DV0101EN-Exercise-Introduction-to-Matplotlib-and-Line-Plots-py

August 6, 2019

Introduction to Matplotlib and Line Plots

0.1 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 avaiblable 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 visualitzation technique and tool for a given problem *and* audience.

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

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 **Data Analysis with Python**.

0.2 Table of Contents

1 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 familizare yourself with the *pandas* API Reference: http://pandas.pydata.org/pandas-docs/stable/api.html.

1.1 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.

For sake of simplicity, Canada's immigration data has been extracted and uploaded to one of IBM servers. You can fetch the data from here.

1.2 *pandas* Basics

The first thing 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* `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
```

Now we are ready to read in our data.

```
In [2]: df_can = pd.read_excel('https://s3-api.us-geo.objectstorage.softlayer.net/cf-courses-da
                               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.

```
In [3]: df_can.head()
        # tip: You can specify the number of rows you'd like to see as follows: df_can.head(10
```

```
Out[3]:          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]
```

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

```
In [4]: df_can.tail()
```

```
Out[4]:            Type    Coverage          OdName  AREA AreaName  REG  \
190  Immigrants  Foreigners        Viet Nam   935     Asia  920
191  Immigrants  Foreigners  Western Sahara   903   Africa  912
192  Immigrants  Foreigners           Yemen   935     Asia  922
193  Immigrants  Foreigners          Zambia   903   Africa  910
194  Immigrants  Foreigners        Zimbabwe   903   Africa  910

                RegName  DEV             DevName  1980  ...  2004  2005  2006  \
190  South-Eastern Asia  902  Developing regions  1191  ...  1816  1852  3153
191     Northern Africa  902  Developing regions     0  ...     0     0     1
192        Western Asia  902  Developing regions     1  ...   124   161   140
193      Eastern Africa  902  Developing regions    11  ...    56    91    77
194      Eastern Africa  902  Developing regions    72  ...  1450   615   454

     2007  2008  2009  2010  2011  2012  2013
190  2574  1784  2171  1942  1723  1731  2112
191     0     0     0     0     0     0     0
192   122   133   128   211   160   174   217
193    71    64    60   102    69    46    59
194   663   611   508   494   434   437   407

[5 rows x 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.

```
In [5]: df_can.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 195 entries, 0 to 194
Data columns (total 43 columns):
Type        195 non-null object
Coverage    195 non-null object
OdName      195 non-null object
AREA        195 non-null int64
AreaName    195 non-null object
REG         195 non-null int64
RegName     195 non-null object
DEV         195 non-null int64
DevName     195 non-null object
1980        195 non-null int64
1981        195 non-null int64
1982        195 non-null int64
1983        195 non-null int64
1984        195 non-null int64
1985        195 non-null int64
1986        195 non-null int64
1987        195 non-null int64
1988        195 non-null int64
1989        195 non-null int64
1990        195 non-null int64
1991        195 non-null int64
1992        195 non-null int64
1993        195 non-null int64
1994        195 non-null int64
1995        195 non-null int64
1996        195 non-null int64
1997        195 non-null int64
1998        195 non-null int64
1999        195 non-null int64
2000        195 non-null int64
2001        195 non-null int64
2002        195 non-null int64
2003        195 non-null int64
2004        195 non-null int64
2005        195 non-null int64
2006        195 non-null int64
2007        195 non-null int64
2008        195 non-null int64
2009        195 non-null int64
2010        195 non-null int64
2011        195 non-null int64
2012        195 non-null int64
2013        195 non-null int64
dtypes: int64(37), object(6)
memory usage: 65.6+ KB
```

To get the list of column headers we can call upon the dataframe's `.columns` parameter.

```
In [6]: df_can.columns.values
```

```
Out[6]: array(['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 indicies we use the `.index` parameter.

```
In [7]: df_can.index.values
```

```
Out[7]: array([  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,  58,  59,  60,  61,  62,  63,  64,
                65,  66,  67,  68,  69,  70,  71,  72,  73,  74,  75,  76,  77,
                78,  79,  80,  81,  82,  83,  84,  85,  86,  87,  88,  89,  90,
                91,  92,  93,  94,  95,  96,  97,  98,  99, 100, 101, 102, 103,
               104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116,
               117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129,
               130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142,
               143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155,
               156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168,
               169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181,
               182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194],
              dtype=int64)
```

Note: The default type of index and columns is NOT list.

```
In [8]: 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.

```
In [9]: df_can.columns.tolist()
        df_can.index.tolist()

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

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

```
['Type', 'Coverage', 'OdName', 'AREA', 'AreaName', 'REG', 'RegName', 'DEV', 'DevName', 1980, 19
[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,
<class 'list'>
<class 'list'>
```

To view the dimensions of the dataframe, we use the `.shape` parameter.

```
In [10]: # size of dataframe (rows, columns)
         df_can.shape
```

```
Out[10]: (195, 43)
```

Note: The main types stored in *pandas* objects are *float*, *int*, *bool*, *datetime64[ns]* and *datetime64[ns, tz] (in >= 0.17.0)*, *timedelta[ns]*, *category (in >= 0.15.0)*, 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 [12]: # 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)
```

```
Out[12]:         OdName AreaName          RegName             DevName  1980  1981  \
         0  Afghanistan     Asia    Southern Asia  Developing regions    16    39
         1      Albania   Europe  Southern Europe   Developed regions     1     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

            2011  2012  2013
         0  2203  2635  2004
         1   539   620   603

         [2 rows x 38 columns]
```

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:

```
In [13]: df_can.rename(columns={'OdName':'Country', 'AreaName':'Continent', 'RegName':'Region'}
         df_can.columns
```

```
Out[13]: 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:

```
In [14]: df_can['Total'] = df_can.sum(axis=1) #interesting
         df_can.head()
```

```
Out[14]:          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  ...  2005  2006  2007  2008  2009  2010  2011  \
         0    39    47    71   340  ...  3436  3009  2652  2111  1746  1758  2203
         1     0     0     0     0  ...  1223   856   702   560   716   561   539
         2    71    69    63    44  ...  3626  4807  3623  4005  5393  4752  4325
         3     0     0     0     0  ...     0     1     0     0     0     0     0
         4     0     0     0     0  ...     0     1     1     0     0     0     0

            2012  2013  Total
         0  2635  2004  58639
         1   620   603  15699
         2  3774  4331  69439
         3     0     0      6
         4     1     1     15

         [5 rows x 39 columns]
```

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

```
In [15]: df_can.isnull().sum()
```

```
Out[15]: 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
Total        0
dtype: int64
```

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

```
In [16]: df_can.describe()
```

Out[16]:

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

	1985	1986	1987	1988	1989
count	195.000000	195.000000	195.000000	195.000000	195.000000
mean	358.861538	441.271795	691.133333	714.389744	843.241026
std	1079.309600	1225.576630	2109.205607	2443.606788	2555.048874
min	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.500000	0.500000	1.000000	1.000000
50%	17.000000	18.000000	26.000000	34.000000	44.000000
75%	197.000000	254.000000	434.000000	409.000000	508.500000

```
max    9564.000000  9470.000000  21337.000000  27359.000000  23795.000000

       ...          2005          2006          2007          2008  \
count  ...    195.000000    195.000000    195.000000    195.000000
mean   ...   1320.292308   1266.958974   1191.820513   1246.394872
std    ...   4425.957828   3926.717747   3443.542409   3694.573544
min    ...      0.000000      0.000000      0.000000      0.000000
25%    ...     28.500000     25.000000     31.000000     31.000000
50%    ...    210.000000    218.000000    198.000000    205.000000
75%    ...    832.000000    842.000000    899.000000    934.500000
max    ...  42584.000000  33848.000000  28742.000000  30037.000000

              2009          2010          2011          2012          2013  \
count    195.000000    195.000000    195.000000    195.000000    195.000000
mean    1275.733333   1420.287179   1262.533333   1313.958974   1320.702564
std     3829.630424   4462.946328   4030.084313   4247.555161   4237.951988
min        0.000000      0.000000      0.000000      0.000000      0.000000
25%       36.000000     40.500000     37.500000     42.500000     45.000000
50%      214.000000    211.000000    179.000000    233.000000    213.000000
75%      888.000000    932.000000    772.000000    783.000000    796.000000
max    29622.000000  38617.000000  36765.000000  34315.000000  34129.000000

              Total
count     195.000000
mean    32867.451282
std     91785.498686
min         1.000000
25%       952.000000
50%      5018.000000
75%     22239.500000
max    691904.000000

[8 rows x 35 columns]
```

1.3 *pandas* Intermediate: Indexing and Selection (slicing)

1.3.1 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').

```
In [17]: df_can.Country  # returns a series
```

```
Out[17]: 0                                      Afghanistan
         1                                          Albania
         2                                          Algeria
         3                                   American Samoa
         4                                          Andorra
         5                                           Angola
         6                                Antigua and Barbuda
         7                                        Argentina
         8                                          Armenia
         9                                        Australia
         10                                         Austria
         11                                      Azerbaijan
         12                                         Bahamas
         13                                         Bahrain
         14                                      Bangladesh
         15                                        Barbados
         16                                         Belarus
         17                                         Belgium
         18                                          Belize
         19                                           Benin
         20                                          Bhutan
         21                  Bolivia (Plurinational State of)
         22                            Bosnia and Herzegovina
         23                                        Botswana
         24                                          Brazil
         25                              Brunei Darussalam
         26                                        Bulgaria
         27                                    Burkina Faso
         28                                         Burundi
         29                                     Cabo Verde
                                        ...
         165                                     Suriname
         166                                    Swaziland
         167                                       Sweden
         168                                  Switzerland
         169                           Syrian Arab Republic
         170                                   Tajikistan
```

```
171                                          Thailand
172          The former Yugoslav Republic of Macedonia
173                                              Togo
174                                             Tonga
175                                   Trinidad and Tobago
176                                           Tunisia
177                                            Turkey
178                                        Turkmenistan
179                                            Tuvalu
180                                            Uganda
181                                           Ukraine
182                                 United Arab Emirates
183   United Kingdom of Great Britain and Northern I...
184                           United Republic of Tanzania
185                              United States of America
186                                           Uruguay
187                                         Uzbekistan
188                                           Vanuatu
189                 Venezuela (Bolivarian Republic of)
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 ('OdName') and the data for years: 1980 - 1985.

```
In [18]: 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 on.
```

Out[18]:

	Country	1980	1981	1982
0	Afghanistan	16	39	39
1	Albania	1	0	0
2	Algeria	80	67	71
3	American Samoa	0	1	0
4	Andorra	0	0	0
5	Angola	1	3	6
6	Antigua and Barbuda	0	0	0
7	Argentina	368	426	626
8	Armenia	0	0	0
9	Australia	702	639	484
10	Austria	234	238	201
11	Azerbaijan	0	0	0
12	Bahamas	26	23	38
13	Bahrain	0	2	1
14	Bangladesh	83	84	86

15	Barbados	372	376	299
16	Belarus	0	0	0
17	Belgium	511	540	519
18	Belize	16	27	13
19	Benin	2	5	4
20	Bhutan	0	0	0
21	Bolivia (Plurinational State of)	44	52	42
22	Bosnia and Herzegovina	0	0	0
23	Botswana	10	1	3
24	Brazil	211	220	192
25	Brunei Darussalam	79	6	8
26	Bulgaria	24	20	12
27	Burkina Faso	2	1	3
28	Burundi	0	0	0
29	Cabo Verde	1	1	2
..	...	...	...	...
165	Suriname	15	10	21
166	Swaziland	4	1	1
167	Sweden	281	308	222
168	Switzerland	806	811	634
169	Syrian Arab Republic	315	419	409
170	Tajikistan	0	0	0
171	Thailand	56	53	113
172	The former Yugoslav Republic of Macedonia	0	0	0
173	Togo	5	5	2
174	Tonga	2	4	7
175	Trinidad and Tobago	958	947	972
176	Tunisia	58	51	55
177	Turkey	481	874	706
178	Turkmenistan	0	0	0
179	Tuvalu	0	1	0
180	Uganda	13	16	17
181	Ukraine	0	0	0
182	United Arab Emirates	0	2	2
183	United Kingdom of Great Britain and Northern I...	22045	24796	20620
184	United Republic of Tanzania	635	832	621
185	United States of America	9378	10030	9074
186	Uruguay	128	132	146
187	Uzbekistan	0	0	0
188	Vanuatu	0	0	0
189	Venezuela (Bolivarian Republic of)	103	117	174
190	Viet Nam	1191	1829	2162
191	Western Sahara	0	0	0
192	Yemen	1	2	1
193	Zambia	11	17	11
194	Zimbabwe	72	114	102

```
      1983   1984  1985
```

0	47	71	340
1	0	0	0
2	69	63	44
3	0	0	0
4	0	0	0
5	6	4	3
6	0	42	52
7	241	237	196
8	0	0	0
9	317	317	319
10	117	127	165
11	0	0	0
12	12	21	28
13	1	1	3
14	81	98	92
15	244	265	285
16	0	0	0
17	297	183	181
18	21	37	26
19	3	4	3
20	0	1	0
21	49	38	44
22	0	0	0
23	3	7	4
24	139	145	130
25	2	2	4
26	33	11	24
27	2	3	2
28	0	1	2
29	0	11	1
..	...	...	...
165	12	5	16
166	0	10	7
167	176	128	158
168	370	326	314
169	269	264	385
170	0	0	0
171	65	82	66
172	0	0	0
173	3	6	5
174	1	2	5
175	766	606	699
176	46	51	57
177	280	338	202
178	0	0	0
179	0	1	0
180	38	32	29
181	0	0	0

