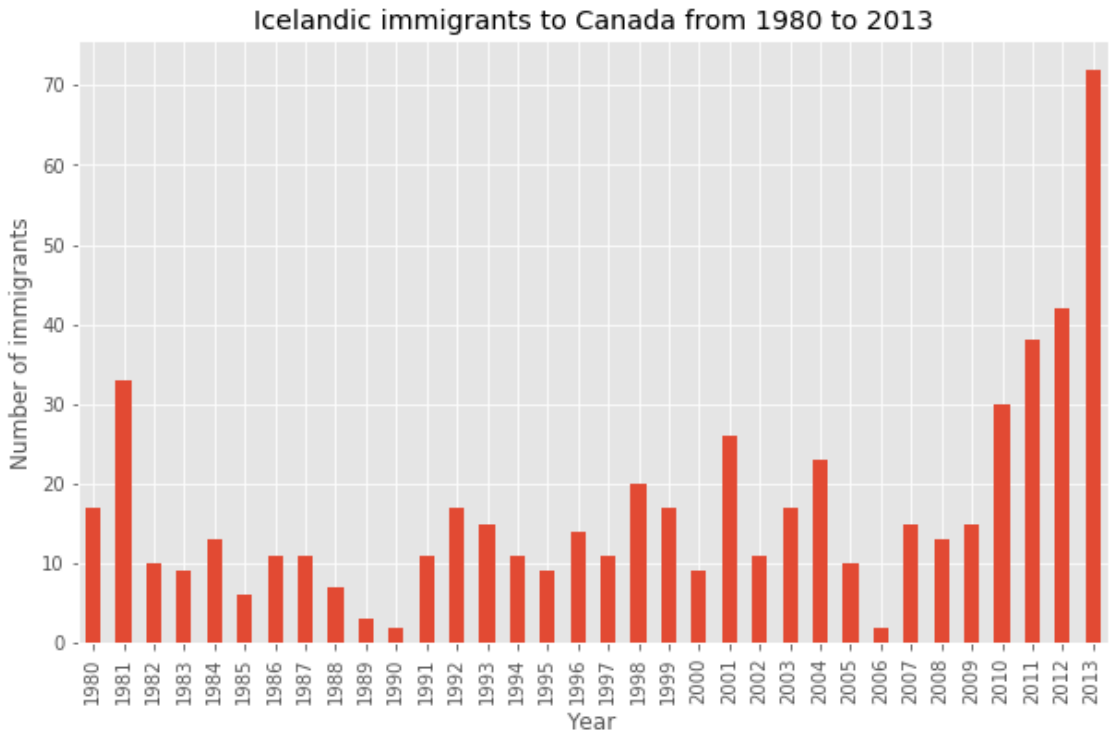
The 2008 - 2011 Icelandic Financial Crisis was a major economic and political event in Iceland. Relative to the size of its economy, Iceland's systemic banking collapse was the largest experienced by any country in economic history. The crisis led to a severe economic depression in 2008 - 2011 and significant political unrest.

Question: Let's compare the number of Icelandic immigrants (country = 'Iceland') to Canada from year 1980 to 2013.

[33]:
```
# step 1: get the data
df_iceland = df_can.loc['Iceland', years]
df_iceland.head()
```

[33]:
```
1980    17
1981    33
1982    10
1983     9
1984    13
Name: Iceland, dtype: object
```

[34]:
```
# step 2: plot data
df_iceland.plot(kind='bar', figsize=(10, 6))

plt.xlabel('Year') # add to x-label to the plot
plt.ylabel('Number of immigrants') # add y-label to the plot
plt.title('Icelandic immigrants to Canada from 1980 to 2013') # add title to␣
 ↪the plot

plt.show()
```



