Data Visualization

Estimated time needed: **30** 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 data visualization with Python as concrete and as consistent as possible. Speaking of consistency, because there is no *best* data visualization library available for Python - up to creating these labs - we have to introduce different libraries and show their benefits when we are discussing new visualization concepts. Doing so, we hope to make students well-rounded with visualization libraries and concepts so that they are able to judge and decide on the best visualization technique and tool for a given problem *and* audience.

Please make sure that you have completed the prerequisites for this course, namely **Python Basics for Data Science** and **Analyzing Data with Python**.

Note: The majority of the plots and visualizations will be generated using data stored in *pandas* dataframes. Therefore, in this lab, we provide a brief crash course on *pandas*. However, if you are interested in learning more about the *pandas* library, detailed description and explanation of how to use it and how to clean, munge, and process data stored in a *pandas* dataframe are provided in our course **Analyzing Data with Python**.

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7. Line Plots

Exploring Datasets with *pandas*

pandas is an essential data analysis toolkit for Python. From their website:

> *pandas* is a Python package providing fast, flexible, and expressive data structures designed to make working with “relational” or “labeled” data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, **real world** data analysis in Python.

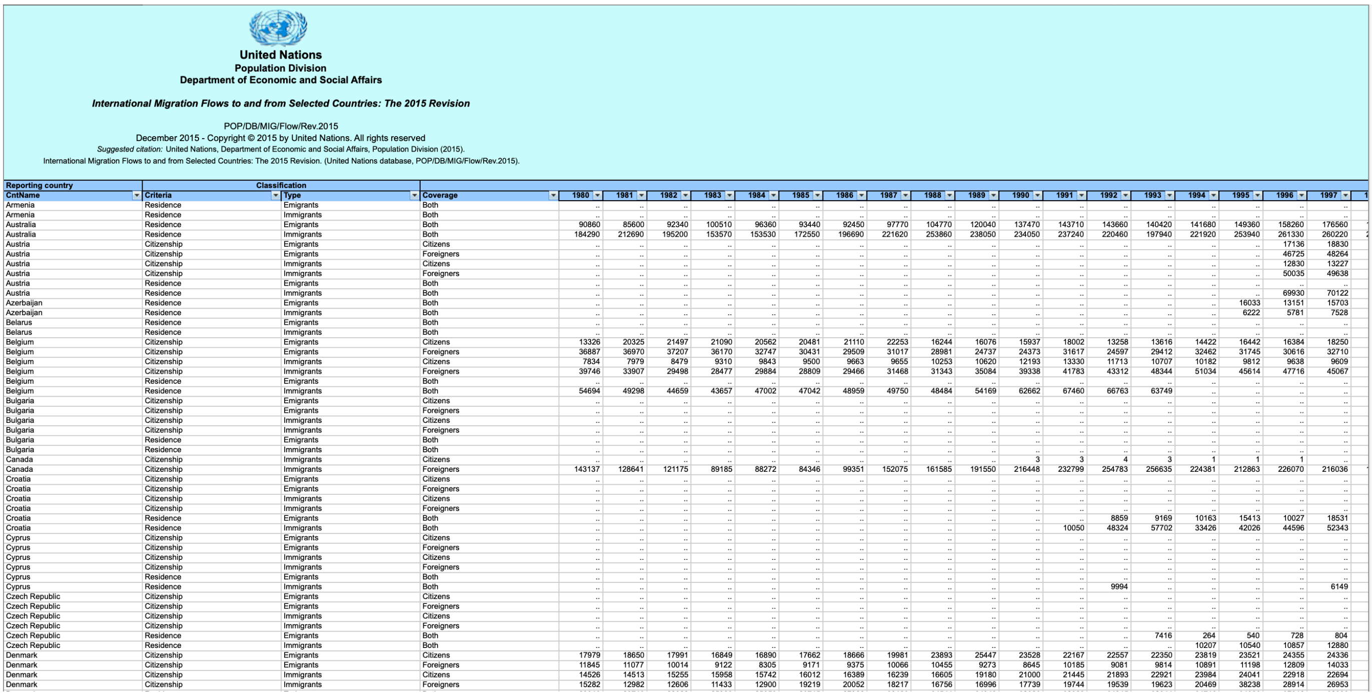
The course heavily relies on *pandas* for data wrangling, analysis, and visualization. We encourage you to spend some time and familiarize yourself with the *pandas* API Reference: http://pandas.pydata.org/pandas-docs/stable/api.html.

The Dataset: Immigration to Canada from 1980 to 2013

Dataset Source: [International migration flows to and from selected countries - The 2015 revision](#).

The dataset contains annual data on the flows of international immigrants 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. The current version presents data pertaining to 45 countries.

In this lab, we will focus on the Canadian immigration data.



The Canada Immigration dataset can be fetched from [here](#).

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pandas Basics

The first thing we'll do is install **openpyxl** (formerly **xlrd**), a module that *pandas* requires to read Excel files.

```
pip install openpyxl==3.0.9 -y
```

```
Usage:
  pip3 install [options] <requirement specifier> [package-index-options] ...
  pip3 install [options] -r <requirements file> [package-index-options] ...
  pip3 install [options] [-e] <vcs project url> ...
  pip3 install [options] [-e] <local project path> ...
  pip3 install [options] <archive url/path> ...

no such option: -y
```

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

```
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_excel()` method.

