CS4132 Data Analytics

Lab 7.2: Data Exploration II (Multivariate Data)

Submission Instructions

- Complete the following questions and upload your `.ipynb` file to Coursemology.
- Name the file in the following format: `Lab<num><YourName>.ipynb`
- Before submitting, please ensure you click on "Kernel" > "Restart and Run All" on your jupyter notebook.
- Finally, print a copy of your final solution to OneNote > Your Individual Student Notebook > Labs. Name the page `Lab <num>`.

Q1

Manatees are large, gentle sea creatures that live along the Florida coast. Many manatees are killed or injured by powerboats. The data on powerboat registrations (in thousands) and the number of manatees killed by boats in Florida in the years 1977 to 1990 is given below:

In [190]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from scipy.stats import *
import seaborn as sns
df = pd.read_csv("Lab7iiQ1.csv")
df
```

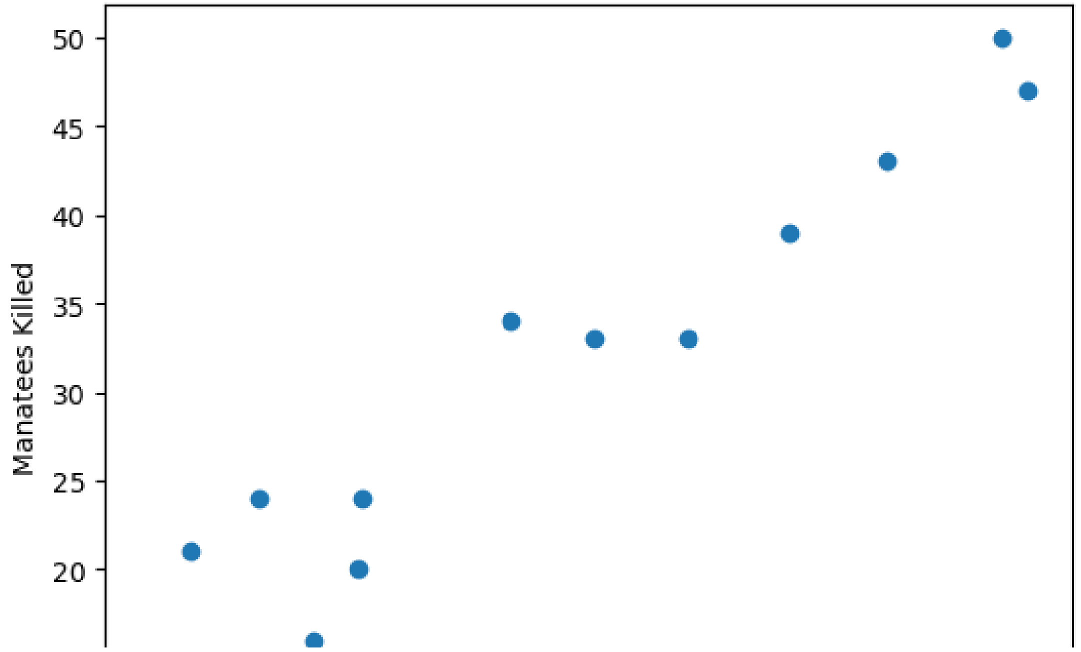
Out[190]:

	Year	Powerboat Registration	Manatees Killed
0	1977	447	13
1	1978	460	21
2	1979	481	24
3	1980	498	16
4	1981	513	24
5	1982	512	20
6	1983	526	15
7	1984	559	34
8	1985	585	33
9	1986	614	33
10	1987	645	39
11	1988	675	43
12	1989	711	50
13	1990	719	47

a) Draw a relevant scatterplot of these data.

In [191]:

```
#your solution
plt.scatter(df['Powerboat Registration'], df['Manatees Killed'])
plt.xlabel('Powerboat Registration')
plt.ylabel('Manatees Killed')
plt.show()
```



b) Find the correlation between number of powerboat registration and number of manatees killed. Conclude your findings.

In [192]:

```
#your solution
pearson_coef = pearsonr(df['Powerboat Registration'], df['Manatees Killed'])[0]
print('r = ', pearson_coef)
print('r^2 = ', pearson_coef**2)
```

```
r =  0.9414772887893057
r^2 =  0.8863794853060617
```

c) Describe your findings from (a) and (b).

```
There is a strong positive linear correlation between number of powerboat regis
tration and the number of manatees killed. That means the more powerboats are r
egistered, the higher the number of manatees killed.
```

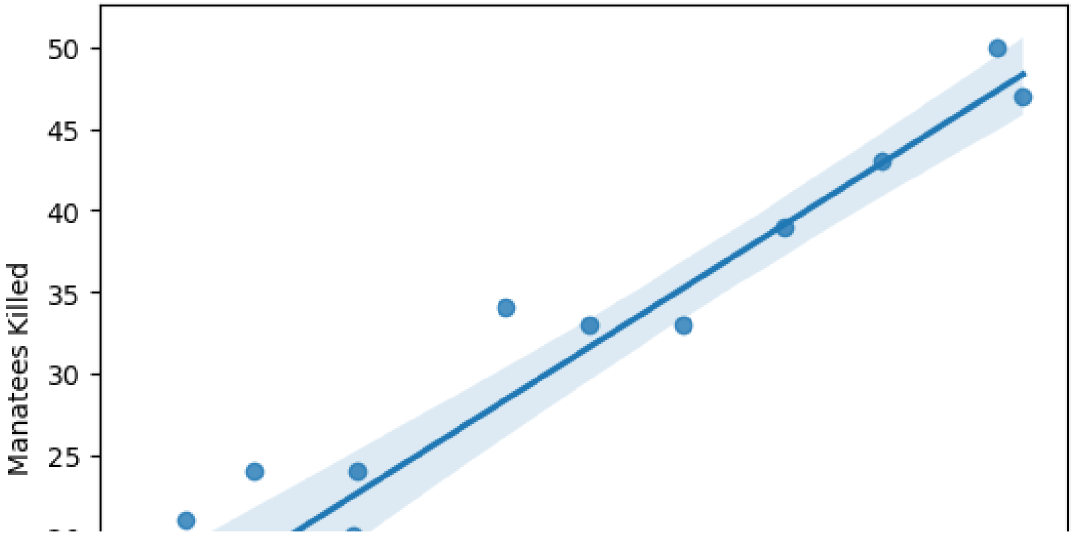
d) Plot a regression line for on the scatterplot.

In [193]:

```
#your solution
sns.regplot(x = df['Powerboat Registration'], y = df['Manatees Killed'], data = df)
```

Out[193]:

```
<Axes: xlabel='Powerboat Registration', ylabel='Manatees Killed'>
```



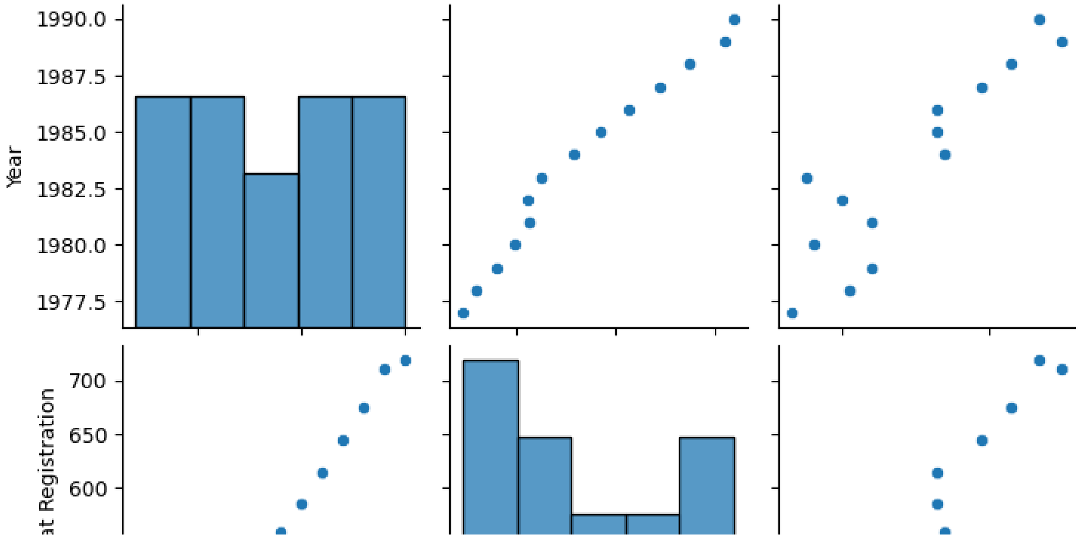
e) Create a pairplot for the data given.

In [194]:

```
#your solution
sns.pairplot(df)
```

Out[194]:

```
<seaborn.axisgrid.PairGrid at 0x2b457477e90>
```



Q2

In this question, we will use the World Happiness Report, which is a survey about the state of global happiness. The data is imported as follows:

In [195]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from scipy.stats import *
import seaborn as sns
data = pd.read_csv('Lab7iiQ2.csv', index_col=0)
data.sort_values(['Year', "Happiness Score"], ascending=[True, False], inplace=True)
data.head()
```

Out[195]:

	Country	Region	Happiness Rank	Happiness Score	Economy (GDP per Capita)	Family	Health (Life Expectancy)	Freedom
141	Switzerland	Western Europe	1.0	7.587	1.39651	1.34951	0.94143	0.66557
60	Iceland	Western Europe	2.0	7.561	1.30232	1.40223	0.94784	0.62877
38	Denmark	Western Europe	3.0	7.527	1.32548	1.36058	0.87464	0.64938
108	Norway	Western Europe	4.0	7.522	1.45900	1.33095	0.88521	0.66973
25	Canada	North America	5.0	7.427	1.32629	1.32261	0.90563	0.63297

Below is a short description of what each column means:

- **Happiness Score:** A metric measured in 2015 by asking the sampled people the question: "How would you rate your happiness on a scale of 0 to 10 where 10 is the happiest."
- **Economy (GDP per Capita):** The extent to which GDP contributes to the calculation of the Happiness Score.
- **Family:** The extent to which Family contributes to the calculation of the Happiness Score
- **Health (Life Expectancy):** The extent to which Life expectancy contributed to the calculation of the Happiness Score
- **Freedom:** The extent to which Freedom contributed to the calculation of the Happiness Score.
- **Trust (Government Corruption):** The extent to which Perception of Corruption contributes to Happiness Score.
- **Generosity:** The extent to which Generosity contributed to the calculation of the Happiness Score.

a) We will summarize the happiness score in this part (using mean).

i) Summarize the happiness score by year in a table.

In [196]:

```
#your solution
data.groupby('Year')['Happiness Score'].mean().to_frame()
```

Out[196]:

	Happiness Score
Year	
2015	5.375734
2016	5.382185
2017	5.354019

ii) Summarize the happiness score by region in a table.

In [197]:

```
#your solution
data.groupby('Region')['Happiness Score'].mean().to_frame()
```

Out[197]:

	Happiness Score
Region	
Australia and New Zealand	7.302500
Central and Eastern Europe	5.371184
Eastern Asia	5.632333
Latin America and Caribbean	6.069074
Middle East and Northern Africa	5.387879
North America	7.227167
Southeastern Asia	5.364077
Southern Asia	4.590857
Sub-Saharan Africa	4.150957
Western Europe	6.693000

iii) Summarize the happiness score by region, per year in a table.

Sample output:

		Happiness Score
Region	**Year**	
Australia and New Zealand	2015	7.285000
	2016	7.323500
	2017	7.299000

In [198]:

```
#your solution
data.groupby(['Region', 'Year'])['Happiness Score'].mean().to_frame()
```

Out[198]:

```
                                   Happiness Score
              Region        Year
Australia and New Zealand   2015          7.285000
                            2016          7.323500
                            2017          7.299000
Central and Eastern Europe  2015          5.332931
                            2016          5.370690
                            2017          5.409931
             Eastern Asia   2015          5.626167
                            2016          5.624167
                            2017          5.646667
                            2015          6.144682
```

iv) Summarize the happiness score by region, per year similar to (c), but we would like the years to be in columns.

Sample output:

Year	2015	2016	2017
Region			
Australia and New Zealand	7.285000	7.323500	7.299000
Central and Eastern Europe	5.332931	5.370690	5.409931

In [199]:

```
#your solution
pivot = pd.pivot_table(data, index = 'Region', columns='Year', values='Happiness Score')
pivot
```

Out[199]:

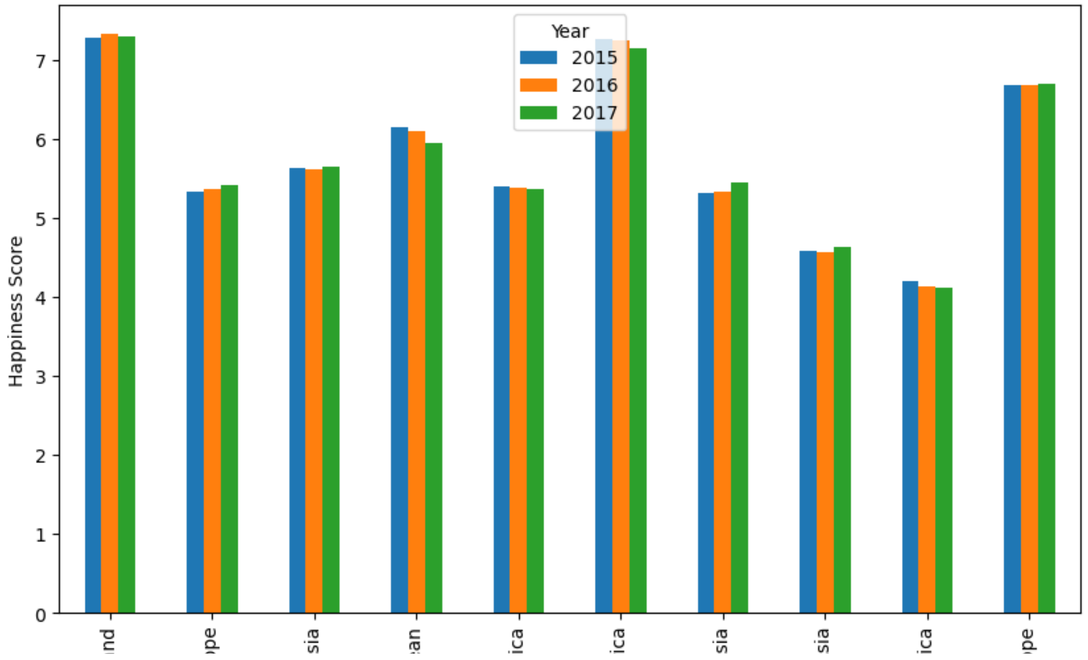
Year	2015	2016	2017
Region			
Australia and New Zealand	7.285000	7.323500	7.299000
Central and Eastern Europe	5.332931	5.370690	5.409931
Eastern Asia	5.626167	5.624167	5.646667
Latin America and Caribbean	6.144682	6.101750	5.957818
Middle East and Northern Africa	5.406900	5.386053	5.369684
North America	7.273000	7.254000	7.154500
Southeastern Asia	5.317444	5.338889	5.444875
Southern Asia	4.580857	4.563286	4.628429
Sub-Saharan Africa	4.202800	4.136421	4.111949
Western Europe	6.689619	6.685667	6.703714