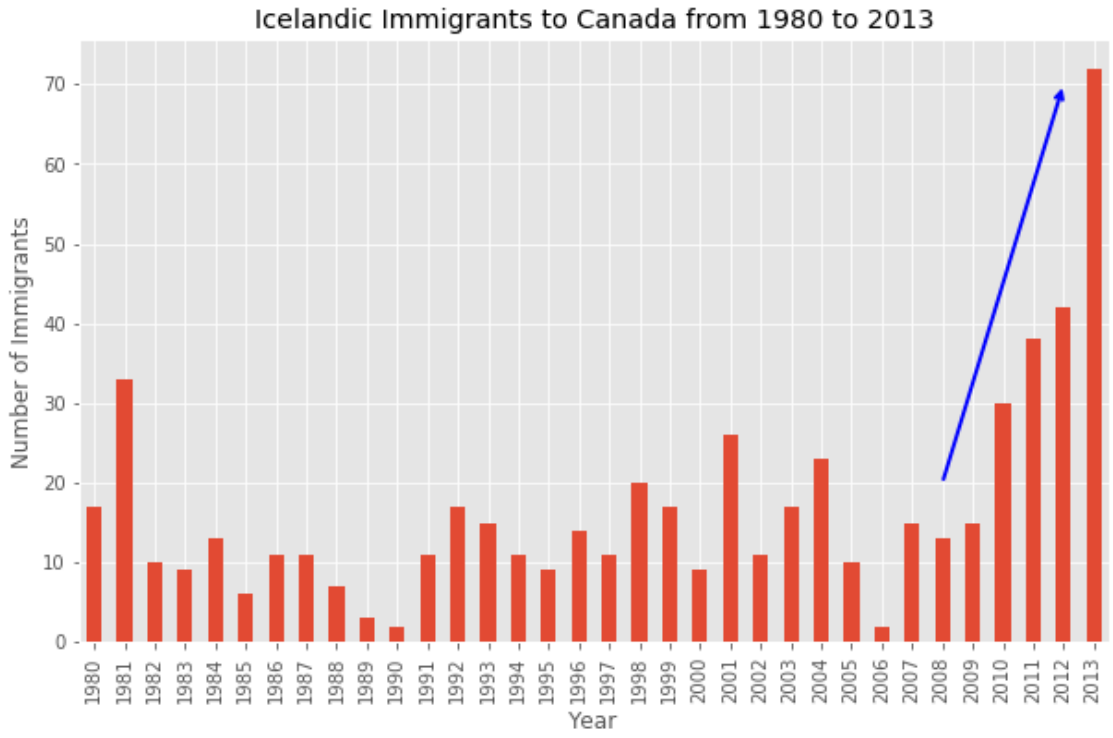
The bar plot above shows the total number of immigrants broken down by each year. We can clearly see the impact of the financial crisis; the number of immigrants to Canada started increasing rapidly

after 2008.

Let's annotate this on the plot using the `annotate` method of the **scripting layer** or the **pyplot interface**. We will pass in the following parameters: - `s`: str, the text of annotation. - `xy`: Tuple specifying the (x,y) point to annotate (in this case, end point of arrow). - `xytext`: Tuple specifying the (x,y) point to place the text (in this case, start point of arrow). - `xycoords`: The coordinate system that xy is given in - 'data' uses the coordinate system of the object being annotated (default). - `arrowprops`: Takes a dictionary of properties to draw the arrow: - `arrowstyle`: Specifies the arrow style, `'->'` is standard arrow. - `connectionstyle`: Specifies the connection type. `arc3` is a straight line. - `color`: Specifes color of arror. - `lw`: Specifies the line width.

I encourage you to read the Matplotlib documentation for more details on annotations: http://matplotlib.org/api/pyplot_api.html#matplotlib.pyplot.annotate.

