Introduction to Matplotlib and Line Plots

Estimated time needed: **20** minutes

Objectives

After completing this lab you will be able to:

- Create Data Visualization with Python
- Use various Python libraries for visualization

Introduction

The aim of these labs is to introduce you to introduction you to Matplotlib and creating Line Plots. Please make sure that you have completed the prerequisites for this course, namely **Python Basics for Data Science** and **Analyzing Data with Python**.

Table of Contents

1. *pandas* Refresher
2. The Dataset: Immigration to Canada from 1980 to 2013
3. Visualizing Data using Matplotlib
   Matplotlib: Standard Python Visualization Library
4. Line Plots

pandas Refresher

The course heavily relies on *pandas* for data wrangling, analysis. Refresh your Panads skill quickly with the lab on Data pre-processing with Pandas

pandas is an essential data analysis toolkit for Python.

We encourage you to spend some time and familiarize yourself with the *pandas* from the [website](http://pandas.pydata.org/)

The Dataset: Immigration to Canada from 1980 to 2013

Dataset Source: International migration flows to and from selected countries - The 2015 revision. In this lab, we will focus on the Canadian immigration data.

We have already **pre-processed** the data, we will use the **clean data** saved in the csv format for this lab. The Canada Immigration dataset can be fetched from here.

Next, we'll do is import two key data analysis modules: *pandas* and *numpy*

In [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*'s `read_csv()` method.

In [2]:
```
df_can = pd.read_csv('https://cf-courses-data.s3.us.cloud-object-storage.appdomain.

print('Data read into a pandas dataframe!')
```

```
Data read into a pandas dataframe!
```

Let's view the top 5 rows of the dataset using the `head()` function.

In [3]:
```
df_can.head()
# tip: You can specify the number of rows you'd like to see as follows: df_can.head
```

Out[3]:

	Country	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	...
0	Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	...
1	Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	...
2	Algeria	Africa	Northern Africa	Developing regions	80	67	71	69	63	44	...
3	American Samoa	Oceania	Polynesia	Developing regions	0	1	0	0	0	0	...
4	Andorra	Europe	Southern Europe	Developed regions	0	0	0	0	0	0	...

5 rows × 39 columns

Let's set Country as the index, it will help you to plot the charts easily, by refering to the country names as index value

In [4]:
```
df_can.set_index('Country', inplace=True)
# tip: The opposite of set is reset. So to reset the index, we can use df_can.reset
```

In [5]:
```
#Let's check
df_can.head(3)
```

Out[5]:

Country	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496
Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	1
Algeria	Africa	Northern Africa	Developing regions	80	67	71	69	63	44	69

3 rows × 38 columns

In [6]:
```
# optional: to remove the name of the index
df_can.index.name = None
```

Since we converted the years to string, let's declare a variable that will allow us to easily call upon the full range of years:

In [7]:
```
# useful for plotting later on
years = list(map(str, range(1980, 2014)))
years
```

Out[7]:
```
['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']
```

Visualizing Data using Matplotlib

Matplotlib: Standard Python Visualization Library

The primary plotting library we will explore in the course is Matplotlib. As mentioned on their website:

> Matplotlib is a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib can be used in Python scripts, the Python and IPython

> shell, the jupyter notebook, web application servers, and four graphical user interface toolkits.

If you are aspiring to create impactful visualization with python, Matplotlib is an essential tool to have at your disposal.

Matplotlib.Pyplot

One of the core aspects of Matplotlib is `matplotlib.pyplot`. It is Matplotlib's scripting layer which we studied in details in the videos about Matplotlib. Recall that it is a collection of command style functions that make Matplotlib work like MATLAB. Each `pyplot` function makes some change to a figure: e.g., creates a figure, creates a plotting area in a figure, plots some lines in a plotting area, decorates the plot with labels, etc. In this lab, we will work with the scripting layer to learn how to generate line plots. In future labs, we will get to work with the Artist layer as well to experiment first hand how it differs from the scripting layer.

Let's start by importing `matplotlib` and `matplotlib.pyplot` as follows:

In [8]:
```
# we are using the inline backend
%matplotlib inline

import matplotlib as mpl
import matplotlib.pyplot as plt
```

*optional: check if Matplotlib is loaded.