```
182      1      2     0
183  10015  10170  9564
184    474    473   460
185   7100   6661  6543
186    105     90    92
187      0      0     0
188      0      0     0
189    124    142   165
190   3404   7583  5907
191      0      0     0
192      6      0    18
193      7     16     9
194     44     32    29

[195 rows x 7 columns]
```

1.3.2 Select Row

There are main 3 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 defaul 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 corressponding index value.

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

```
In [19]: 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_i

In [20]: df_can.head(3)

Out[20]:            Continent           Region             DevName  1980  1981  1982  \
         Country
         Afghanistan      Asia    Southern Asia  Developing regions    16    39    39
         Albania        Europe  Southern Europe   Developed regions     1     0     0
         Algeria        Africa  Northern Africa  Developing regions    80    67    71

                      1983  1984  1985  1986  ...  2005  2006  2007  2008  2009  2010  \
         Country                              ...
         Afghanistan    47    71   340   496  ...  3436  3009  2652  2111  1746  1758
         Albania         0     0     0     1  ...  1223   856   702   560   716   561
         Algeria        69    63    44    69  ...  3626  4807  3623  4005  5393  4752

                      2011  2012  2013  Total
```

```
Country
Afghanistan  2203  2635  2004  58639
Albania       539   620   603  15699
Algeria      4325  3774  4331  69439

[3 rows x 38 columns]
```

```
In [21]: # optional: to remove the name of the index
         df_can.index.name = None
         df_can.head()
```

Out[21]:

	Continent	Region	DevName	1980	1981	\
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	\
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
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]

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

```
In [22]: # 1. the full row data (all columns)
         print(df_can.loc['Japan'])

         # alternate methods
         print(df_can.iloc[87])
         print(df_can[df_can.index == 'Japan'].T.squeeze())
```

```
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
Total                   27707
Name: Japan, dtype: object
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
Total                   27707
Name: Japan, dtype: object
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
Total                  27707
Name: Japan, dtype: object
```

```
In [23]: # 2. for year 2013
         print(df_can.loc['Japan', 2013])

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

```
982
982
```

```
In [24]: # 3. for years 1980 to 1985
         print(df_can.loc['Japan', [1980, 1981, 1982, 1983, 1984, 1984]])
         print(df_can.iloc[87, [3, 4, 5, 6, 7, 8]])
```

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

```
In [28]: df_can.columns = list(map(str, df_can.columns))
         # [print (type(x)) for x in df_can.columns.values] #<-- uncomment to check type of co
```

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

1.3.3 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).

```
In [31]: # 1. create the condition boolean series
         condition = df_can['Continent'] == 'Asia'
         print(condition)
```

```
Afghanistan                                 True
Albania                                    False
Algeria                                    False
American Samoa                             False
Andorra                                    False
Angola                                     False
Antigua and Barbuda                        False
Argentina                                  False
Armenia                                     True
Australia                                  False
Austria                                    False
Azerbaijan                                  True
Bahamas                                    False
Bahrain                                     True
Bangladesh                                  True
Barbados                                   False
Belarus                                    False
Belgium                                    False
Belize                                     False
Benin                                      False
Bhutan                                      True
Bolivia (Plurinational State of)           False
Bosnia and Herzegovina                     False
Botswana                                   False
Brazil                                     False
```

```
Brunei Darussalam                                    True
Bulgaria                                            False
Burkina Faso                                        False
Burundi                                             False
Cabo Verde                                          False
                                                    ...
Suriname                                            False
Swaziland                                           False
Sweden                                              False
Switzerland                                         False
Syrian Arab Republic                                 True
Tajikistan                                           True
Thailand                                             True
The former Yugoslav Republic of Macedonia           False
Togo                                                False
Tonga                                               False
Trinidad and Tobago                                 False
Tunisia                                             False
Turkey                                               True
Turkmenistan                                         True
Tuvalu                                              False
Uganda                                              False
Ukraine                                             False
United Arab Emirates                                 True
United Kingdom of Great Britain and Northern Ireland False
United Republic of Tanzania                         False
United States of America                            False
Uruguay                                             False
Uzbekistan                                           True
Vanuatu                                             False
Venezuela (Bolivarian Republic of)                  False
Viet Nam                                             True
Western Sahara                                      False
Yemen                                                True
Zambia                                              False
Zimbabwe                                            False
Name: Continent, Length: 195, dtype: bool
```

```
In [32]: # 2. pass this condition into the dataFrame
         df_can[condition]
```

```
Out[32]:                                          Continent             Region  \
         Afghanistan                                   Asia      Southern Asia
         Armenia                                       Asia       Western Asia
         Azerbaijan                                    Asia       Western Asia
         Bahrain                                       Asia       Western Asia
         Bangladesh                                    Asia      Southern Asia
```

```
Bhutan                                                 Asia       Southern Asia
Brunei Darussalam                                      Asia  South-Eastern Asia
Cambodia                                               Asia  South-Eastern Asia
China                                                  Asia        Eastern Asia
China, Hong Kong Special Administrative Region         Asia        Eastern Asia
China, Macao Special Administrative Region             Asia        Eastern Asia
Cyprus                                                 Asia        Western Asia
Democratic People's Republic of Korea                  Asia        Eastern Asia
Georgia                                                Asia        Western Asia
India                                                  Asia       Southern Asia
Indonesia                                              Asia  South-Eastern Asia
Iran (Islamic Republic of)                             Asia       Southern Asia
Iraq                                                   Asia        Western Asia
Israel                                                 Asia        Western Asia
Japan                                                  Asia        Eastern Asia
Jordan                                                 Asia        Western Asia
Kazakhstan                                             Asia        Central Asia
Kuwait                                                 Asia        Western Asia
Kyrgyzstan                                             Asia        Central Asia
Lao People's Democratic Republic                       Asia  South-Eastern Asia
Lebanon                                                Asia        Western Asia
Malaysia                                               Asia  South-Eastern Asia
Maldives                                               Asia       Southern Asia
Mongolia                                               Asia        Eastern Asia
Myanmar                                                Asia  South-Eastern Asia
Nepal                                                  Asia       Southern Asia
Oman                                                   Asia        Western Asia
Pakistan                                               Asia       Southern Asia
Philippines                                            Asia  South-Eastern Asia
Qatar                                                  Asia        Western Asia
Republic of Korea                                      Asia        Eastern Asia
Saudi Arabia                                           Asia        Western Asia
Singapore                                              Asia  South-Eastern Asia
Sri Lanka                                              Asia       Southern Asia
State of Palestine                                     Asia        Western Asia
Syrian Arab Republic                                   Asia        Western Asia
Tajikistan                                             Asia        Central Asia
Thailand                                               Asia  South-Eastern Asia
Turkey                                                 Asia        Western Asia
Turkmenistan                                           Asia        Central Asia
United Arab Emirates                                   Asia        Western Asia
Uzbekistan                                             Asia        Central Asia
Viet Nam                                               Asia  South-Eastern Asia
Yemen                                                  Asia        Western Asia

                                                          DevName  1980  \
Afghanistan                                 Developing regions    16
Armenia                                     Developing regions     0
```