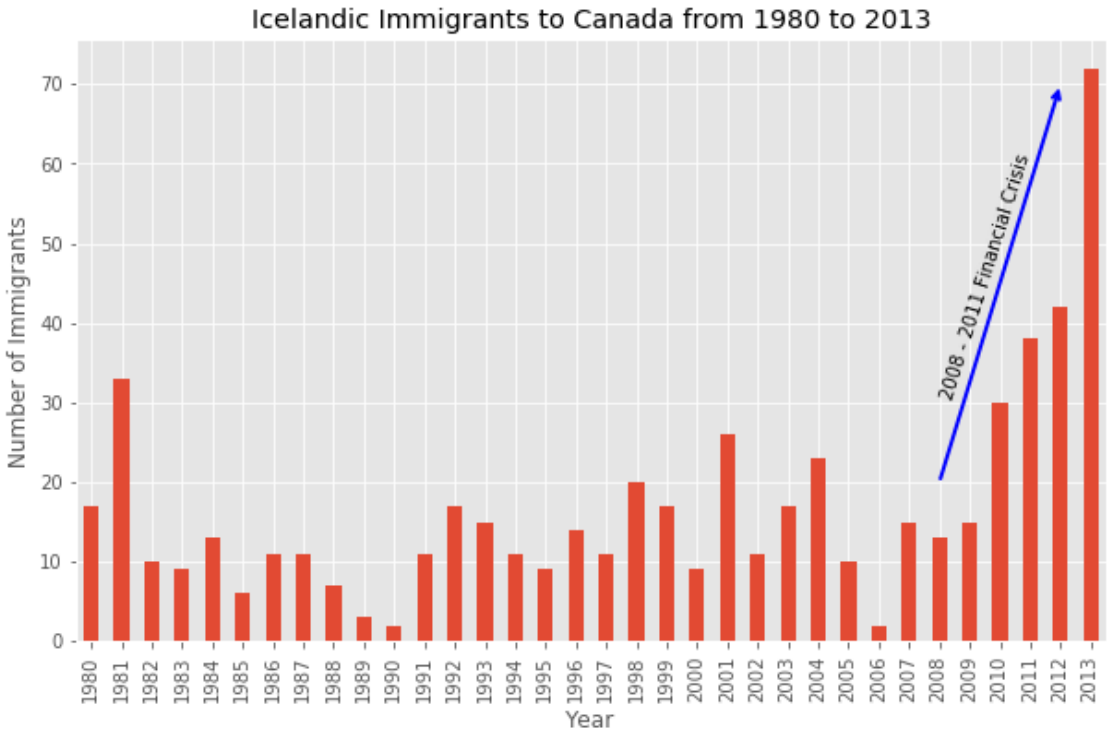
[39]:
```
df_iceland.plot(kind='bar', figsize=(10, 6), rot=90) # rotate the bars by 90␣
↪degrees

plt.xlabel('Year')
plt.ylabel('Number of Immigrants')
plt.title('Icelandic Immigrants to Canada from 1980 to 2013')

# Annotate arrow
plt.annotate('',                      # s: str. Will leave it blank for no text
             xy=(32, 70),             # place head of the arrow at point (year␣
↪2012 , pop 70)
             xytext=(28, 20),         # place base of the arrow at point (year␣
↪2008 , pop 20)
             xycoords='data',         # will use the coordinate system of the␣
↪object being annotated
             arrowprops=dict(arrowstyle='->', connectionstyle='arc3',␣
↪color='blue', lw=2)
            )

plt.show()
```



Let's also annotate a text to go over the arrow. We will pass in the following additional parameters: - `rotation`: rotation angle of text in degrees (counter clockwise) - `va`: vertical alignment of text ['center' | 'top' | 'bottom' | 'baseline'] - `ha`: horizontal alignment of text ['center' | 'right' | 'left']

[46]:
```
df_iceland.plot(kind='bar', figsize=(10, 6), rot=90)

plt.xlabel('Year')
plt.ylabel('Number of Immigrants')
plt.title('Icelandic Immigrants to Canada from 1980 to 2013')

# Annotate arrow
plt.annotate('',                      # s: str. will leave it blank for no text
             xy=(32, 70),             # place head of the arrow at point (year␣
 ↪2012 , pop 70)
             xytext=(28, 20),         # place base of the arrow at point (year␣
 ↪2008 , pop 20)
             xycoords='data',         # will use the coordinate system of the␣
 ↪object being annotated
             arrowprops=dict(arrowstyle='->', connectionstyle='arc3',␣
 ↪color='blue', lw=2)
            )

# Annotate Text
```

```
plt.annotate('2008 - 2011 Financial Crisis', # text to display
             xy=(28, 30),                    # start the text at at point (year␣
 ↪2008 , pop 30)
             rotation=72.5,                  # based on trial and error to␣
 ↪match the arrow
             va='bottom',                    # want the text to be vertically␣
 ↪'bottom' aligned
             ha='left',                      # want the text to be horizontally␣
 ↪'left' algned.
             )

plt.show()
```



Horizontal Bar Plot

Sometimes it is more practical to represent the data horizontally, especially if you need more room for labelling the bars. In horizontal bar graphs, the y-axis is used for labelling, and the length of bars on the x-axis corresponds to the magnitude of the variable being measured. As you will see, there is more room on the y-axis to label categetorical variables.

Question: Using the scripting layter and the `df_can` dataset, create a *horizontal* bar plot showing the *total* number of immigrants to Canada from the top 15 countries, for the period 1980 - 2013. Label each country with the total immigrant count.