In [9]:
```
print('Matplotlib version: ', mpl.__version__)  # >= 2.0.0
```

```
Matplotlib version:  3.5.3
```

*optional: apply a style to Matplotlib.

In [10]:
```
print(plt.style.available)
mpl.style.use(['ggplot']) # optional: for ggplot-like style
```

```
['Solarize_Light2', '_classic_test_patch', '_mpl-gallery', '_mpl-gallery-nogrid', 'bmh', 'classic', 'dark_background', 'fast', 'fivethirtyeight', 'ggplot', 'grayscale', 'seaborn', 'seaborn-bright', 'seaborn-colorblind', 'seaborn-dark', 'seaborn-dark-palette', 'seaborn-darkgrid', 'seaborn-deep', 'seaborn-muted', 'seaborn-notebook', 'seaborn-paper', 'seaborn-pastel', 'seaborn-poster', 'seaborn-talk', 'seaborn-ticks', 'seaborn-white', 'seaborn-whitegrid', 'tableau-colorblind10']
```

Plotting in *pandas*

Fortunately, pandas has a built-in implementation of Matplotlib that we can use. Plotting in *pandas* is as simple as appending a `.plot()` method to a series or dataframe.

Documentation:

- Plotting with Series

- Plotting with Dataframes

Line Pots (Series/Dataframe)

What is a line plot and why use it?

A line chart or line plot is a type of plot which displays information as a series of data points called 'markers' connected by straight line segments. It is a basic type of chart common in many fields. Use line plot when you have a continuous data set. These are best suited for trend-based visualizations of data over a period of time.

Let's start with a case study:

In 2010, Haiti suffered a catastrophic magnitude 7.0 earthquake. The quake caused widespread devastation and loss of life and about three million people were affected by this natural disaster. As part of Canada's humanitarian effort, the Government of Canada stepped up its effort in accepting refugees from Haiti. We can quickly visualize this effort using a `Line` plot:

Question: Plot a line graph of immigration from Haiti using `df.plot()`.

First, we will extract the data series for Haiti.

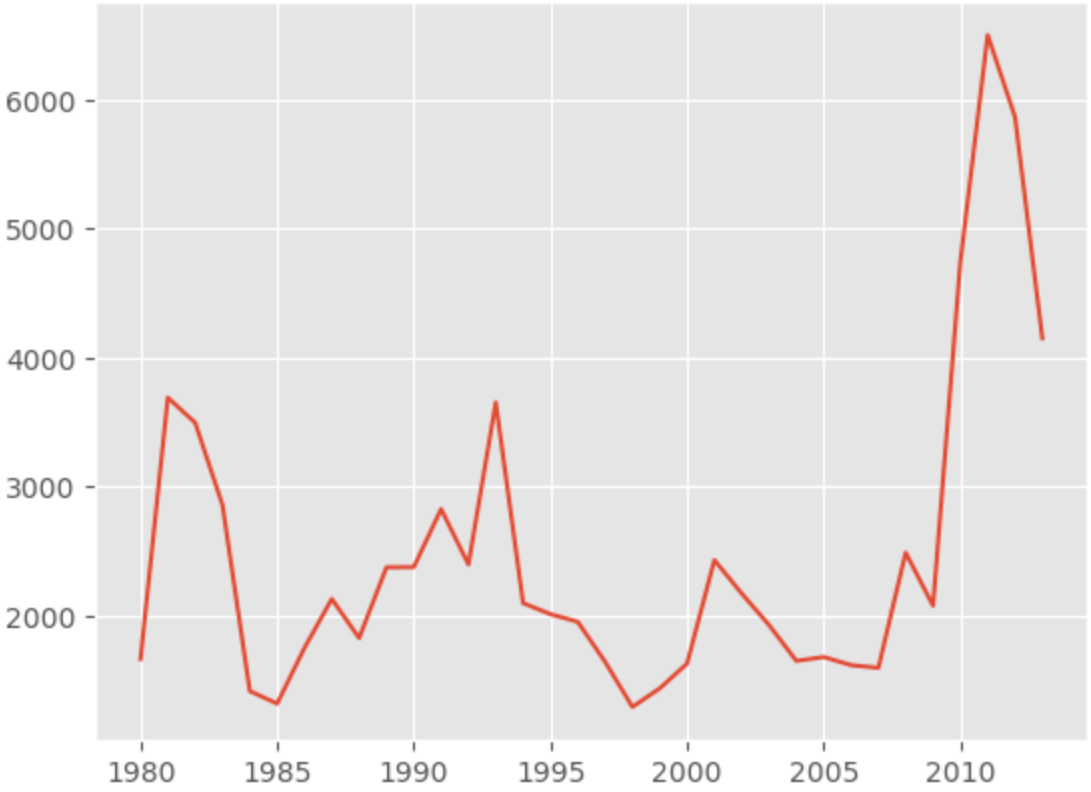
In [11]:
```
#Since we converted the years to string,
#let's declare a variable that will allow us to easily call upon the full range of
years = list(map(str, range(1980, 2014)))
#creating data series
haiti = df_can.loc['Haiti', years] # passing in years 1980 - 2013 to exclude the 't
haiti.head()
```