Let's visualize the data in (iv)

Plot a suitable grouped bar chart for the data in (iv)

In [200]:

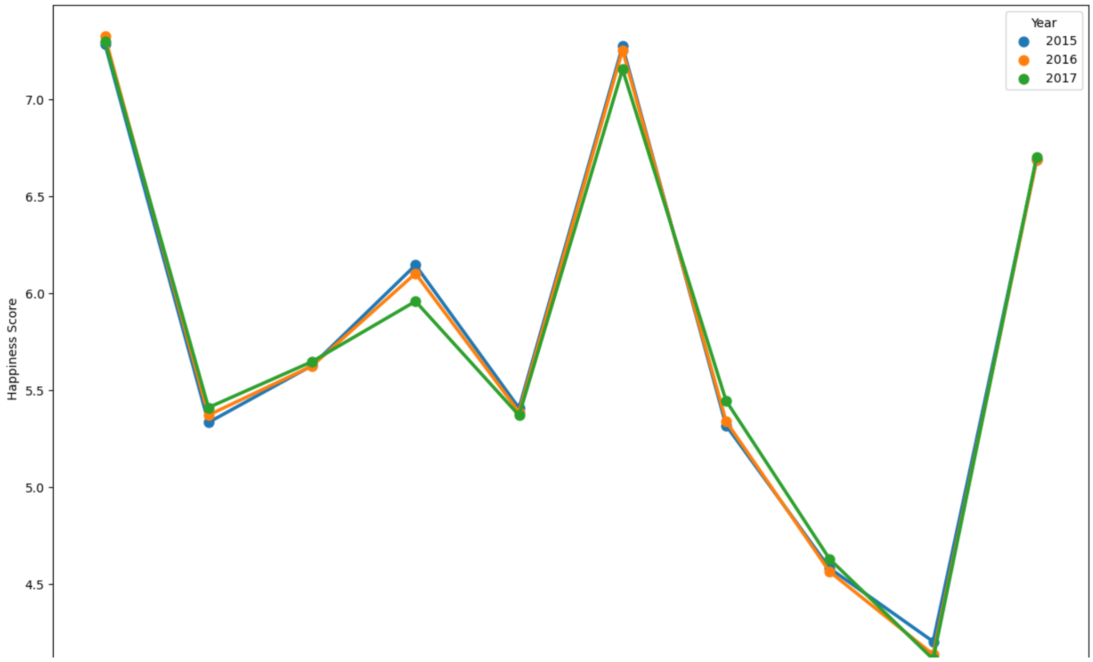
```
#your solution
pivot.plot(kind= 'bar', figsize=(10, 6))
plt.ylabel("Happiness Score")
plt.show()
```



Plot a suitable pointplot for the data in (iv)

In [201]:

```
#your solution
plt.figure(figsize = (15, 10))
plt.xticks(rotation = 90)
sns.pointplot(x = 'Region', y = 'Happiness Score', hue = 'Year', data = pivot.reset_inde
plt.show()
```



Hence, which plot do you think is a better visualization for data in (iv). Justify your answer clearly.

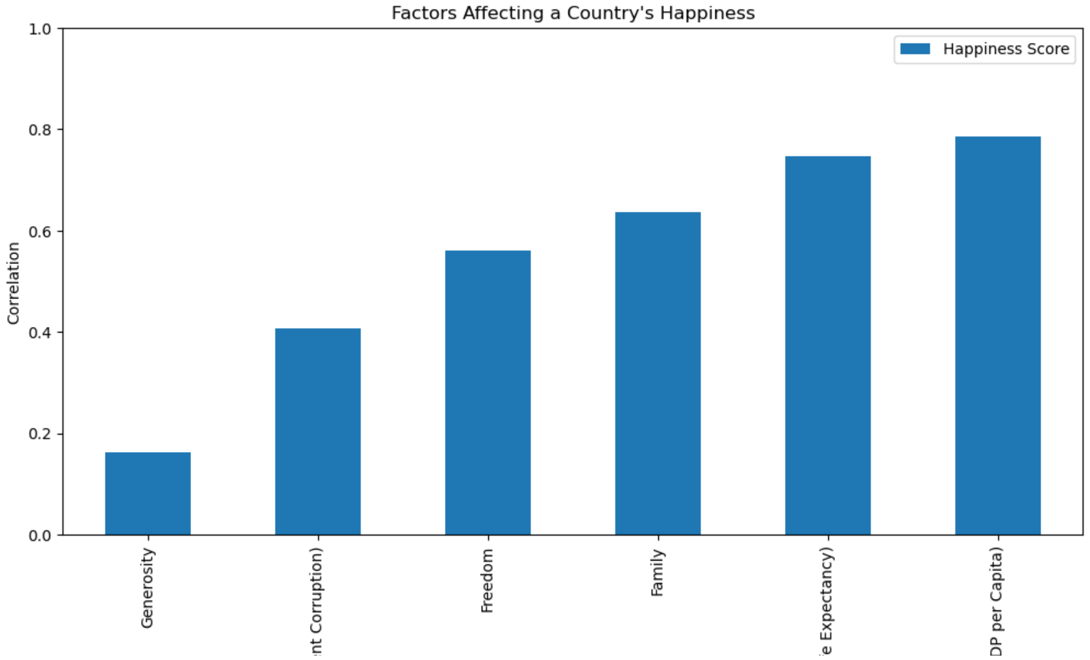
Grouped bar chart. We are not looking for trends over a period of time, and the points are very close together on the pointplot.

b) Perform relevant EDA to answer the following question:

Which of the six variables ['Economy (GDP per Capita)', 'Family', 'Health (Life Expectancy)','Freedom', 'Trust (Government Corruption)', 'Generosity'] most affect a country’s “happiness”?

In [202]:

```
#your solution
columns = ['Happiness Score', 'Economy (GDP per Capita)', 'Family', 'Health (Life Expect
newdata = data[columns]
newdata = newdata[(~newdata.Family.isnull())]
correlations = newdata[columns].corr().iloc[0, 1:].to_frame().sort_values(by = 'Happines
correlations.plot(kind='bar', figsize=(12, 6))
plt.title('Factors Affecting a Country\'s Happiness')
plt.xlabel('Factor')
plt.ylabel('Correlation')
plt.ylim((0, 1))
plt.show()
```



Justify your answer based on the insights gained from the plot.

GDP Per Capita. The GDP Per Capita has the strongest postive linear correlation with a country's happiness and hence the highest value in the bar chart.

c) Find each factor's correlation with the overall happiness score. Store the data in a dataframe.