Azerbaijan	Developing regions	0
Bahrain	Developing regions	0
Bangladesh	Developing regions	83
Bhutan	Developing regions	0
Brunei Darussalam	Developing regions	79
Cambodia	Developing regions	12
China	Developing regions	5123
China, Hong Kong Special Administrative Region	Developing regions	0
China, Macao Special Administrative Region	Developing regions	0
Cyprus	Developing regions	132
Democratic People's Republic of Korea	Developing regions	1
Georgia	Developing regions	0
India	Developing regions	8880
Indonesia	Developing regions	186
Iran (Islamic Republic of)	Developing regions	1172
Iraq	Developing regions	262
Israel	Developing regions	1403
Japan	Developed regions	701
Jordan	Developing regions	177
Kazakhstan	Developing regions	0
Kuwait	Developing regions	1
Kyrgyzstan	Developing regions	0
Lao People's Democratic Republic	Developing regions	11
Lebanon	Developing regions	1409
Malaysia	Developing regions	786
Maldives	Developing regions	0
Mongolia	Developing regions	0
Myanmar	Developing regions	80
Nepal	Developing regions	1
Oman	Developing regions	0
Pakistan	Developing regions	978
Philippines	Developing regions	6051
Qatar	Developing regions	0
Republic of Korea	Developing regions	1011
Saudi Arabia	Developing regions	0
Singapore	Developing regions	241
Sri Lanka	Developing regions	185
State of Palestine	Developing regions	0
Syrian Arab Republic	Developing regions	315
Tajikistan	Developing regions	0
Thailand	Developing regions	56
Turkey	Developing regions	481
Turkmenistan	Developing regions	0
United Arab Emirates	Developing regions	0
Uzbekistan	Developing regions	0
Viet Nam	Developing regions	1191
Yemen	Developing regions	1

	1981	1982	1983	1984	1985	\
Afghanistan	39	39	47	71	340	
Armenia	0	0	0	0	0	
Azerbaijan	0	0	0	0	0	
Bahrain	2	1	1	1	3	
Bangladesh	84	86	81	98	92	
Bhutan	0	0	0	1	0	
Brunei Darussalam	6	8	2	2	4	
Cambodia	19	26	33	10	7	
China	6682	3308	1863	1527	1816	
China, Hong Kong Special Administrative Region	0	0	0	0	0	
China, Macao Special Administrative Region	0	0	0	0	0	
Cyprus	128	84	46	46	43	
Democratic People's Republic of Korea	1	3	1	4	3	
Georgia	0	0	0	0	0	
India	8670	8147	7338	5704	4211	
Indonesia	178	252	115	123	100	
Iran (Islamic Republic of)	1429	1822	1592	1977	1648	
Iraq	245	260	380	428	231	
Israel	1711	1334	541	446	680	
Japan	756	598	309	246	198	
Jordan	160	155	113	102	179	
Kazakhstan	0	0	0	0	0	
Kuwait	0	8	2	1	4	
Kyrgyzstan	0	0	0	0	0	
Lao People's Democratic Republic	6	16	16	7	17	
Lebanon	1119	1159	789	1253	1683	
Malaysia	816	813	448	384	374	
Maldives	0	0	1	0	0	
Mongolia	0	0	0	0	0	
Myanmar	62	46	31	41	23	
Nepal	1	6	1	2	4	
Oman	0	0	8	0	0	
Pakistan	972	1201	900	668	514	
Philippines	5921	5249	4562	3801	3150	
Qatar	0	0	0	0	0	
Republic of Korea	1456	1572	1081	847	962	
Saudi Arabia	0	1	4	1	2	
Singapore	301	337	169	128	139	
Sri Lanka	371	290	197	1086	845	
State of Palestine	0	0	0	0	0	
Syrian Arab Republic	419	409	269	264	385	
Tajikistan	0	0	0	0	0	
Thailand	53	113	65	82	66	
Turkey	874	706	280	338	202	
Turkmenistan	0	0	0	0	0	
United Arab Emirates	2	2	1	2	0	
Uzbekistan	0	0	0	0	0	

Viet Nam	1829	2162	3404	7583	5907
Yemen	2	1	6	0	18

	1986	...	2005	2006	\
Afghanistan	496	...	3436	3009	
Armenia	0	...	224	218	
Azerbaijan	0	...	359	236	
Bahrain	0	...	12	12	
Bangladesh	486	...	4171	4014	
Bhutan	0	...	5	10	
Brunei Darussalam	12	...	4	5	
Cambodia	8	...	370	529	
China	1960	...	42584	33518	
China, Hong Kong Special Administrative Region	0	...	729	712	
China, Macao Special Administrative Region	0	...	21	32	
Cyprus	48	...	7	9	
Democratic People's Republic of Korea	0	...	14	10	
Georgia	0	...	114	125	
India	7150	...	36210	33848	
Indonesia	127	...	632	613	
Iran (Islamic Republic of)	1794	...	5837	7480	
Iraq	265	...	2226	1788	
Israel	1212	...	2446	2625	
Japan	248	...	1067	1212	
Jordan	181	...	1940	1827	
Kazakhstan	0	...	506	408	
Kuwait	4	...	66	35	
Kyrgyzstan	0	...	173	161	
Lao People's Democratic Republic	21	...	42	74	
Lebanon	2576	...	3709	3802	
Malaysia	425	...	593	580	
Maldives	0	...	0	0	
Mongolia	0	...	59	64	
Myanmar	18	...	210	953	
Nepal	13	...	607	540	
Oman	0	...	14	18	
Pakistan	691	...	14314	13127	
Philippines	4166	...	18139	18400	
Qatar	1	...	11	2	
Republic of Korea	1208	...	5832	6215	
Saudi Arabia	5	...	198	252	
Singapore	205	...	392	298	
Sri Lanka	1838	...	4930	4714	
State of Palestine	0	...	453	627	
Syrian Arab Republic	493	...	1458	1145	
Tajikistan	0	...	85	46	
Thailand	78	...	575	500	
Turkey	257	...	2065	1638	

Turkmenistan	0	...	40	26	
United Arab Emirates	5	...	31	42	
Uzbekistan	0	...	330	262	
Viet Nam	2741	...	1852	3153	
Yemen	7	...	161	140	