Out[11]:
```
1980    1666
1981    3692
1982    3498
1983    2860
1984    1418
Name: Haiti, dtype: object
```

Next, we will plot a line plot by appending `.plot()` to the `haiti` dataframe.

In [12]:
```
haiti.plot()
```

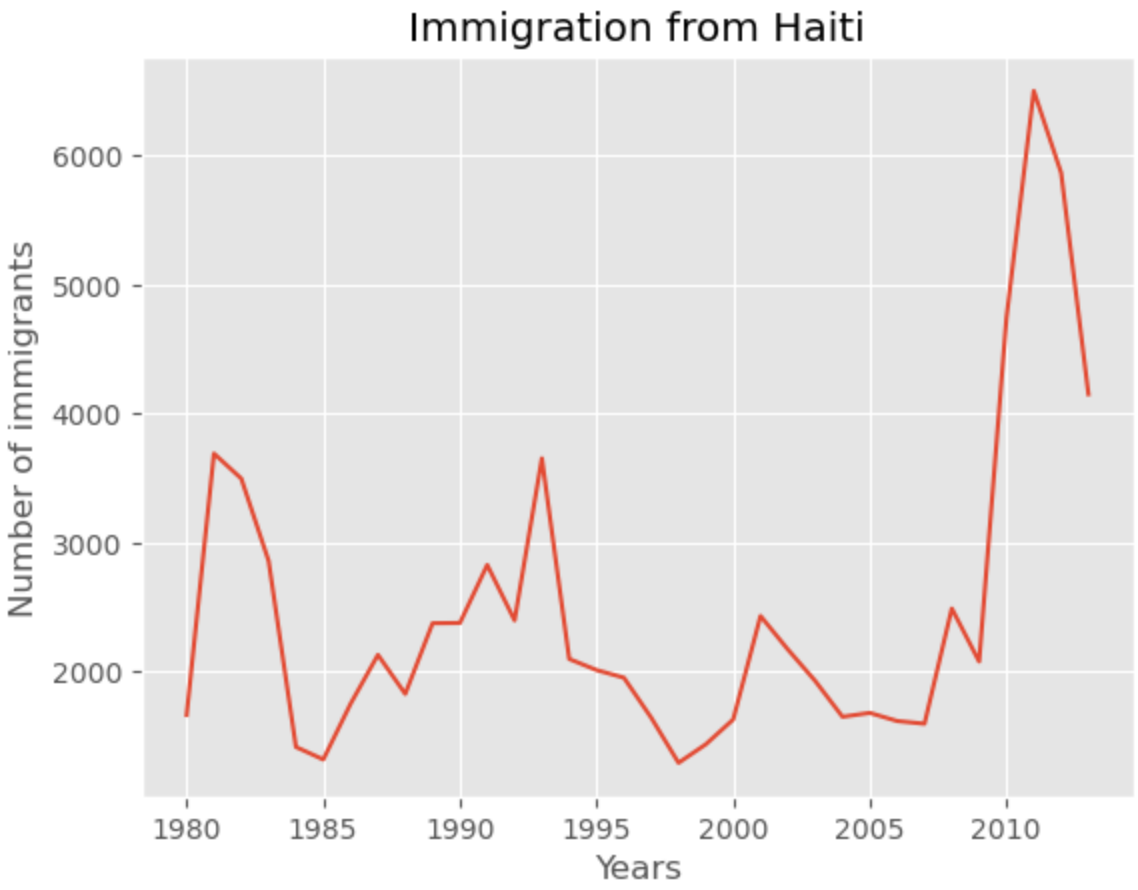
Out[12]:
```
<AxesSubplot:>
```



pandas automatically populated the x-axis with the index values (years), and the y-axis with the column values (population).