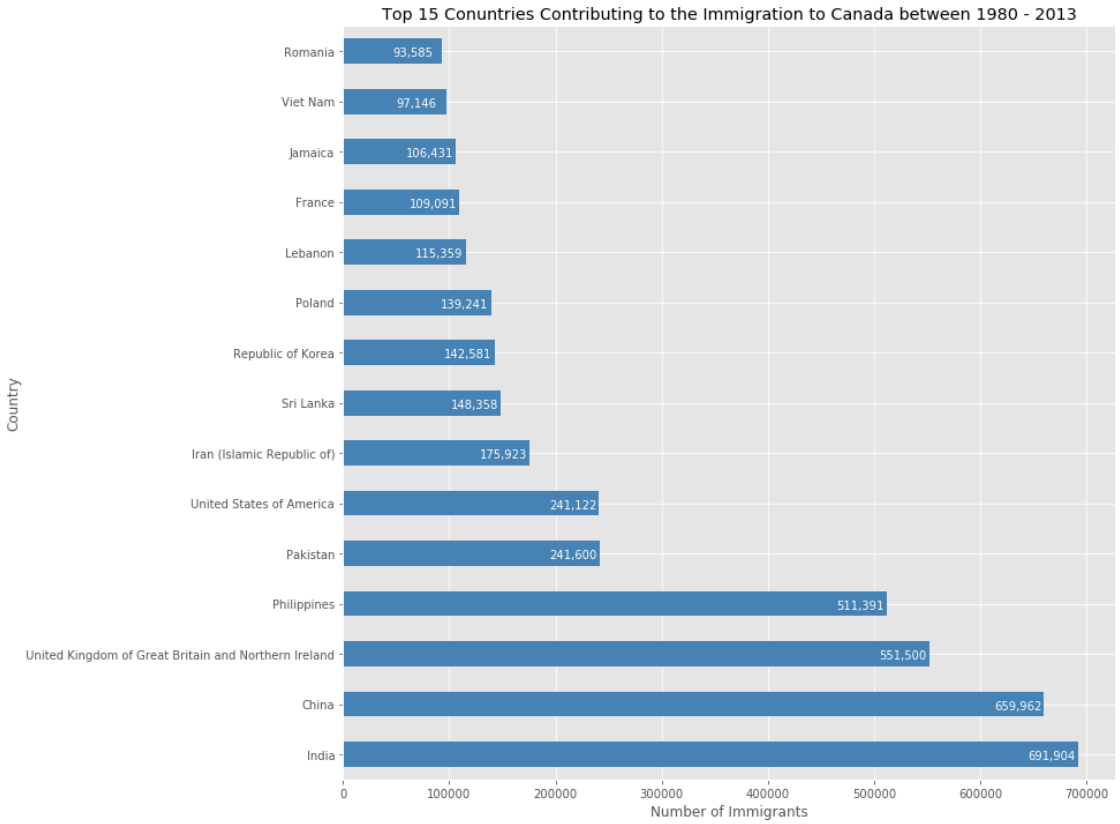
Step 1: Get the data pertaining to the top 15 countries.

[49]:
```
df_can.sort_values(by='Total', ascending=False, inplace=True)
df_top15 = df_can['Total'].head(15)
df_top15
```

[49]:
```
Country
India                                                691904
China                                                659962
United Kingdom of Great Britain and Northern Ireland 551500
Philippines                                          511391
Pakistan                                             241600
United States of America                             241122
Iran (Islamic Republic of)                           175923
Sri Lanka                                            148358
Republic of Korea                                    142581
Poland                                               139241
Lebanon                                              115359
France                                               109091
Jamaica                                              106431
Viet Nam                                              97146
Romania                                               93585
Name: Total, dtype: int64
```

Step 2: Plot data: 1. Use `kind='barh'` to generate a bar chart with horizontal bars. 2. Make sure to choose a good size for the plot and to label your axes and to give the plot a title. 3. Loop through the countries and annotate the immigrant population using the anotate function of the scripting interface.

[50]:
```
df_top15.plot(kind='barh', figsize=(12, 12), color='steelblue')
plt.xlabel('Number of Immigrants')
plt.title('Top 15 Conuntries Contributing to the Immigration to Canada between␣
 ↪1980 - 2013')
# annotate value labels to each country
for index, value in enumerate(df_top15):
    label = format(int(value), ',') # format int with commas

    # place text at the end of bar (subtracting 47000 from x, and 0.1 from y to␣
 ↪make it fit within the bar)
    plt.annotate(label, xy=(value - 47000, index - 0.10), color='white')

plt.show()
```


Top 15 Conuntries Contributing to the Immigration to Canada between 1980 - 2013
Country
Romania
Viet Nam
Jamaica
France
Lebanon
Poland
Republic of Korea
Sri Lanka
Iran (Islamic Republic of)
United States of America
Pakistan
Philippines
United Kingdom of Great Britain and Northern Ireland
China
India
93,585
97,146
106,431
109,091
115,359
139,241
142,581
148,358
175,923
241,122
241,600
511,391
551,500
659,962
691,904
0
100000
200000
300000
400000
500000
600000
700000
Number of Immigrants