	2007	2008	2009	2010	\
Afghanistan	2652	2111	1746	1758	
Armenia	198	205	267	252	
Azerbaijan	203	125	165	209	
Bahrain	22	9	35	28	
Bangladesh	2897	2939	2104	4721	
Bhutan	7	36	865	1464	
Brunei Darussalam	11	10	5	12	
Cambodia	460	354	203	200	
China	27642	30037	29622	30391	
China, Hong Kong Special Administrative Region	674	897	657	623	
China, Macao Special Administrative Region	16	12	21	21	
Cyprus	4	7	6	18	
Democratic People's Republic of Korea	7	19	11	45	
Georgia	132	112	128	126	
India	28742	28261	29456	34235	
Indonesia	657	661	504	712	
Iran (Islamic Republic of)	6974	6475	6580	7477	
Iraq	2406	3543	5450	5941	
Israel	2401	2562	2316	2755	
Japan	1250	1284	1194	1168	
Jordan	1421	1581	1235	1831	
Kazakhstan	436	394	431	377	
Kuwait	62	53	68	67	
Kyrgyzstan	135	168	173	157	
Lao People's Democratic Republic	53	32	39	54	
Lebanon	3467	3566	3077	3432	
Malaysia	600	658	640	802	
Maldives	2	1	7	4	
Mongolia	82	59	118	169	
Myanmar	1887	975	1153	556	
Nepal	511	581	561	1392	
Oman	16	10	7	14	
Pakistan	10124	8994	7217	6811	
Philippines	19837	24887	28573	38617	
Qatar	5	9	6	18	
Republic of Korea	5920	7294	5874	5537	
Saudi Arabia	188	249	246	330	
Singapore	690	734	366	805	
Sri Lanka	4123	4756	4547	4422	
State of Palestine	441	481	400	654	
Syrian Arab Republic	1056	919	917	1039	

Tajikistan	44	15	50	52
Thailand	487	519	512	499
Turkey	1463	1122	1238	1492
Turkmenistan	37	13	20	30
United Arab Emirates	37	33	37	86
Uzbekistan	284	215	288	289
Viet Nam	2574	1784	2171	1942
Yemen	122	133	128	211

	2011	2012	2013	Total
Afghanistan	2203	2635	2004	58639
Armenia	236	258	207	3310
Azerbaijan	138	161	57	2649
Bahrain	21	39	32	475
Bangladesh	2694	2640	3789	65568
Bhutan	1879	1075	487	5876
Brunei Darussalam	6	3	6	600
Cambodia	196	233	288	6538
China	28502	33024	34129	659962
China, Hong Kong Special Administrative Region	591	728	774	9327
China, Macao Special Administrative Region	13	33	29	284
Cyprus	6	12	16	1126
Democratic People's Republic of Korea	97	66	17	388
Georgia	139	147	125	2068
India	27509	30933	33087	691904
Indonesia	390	395	387	13150
Iran (Islamic Republic of)	7479	7534	11291	175923
Iraq	6196	4041	4918	69789
Israel	1970	2134	1945	66508
Japan	1265	1214	982	27707
Jordan	1635	1206	1255	35406
Kazakhstan	381	462	348	8490
Kuwait	58	73	48	2025
Kyrgyzstan	159	278	123	2353
Lao People's Democratic Republic	22	25	15	1089
Lebanon	3072	1614	2172	115359
Malaysia	409	358	204	24417
Maldives	3	1	1	30
Mongolia	103	68	99	952
Myanmar	368	193	262	9245
Nepal	1129	1185	1308	10222
Oman	10	13	11	224
Pakistan	7468	11227	12603	241600
Philippines	36765	34315	29544	511391
Qatar	3	14	6	157
Republic of Korea	4588	5316	4509	142581
Saudi Arabia	278	286	267	3425
Singapore	219	146	141	14579

```
Sri Lanka                                3309   3338   2394  148358
State of Palestine                        555    533    462    6512
Syrian Arab Republic                     1005    650   1009   31485
Tajikistan                                 47     34     39     503
Thailand                                  396    296    400    9174
Turkey                                   1257   1068    729   31781
Turkmenistan                               20     20     14     310
United Arab Emirates                       60     54     46     836
Uzbekistan                                162    235    167    3368
Viet Nam                                 1723   1731   2112   97146
Yemen                                     160    174    217    2985

[49 rows x 38 columns]
```

In [33]:
```
# we can pass mutliple 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 '|' inste
# don't forget to enclose the two conditions in parentheses
```

Out[33]:
```
                          Continent         Region             DevName  1980  \
Afghanistan                    Asia  Southern Asia  Developing regions    16
Bangladesh                     Asia  Southern Asia  Developing regions    83
Bhutan                         Asia  Southern Asia  Developing regions     0
India                          Asia  Southern Asia  Developing regions  8880
Iran (Islamic Republic of)     Asia  Southern Asia  Developing regions  1172
Maldives                       Asia  Southern Asia  Developing regions     0
Nepal                          Asia  Southern Asia  Developing regions     1
Pakistan                       Asia  Southern Asia  Developing regions   978
Sri Lanka                      Asia  Southern Asia  Developing regions   185

                           1981  1982  1983  1984  1985  1986  ...   2005  \
Afghanistan                  39    39    47    71   340   496  ...   3436
Bangladesh                   84    86    81    98    92   486  ...   4171
Bhutan                        0     0     0     1     0     0  ...      5
India                      8670  8147  7338  5704  4211  7150  ...  36210
Iran (Islamic Republic of) 1429  1822  1592  1977  1648  1794  ...   5837
Maldives                      0     0     1     0     0     0  ...      0
Nepal                         1     6     1     2     4    13  ...    607
Pakistan                    972  1201   900   668   514   691  ...  14314
Sri Lanka                   371   290   197  1086   845  1838  ...   4930

                           2006  2007  2008  2009  2010  2011  2012  \
Afghanistan                3009  2652  2111  1746  1758  2203  2635
Bangladesh                 4014  2897  2939  2104  4721  2694  2640
Bhutan                       10     7    36   865  1464  1879  1075
```

```
India                          33848  28742  28261  29456  34235  27509  30933
Iran (Islamic Republic of)      7480   6974   6475   6580   7477   7479   7534
Maldives                           0      2      1      7      4      3      1
Nepal                            540    511    581    561   1392   1129   1185
Pakistan                       13127  10124   8994   7217   6811   7468  11227
Sri Lanka                       4714   4123   4756   4547   4422   3309   3338

                               2013   Total
Afghanistan                    2004   58639
Bangladesh                     3789   65568
Bhutan                          487    5876
India                         33087  691904
Iran (Islamic Republic of)    11291  175923
Maldives                          1      30
Nepal                          1308   10222
Pakistan                      12603  241600
Sri Lanka                      2394  148358

[9 rows x 38 columns]
```

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

```
In [34]: print('data dimensions:', df_can.shape)
         print(df_can.columns)
         df_can.head(2)
```

```
data dimensions: (195, 38)
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', 'Total'],
      dtype='object')
```

```
Out[34]:             Continent           Region             DevName  1980  1981  1982  \
         Afghanistan      Asia    Southern Asia  Developing regions    16    39    39
         Albania        Europe  Southern Europe   Developed regions     1     0     0

                      1983  1984  1985  1986  ...  2005  2006  2007  2008  2009  2010  \
         Afghanistan    47    71   340   496  ...  3436  3009  2652  2111  1746  1758
         Albania         0     0     0     1  ...  1223   856   702   560   716   561

                      2011  2012  2013  Total
         Afghanistan  2203  2635  2004  58639
         Albania       539   620   603  15699

         [2 rows x 38 columns]
```

2 Visualizing Data using Matplotlib

2.1 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.

2.1.1 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 [35]: # we are using the inline backend
         %matplotlib inline

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

*optional: check if Matplotlib is loaded.

```
In [36]: print ('Matplotlib version: ', mpl.__version__) # >= 2.0.0
```

```
Matplotlib version:  3.0.2
```

*optional: apply a style to Matplotlib.

```
In [37]: print(plt.style.available)
         mpl.style.use(['ggplot']) # optional: for ggplot-like style
```

```
['bmh', 'classic', 'dark_background', 'fast', 'fivethirtyeight', 'ggplot', 'grayscale', 'seabo
```

2.1.2 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

3 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.

```
In [38]: years = list(map(str, range(1980, 2014)))
         print(years)

         # print(df_can.loc['Haiti'])

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

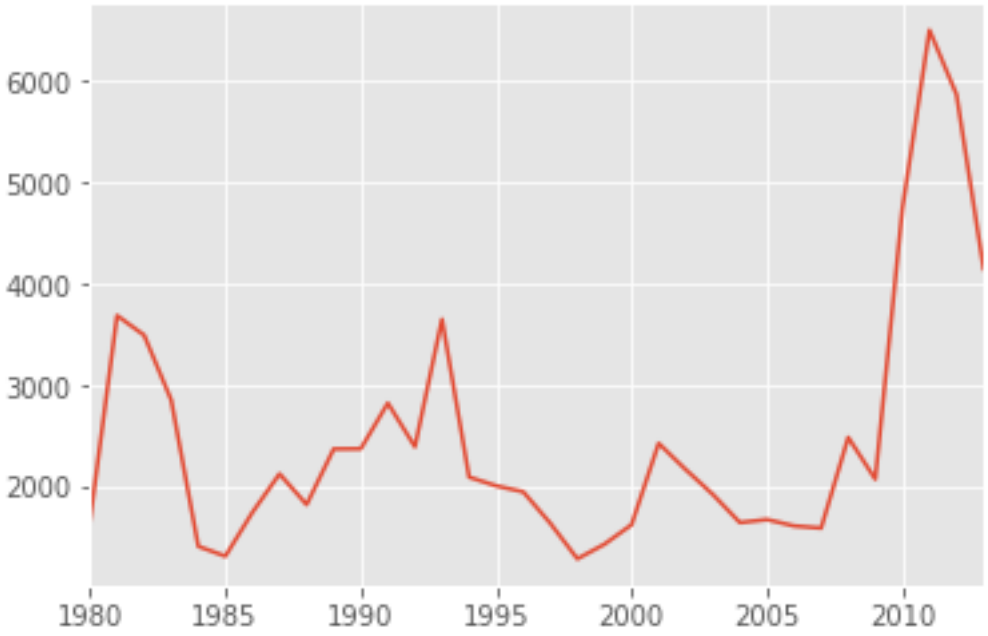
```
['1980', '1981', '1982', '1983', '1984', '1985', '1986', '1987', '1988', '1989', '1990', '1991
```

```
Out[38]: 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 [39]: haiti.plot()
```

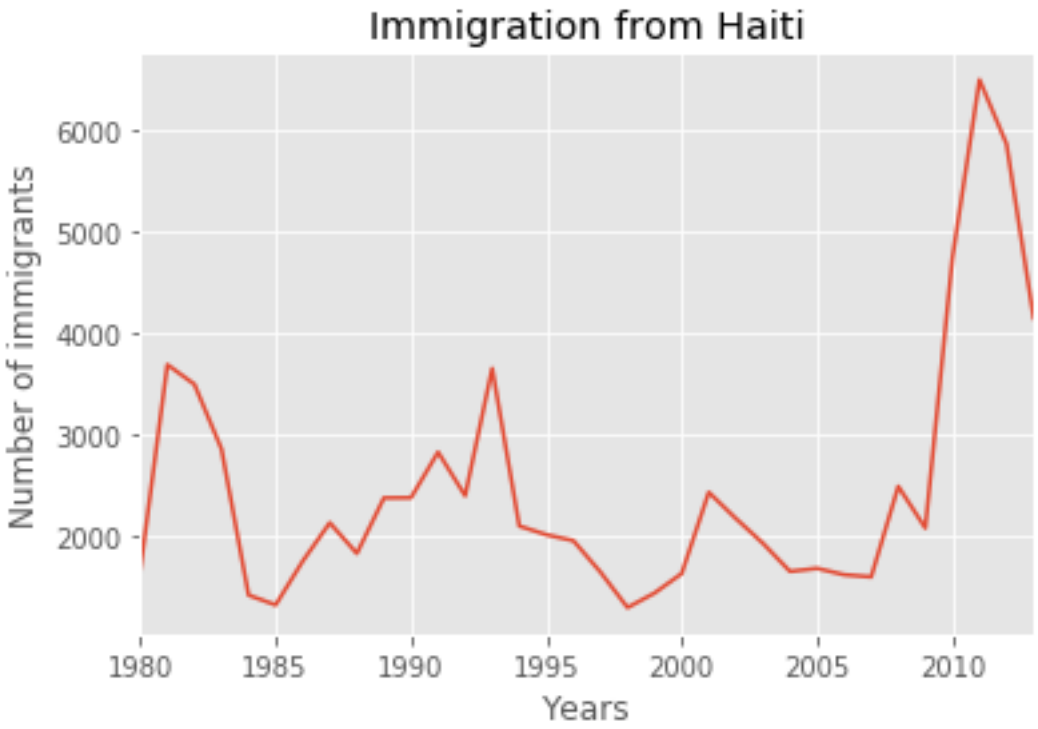
```
Out[39]: <matplotlib.axes._subplots.AxesSubplot at 0x241491451d0>
```



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.

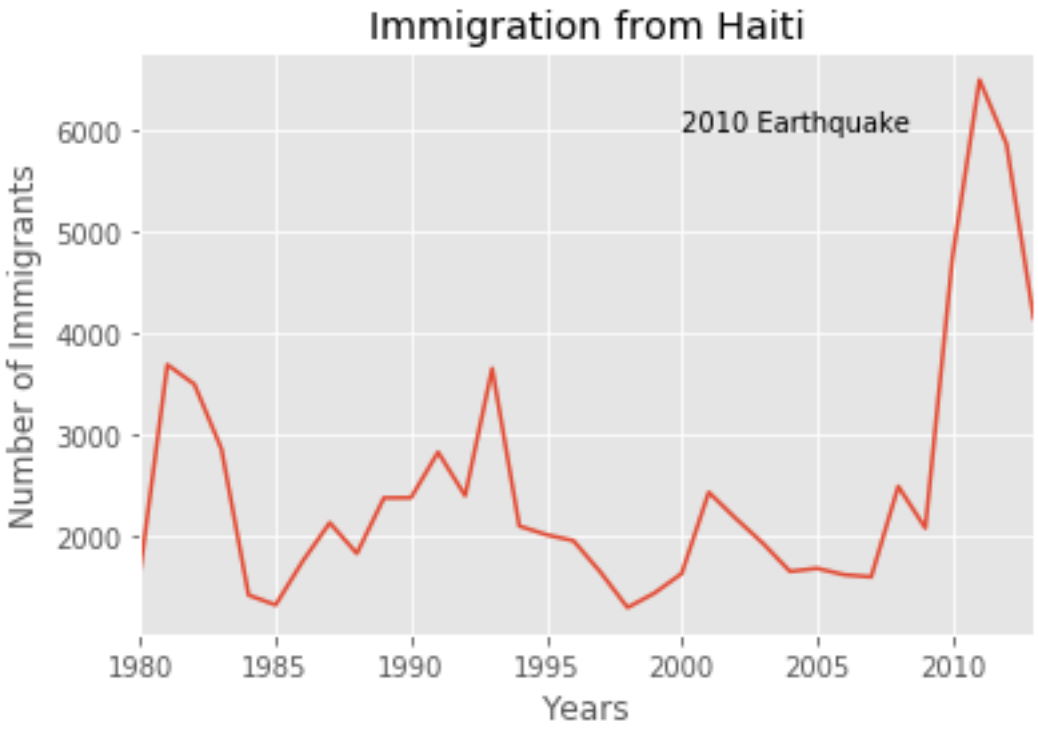
Also, let's label the x and y axis using `plt.title()`, `plt.ylabel()`, and `plt.xlabel()` as follows:

```
In [40]: haiti.index = haiti.index.map(int) # let's change the index values of Haiti to type i
         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.

```
In [41]: 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 i

    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

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

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 dataframe.

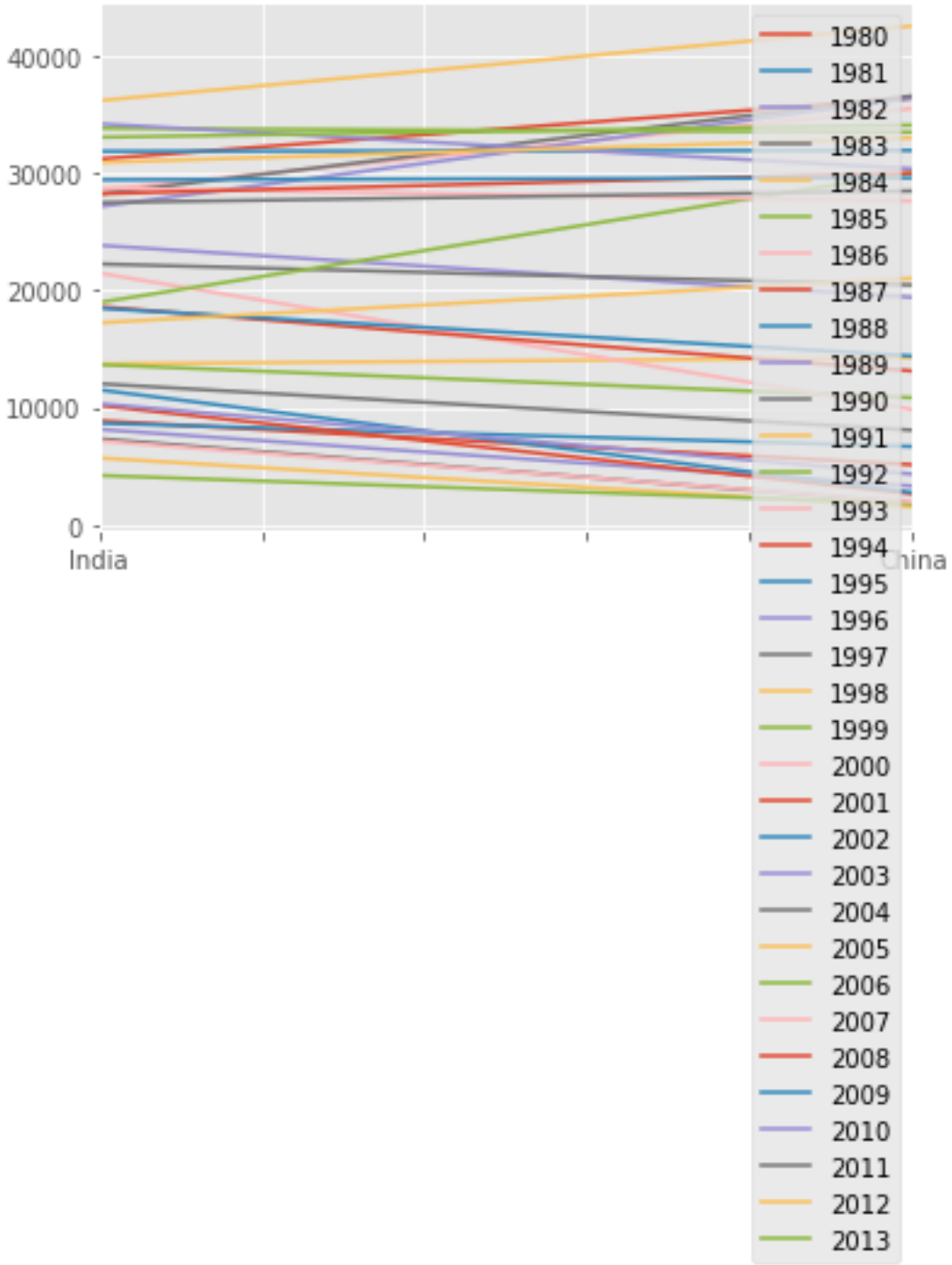
```
In [42]: ### type your answer here

         df_Ind_Chn = df_can.loc[['India','China'], years] # passing in years 1980 - 2013 to e
         df_Ind_Chn.head()
```

```
Out[42]:        1980  1981  1982  1983  1984  1985  1986   1987   1988   1989  ...  \
         India  8880  8670  8147  7338  5704  4211  7150  10189  11522  10343  ...
         China  5123  6682  3308  1863  1527  1816  1960   2643   2758   4323  ...

                 2004   2005   2006   2007   2008   2009   2010   2011   2012   2013
         India  28235  36210  33848  28742  28261  29456  34235  27509  30933  33087
         China  36619  42584  33518  27642  30037  29622  30391  28502  33024  34129

         [2 rows x 34 columns]
```

Double-click **here** for the solution.

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

```
In [43]: ### type your answer here
         df_Ind_Chn.plot(kind='line')

Out[43]: <matplotlib.axes._subplots.AxesSubplot at 0x24149bbb3c8>
```



Double-click **here** for the solution.

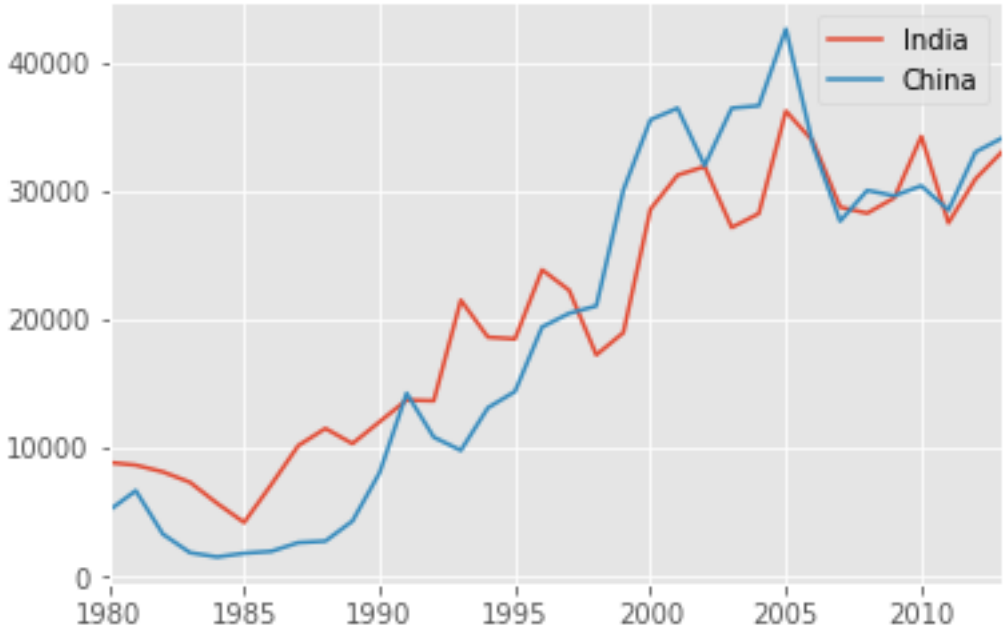
That doesn't look right...

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 [44]: df_Ind_Chn = df_Ind_Chn.transpose()
         df_Ind_Chn.head()

Out[44]:       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 [45]: ### type your answer here
         df_Ind_Chn.index = df_Ind_Chn.index.map(int) # let's change the index values of df_In
         df_Ind_Chn.plot(kind='line')

Out[45]: <matplotlib.axes._subplots.AxesSubplot at 0x24149c05c50>
```



Double-click **here** for the 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.

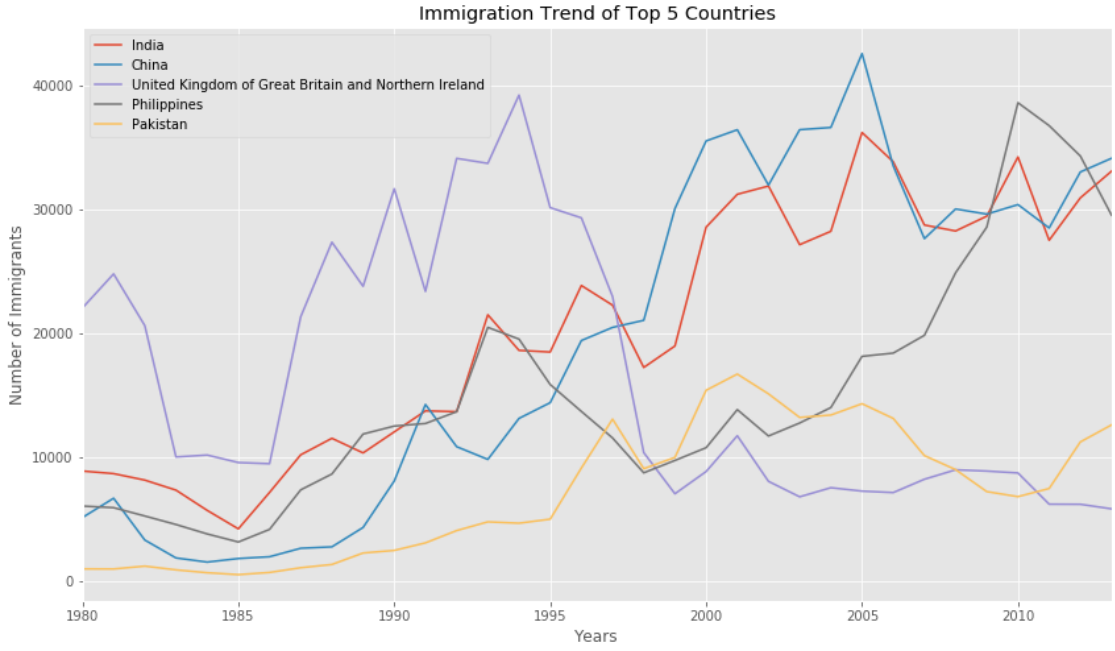
```
print(type(haiti))
print(haiti.head(5))
```

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 [46]: ### type your answer here
         df_can.sort_values(by='Total', ascending=False, axis=0, inplace=True)
         df_top5 = df_can.head(5)
         df_top5 = df_top5[years].transpose()
         # print(df_top5)

         df_top5.index = df_top5.index.map(int) # let's change the index values of df_top5 to
         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()
```



Double-click **here** for the solution.

3.0.1 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

3.0.2 Thank you for completing this lab!

This notebook was originally created by Jay Rajasekharan with contributions from Ehsan M. Kermani, and Slobodan Markovic.

This notebook was recently revised by Alex Aklson. I hope you found this lab session interesting. Feel free to contact me if you have any questions!

This notebook is part of the free course on **Cognitive Class** called *Data Visualization with Python*. If you accessed this notebook outside the course, you can take this free self-paced course online by clicking here.