Also, let's label the x and y axis using `plt.title()`, `plt.ylabel()`, and `plt.xlabel()` as follows:

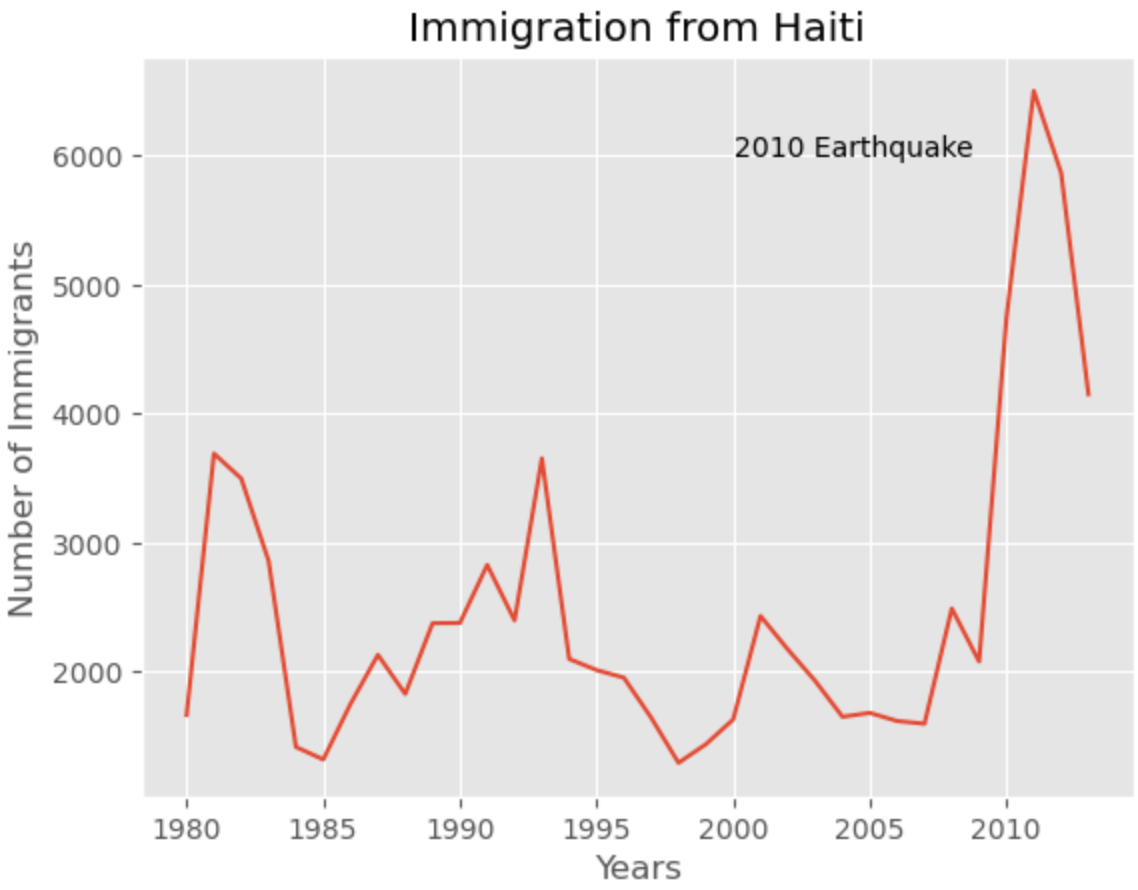
In [13]:
```
haiti.plot(kind='line')

plt.title('Immigration from Haiti')
plt.ylabel('Number of immigrants')
plt.xlabel('Years')

plt.show() # need this line to show the updates made to the figure
```



We can clearly notice how number of immigrants from Haiti spiked up from 2010 as Canada stepped up its efforts to accept refugees from Haiti. Let's annotate this spike in the plot by using the `plt.text()` method.

However, notice that years are of type *string*. Let's change the type of the index values to *integer* first.

In [14]:
```
haiti.index = haiti.index.map(int)
haiti.plot(kind='line')

plt.title('Immigration from Haiti')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

# annotate the 2010 Earthquake.
# syntax: plt.text(x, y, label)
plt.text(2000, 6000, '2010 Earthquake') # see note below

plt.show()
```



With just a few lines of code, you were able to quickly identify and visualize the spike in immigration!