```
df_can = pd.read_excel(
    'https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBMDevelo
    sheet_name='Canada by Citizenship',
    skiprows=range(20),
    skipfooter=2)

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.

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

	Type	Coverage	OdName	AREA	AreaName	REG	RegName	DEV	DevName
0	Immigrants	Foreigners	Afghanistan	935	Asia	5501	Southern Asia	902	Developing regions
1	Immigrants	Foreigners	Albania	908	Europe	925	Southern Europe	901	Developed regions
2	Immigrants	Foreigners	Algeria	903	Africa	912	Northern Africa	902	Developing regions
3	Immigrants	Foreigners	American Samoa	909	Oceania	957	Polynesia	902	Developing regions
4	Immigrants	Foreigners	Andorra	908	Europe	925	Southern Europe	901	Developed regions

5 rows × 43 columns

We can also view the bottom 5 rows of the dataset using the `tail()` function.

```
df_can.tail()
```

	Type	Coverage	OdName	AREA	AreaName	REG	RegName	DEV	DevName
190	Immigrants	Foreigners	Viet Nam	935	Asia	920	South-Eastern Asia	902	Developing regions
191	Immigrants	Foreigners	Western Sahara	903	Africa	912	Northern Africa	902	Developing regions
192	Immigrants	Foreigners	Yemen	935	Asia	922	Western Asia	902	Developing regions
193	Immigrants	Foreigners	Zambia	903	Africa	910	Eastern Africa	902	Developing regions
194	Immigrants	Foreigners	Zimbabwe	903	Africa	910	Eastern Africa	902	Developing regions

5 rows × 43 columns

When analyzing a dataset, it's always a good idea to start by getting basic information about your dataframe. We can do this by using the `info()` method.

This method can be used to get a short summary of the dataframe.

```
df_can.info(verbose=False)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 195 entries, 0 to 194
Columns: 43 entries, Type to 2013
dtypes: int64(37), object(6)
memory usage: 65.6+ KB
```

To get the list of column headers we can call upon the data frame's `columns` instance variable.

```
df_can.columns
```

```
Index([    'Type', 'Coverage',   'OdName',     'AREA', 'AreaName',
'REG',
         'RegName',      'DEV',  'DevName',       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],
      dtype='object')
```

Similarly, to get the list of indices we use the `.index` instance variables.

```
df_can.index
```

```
RangeIndex(start=0, stop=195, step=1)
```

Note: The default type of intance variables `index` and `columns` are **NOT** `list`.

```
print(type(df_can.columns))
print(type(df_can.index))
```

```
<class 'pandas.core.indexes.base.Index'>
<class 'pandas.core.indexes.range.RangeIndex'>
```

To get the index and columns as lists, we can use the `tolist()` method.

```
df_can.columns.tolist()
```

```
['Type',
 'Coverage',
 'OdName',
 'AREA',
 'AreaName',
 'REG',
 'RegName',
 'DEV',
 'DevName',
 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]
```

```
df_can.index.tolist()
```

```
[0,
 1,
 2,
 3,
 4,
 5,
 6,
 7,
 8,
 9,
 10,
 11,
 12,
 13,
 14,
 15,
 16,
 17,
 18,
 19,
 20,
 21,
 22,
 23,
 24,
 25,
 26,
 27,
 28,
 29,
 30,
 31,
 32,
 33,
 34,
 35,
 36,
 37,
 38,
 39,
 40,
 41,
 42,
 43,
 44,
 45,
 46,
 47,
 48,
```

```
      49,
      50,
      51,
      52,
      53,
      54,
      55,
      56,
      57.
```

```
print(type(df_can.columns.tolist()))
print(type(df_can.index.tolist()))
```

```
<class 'list'>
<class 'list'>
```

To view the dimensions of the dataframe, we use the `shape` instance variable of it.

```
# size of dataframe (rows, columns)
df_can.shape
```

```
(195, 43)
```

Note: The main types stored in *pandas* objects are `float`, `int`, `bool`, `datetime64[ns]`, `datetime64[ns, tz]`, `timedelta[ns]`, `category`, and `object` (string). In addition, these dtypes have item sizes, e.g. `int64` and `int32`.

Let's clean the data set to remove a few unnecessary columns. We can use *pandas* `drop()` method as follows:

```
# in pandas axis=0 represents rows (default) and axis=1 represents columns.
df_can.drop(['AREA','REG','DEV','Type','Coverage'], axis=1, inplace=True)
df_can.head(2)
```

	OdName	AreaName	RegName	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	

Let's rename the columns so that they make sense. We can use `rename()` method by passing in a dictionary of old and new names as follows:

```
df_can.rename(columns={'OdName':'Country', 'AreaName':'Continent', 'RegName':'Reg
df_can.columns
```

```
Index([  'Country', 'Continent',    'Region',   'DevName',         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],
         dtype='object')
```

We will also add a 'Total' column that sums up the total immigrants by country over the entire period 1980 - 2013, as follows:

```
Start coding or generate with AI.
```