In [203]:

```
#your solution
factors = data.corr().loc['Happiness Score'].to_frame()
factors
```

```
C:\Users\user\AppData\Local\Temp\ipykernel_24836\1758012939.py:2: FutureWa
rning: The default value of numeric_only in DataFrame.corr is deprecated.
In a future version, it will default to False. Select only valid columns o
r specify the value of numeric_only to silence this warning.
  factors = data.corr().loc['Happiness Score'].to_frame()
```

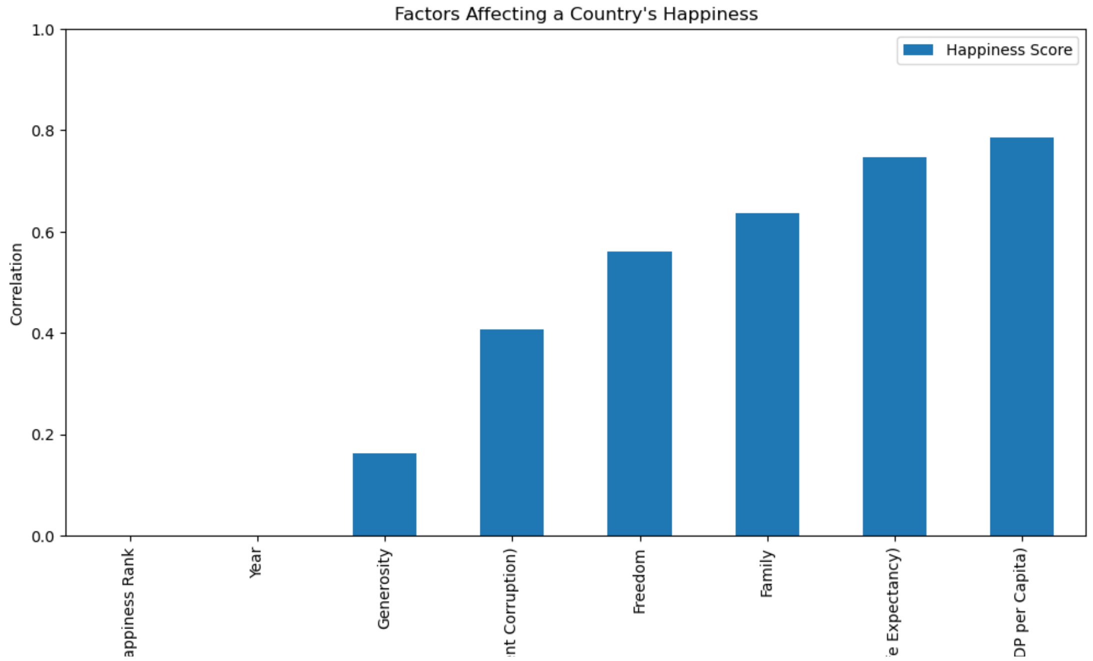
Out[203]:

	Happiness Score
Happiness Rank	-0.993268
Happiness Score	1.000000
Economy (GDP per Capita)	0.785450
Family	0.636532
Health (Life Expectancy)	0.748040
Freedom	0.560353
Trust (Government Corruption)	0.406340
Generosity	0.163562
Year	-0.007761

d) Plot a bar graph to visualize the data in c)

In [204]:

```
#your solution
factors = factors.loc[~factors.index.str.contains('Happiness Score')].sort_values(by = '
factors.plot(kind='bar', figsize=(12, 6))
plt.title('Factors Affecting a Country\'s Happiness')
plt.xlabel('Factor')
plt.ylabel('Correlation')
plt.ylim((0, 1))
plt.show()
```



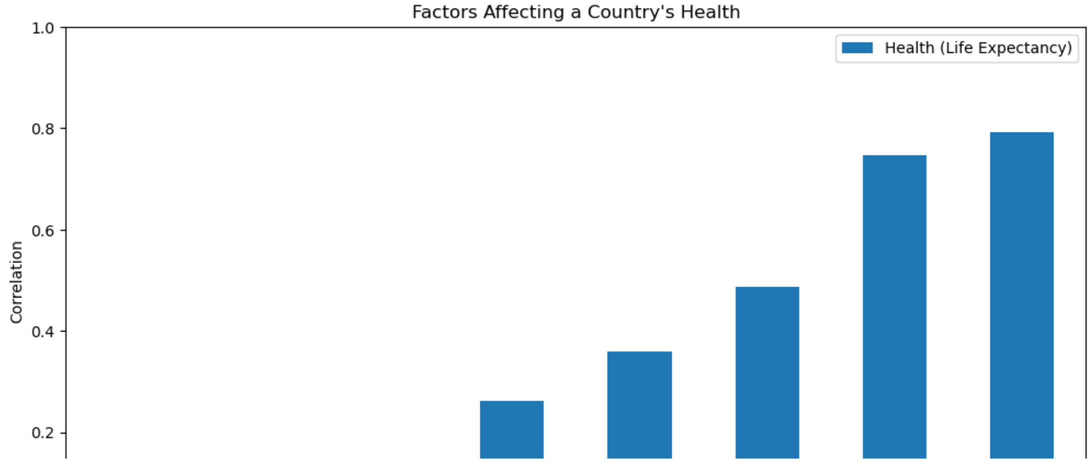
e) You are to shortlist a question you wish to investigate (and not already covered above) using the data given.

Based on what you have learnt thus far, perform relevant EDA to help answer your question.

In [205]:

```
#your solution
#What factors affect a country's health the most?
factors = data.corr().loc['Health (Life Expectancy)'].to_frame()
factors = factors.loc[(~factors.index.str.contains('Health'))].sort_values(by = 'Health
factors.plot(kind='bar', figsize=(12, 6))
plt.title('Factors Affecting a Country\'s Health')
plt.xlabel('Factor')
plt.ylabel('Correlation')
plt.ylim((0, 1))
plt.show()
```

```
C:\Users\user\AppData\Local\Temp\ipykernel_24836\258552304.py:3: Future
Warning: The default value of numeric_only in DataFrame.corr is depreca
ted. In a future version, it will default to False. Select only valid c
olumns or specify the value of numeric_only to silence this warning.
  factors = data.corr().loc['Health (Life Expectancy)'].to_frame()
```



Hence, state your observations/conclusion.

Excluding Happiness rank and Year, the country's economy has the highest effect on a country's health.

f) We discussed the pairplot in the notes. In contrast to the `sns.pairplot` function, `sns.PairGrid` is a class which means that it does not automatically fill in the plots for us. Instead, we create a class instance and then we map specific functions to the different sections of the grid.