Quick note on x and y values in `plt.text(x, y, label)`:

```
 Since the x-axis (years) is type 'integer', we specified x as a
year. The y axis (number of immigrants) is type 'integer', so we
can just specify the value y = 6000.
```

```
plt.text(2000, 6000, '2010 Earthquake') # years stored as type int
```

```
If the years were stored as type 'string', we would need to specify
x as the index position of the year. Eg 20th index is year 2000
since it is the 20th year with a base year of 1980.
```

```
plt.text(20, 6000, '2010 Earthquake') # years stored as type int
```

```
We will cover advanced annotation methods in later modules.
```

We can easily add more countries to line plot to make meaningful comparisons immigration from different countries.

Question: Let's compare the number of immigrants from India and China from 1980 to 2013.

Step 1: Get the data set for China and India, and display the dataframe.

In [18]:
```
### type your answer here

years1 = list(map(str, range(1980, 2013)))
#creating data series
df_CI = df_can.loc[['India', 'China'], years]
df_CI
```

Out[18]:

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	...	2004	200
India	8880	8670	8147	7338	5704	4211	7150	10189	11522	10343	...	28235	3621
China	5123	6682	3308	1863	1527	1816	1960	2643	2758	4323	...	36619	4258

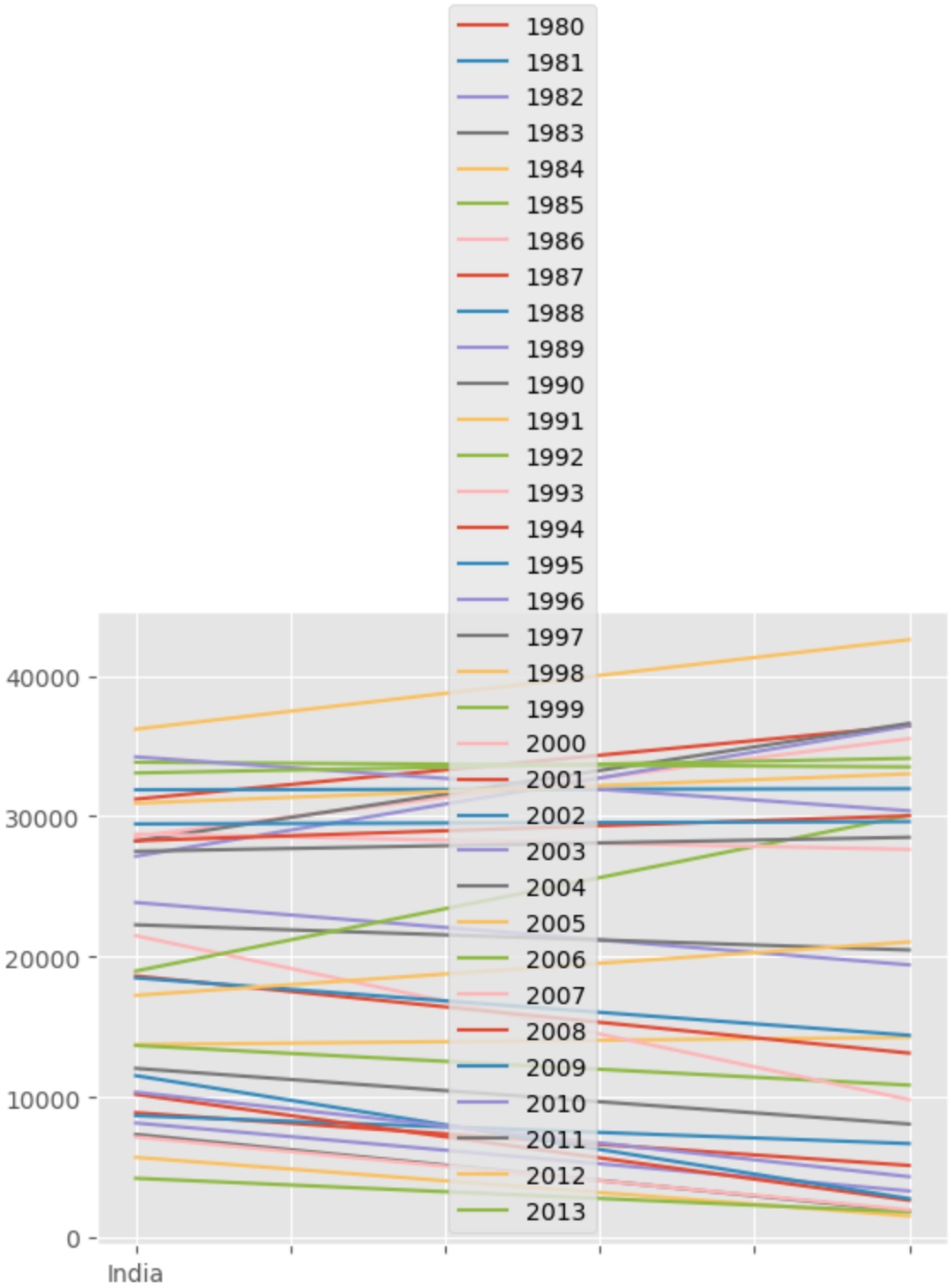
2 rows × 34 columns

▶ Click here for a sample python solution

Step 2: Plot graph. We will explicitly specify line plot by passing in `kind` parameter to `plot()`.

In [20]:
```
### type your answer here
df_CI.plot(kind='line')
```

Out[20]:
```
<AxesSubplot:>
```



▶ Click here for a sample python solution

That doesn't look right...

Recall that *pandas* plots the indices on the x-axis and the columns as individual lines on the y-axis. Since `df_CI` is a dataframe with the `country` as the index and `years` as the columns, we must first transpose the dataframe using `transpose()` method to swap the row and columns.

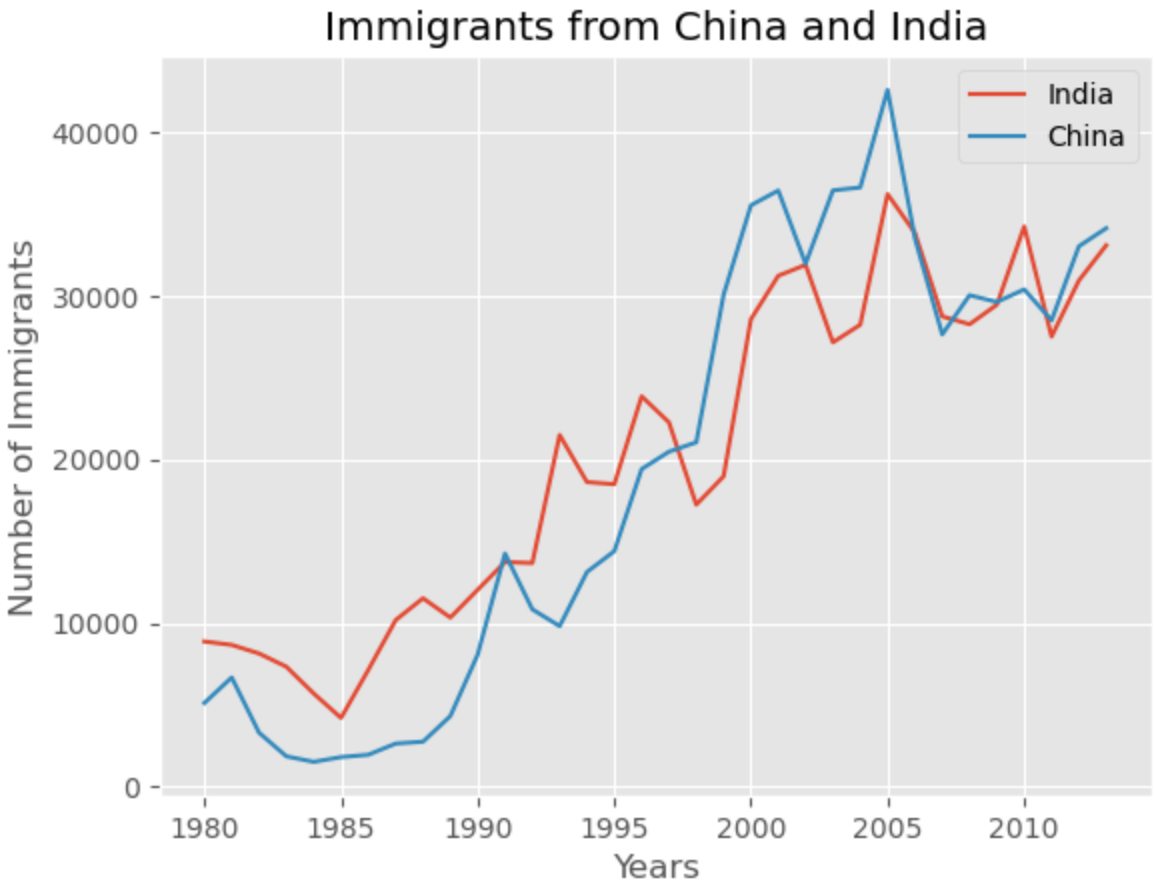
In [21]:
```
df_CI = df_CI.transpose()
df_CI.head()
```