We can check to see how many null objects we have in the dataset as follows:

```
df_can.isnull().sum()
```

```
Country      0
Continent    0
Region       0
DevName      0
1980         0
1981         0
1982         0
1983         0
1984         0
1985         0
1986         0
1987         0
1988         0
1989         0
1990         0
1991         0
1992         0
1993         0
1994         0
1995         0
1996         0
1997         0
1998         0
1999         0
2000         0
2001         0
2002         0
2003         0
2004         0
2005         0
2006         0
2007         0
2008         0
2009         0
2010         0
2011         0
2012         0
```

```
2013        0
dtype: int64
```

Finally, let's view a quick summary of each column in our dataframe using the `describe()` method.

```
df_can.describe()
```

	1980	1981	1982	1983	1984	198
count	195.000000	195.000000	195.000000	195.000000	195.000000	195.00000
mean	508.394872	566.989744	534.723077	387.435897	376.497436	358.86153
std	1949.588546	2152.643752	1866.997511	1204.333597	1198.246371	1079.30960
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000
25%	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000
50%	13.000000	10.000000	11.000000	12.000000	13.000000	17.00000
75%	251.500000	295.500000	275.000000	173.000000	181.000000	197.00000
max	22045.000000	24796.000000	20620.000000	10015.000000	10170.000000	9564.00000

8 rows × 34 columns

---

pandas Intermediate: Indexing and Selection (slicing)

Select Column

There are two ways to filter on a column name:

Method 1: Quick and easy, but only works if the column name does NOT have spaces or special characters.

```
df.column_name               # returns series
```

Method 2: More robust, and can filter on multiple columns.

```
df['column']                  # returns series
```

```
df[['column 1', 'column 2']]  # returns dataframe
```

Example: Let's try filtering on the list of countries ('Country').

```
df_can.Country  # returns a series
```

```
0           Afghanistan
1               Albania
2               Algeria
3        American Samoa
4               Andorra
             ...
190            Viet Nam
191      Western Sahara
192               Yemen
193              Zambia
194            Zimbabwe
Name: Country, Length: 195, dtype: object
```

Let's try filtering on the list of countries ('Country') and the data for years: 1980 - 1985.

```
df_can[['Country', 1980, 1981, 1982, 1983, 1984, 1985]] # returns a dataframe
# notice that 'Country' is string, and the years are integers.
# for the sake of consistency, we will convert all column names to string later o
```

	Country	1980	1981	1982	1983	1984	1985
0	Afghanistan	16	39	39	47	71	340
1	Albania	1	0	0	0	0	0
2	Algeria	80	67	71	69	63	44
3	American Samoa	0	1	0	0	0	0
4	Andorra	0	0	0	0	0	0
...	...	...	...	...	...	...	...
190	Viet Nam	1191	1829	2162	3404	7583	5907
191	Western Sahara	0	0	0	0	0	0
192	Yemen	1	2	1	6	0	18
193	Zambia	11	17	11	7	16	9
194	Zimbabwe	72	114	102	44	32	29

195 rows × 7 columns

Select Row

There are main 2 ways to select rows:

```
df.loc[label]    # filters by the labels of the index/column
df.iloc[index]   # filters by the positions of the index/column
```

Before we proceed, notice that the default index of the dataset is a numeric range from 0 to 194. This makes it very difficult to do a query by a specific country. For example to search for data on Japan, we need to know the corresponding index value.

This can be fixed very easily by setting the 'Country' column as the index using `set_index()` method.

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

```
df_can.head(3)
```

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	19
Country										
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	4
Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	
Algeria	Africa	Northern Africa	Developing regions	80	67	71	69	63	44	

3 rows × 37 columns

```
# optional: to remove the name of the index
df_can.index.name = None
```

Example: Let's view the number of immigrants from Japan (row 87) for the following scenarios: 1. The full row data (all columns) 2. For year 2013 3. For years 1980 to 1985

```
# 1. the full row data (all columns)
df_can.loc['Japan']
```

```
Continent                   Asia
Region              Eastern Asia
DevName         Developed regions
1980                         701
1981                         756
1982                         598
1983                         309
1984                         246
1985                         198
1986                         248
1987                         422
```

```
1988                      324
1989                      494
1990                      379
1991                      506
1992                      605
1993                      907
1994                      956
1995                      826
1996                      994
1997                      924
1998                      897
1999                     1083
2000                     1010
2001                     1092
2002                      806
2003                      817
2004                      973
2005                     1067
2006                     1212
2007                     1250
2008                     1284
2009                     1194
2010                     1168
2011                     1265
2012                     1214
2013                      982
Name: Japan, dtype: object
```

```
# alternate methods
df_can.iloc[87]
```

```
Continent                    Asia
Region               Eastern Asia
DevName          Developed regions
1980                      701
1981                      756
1982                      598
1983                      309
1984                      246
1985                      198
1986                      248
1987                      422
1988                      324
1989                      494
1990                      379
1991                      506
1992                      605
1993                      907
1994                      956
1995                      826
1996                      994
1997                      924
1998                      897
1999                     1083
2000                     1010
2001                     1092
2002                      806
2003                      817
2004                      973
```

```
2005                 1067
2006                 1212
2007                 1250
2008                 1284
2009                 1194
2010                 1168
2011                 1265
2012                 1214
2013                  982
Name: Japan, dtype: object
```

```
df_can[df_can.index == 'Japan']
```

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...
Japan	Asia	Eastern Asia	Developed regions	701	756	598	309	246	198	248	..

1 rows × 37 columns

```
# 2. for year 2013
df_can.loc['Japan', 2013]
```

```
982
```

```
# alternate method
# year 2013 is the last column, with a positional index of 36
df_can.iloc[87, 36]
```

```
982
```

```
# 3. for years 1980 to 1985
df_can.loc['Japan', [1980, 1981, 1982, 1983, 1984, 1984]]
```

```
1980    701
1981    756
1982    598
1983    309
1984    246
1984    246
Name: Japan, dtype: object
```

```
# Alternative Method
df_can.iloc[87, [3, 4, 5, 6, 7, 8]]
```

```
1980    701
1981    756
1982    598
1983    309
1984    246
1985    198
Name: Japan, dtype: object
```

Column names that are integers (such as the years) might introduce some confusion. For example, when we are referencing the year 2013, one might confuse that when the 2013th positional index.

To avoid this ambuigity, let's convert the column names into strings: '1980' to '2013'.

```
df_can.columns = list(map(str, df_can.columns))
# [print (type(x)) for x in df_can.columns.values] #<-- uncomment to check type o
```

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:

```
# useful for plotting later on
years = list(map(str, range(1980, 2014)))
years
```

```
['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']
```

Filtering based on a criteria

To filter the dataframe based on a condition, we simply pass the condition as a boolean vector.

For example, Let's filter the dataframe to show the data on Asian countries (AreaName = Asia).

```
# 1. create the condition boolean series
condition = df_can['Continent'] == 'Asia'
print(condition)
```

```
Afghanistan        True
Albania           False
Algeria           False
American Samoa    False
Andorra           False
                  ...
Viet Nam           True
Western Sahara    False
Yemen              True
Zambia            False
Zimbabwe          False
Name: Continent, Length: 195, dtype: bool
```

```
# 2. pass this condition into the dataFrame
df_can[condition]
```

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340
Armenia	Asia	Western Asia	Developing regions	0	0	0	0	0	0
Azerbaijan	Asia	Western Asia	Developing regions	0	0	0	0	0	0
Bahrain	Asia	Western Asia	Developing regions	0	2	1	1	1	3
Bangladesh	Asia	Southern Asia	Developing regions	83	84	86	81	98	92
Bhutan	Asia	Southern Asia	Developing regions	0	0	0	0	1	0
Brunei Darussalam	Asia	South-Eastern Asia	Developing regions	79	6	8	2	2	4
Cambodia	Asia	South-Eastern Asia	Developing regions	12	19	26	33	10	7
China	Asia	Eastern Asia	Developing regions	5123	6682	3308	1863	1527	1816
China, Hong Kong Special Administrative Region	Asia	Eastern Asia	Developing regions	0	0	0	0	0	0
China, Macao Special Administrative Region	Asia	Eastern Asia	Developing regions	0	0	0	0	0	0
Cyprus	Asia	Western Asia	Developing regions	132	128	84	46	46	43
Democratic People's Republic of Korea	Asia	Eastern Asia	Developing regions	1	1	3	1	4	3
Georgia	Asia	Western Asia	Developing regions	0	0	0	0	0	0
India	Asia	Southern Asia	Developing regions	8880	8670	8147	7338	5704	4211
Indonesia	Asia	South-Eastern Asia	Developing regions	186	178	252	115	123	100
Iran (Islamic Republic of)	Asia	Southern Asia	Developing regions	1172	1429	1822	1592	1977	1648
Iraq	Asia	Western	Developing	262	245	260	380	428	231

Iraq	Asia	Western Asia	Developing regions	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Israel	Asia	Western Asia	Developing regions	1403	1711	1334	541	446	680
Japan	Asia	Eastern Asia	Developed regions	701	756	598	309	246	198
Jordan	Asia	Western Asia	Developing regions	177	160	155	113	102	179
Kazakhstan	Asia	Central Asia	Developing regions	0	0	0	0	0	0
Kuwait	Asia	Western Asia	Developing regions	1	0	8	2	1	4
Kyrgyzstan	Asia	Central Asia	Developing regions	0	0	0	0	0	0
Lao People's Democratic Republic	Asia	South-Eastern Asia	Developing regions	11	6	16	16	7	17
Lebanon	Asia	Western Asia	Developing regions	1409	1119	1159	789	1253	1683
Malaysia	Asia	South-Eastern Asia	Developing regions	786	816	813	448	384	374
Maldives	Asia	Southern Asia	Developing regions	0	0	0	1	0	0
Mongolia	Asia	Eastern Asia	Developing regions	0	0	0	0	0	0
Myanmar	Asia	South-Eastern Asia	Developing regions	80	62	46	31	41	23
Nepal	Asia	Southern Asia	Developing regions	1	1	6	1	2	4
Oman	Asia	Western Asia	Developing regions	0	0	0	8	0	0
Pakistan	Asia	Southern Asia	Developing regions	978	972	1201	900	668	514
Philippines	Asia	South-Eastern Asia	Developing regions	6051	5921	5249	4562	3801	3150
Qatar	Asia	Western Asia	Developing regions	0	0	0	0	0	0
Republic of Korea	Asia	Eastern Asia	Developing regions	1011	1456	1572	1081	847	962
Saudi Arabia	Asia	Western Asia	Developing regions	0	0	1	4	1	2
[illegible]	[illegible]	South-[illegible]	Developing [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Singapore	Asia	South-Eastern Asia	Developing regions	241	301	337	169	128	139
Sri Lanka	Asia	Southern Asia	Developing regions	185	371	290	197	1086	845
State of Palestine	Asia	Western Asia	Developing regions	0	0	0	0	0	0
Syrian Arab Republic	Asia	Western Asia	Developing regions	315	419	409	269	264	385
Tajikistan	Asia	Central Asia	Developing regions	0	0	0	0	0	0
Thailand	Asia	South-Eastern Asia	Developing regions	56	53	113	65	82	66
Turkey	Asia	Western Asia	Developing regions	481	874	706	280	338	202
Turkmenistan	Asia	Central Asia	Developing regions	0	0	0	0	0	0
United Arab Emirates	Asia	Western Asia	Developing regions	0	2	2	1	2	0
Uzbekistan	Asia	Central Asia	Developing regions	0	0	0	0	0	0
Viet Nam	Asia	South-Eastern Asia	Developing regions	1191	1829	2162	3404	7583	5907
Yemen	Asia	Western Asia	Developing regions	1	2	1	6	0	18

49 rows × 37 columns

```
# we can pass multiple criteria in the same line.
# let's filter for AreaNAme = Asia and RegName = Southern Asia

df_can[(df_can['Continent']=='Asia') & (df_can['Region']=='Southern Asia')]

# note: When using 'and' and 'or' operators, pandas requires we use '&' and '|' i
# don't forget to enclose the two conditions in parentheses
```

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	19
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	4
Bangladesh	Asia	Southern Asia	Developing regions	83	84	86	81	98	92	4
Bhutan	Asia	Southern Asia	Developing regions	0	0	0	0	1	0	
India	Asia	Southern Asia	Developing regions	8880	8670	8147	7338	5704	4211	71
Iran (Islamic Republic of)	Asia	Southern Asia	Developing regions	1172	1429	1822	1592	1977	1648	17
Maldives	Asia	Southern Asia	Developing regions	0	0	0	1	0	0	
Nepal	Asia	Southern Asia	Developing regions	1	1	6	1	2	4	
Pakistan	Asia	Southern Asia	Developing regions	978	972	1201	900	668	514	6
Sri Lanka	Asia	Southern Asia	Developing regions	185	371	290	197	1086	845	18

9 rows × 37 columns

Before we proceed: let's review the changes we have made to our dataframe.

```
print('data dimensions:', df_can.shape)
print(df_can.columns)
df_can.head(2)
```

```
data dimensions: (195, 37)
Index(['Continent', 'Region', 'DevName', '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'],
      dtype='object')
```

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	19
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	4
Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	

2 rows × 37 columns

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:

```
# we are using the inline backend
%matplotlib inline

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

*optional: check if Matplotlib is loaded.

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

```
Matplotlib version:  3.7.1
```

*optional: apply a style to Matplotlib.

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

```
['Solarize_Light2', '_classic_test_patch', '_mpl-gallery', '_mpl-gallery-nogr
```

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 aout 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.

```
haiti = df_can.loc['Haiti', years] # passing in years 1980 - 2013 to exclude the
haiti.head()
```

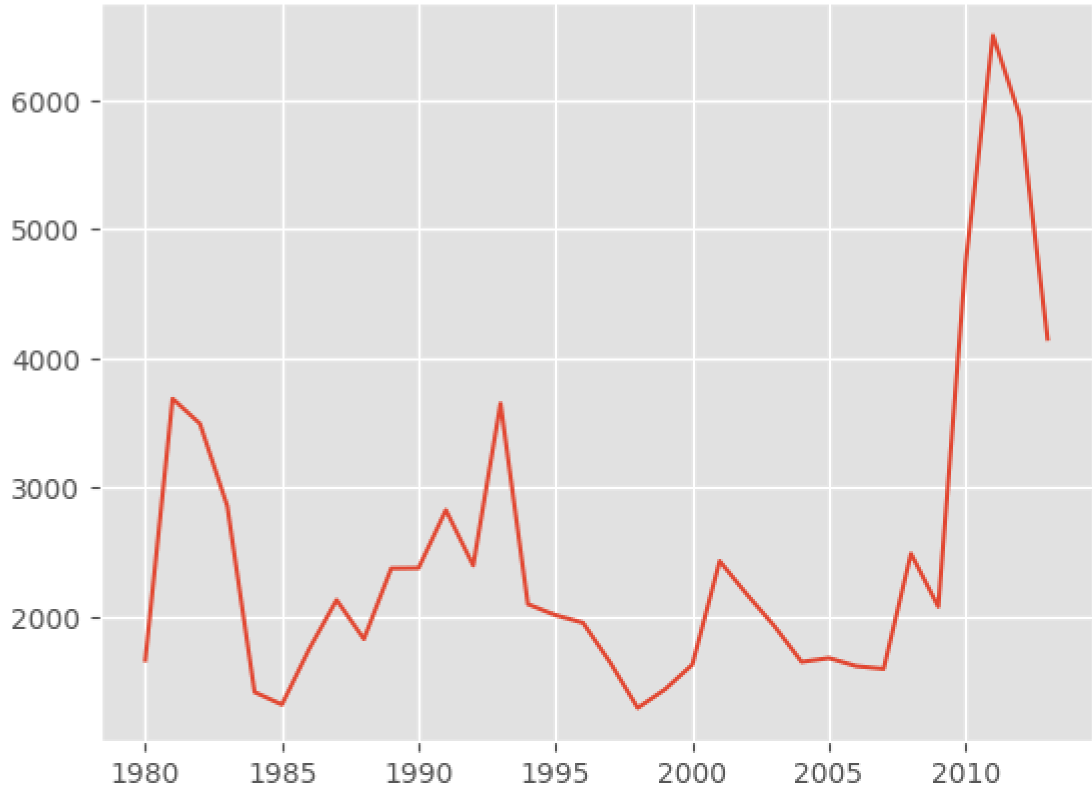
```
1980    1666
1981    3692
1982    3498
1983    2860
```

```
1984    1418
Name: Haiti, dtype: object
```

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

```
haiti.plot()
```

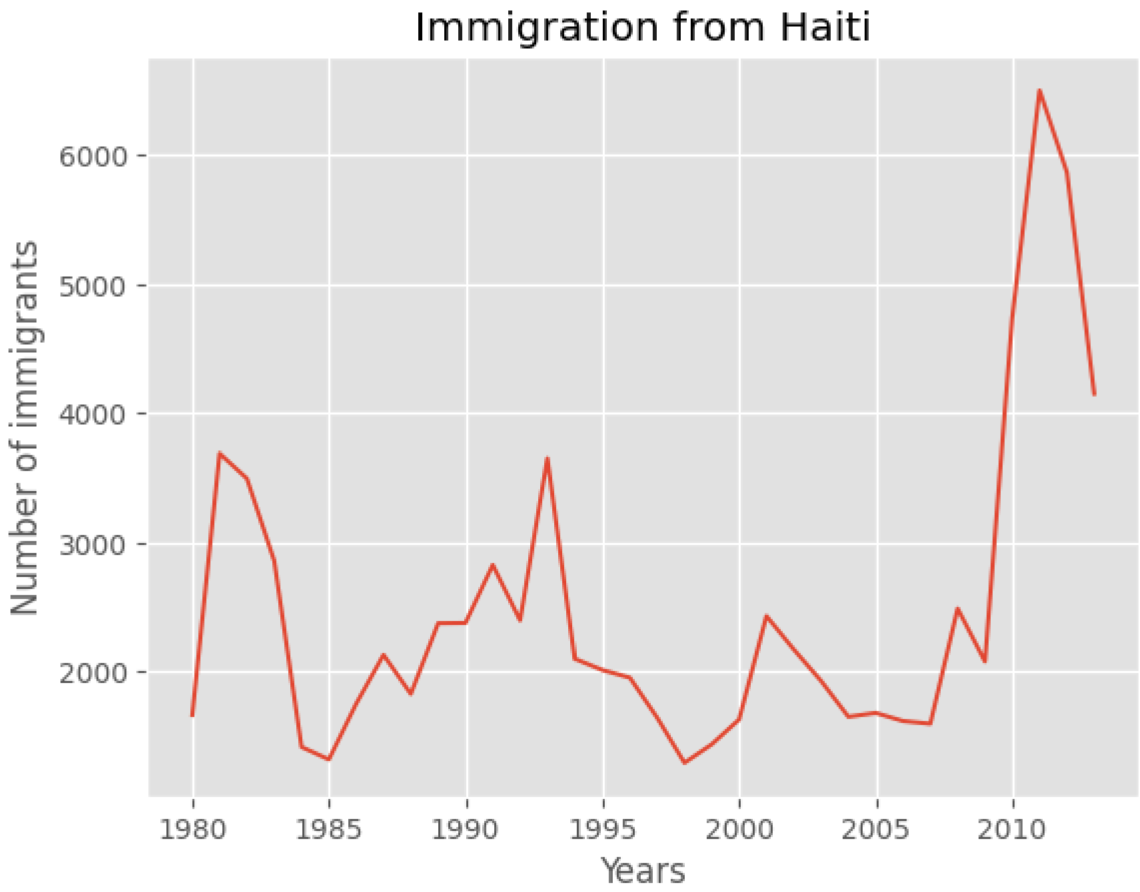
```
<Axes: >
```



pandas automatically populated the x-axis with the index values (years), and the y-axis with the column values (population). However, notice how the years were not displayed because they are of type *string*. Therefore, let's change the type of the index values to *integer* for plotting.

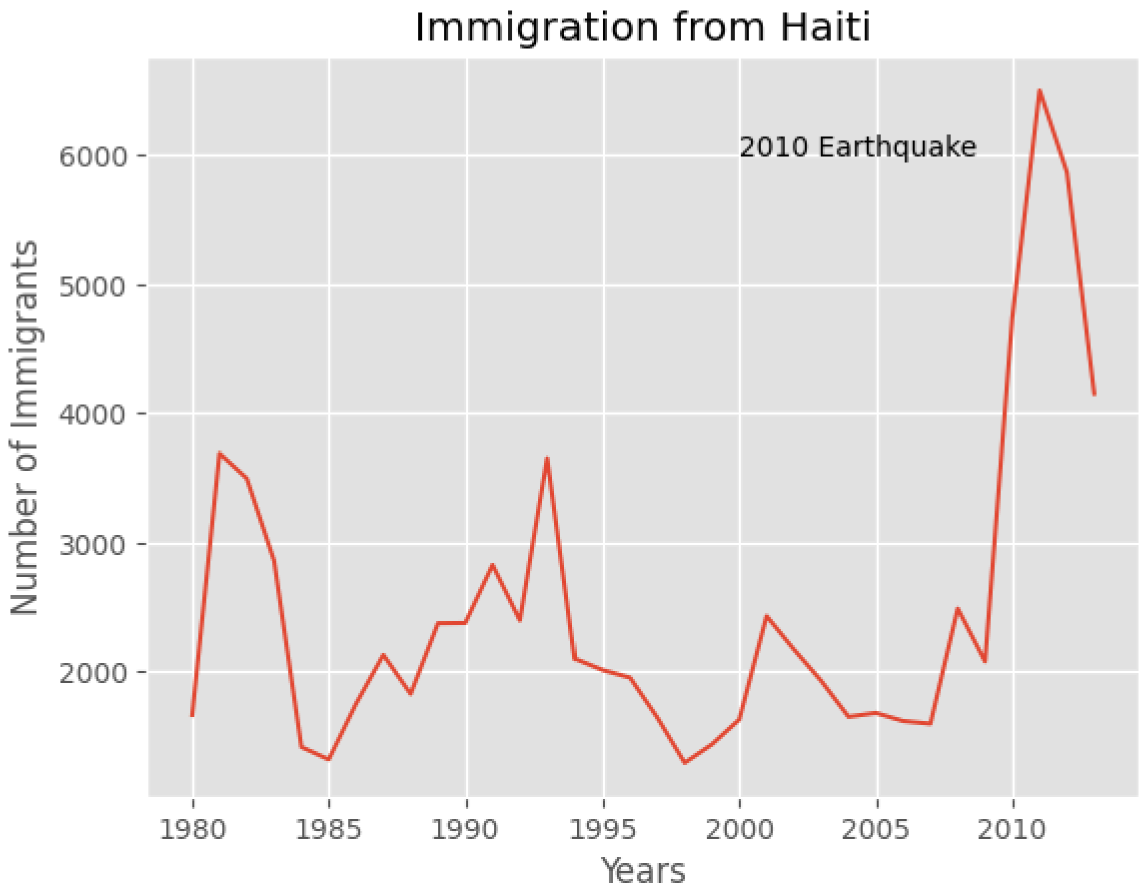
Also, let's label the x and y axis using `plt.title()`, `plt.ylabel()`, and `plt.xlabel()` as follows:

```
haiti.index = haiti.index.map(int) # let's change the index values of Haiti to ty
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.

```
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

    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 positi

    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.

```
#The correct answer is:
df_CI = df_can.loc[['India', 'China'], years]
df_CI
```

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	...	2004	:
India	8880	8670	8147	7338	5704	4211	7150	10189	11522	10343	...	28235	3
China	5123	6682	3308	1863	1527	1816	1960	2643	2758	4323	...	36619	4

2 rows × 34 columns

▼ Click here for a sample python solution

```
#The correct answer is:
df_CI = df_can.loc[['India', 'China'], years]
df_CI
```

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

```
### type your answer here
# df_CI. ...
```

▼ Click here for a sample python solution

```
#The correct answer is:
df_CI.plot(kind='line')
```

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.

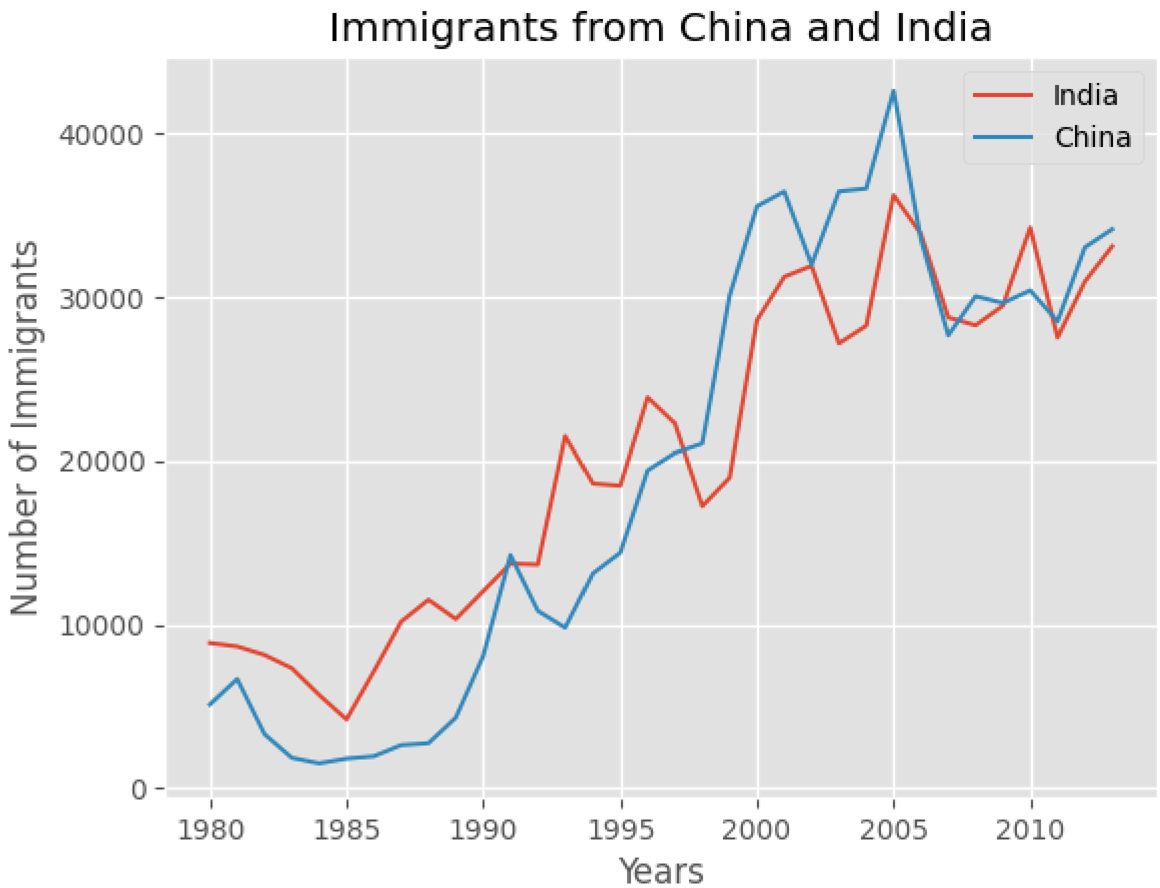
```
df_CI = df_can.loc[['India', 'China'], years]
df_CI = df_CI.transpose()
df_CI.head()
```

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

Next steps: Generate code with `df_CI` View recommended plots

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.

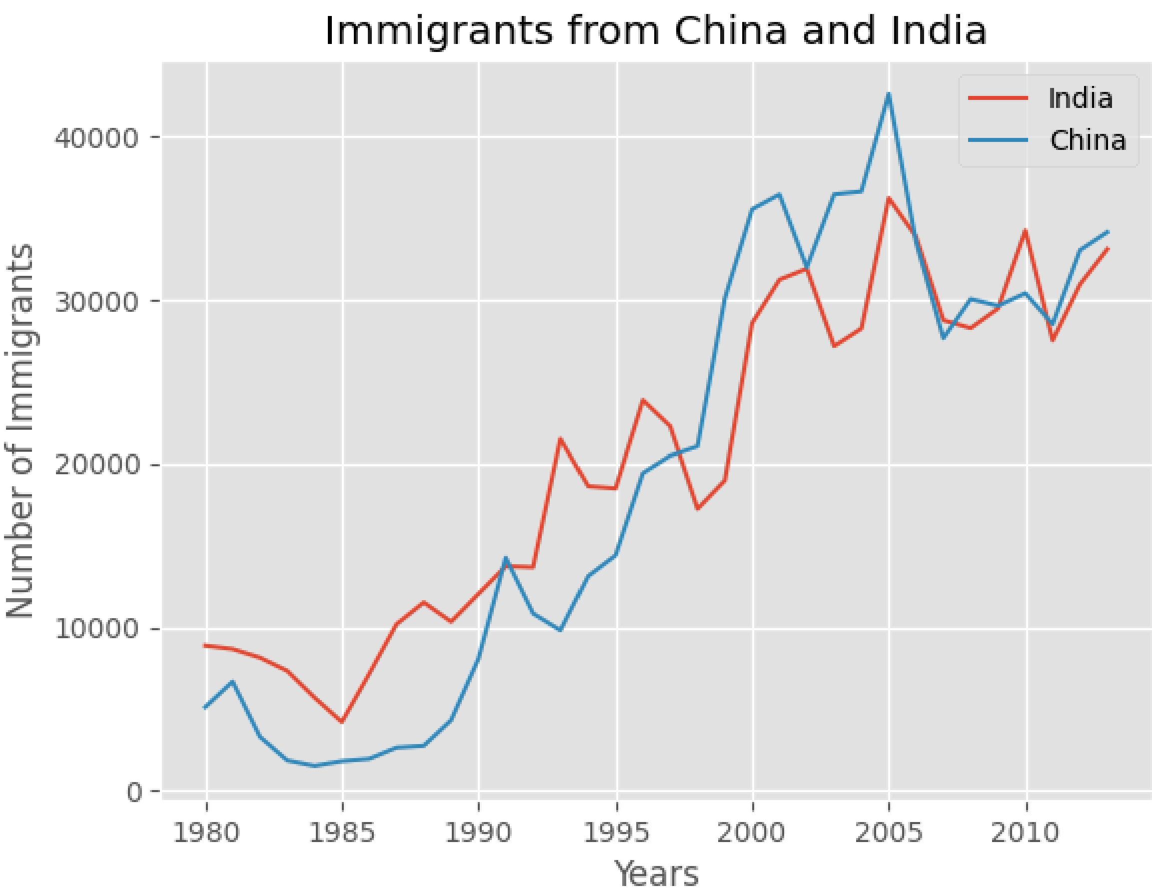
```
### type your answer here


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

```
#The correct answer is:
df_CI.index = df_CI.index.map(int) # let's change the index values of df_CI to type in
df_CI.plot(kind='line')

plt.title('Immigrants from China and India')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

plt.show()
```

```
df_CI.index = df_CI.index.map(int) # let's change the index values of df_CI to ty
df_CI.plot(kind='line')

plt.title('Immigrants from China and India')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

plt.show()
```



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