Read more about PairGrid and how to use it: https://seaborn.pydata.org/generated/seaborn.PairGrid.html (https://seaborn.pydata.org/generated/seaborn.PairGrid.html)

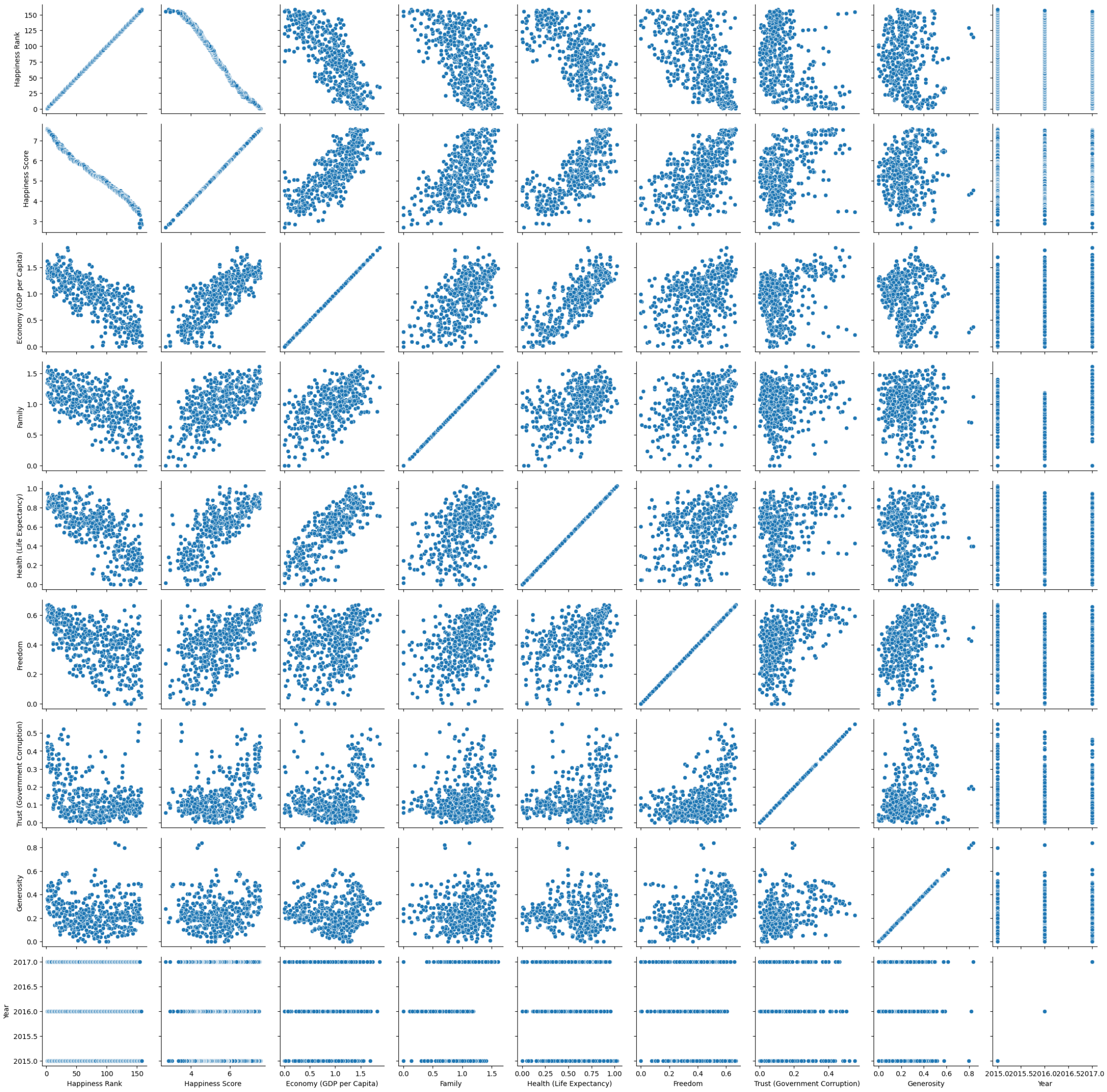
Plot a relevant PairGrid to visualize the data in this question.

In [207]:

```
#your solution
g = sns.PairGrid(data)
g.map(sns.scatterplot)
g
```

Out[207]:

```
<seaborn.axisgrid.PairGrid at 0x2b45eb01490>
```



Do some customization to the PairGrid such that the diagonal will display the respective 5-number summary instead of the histogram.

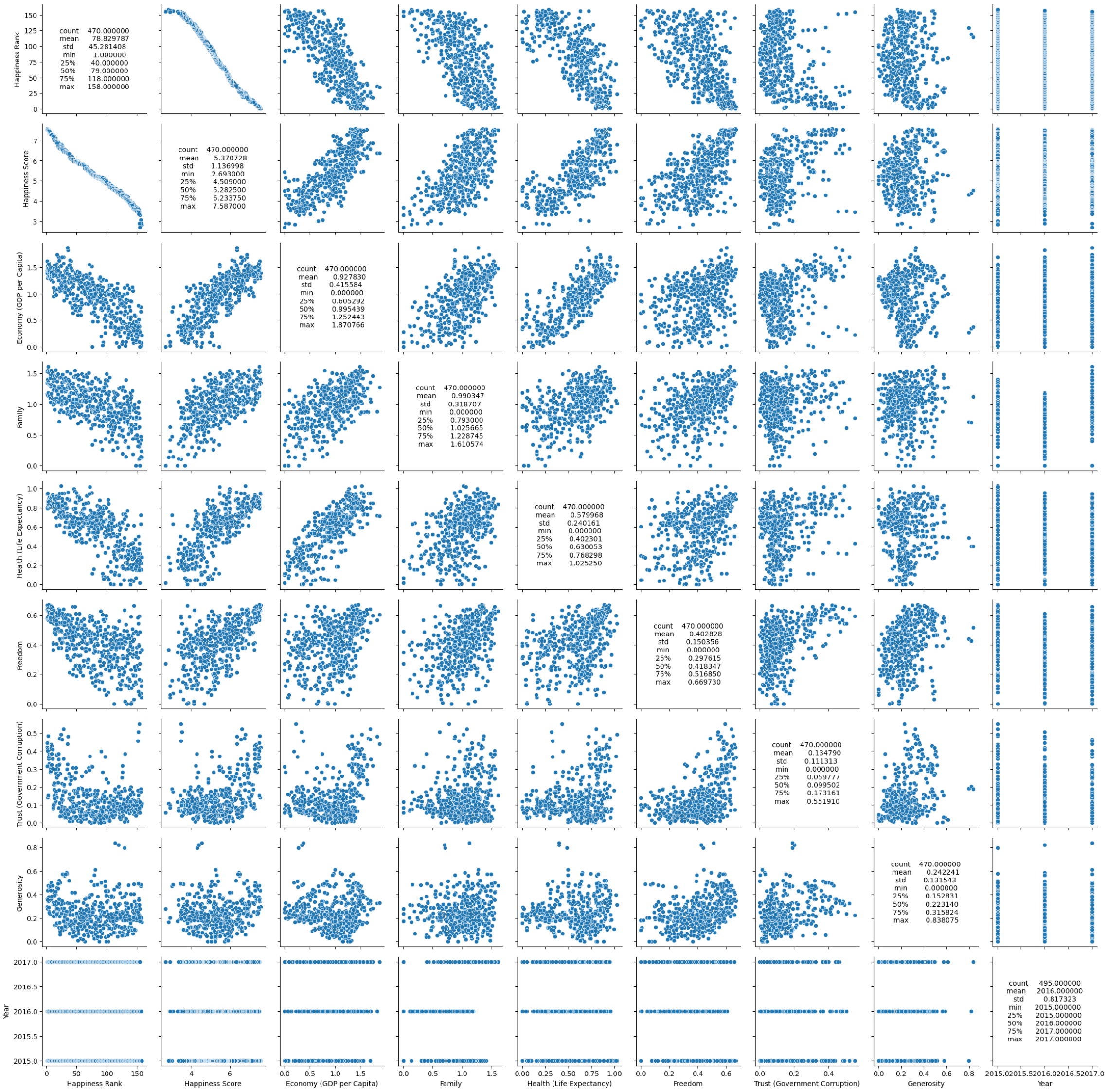
In [ ]:

```
#your solution
def summ(data, **kwargs):
    data = pd.Series(data)
    ax = plt.gca()
    ax.annotate(data.describe().to_string(), xy=(0.5,0.5), xycoords='axes fraction', ha=

g = sns.PairGrid(data)
g.map_diag(summ)
g.map_offdiag(sns.scatterplot)
g
```

Out[170]:

```
<seaborn.axisgrid.PairGrid at 0x2b39b1c1750>
```



```
count    470.000000
mean      78.829787
std       45.281408
min        1.000000
25%       40.000000
50%       79.000000
75%      118.000000
max      158.000000
```

```
count    470.000000
mean       5.370728
std        1.136998
min        2.693000
25%        4.509000
50%        5.282500
75%        6.233750
max        7.587000
```

```
count    470.000000
mean       0.927830
std        0.415584
min        0.000000
25%        0.605292
50%        0.995439
75%        1.252443
max        1.870766
```

```
count    470.000000
mean       0.990347
std        0.318707
min        0.000000
25%        0.793000
50%        1.025665
75%        1.228745
max        1.610574
```

```
count    470.000000
mean       0.579968
std        0.240161
min        0.000000
25%        0.402301
50%        0.630053
75%        0.768298
max        1.025250
```

```
count    470.000000
mean       0.402828
std        0.150356
min        0.000000
25%        0.297615
50%        0.418347
75%        0.516850
max        0.669730
```

```
count    470.000000
mean       0.134790
std        0.111313
min        0.000000
25%        0.059777
50%        0.099502
75%        0.173161
max        0.551910
```

```
count    470.000000
mean       0.242241
std        0.131543
min        0.000000
25%        0.152831
50%        0.223140
75%        0.315824
max        0.838075
```

```
count     495.000000
mean     2016.000000
std         0.817323
min      2015.000000
25%      2015.000000
50%      2016.000000
75%      2017.000000
max      2017.000000
```

g) There is another class called the `sns.FacetGrid` which maps a dataset onto multiple axes arrayed in a grid of rows and columns that correspond to levels of variables in the dataset.

Read more about FacetGrid and how to use it:
[https://seaborn.pydata.org/generated/seaborn.FacetGrid.html (https://seaborn.pydata.org/generated/seaborn.FacetGrid.html)](https://seaborn.pydata.org/generated/seaborn.FacetGrid.html)

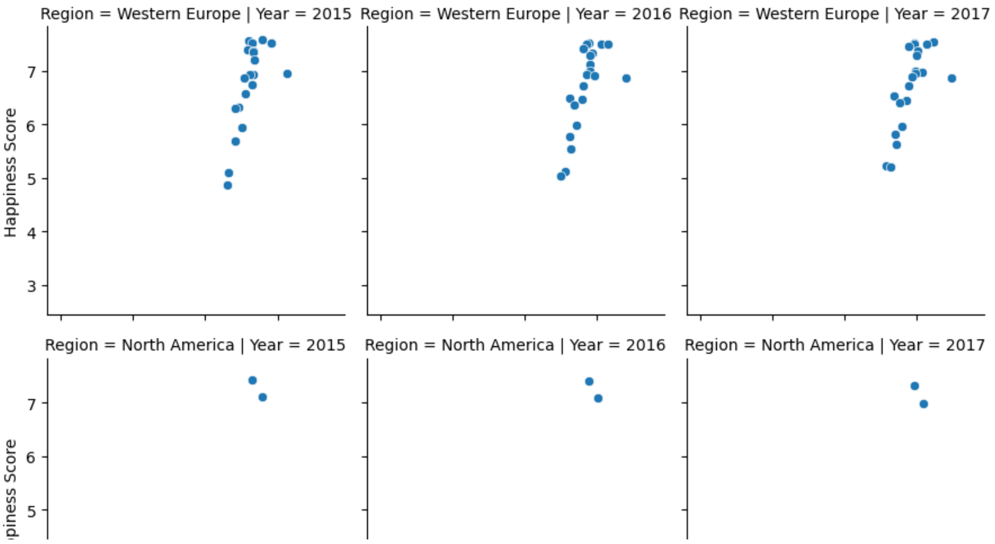
Plot a relevant FacetGrid to visualize the relationship between Happiness Score and GDP by Region (row)

In [ ]:

```
#your solution
g = sns.FacetGrid(data, col = 'Year',  row = 'Region')
g.map(sns.scatterplot, 'Economy (GDP per Capita)', 'Happiness Score')
```

Out[177]:

```
<seaborn.axisgrid.FacetGrid at 0x2b453835d50>
```



Hence, state the differences between pairplot, PairGrid and FacetGrid.

PairGrid plots a relationship using each column of a dataset against every column in a dataset.

FacetGrid plots a relationship of 2 values with every combination of 2 chosen variables

Q3

The data below shows the keyword search on the terms 'diet', 'gym' and 'finance' on Google over time.

In [336]:

```
import pandas as pd, seaborn as sns, matplotlib.pyplot as plt
df = pd.read_csv('Lab7iiQ3.csv', skiprows=1)
df.columns = ['month', 'diet', 'gym', 'finance']
df.head()
```

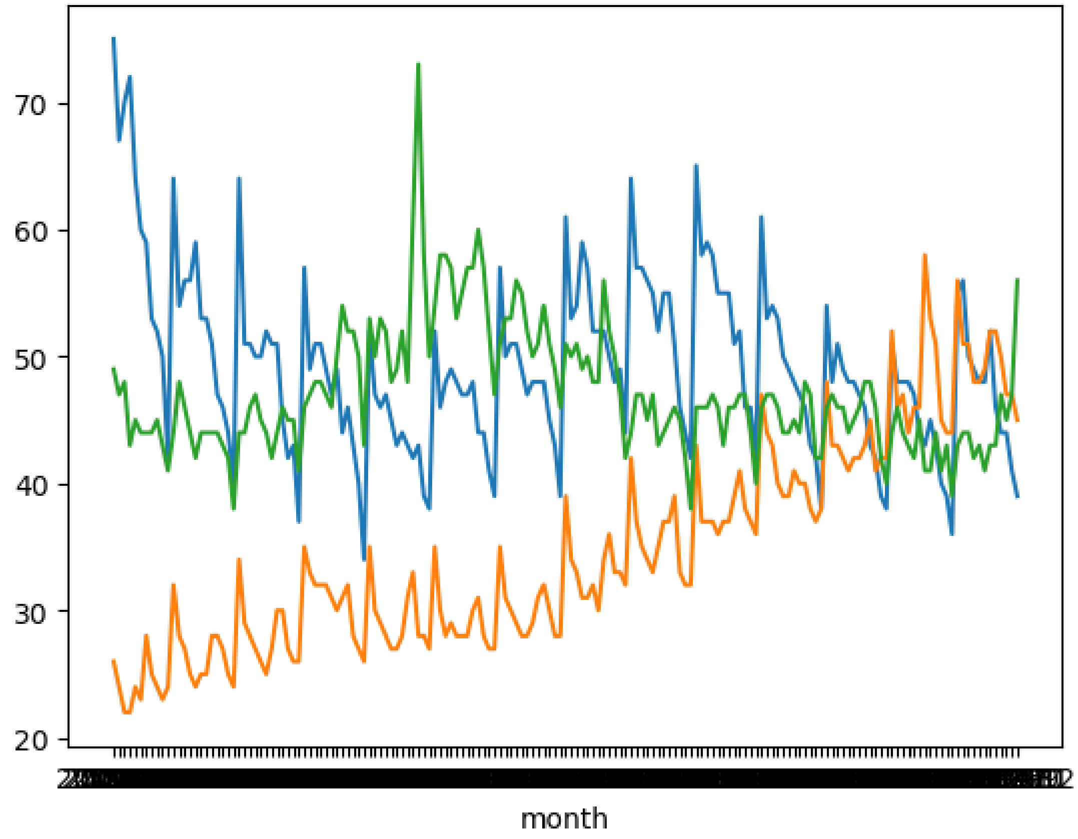
Out[336]:

	month	diet	gym	finance
0	2004-02	75	26	49
1	2004-03	67	24	47
2	2004-04	70	22	48
3	2004-05	72	22	43
4	2004-06	64	24	45

a) Without making any changes to the dataframe, try to plot a trend graph for the data using the lineplot function in seaborn. Note that the 3 lines should be displayed in the same graph. The y-axis will be the frequency, and x-axis will be the months.

In [337]:

```
#your solution
sns.lineplot(data = df, x = df.month, y = df.diet, )
sns.lineplot(data = df, x = df.month, y = df.gym)
sns.lineplot(data = df, x = df.month, y = df.finance)
plt.ylabel('')
plt.show()
```



What do you notice about the x-axis of your plot?

The x-axis displays every single month

b) Now, update month into a datetime attribute. Next, reindex the df such that month is the index. Display the df.

In [338]:

```
#your solution
df.month = pd.to_datetime(df['month'])
df.set_index(keys = 'month')
```

Out[338]:

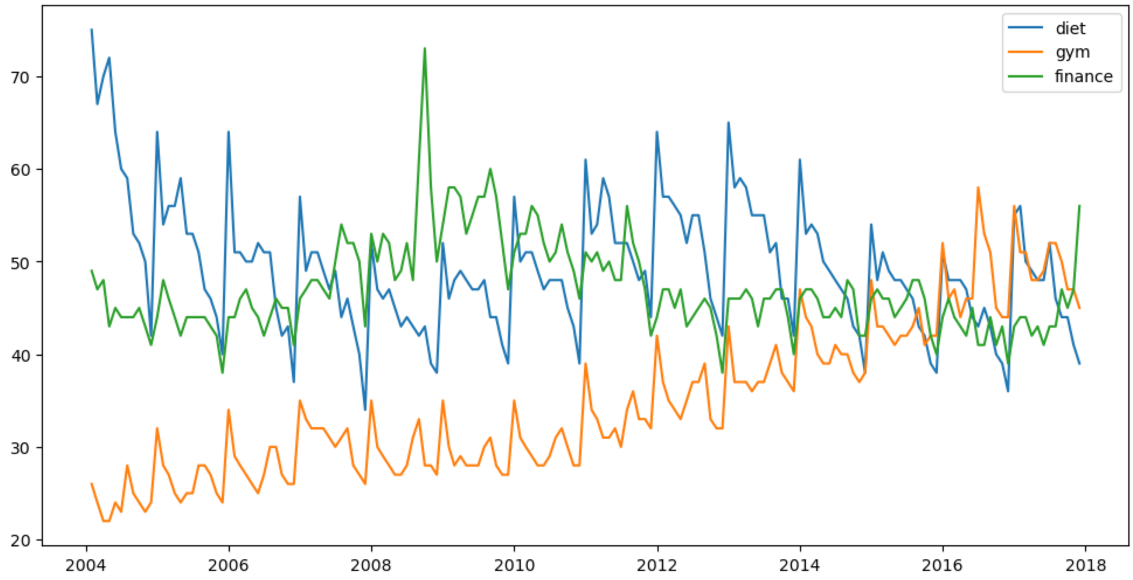
	diet	gym	finance
month			
2004-02-01	75	26	49
2004-03-01	67	24	47
2004-04-01	70	22	48
2004-05-01	72	22	43
2004-06-01	64	24	45
...	...	...	...
2017-08-01	46	52	43
2017-09-01	44	50	47
2017-10-01	44	47	45
2017-11-01	41	47	47
2017-12-01	39	45	56

167 rows × 3 columns

c) Plot a new trend graph using the dataframe from b) using the matplotlib `plot` function.

In [339]:

```
#your solution
plt.figure(figsize = (12, 6))
plt.plot(df.month, df.diet)
plt.plot(df.month, df.gym)
plt.plot(df.month, df.finance)
plt.legend(['diet', 'gym', 'finance'])
plt.show()
```



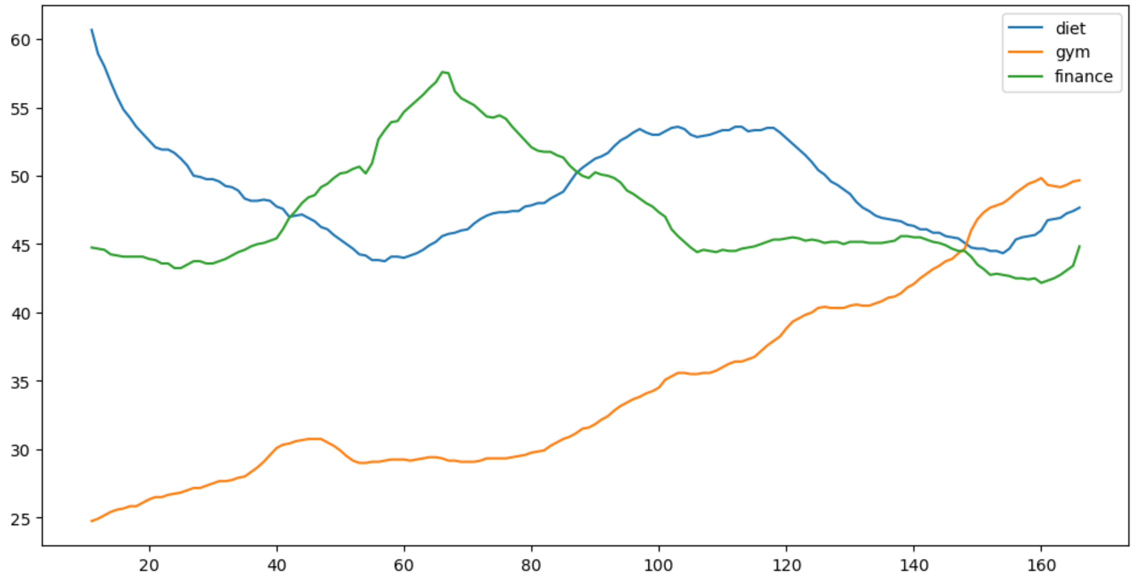
Compare the differences between the graph from (a) and (c).

Graph in a displays every single month and has no legend while graph in c displays by years in the axis and does not show every month, while still showing it in the graph and has a legend.

d) We would now like to identify trends in the time series for the 3 searches. One popular way is by rolling average. Plot a respective trend graph using rolling average method for each of the 3 searches in a single plot.

In [340]:

```
#your solution
df['dietroll'] = df.diet.rolling(window = 12).mean()
df['gymroll'] = df.gym.rolling(window = 12).mean()
df['financeroll'] = df.finance.rolling(window = 12).mean()
df[['dietroll', 'gymroll', 'financeroll']].plot(kind='line', figsize=(12,6))
plt.legend(['diet', 'gym', 'finance'])
plt.show()
```



Key in your observations for each graph.

Rolling average of gym increased from about 25 to 50 over the years

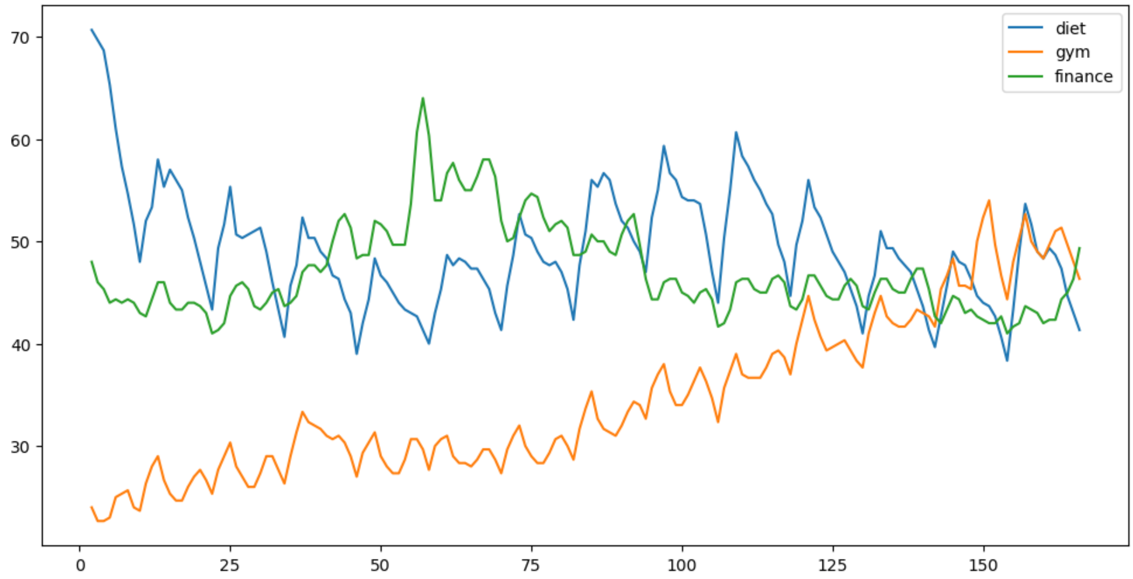
Rolling average of diet decreased then increased and decreased again from 60 to 45

Rolling average of finance increased then decreased then plateaued from 45 to 45

e) Is there any seasonal flunctations in the time series data? How would you investigate this?

In [341]:

```
#your solution
#Use window of 3 since each season is around 3 months
df['dietroll'] = df.diet.rolling(window = 3).mean()
df['gymroll'] = df.gym.rolling(window = 3).mean()
df['financeroll'] = df.finance.rolling(window = 3).mean()
df[['dietroll', 'gymroll', 'financeroll']].plot(kind='line', figsize=(12,6))
plt.legend(['diet', 'gym', 'finance'])
plt.show()
```



Key in your observations for each graph.

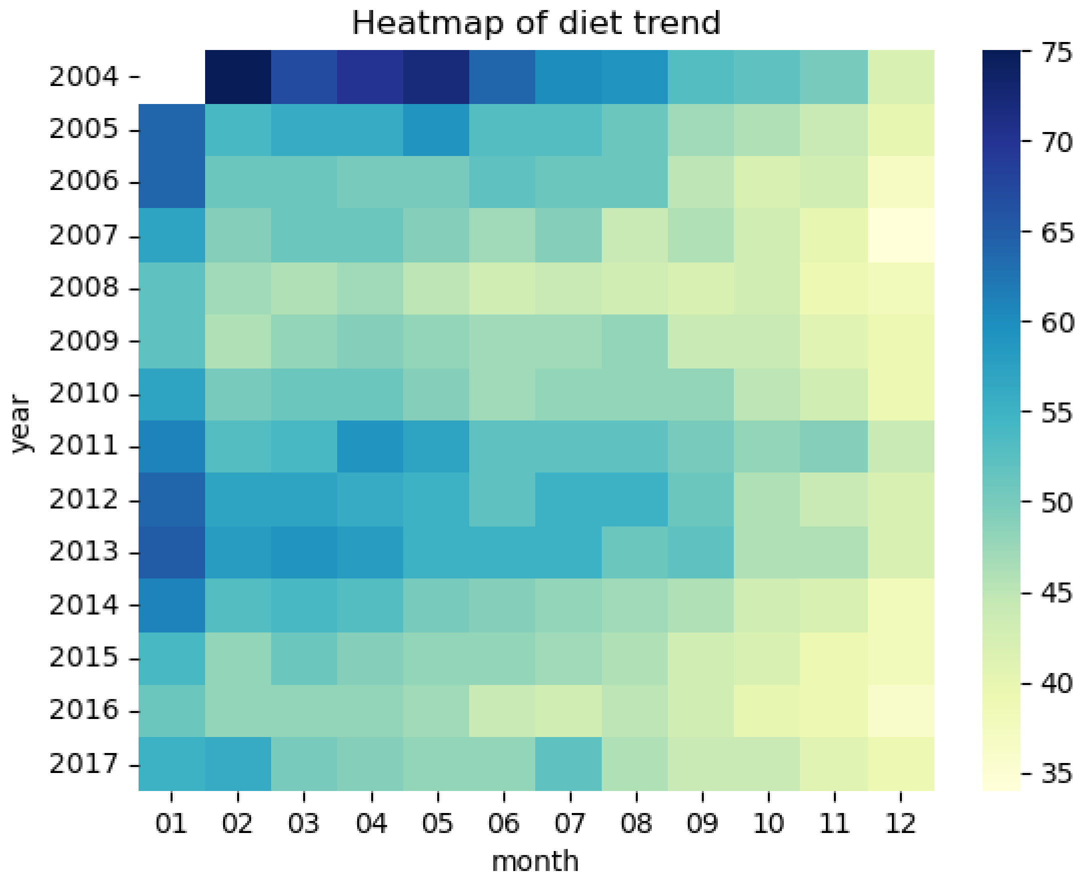
double click to type your answer here

f) Plot a time series heatmap for the 'diet' trend. The x-axis represents the months (from 1 to 12) and the y-axis represents the years.

In [342]:

```
#your solution
df['year'] = df.month.dt.strftime('%Y')
df['month'] = df.month.dt.strftime('%m')
data_pivot = df.pivot('year', 'month', 'diet')
sns.heatmap(data_pivot, cmap='YlGnBu')
plt.title('Heatmap of diet trend')
plt.show()
```

```
C:\Users\user\AppData\Local\Temp\ipykernel_24836\1756572870.py:4: FutureWa
rning: In a future version of pandas all arguments of DataFrame.pivot will
be keyword-only.
  data_pivot = df.pivot('year', 'month', 'diet')
```



Key in your observations for the graph.

Diet frequency decreases over the months of a year.

Diet frequency decreased over the years, except for a spike in around 2011 to 2013