Out[21]:

	India	China
1980	8880	5123
1981	8670	6682
1982	8147	3308
1983	7338	1863
1984	5704	1527

pandas will auomatically graph the two countries on the same graph. Go ahead and plot the new transposed dataframe. Make sure to add a title to the plot and label the axes.

In [23]:
```
### type your answer here
df_CI.index = df_CI.index.map(int) # let's change the index values of df_CI to type
df_CI.plot(kind='line')
plt.title('Immigrants from China and India')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

plt.show()
```



▶ Click here for a sample python solution

From the above plot, we can observe that the China and India have very similar immigration trends through the years.

Note: How come we didn't need to transpose Haiti's dataframe before plotting (like we did for df_CI)?

That's because `haiti` is a series as opposed to a dataframe, and has the years as its indices as shown below.

```
print(type(haiti))
print(haiti.head(5))
```

> class 'pandas.core.series.Series'
> 1980 1666
> 1981 3692
> 1982 3498
> 1983 2860
> 1984 1418
> Name: Haiti, dtype: int64

Line plot is a handy tool to display several dependent variables against one independent variable. However, it is recommended that no more than 5-10 lines on a single graph; any more than that and it becomes difficult to interpret.

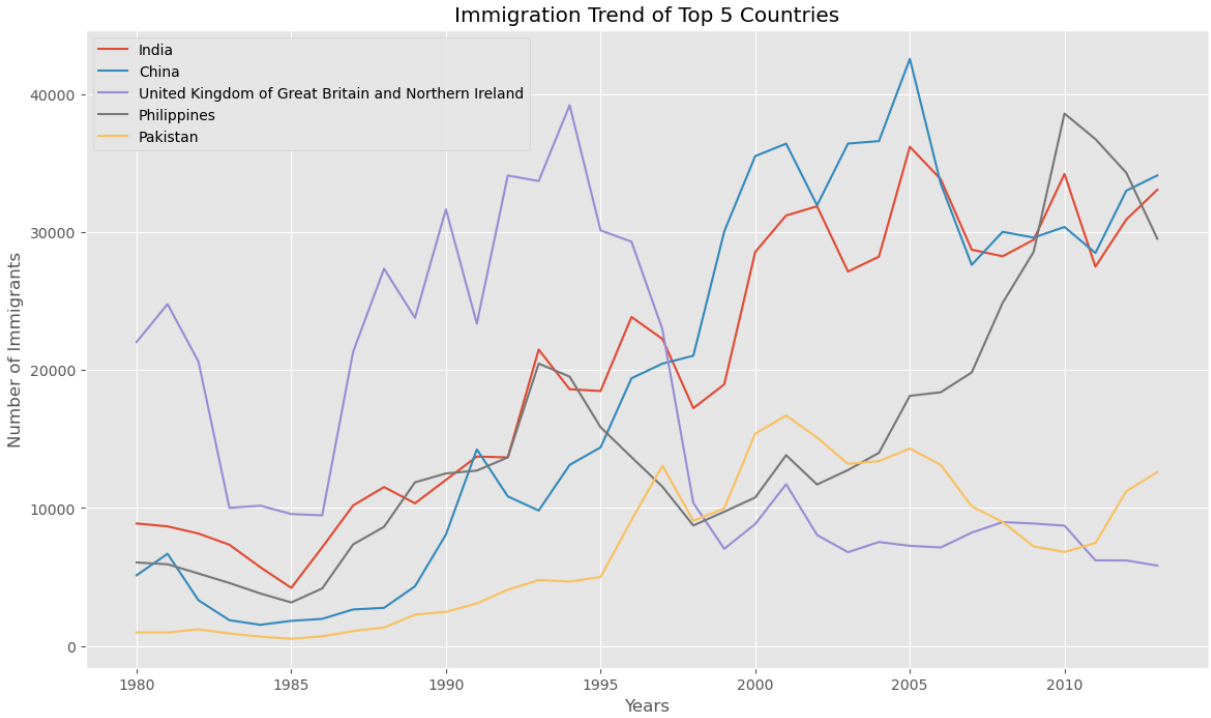
Question: Compare the trend of top 5 countries that contributed the most to immigration to Canada.

In [25]:
```
### type your answer here
#Step 1: Get the dataset. Recall that we created a Total column that calculates cum
    #We will sort on this column to get our top 5 countries using pandas sort_value
inplace = True # paramemter saves the changes to the original df_can dataframe
df_can.sort_values(by='Total', ascending=False, axis=0, inplace=True)

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

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

print(df_top5)


    #Step 2: Plot the dataframe. To make the plot more readeable, we will change th
df_top5.index = df_top5.index.map(int) # let's change the index values of df_top5 t
df_top5.plot(kind='line', figsize=(14, 8)) # pass a tuple (x, y) size
```

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


plt.show()
```

	India	China	United Kingdom of Great Britain and Northern Ireland	Philippines	Pakistan
1980	8880	5123	22045	6051	978
1981	8670	6682	24796	5921	972
1982	8147	3308	20620	5249	1201
1983	7338	1863	10015	4562	900
1984	5704	1527	10170	3801	668
1985	4211	1816	9564	3150	514
1986	7150	1960	9470	4166	691
1987	10189	2643	21337	7360	1072
1988	11522	2758	27359	8639	1334
1989	10343	4323	23795	11865	2261
1990	12041	8076	31668	12509	2470
1991	13734	14255	23380	12718	3079
1992	13673	10846	34123	13670	4071
1993	21496	9817	33720	20479	4777
1994	18620	13128	39231	19532	4666
1995	18489	14398	30145	15864	4994
1996	23859	19415	29322	13692	9125
1997	22268	20475	22965	11549	13073
1998	17241	21049	10367	8735	9068
1999	18974	30069	7045		
2000	28572	35529	8840		
2001	31223	36434	11728		
2002	31889	31961	8046		
2003	27155	36439	6797		
2004	28235	36619	7533		
2005	36210	42584	7258		
2006	33848	33518	7140		
2007	28742	27642	8216		
2008	28261	30037	8979		
2009	29456	29622	8876		
2010	34235	30391	8724		
2011	27509	28502	6204		
2012	30933	33024	6195		
2013	33087	34129	5827		

1999	9734	9979
2000	10763	15400
2001	13836	16708
2002	11707	15110
2003	12758	13205
2004	14004	13399
2005	18139	14314
2006	18400	13127
2007	19837	10124
2008	24887	8994
2009	28573	7217
2010	38617	6811
2011	36765	7468
2012	34315	11227
2013	29544	12603



▶ Click here for a sample python solution

Other Plots

Congratulations! you have learned how to wrangle data with python and create a line plot with Matplotlib. There are many other plotting styles available other than the default Line plot, all of which can be accessed by passing `kind` keyword to `plot()`. The full list of available plots are as follows:

- `bar` for vertical bar plots
- `barh` for horizontal bar plots
- `hist` for histogram
- `box` for boxplot
- `kde` or `density` for density plots
- `area` for area plots

- `pie` for pie plots
- `scatter` for scatter plots
- `hexbin` for hexbin plot

Thank you for completing this lab!

Author

Alex Aklson

Other Contributors

Jay Rajasekharan, Ehsan M. Kermani, Slobodan Markovic, Weiqing Wang, Dr. Pooja

Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2023-06-08	2.5	Dr. Pooja	Updated to work with clean data csv file
2021-05-29	2.4	Weiqing Wang	Fixed typos and code spells.
2021-01-20	2.3	Lakshmi Holla	Changed TOC cell markdown
2020-11-20	2.2	Lakshmi Holla	Changed IBM box URL
2020-11-03	2.1	Lakshmi Holla	Changed URL and info method
2020-08-27	2.0	Lavanya	Moved Lab to course repo in GitLab

In [ ]: