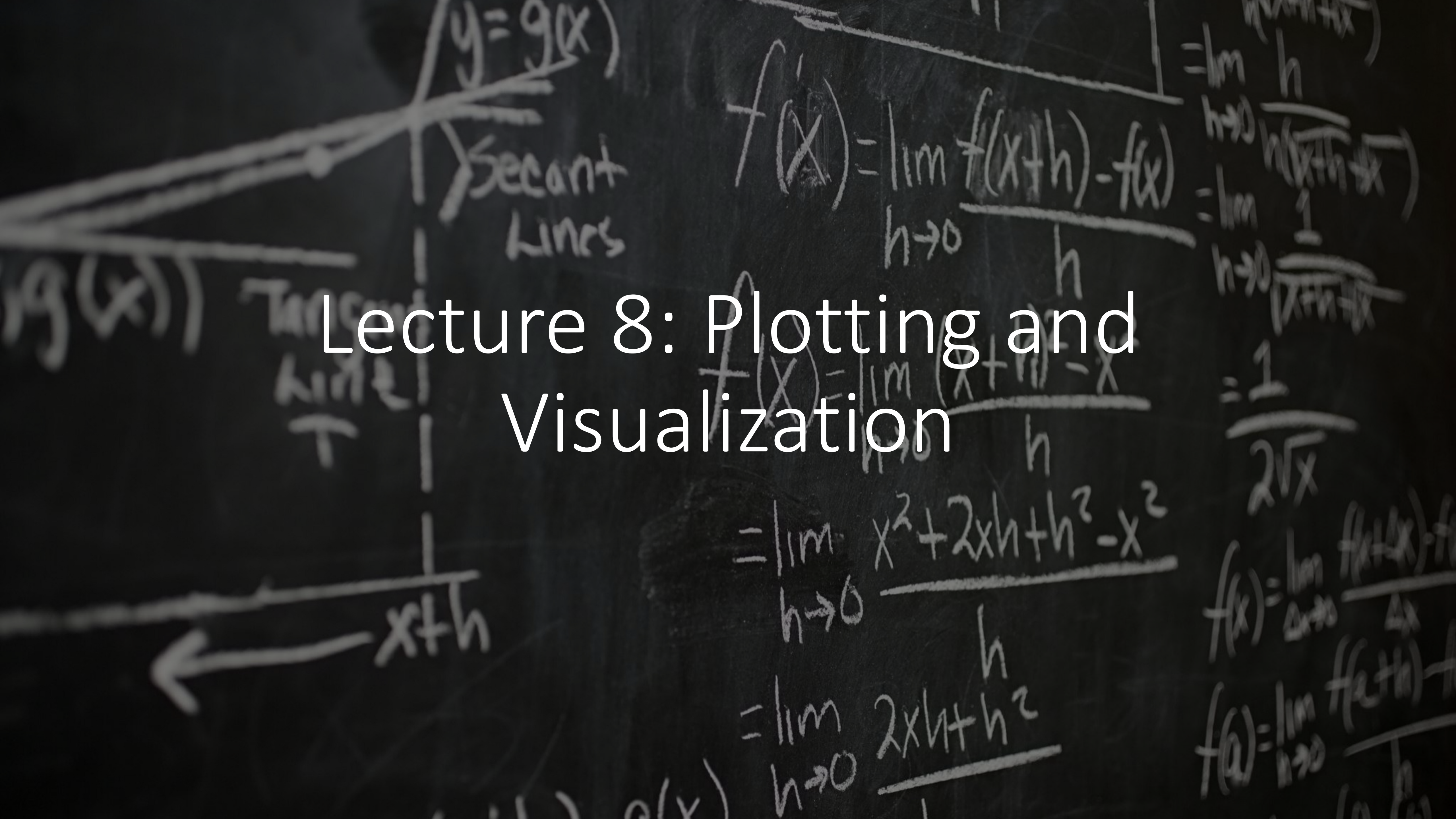
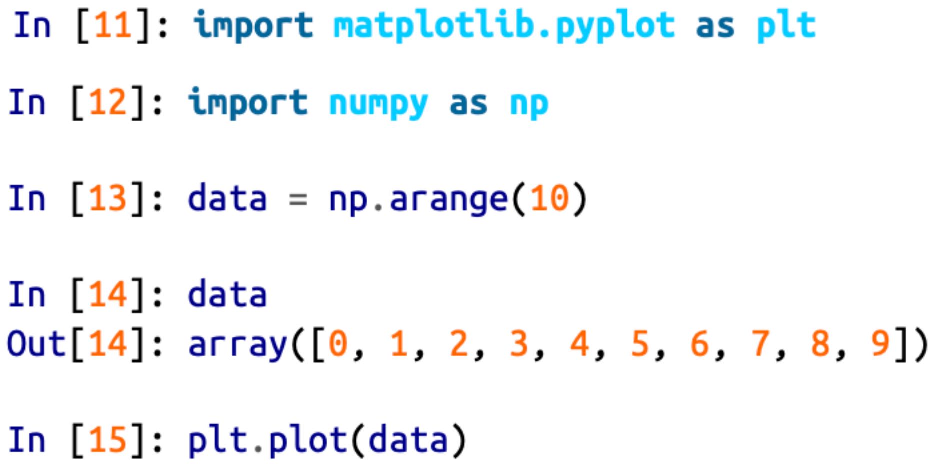
Lecture 8: Plotting and Visualization



matplotlib



```
In [11]: import matplotlib.pyplot as plt

In [12]: import numpy as np

In [13]: data = np.arange(10)

In [14]: data
Out[14]: array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])

In [15]: plt.plot(data)
```

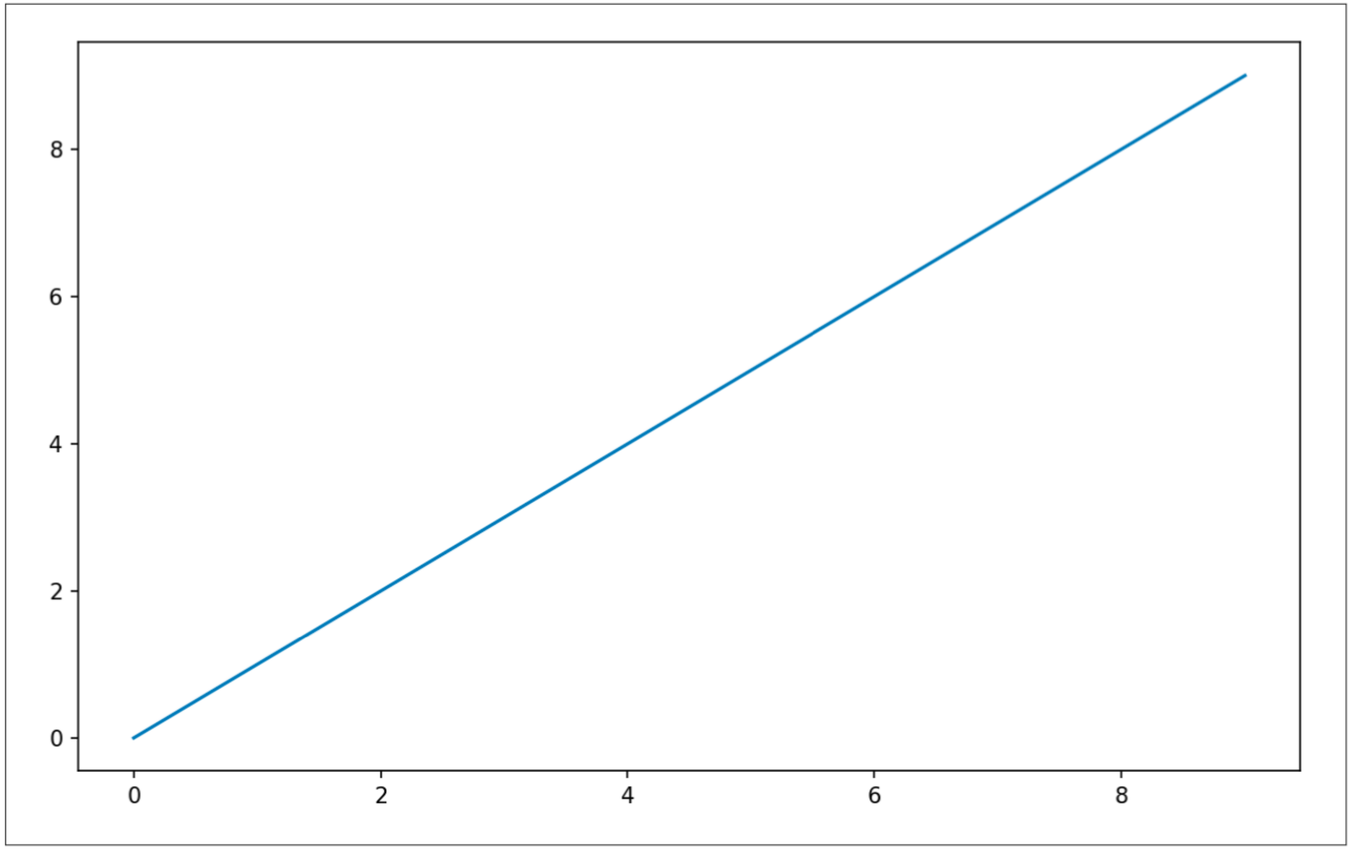
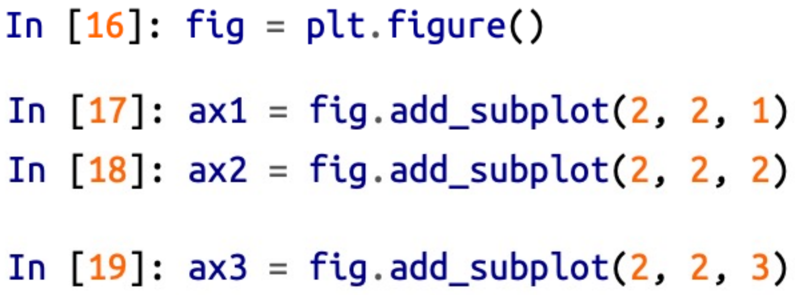


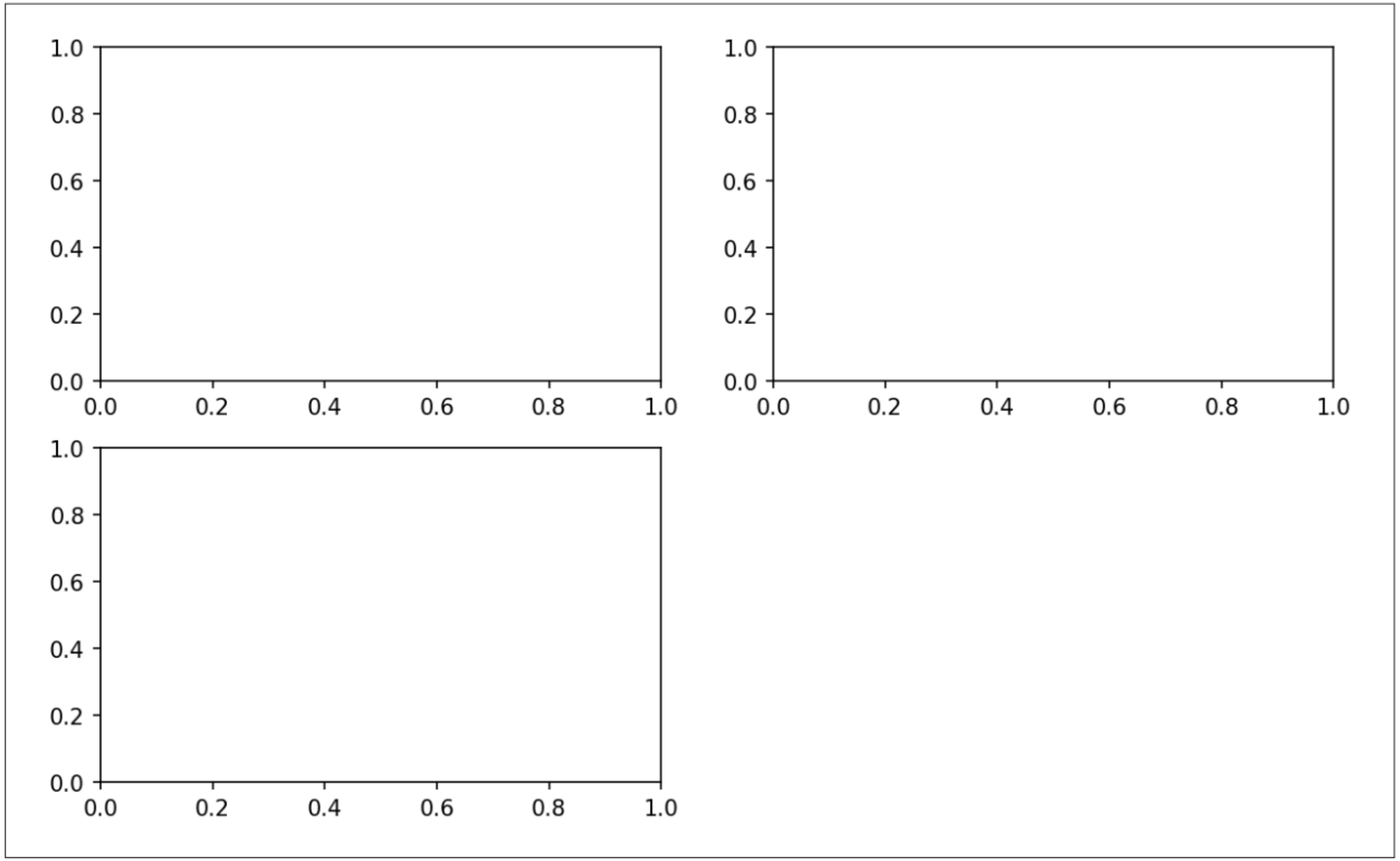
Figure 1: Simple line plot

Figures and Subplots



```
In [16]: fig = plt.figure()

In [17]: ax1 = fig.add_subplot(2, 2, 1)
In [18]: ax2 = fig.add_subplot(2, 2, 2)

In [19]: ax3 = fig.add_subplot(2, 2, 3)
```

Figure 2: An empty matplotlib figure with three subplots



```
In [20]: plt.plot(np.random.randn(50).cumsum(), 'k--')
```

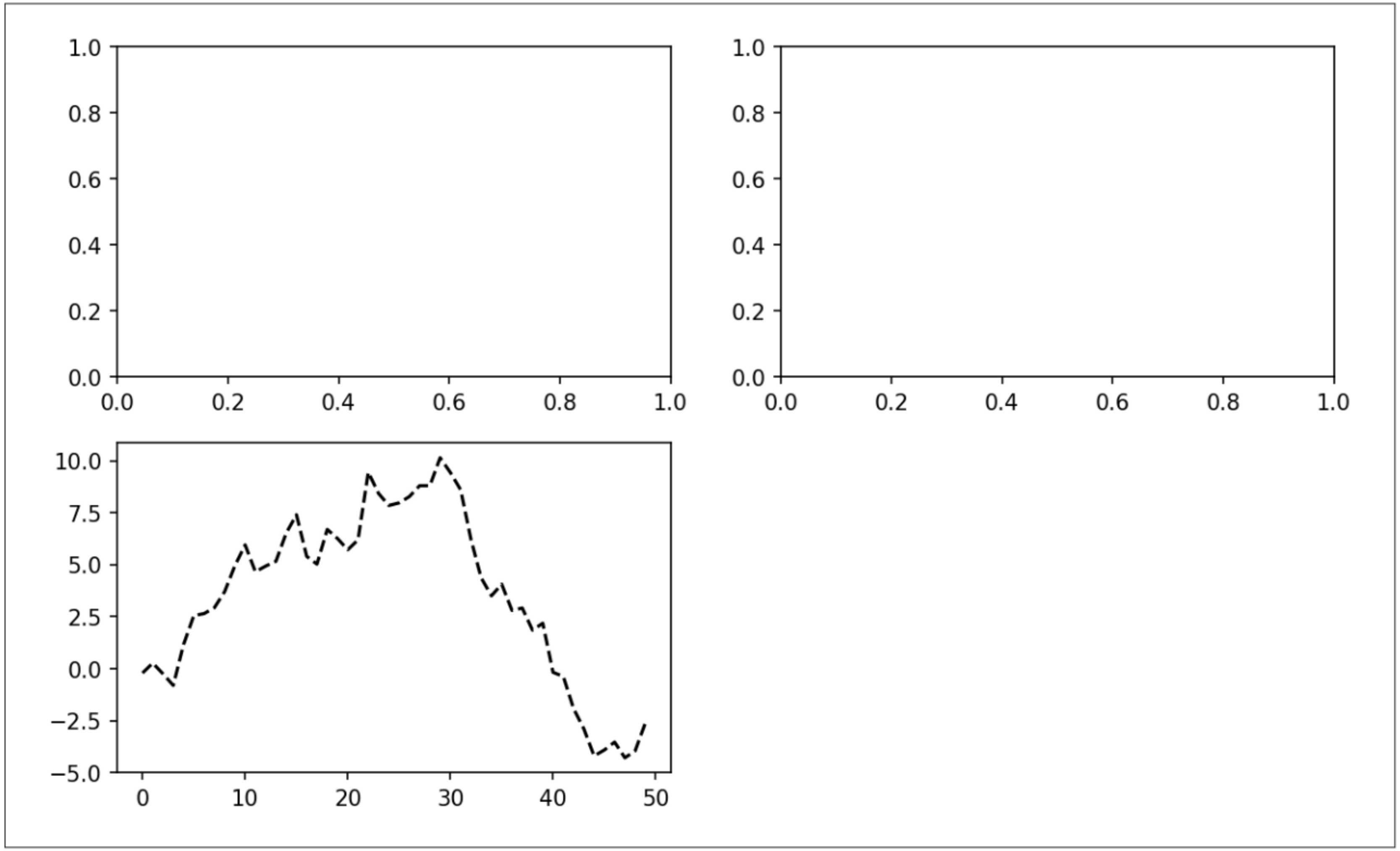
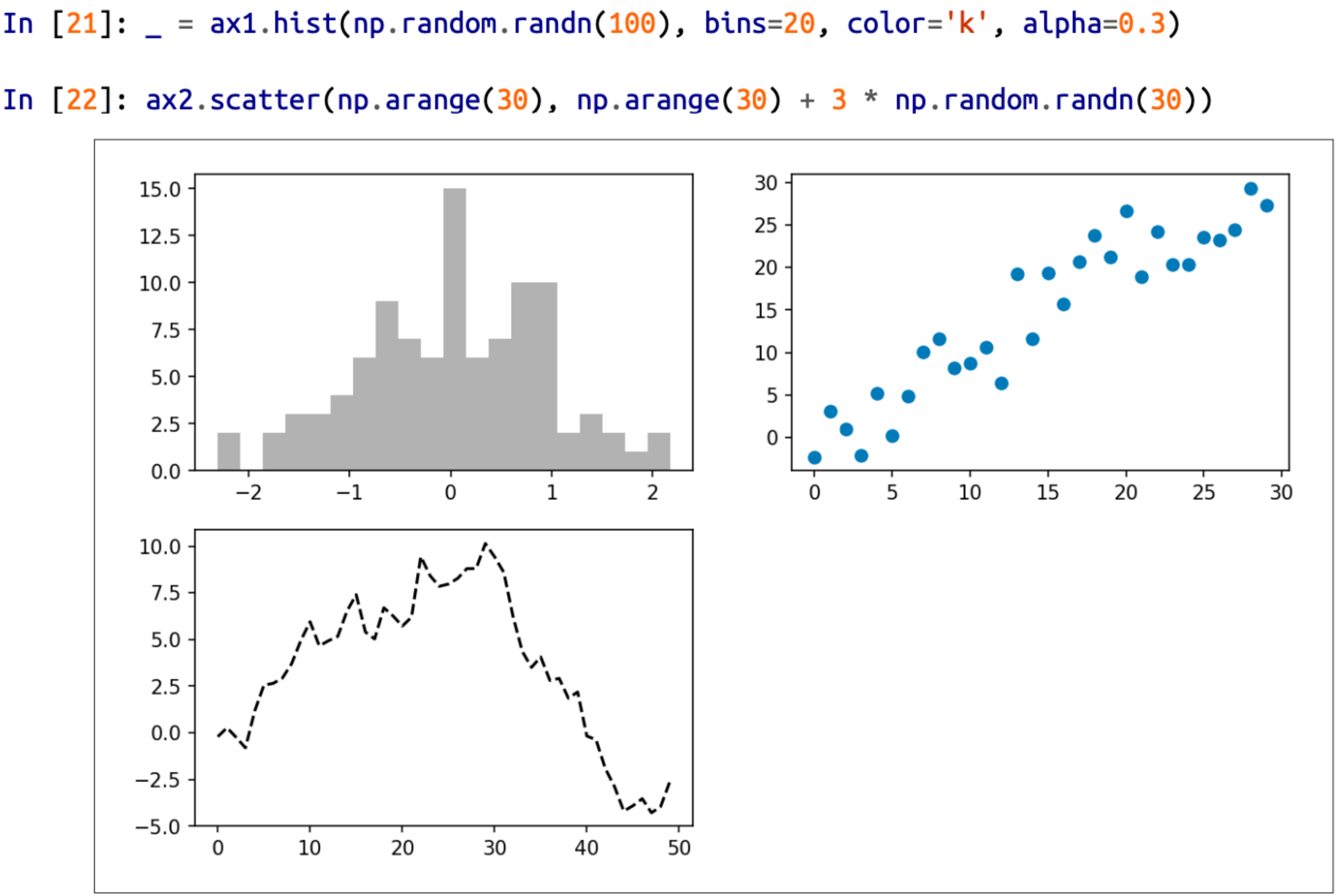


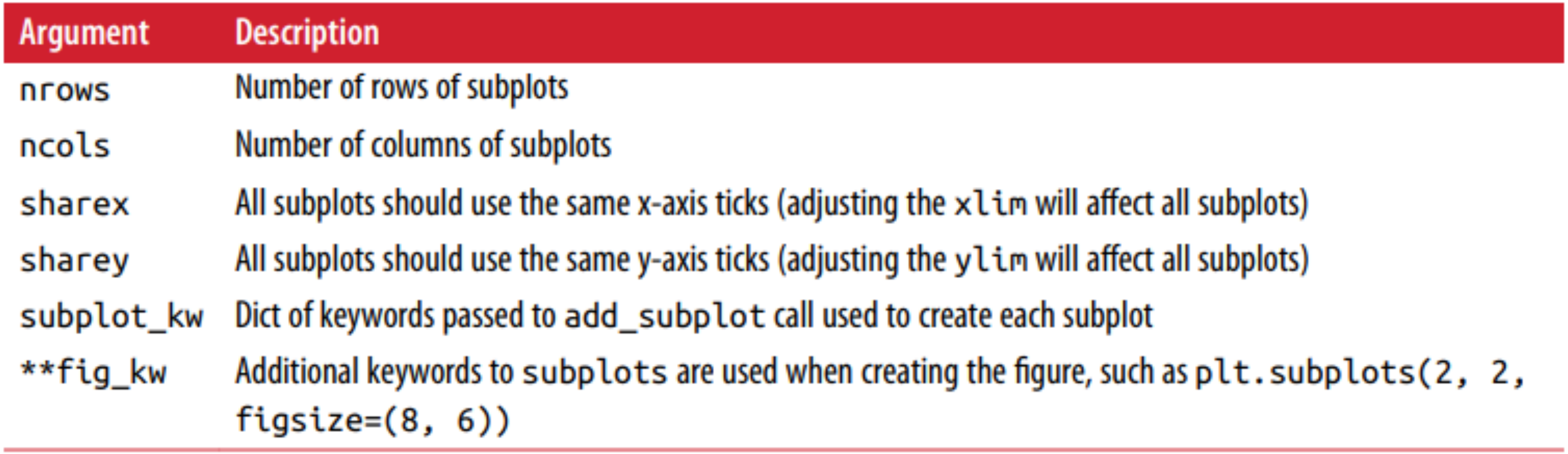
Figure 3: Data visualization after single plot



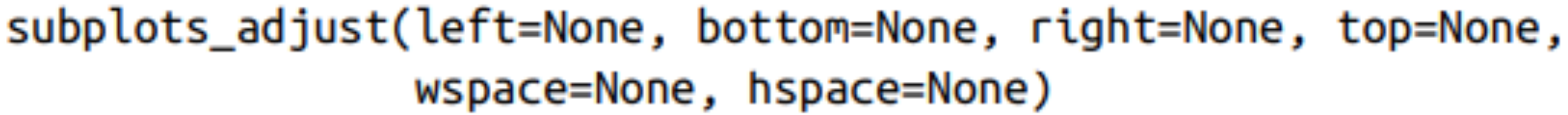
```
In [21]: _ = ax1.hist(np.random.randn(100), bins=20, color='k', alpha=0.3)

In [22]: ax2.scatter(np.arange(30), np.arange(30) + 3 * np.random.randn(30))
```

Figure 4: Data visualization after additional plots

Pyplot.subplots options

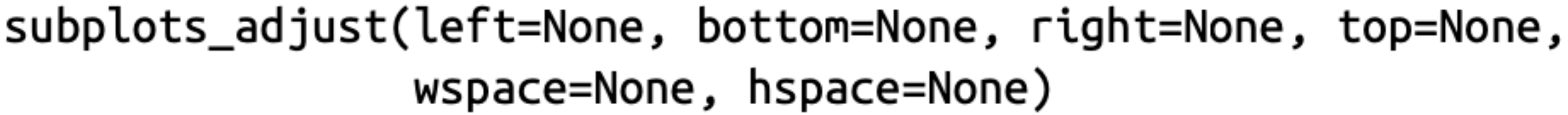


Argument	Description
nrows	Number of rows of subplots
ncols	Number of columns of subplots
sharex	All subplots should use the same x-axis ticks (adjusting the xlim will affect all subplots)
sharey	All subplots should use the same y-axis ticks (adjusting the ylim will affect all subplots)
subplot_kw	Dict of keywords passed to add_subplot call used to create each subplot
**fig_kw	Additional keywords to subplots are used when creating the figure, such as plt.subplots(2, 2, figsize=(8, 6))



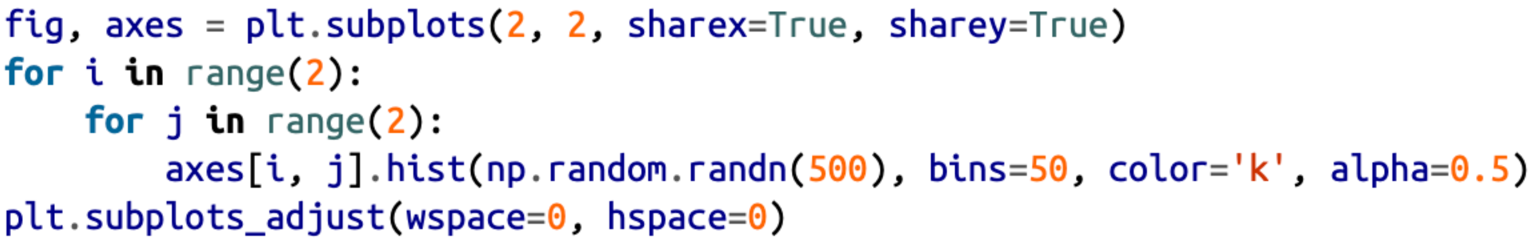
```
subplots_adjust(left=None, bottom=None, right=None, top=None,
                wspace=None, hspace=None)
```

Adjusting the spacing around subplots



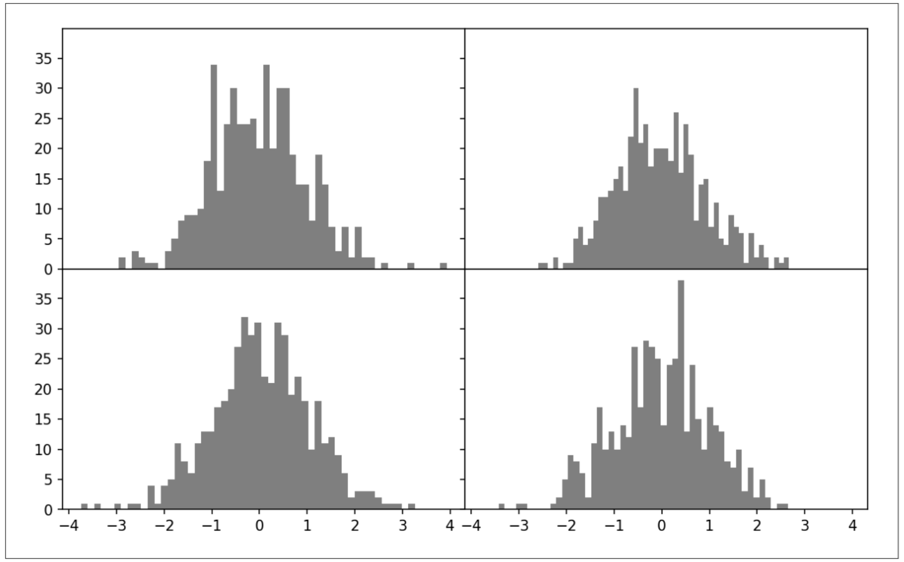
```
subplots_adjust(left=None, bottom=None, right=None, top=None,
                wspace=None, hspace=None)
```

wspace and hspace controls the percent of the figure width and figure height, respectively, to use as spacing between subplots

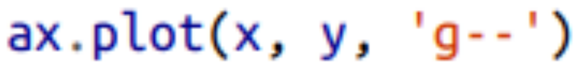


```
fig, axes = plt.subplots(2, 2, sharex=True, sharey=True)
for i in range(2):
    for j in range(2):
        axes[i, j].hist(np.random.randn(500), bins=50, color='k', alpha=0.5)
plt.subplots_adjust(wspace=0, hspace=0)
```

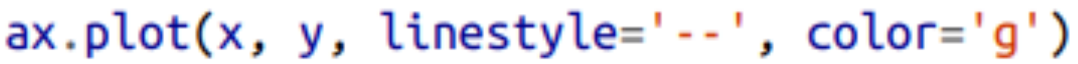
Figure 5: Data visualization with no inter-subplot spacing



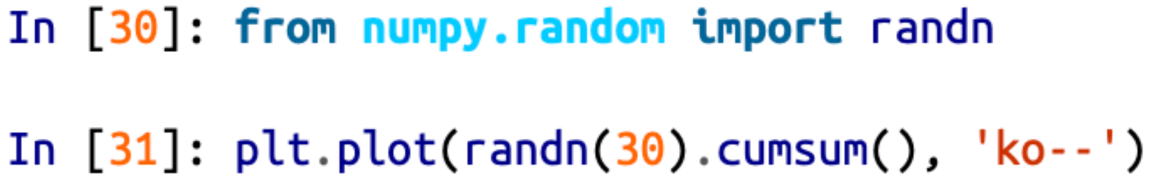
Colors, Markers and Line Styles



```
ax.plot(x, y, 'g--')
```



```
ax.plot(x, y, linestyle='--', color='g')
```



```
In [30]: from numpy.random import randn

In [31]: plt.plot(randn(30).cumsum(), 'ko--')
```

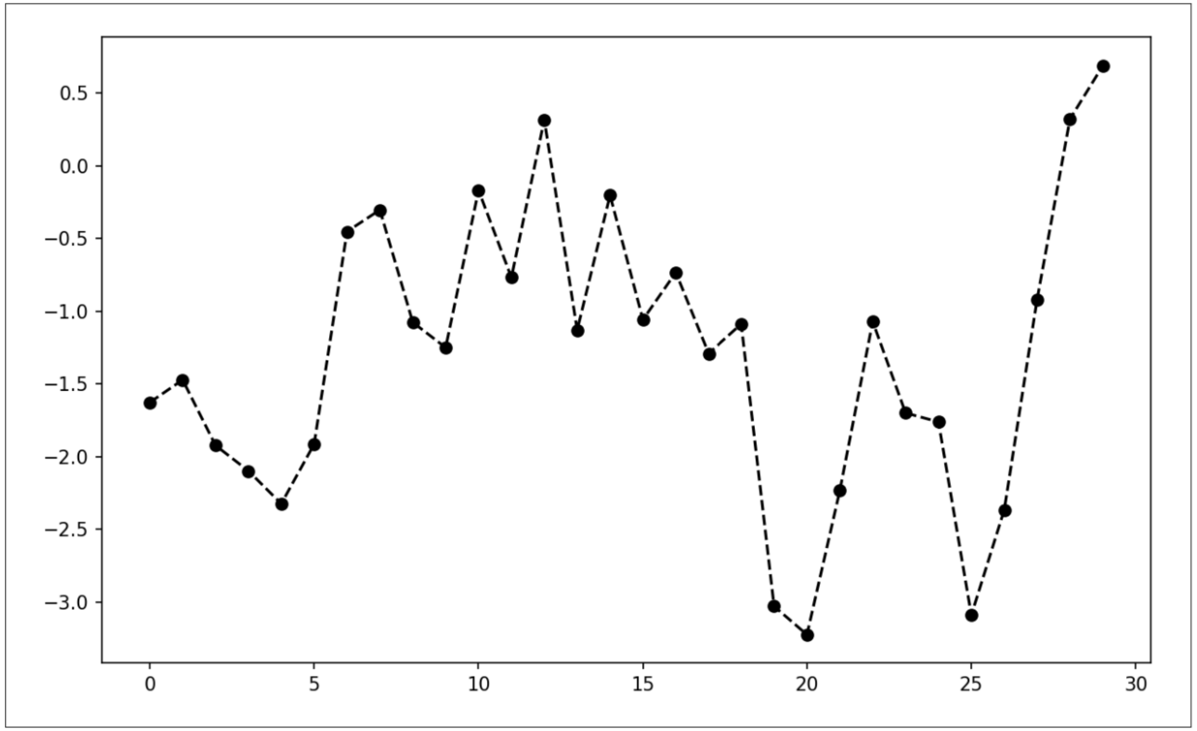
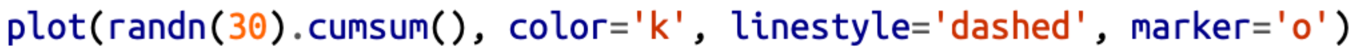


Figure 6: Line plot with markers

This could also have been written more explicitly as:



```
plot(randn(30).cumsum(), color='k', linestyle='dashed', marker='o')
```

- For line plots, you will notice that subsequent points are linearly interpolated by default

```
In [33]: data = np.random.randn(30).cumsum()

In [34]: plt.plot(data, 'k--', label='Default')
Out[34]: [<matplotlib.lines.Line2D at 0x7fb624d86160>]

In [35]: plt.plot(data, 'k-', drawstyle='steps-post', label='steps-post')
Out[35]: [<matplotlib.lines.Line2D at 0x7fb624d869e8>]

In [36]: plt.legend(loc='best')
```

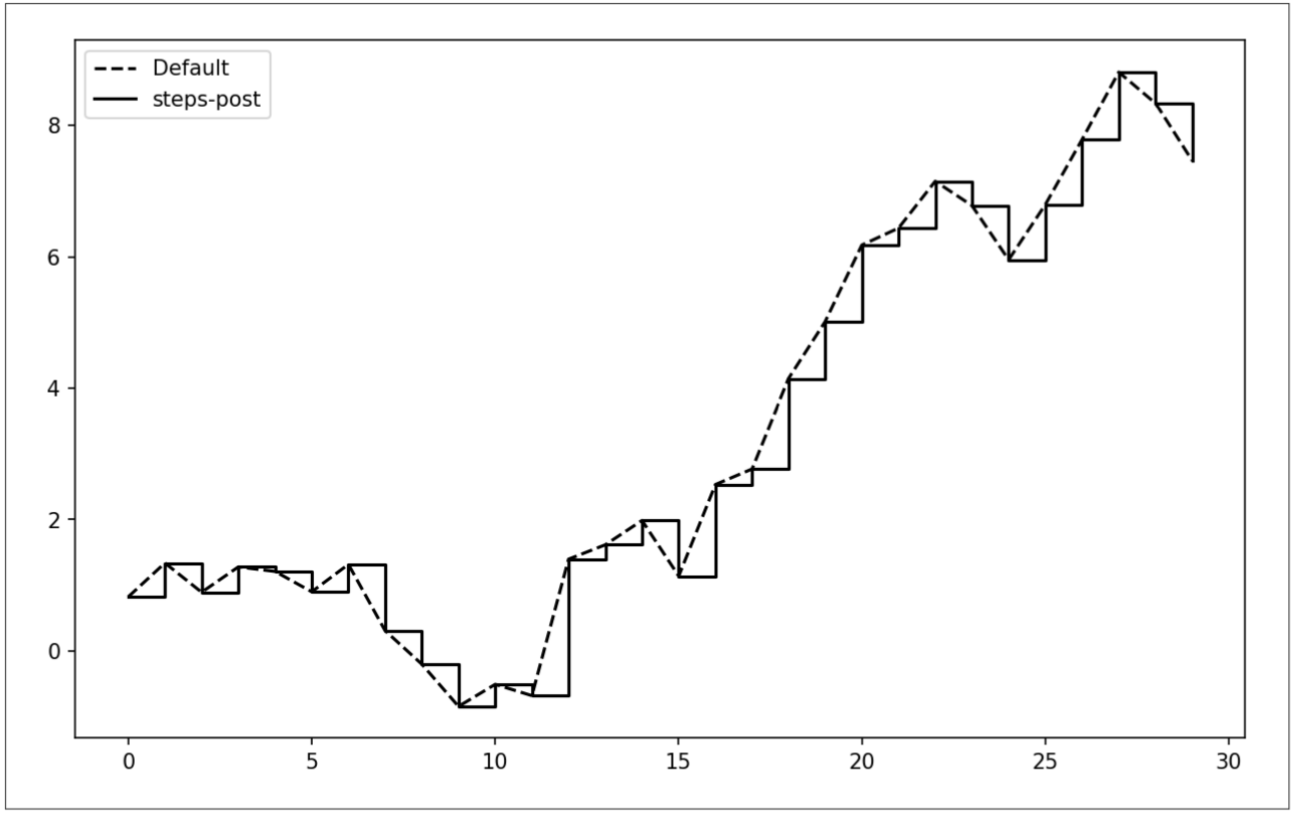
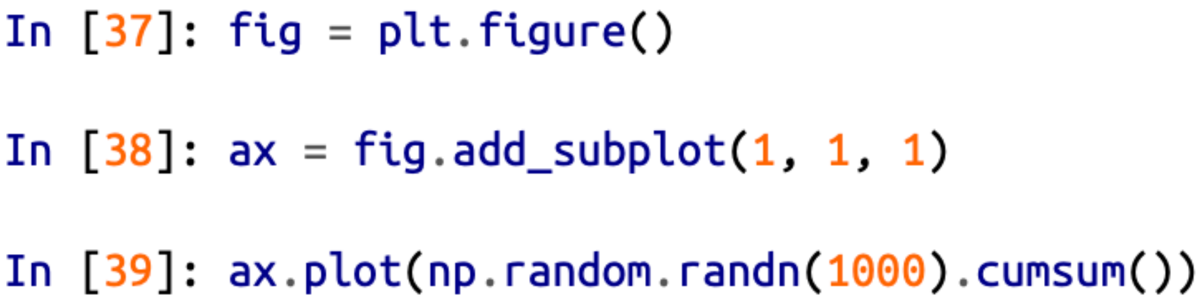


Figure 7: Line plot with different drawstyle options

Ticks, Labels, and Legends

- The pyplot interface, designed for interactive use, consists of methods like xlim, xticks, and xticklabels. These control the plot range, tick locations, and tick labels, respectively. They can be used in two ways:
  - Called with no arguments returns the current parameter value (e.g., plt.xlim() returns the current x-axis plotting range)
  - Called with parameters sets the parameter value (e.g., plt.xlim([0, 10]), sets the x-axis range to 0 to 10)



```
In [37]: fig = plt.figure()

In [38]: ax = fig.add_subplot(1, 1, 1)

In [39]: ax.plot(np.random.randn(1000).cumsum())
```

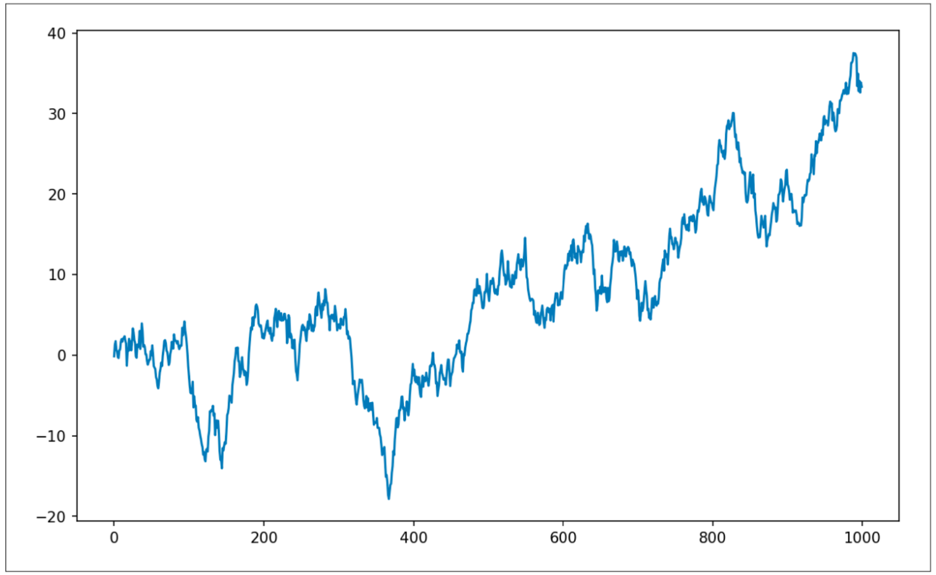
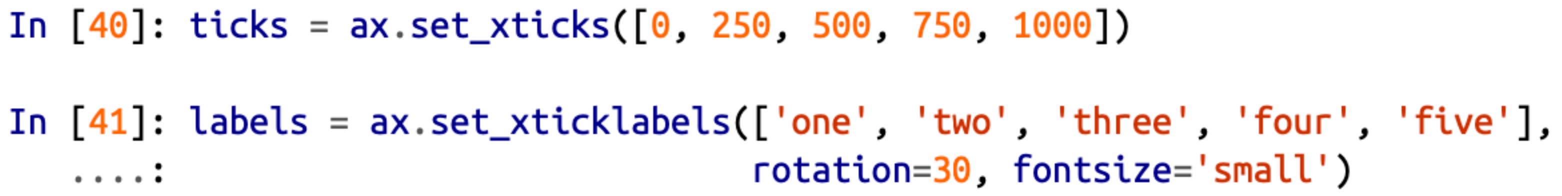
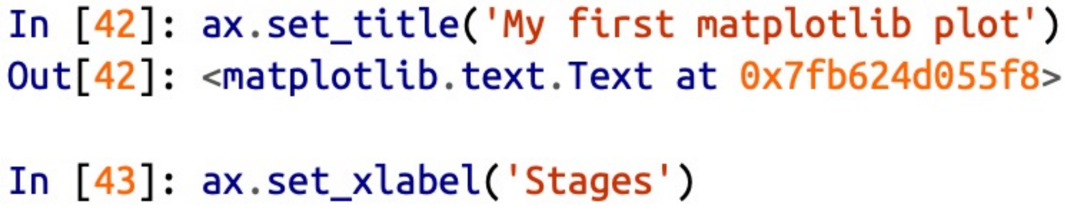


Figure 8: Simple plot for illustrating xticks (with label)



```
In [40]: ticks = ax.set_xticks([0, 250, 500, 750, 1000])

In [41]: labels = ax.set_xticklabels(['one', 'two', 'three', 'four', 'five'],
   ....:                             rotation=30, fontsize='small')
```

The rotation option sets the x tick labels at a 30-degree rotation. Lastly, set_xlabel gives a name to the x-axis and set_title the subplot title



```
In [42]: ax.set_title('My first matplotlib plot')
Out[42]: <matplotlib.text.Text at 0x7fb624d055f8>

In [43]: ax.set_xlabel('Stages')
```

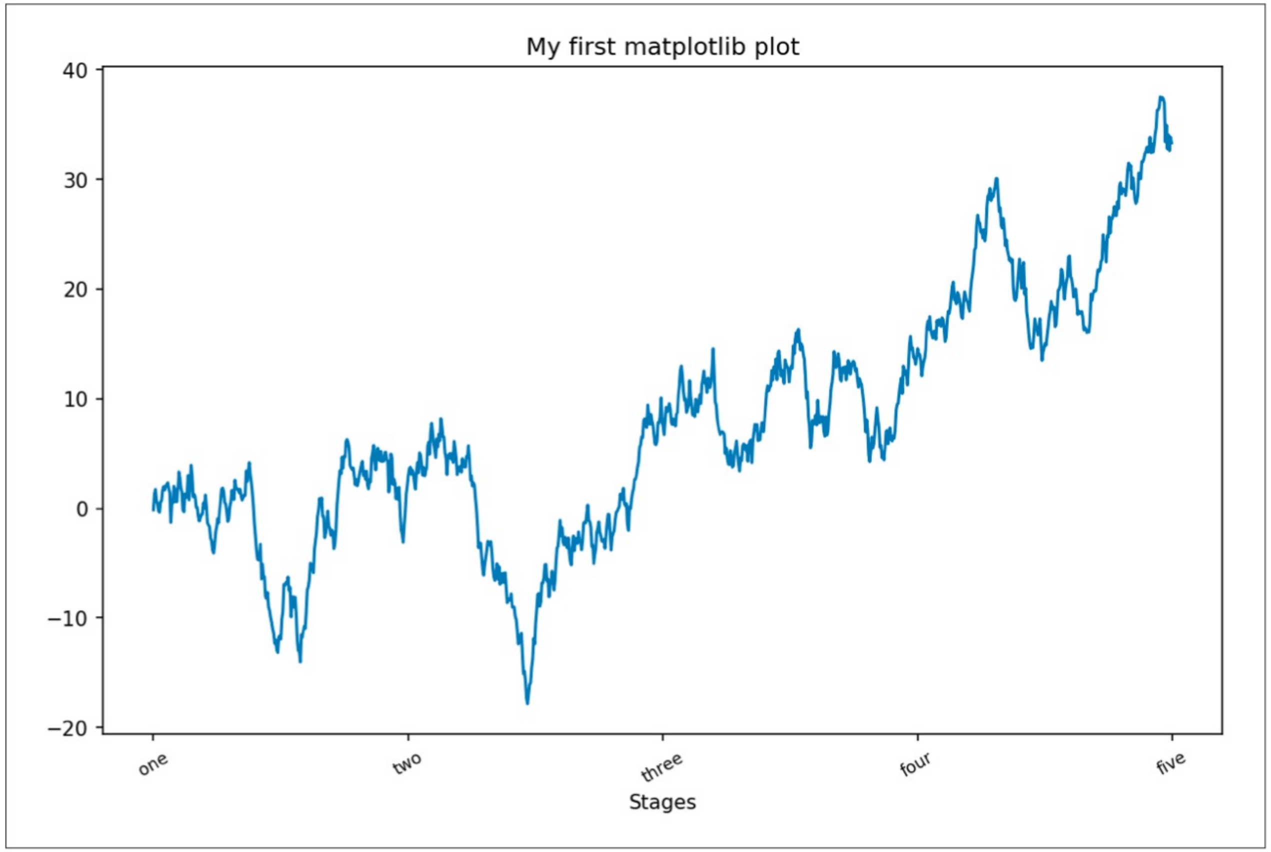
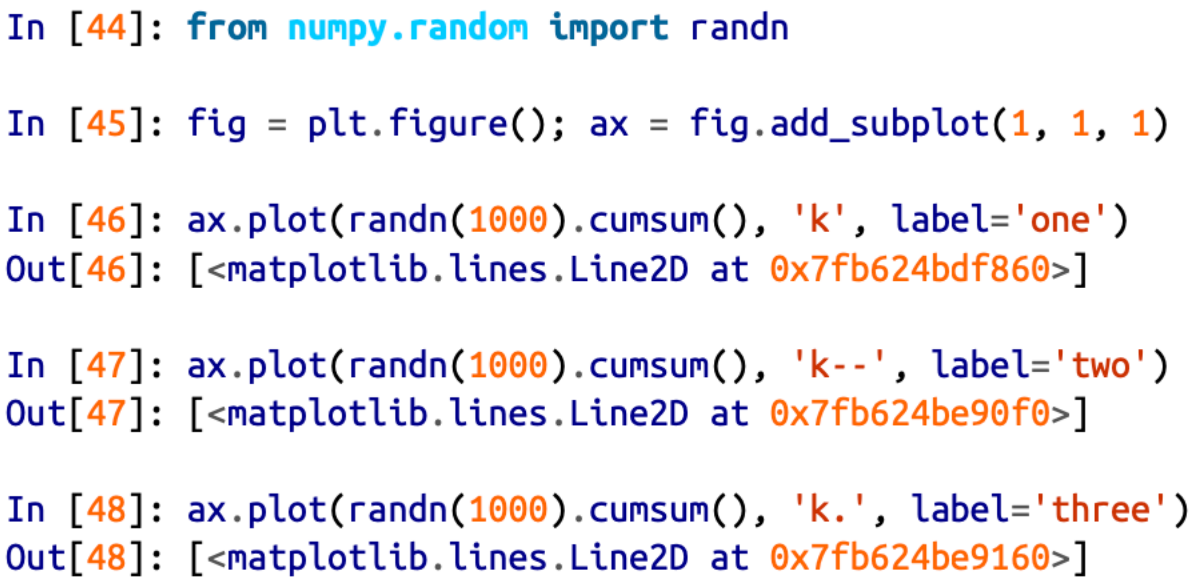


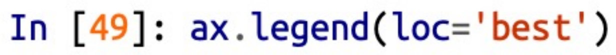
Figure 9: Simple plot for illustrating xticks

Adding legends



```
In [44]: from numpy.random import randn

In [45]: fig = plt.figure(); ax = fig.add_subplot(1, 1, 1)

In [46]: ax.plot(randn(1000).cumsum(), 'k', label='one')
Out[46]: [<matplotlib.lines.Line2D at 0x7fb624bdf860>]

In [47]: ax.plot(randn(1000).cumsum(), 'k--', label='two')
Out[47]: [<matplotlib.lines.Line2D at 0x7fb624be90f0>]

In [48]: ax.plot(randn(1000).cumsum(), 'k.', label='three')
Out[48]: [<matplotlib.lines.Line2D at 0x7fb624be9160>]
```

Once you’ve done this, you can either call ax.legend() or plt.legend() to automatically create a legend



```
In [49]: ax.legend(loc='best')
```

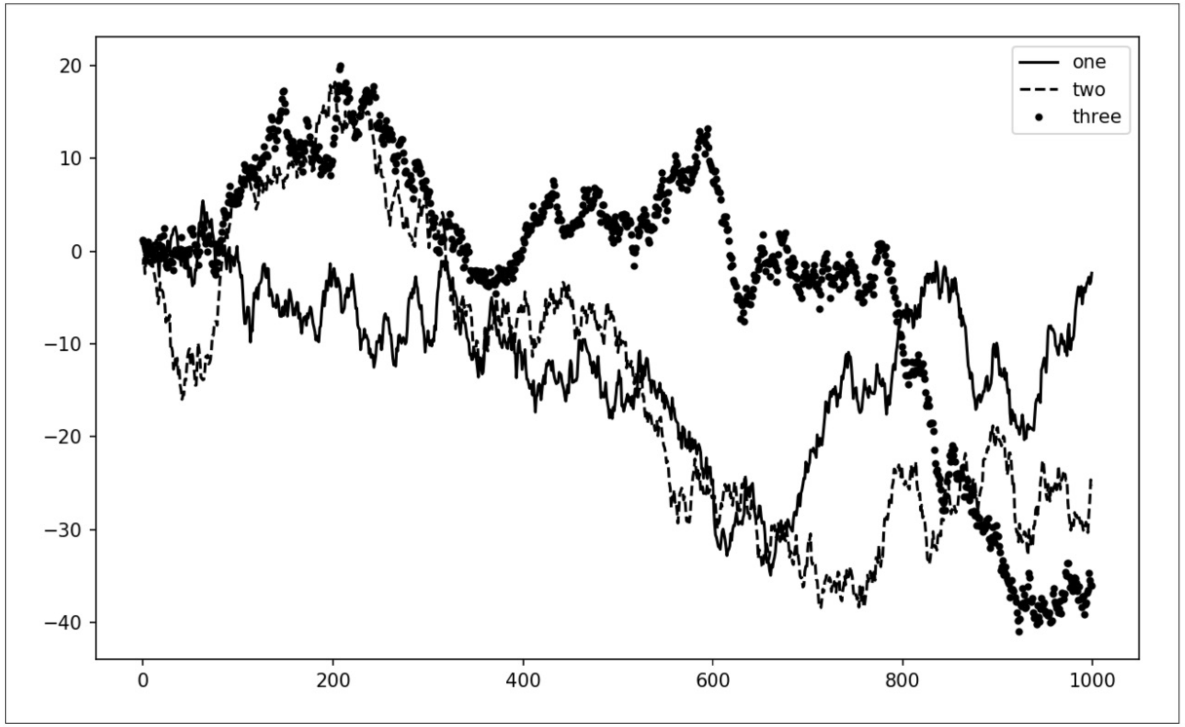
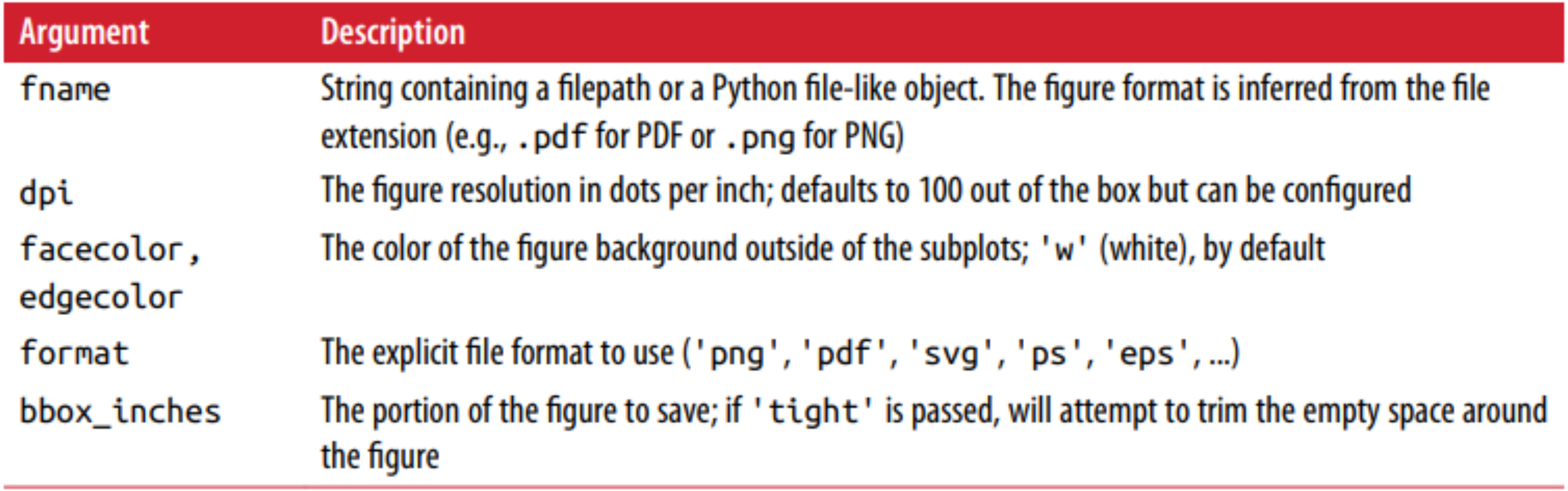


Figure 10: Simple plot with three lines and legend

Saving Plots to a File

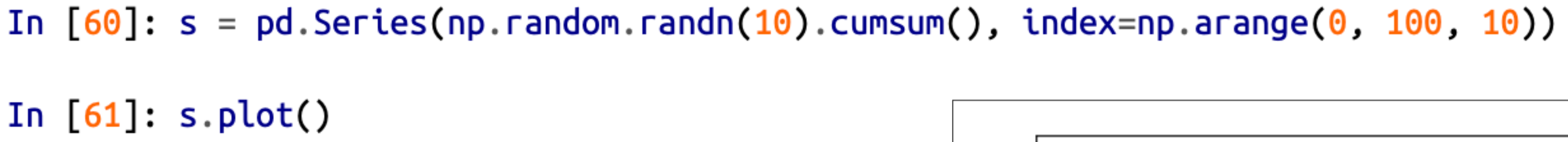
```
plt.savefig('figpath.svg')
```



Argument	Description
`fname`	String containing a filepath or a Python file-like object. The figure format is inferred from the file extension (e.g., `.pdf` for PDF or `.png` for PNG)
`dpi`	The figure resolution in dots per inch; defaults to 100 out of the box but can be configured
`facecolor`, `edgecolor`	The color of the figure background outside of the subplots; `'w'` (white), by default
`format`	The explicit file format to use (`'png'`, `'pdf'`, `'svg'`, `'ps'`, `'eps'`, ...)
`bbox_inches`	The portion of the figure to save; if `'tight'` is passed, will attempt to trim the empty space around the figure

Plotting with pandas and seaborn

- **Line Plots**
- Series and DataFrame each have a plot attribute for making some basic plot types. By default, plot() makes line plots



```
In [60]: s = pd.Series(np.random.randn(10).cumsum(), index=np.arange(0, 100, 10))

In [61]: s.plot()
```

The Series object’s index is passed to matplotlib for plotting on the x-axis, though you can disable this by passing use_index=False

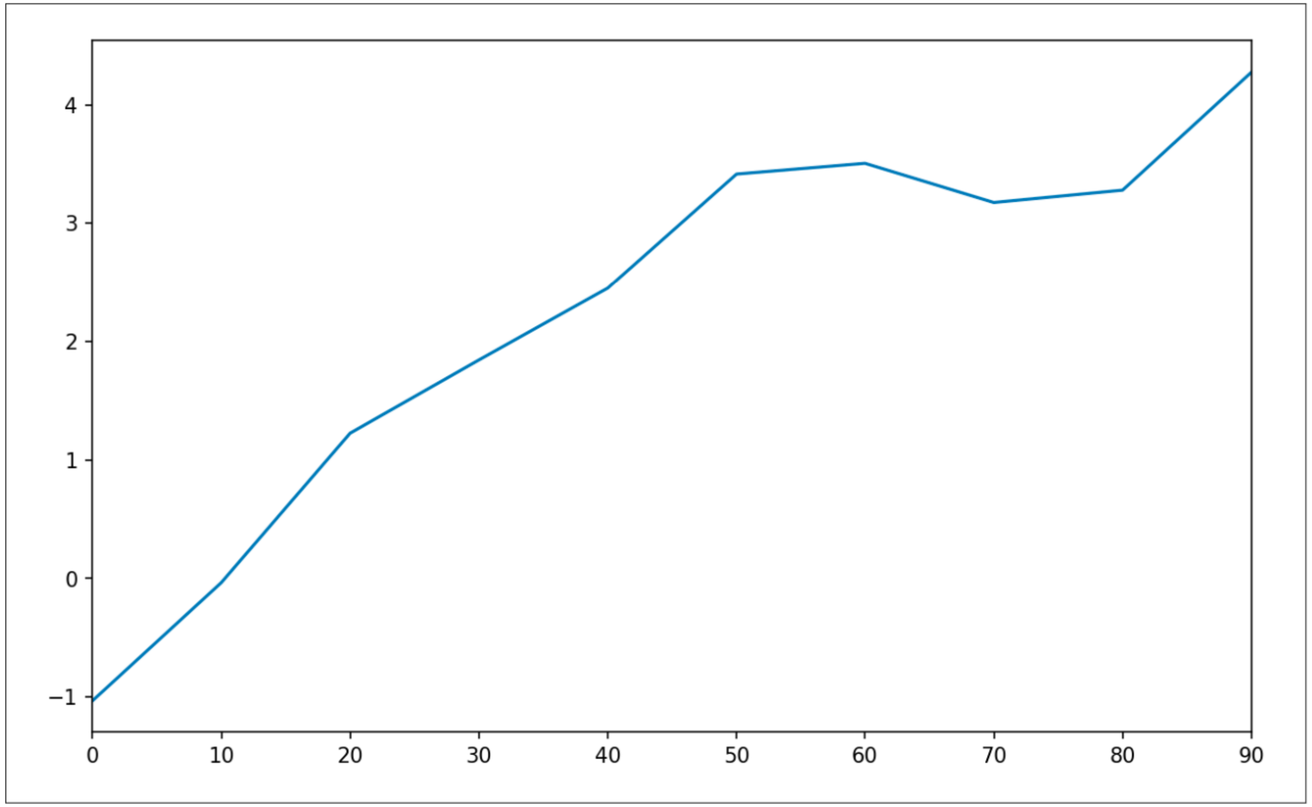
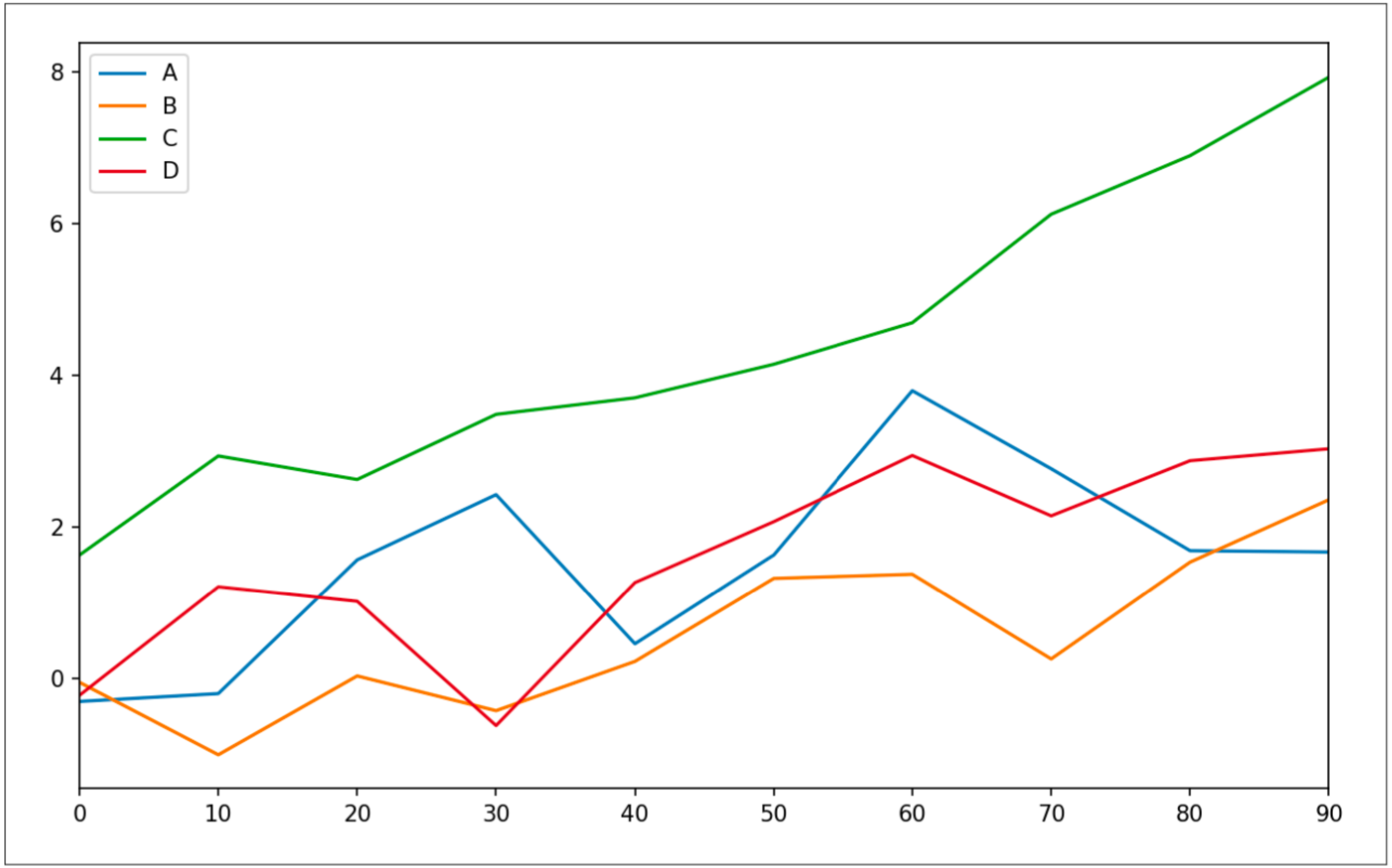


Figure 11: Simple Series plot

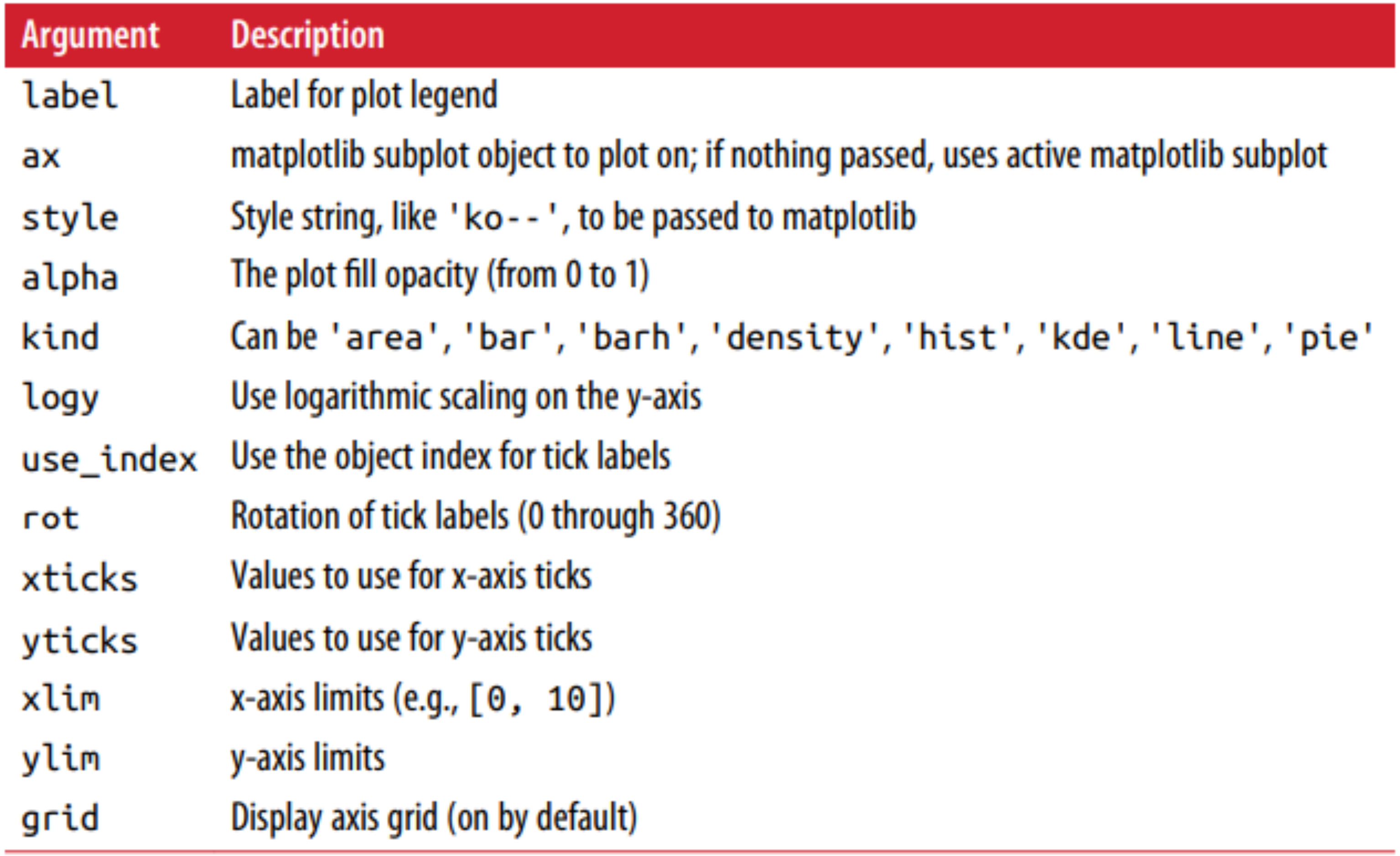
- DataFrame’s plot method plots each of its columns as a different line on the same subplot, creating a legend automatically

```
In [62]: df = pd.DataFrame(np.random.randn(10, 4).cumsum(0),
   ....:                   columns=['A', 'B', 'C', 'D'],
   ....:                   index=np.arange(0, 100, 10))

In [63]: df.plot()
```

Figure 12: Simple DataFrame plot

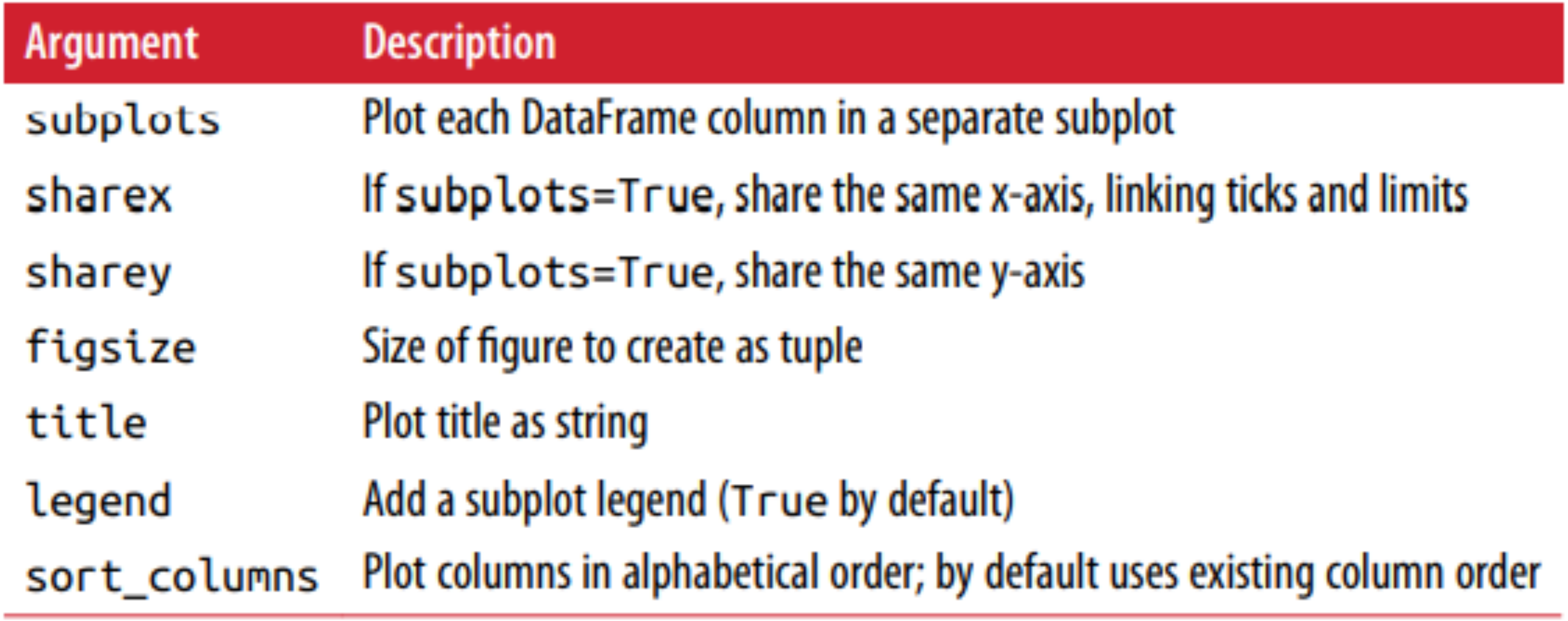


Series.plot method arguments



Argument	Description
label	Label for plot legend
ax	matplotlib subplot object to plot on; if nothing passed, uses active matplotlib subplot
style	Style string, like 'ko--', to be passed to matplotlib
alpha	The plot fill opacity (from 0 to 1)
kind	Can be 'area', 'bar', 'barh', 'density', 'hist', 'kde', 'line', 'pie'
logy	Use logarithmic scaling on the y-axis
use_index	Use the object index for tick labels
rot	Rotation of tick labels (0 through 360)
xticks	Values to use for x-axis ticks
yticks	Values to use for y-axis ticks
xlim	x-axis limits (e.g., [0, 10])
ylim	y-axis limits
grid	Display axis grid (on by default)

DataFrame-specific plot arguments



Argument	Description
`subplots`	Plot each DataFrame column in a separate subplot
`sharex`	If `subplots=True`, share the same x-axis, linking ticks and limits
`sharey`	If `subplots=True`, share the same y-axis
`figsize`	Size of figure to create as tuple
`title`	Plot title as string
`legend`	Add a subplot legend (`True` by default)
`sort_columns`	Plot columns in alphabetical order; by default uses existing column order

Bar Plots

```
In [64]: fig, axes = plt.subplots(2, 1)

In [65]: data = pd.Series(np.random.rand(16), index=list('abcdefghijklmnop'))

In [66]: data.plot.bar(ax=axes[0], color='k', alpha=0.7)
Out[66]: <matplotlib.axes._subplots.AxesSubplot at 0x7fb62493d470>

In [67]: data.plot.barh(ax=axes[1], color='k', alpha=0.7)
```

The options color='k' and alpha=0.7 set the color of the plots to black and use partial transparency on the filling.

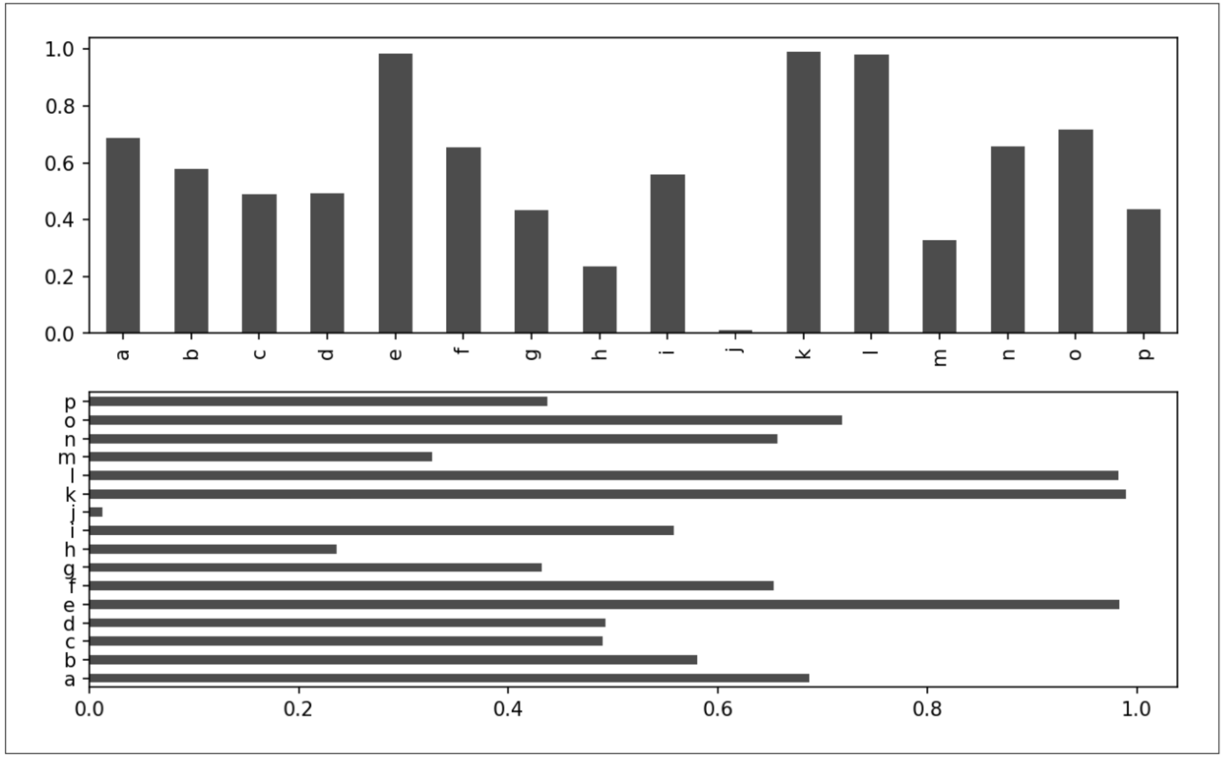
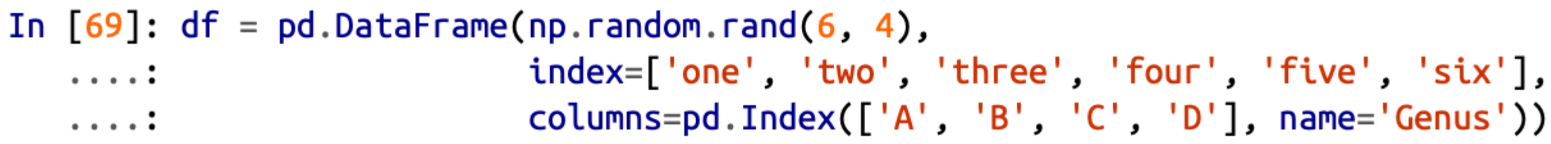
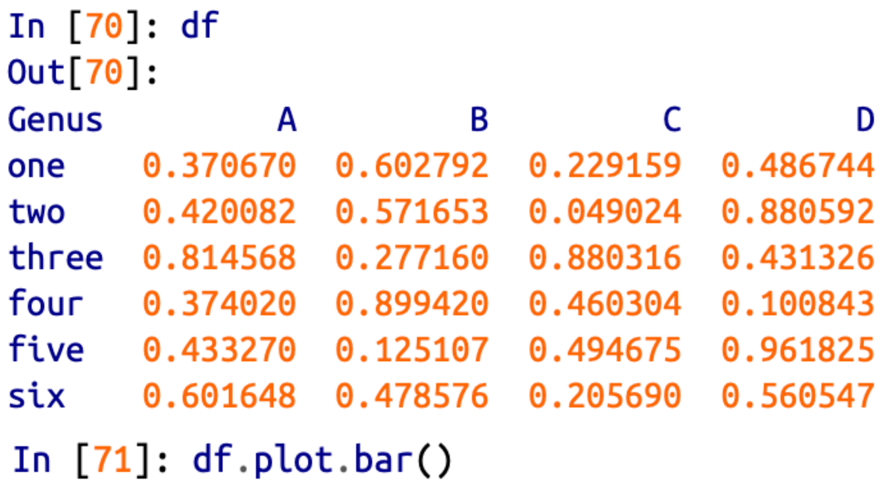


Figure 13: Horizonal and vertical bar plot

With a DataFrame, bar plots group the values in each row together in a group in bars, side by side, for each value

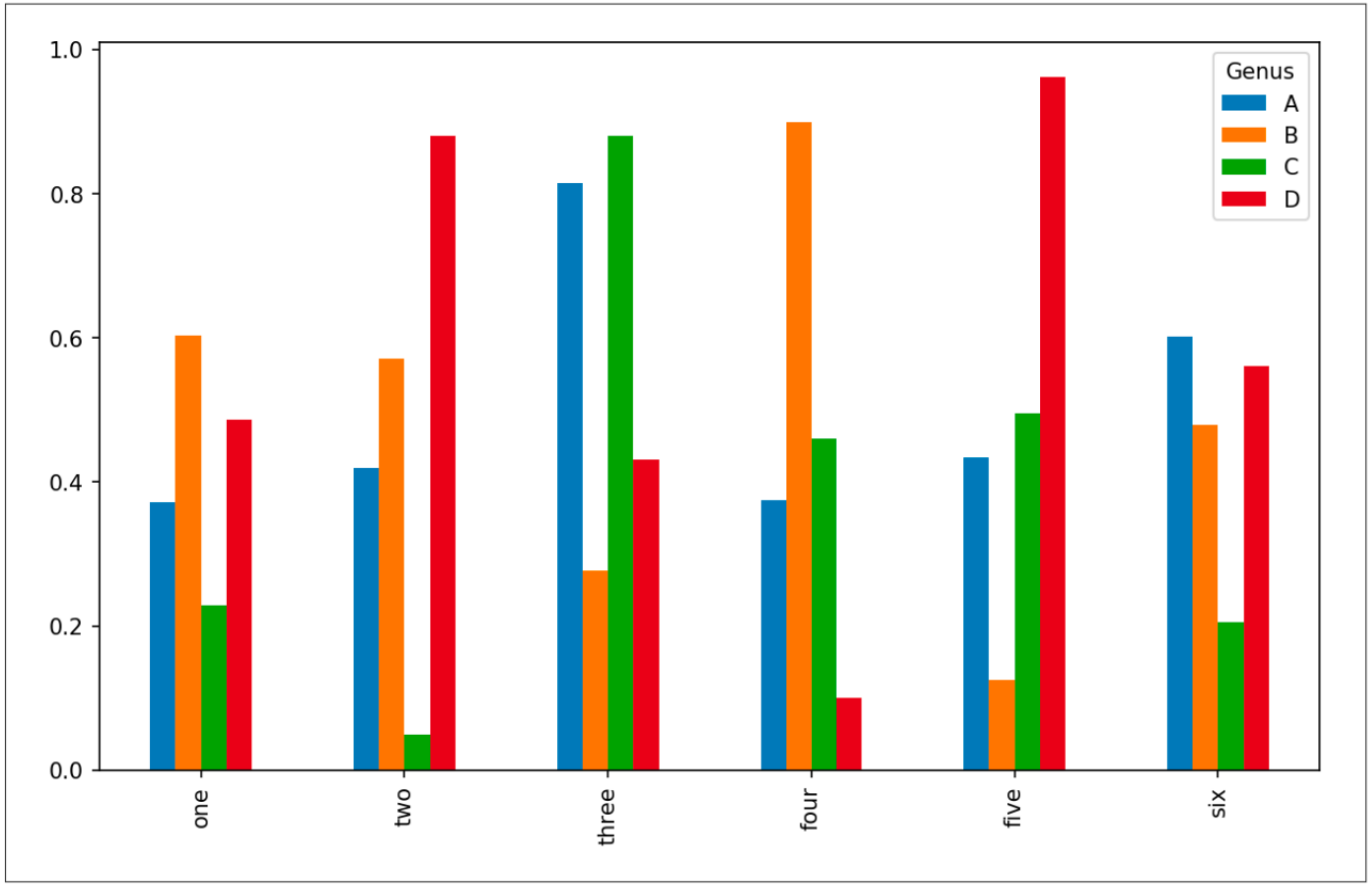


```
In [69]: df = pd.DataFrame(np.random.rand(6, 4),
   ....:                   index=['one', 'two', 'three', 'four', 'five', 'six'],
   ....:                   columns=pd.Index(['A', 'B', 'C', 'D'], name='Genus'))
```



```
In [70]: df
Out[70]:
Genus         A         B         C         D
one    0.370670  0.602792  0.229159  0.486744
two    0.420082  0.571653  0.049024  0.880592
three  0.814568  0.277160  0.880316  0.431326
four   0.374020  0.899420  0.460304  0.100843
five   0.433270  0.125107  0.494675  0.961825
six    0.601648  0.478576  0.205690  0.560547

In [71]: df.plot.bar()
```

Figure 14: DataFrame bar plot



We create stacked bar plots from a DataFrame by passing stacked=True, resulting in the value in each row being stacked together

```
In [73]: df.plot.barh(stacked=True, alpha=0.5)
```

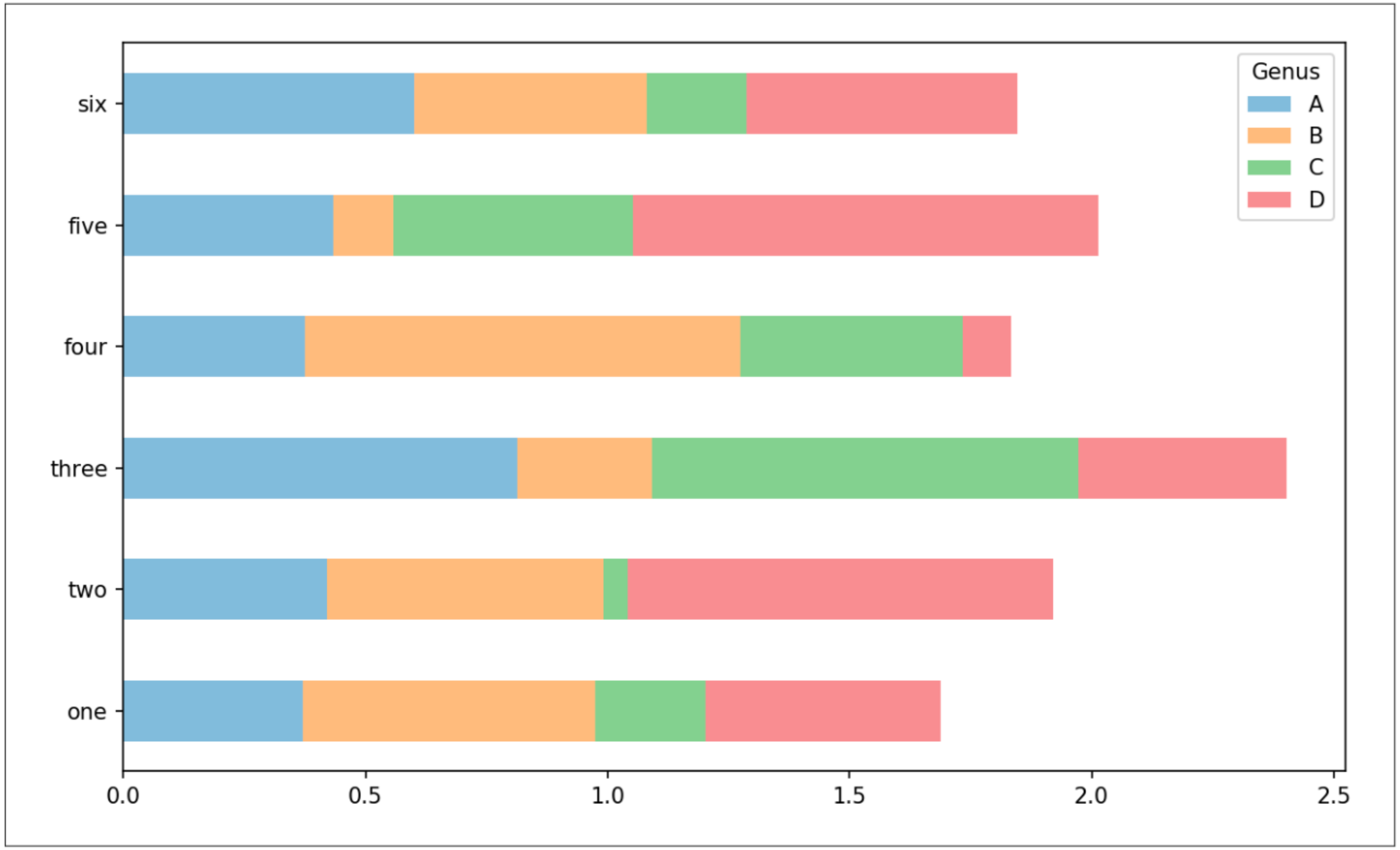


Figure 15: DataFrame stacked bar plot

Histograms and Density Plots

```
In [92]: tips['tip_pct'].plot.hist(bins=50)
```

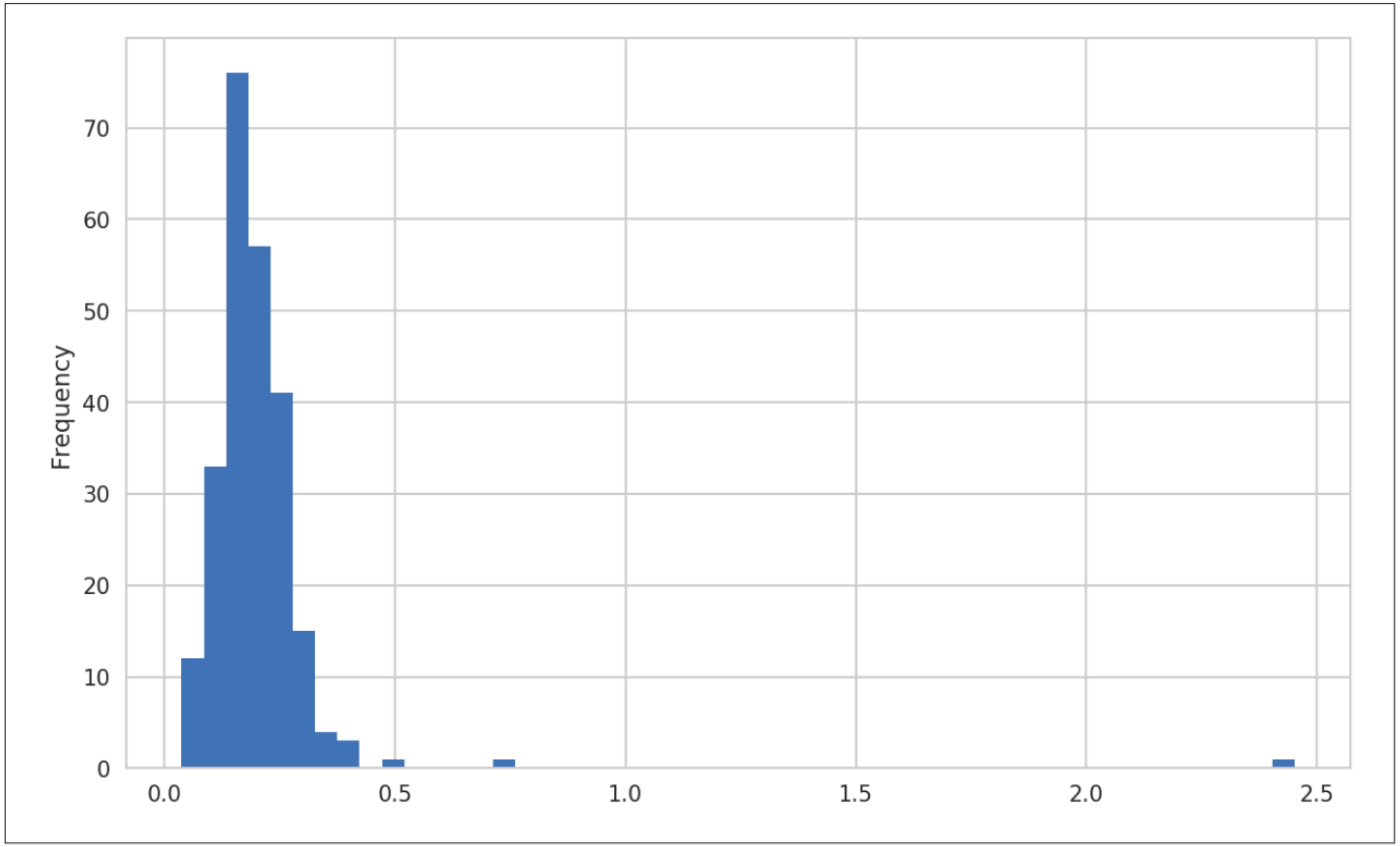
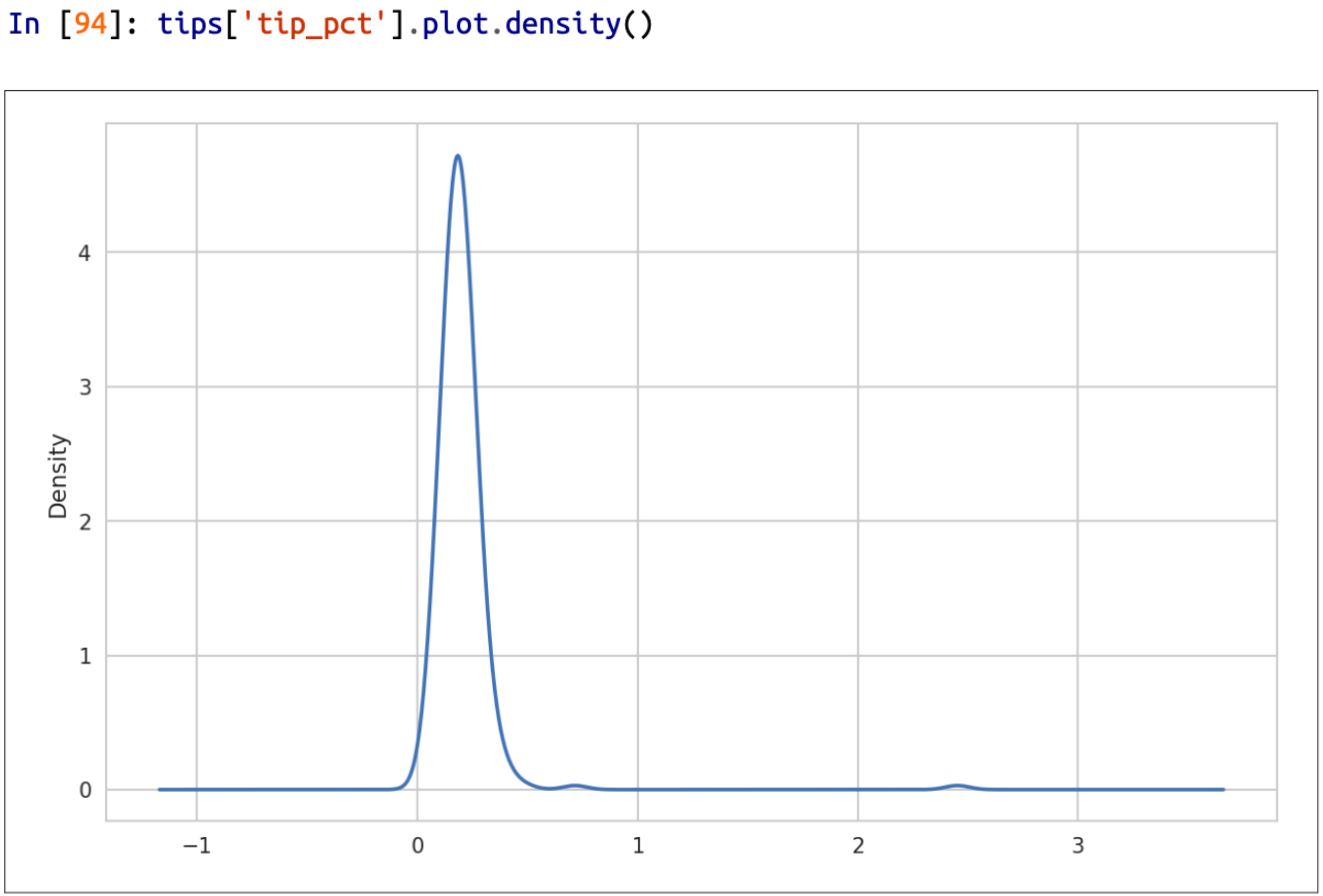


Figure 16: Histogram of tip percentages



```
In [94]: tips['tip_pct'].plot.density()
```

Figure 17: Density plot of tip percentages

```
In [96]: comp1 = np.random.normal(0, 1, size=200)

In [97]: comp2 = np.random.normal(10, 2, size=200)

In [98]: values = pd.Series(np.concatenate([comp1, comp2]))

In [99]: sns.distplot(values, bins=100, color='k')
```

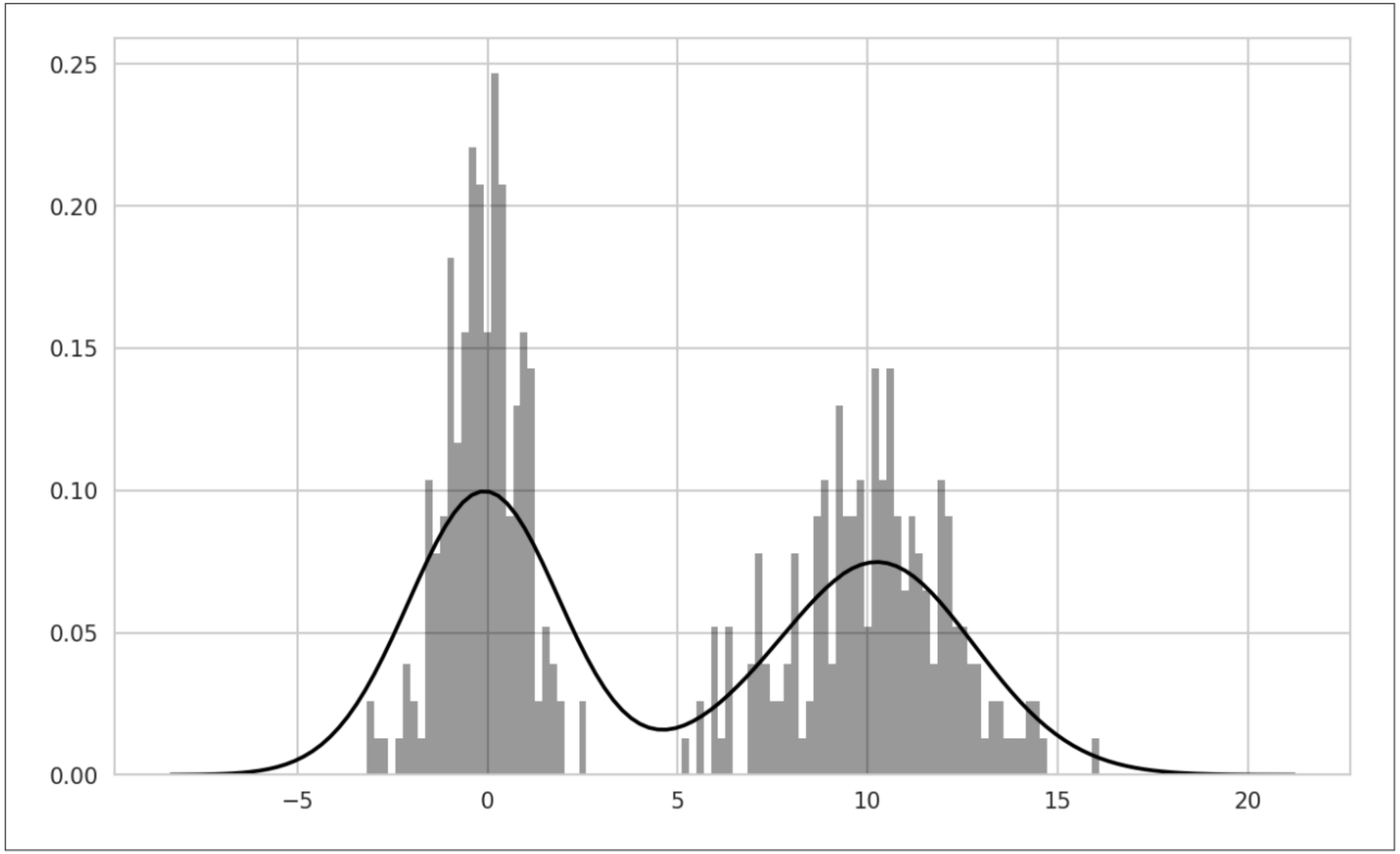
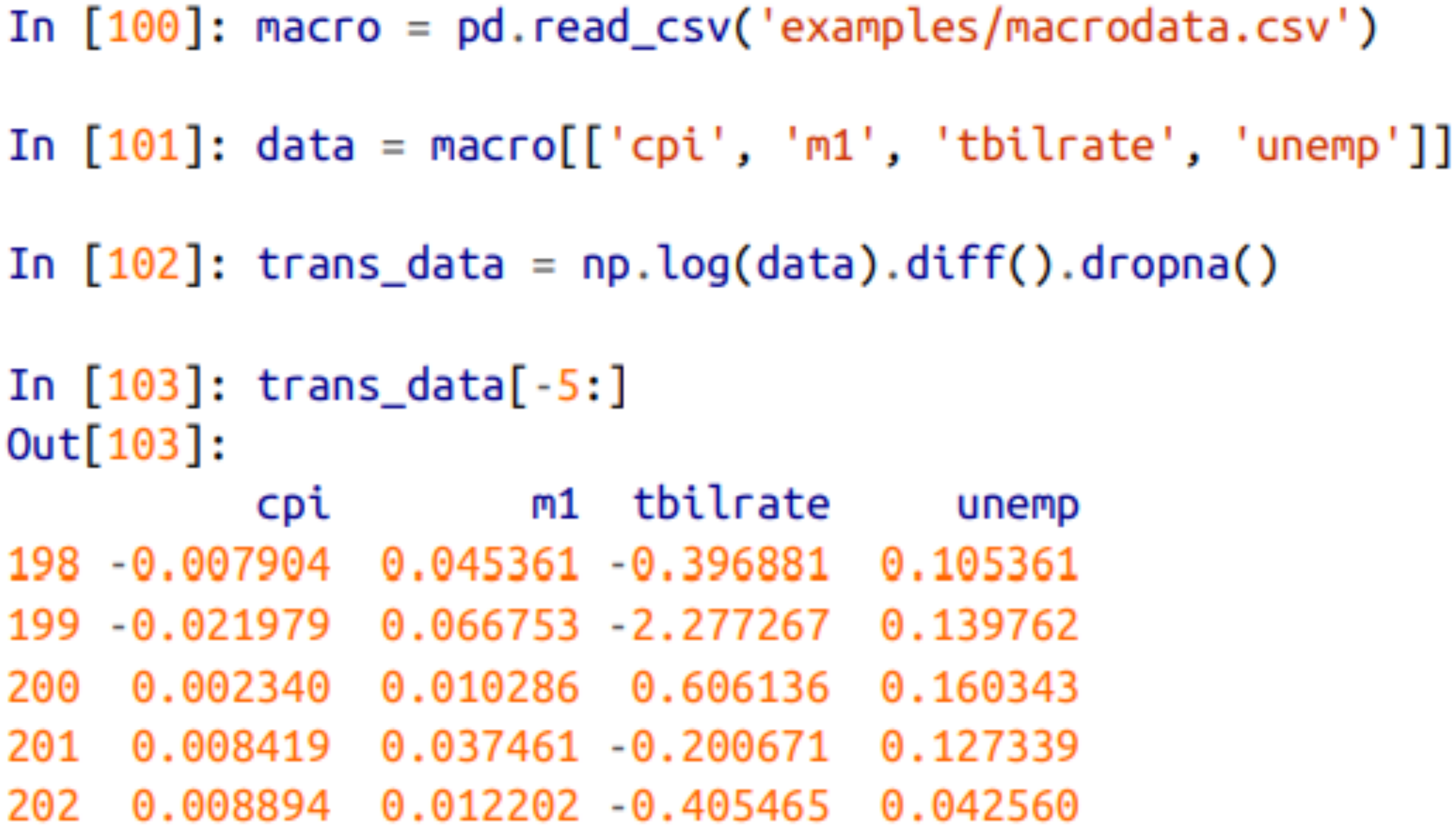
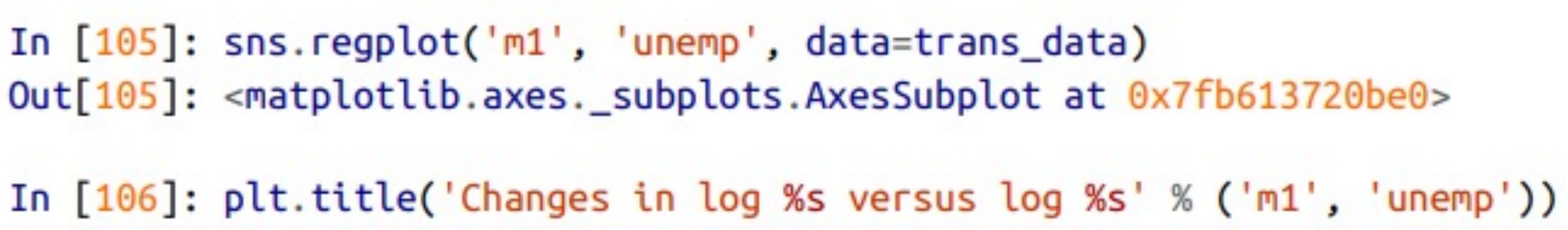


Figure 18: Normalized histogram of normal mixture with density estimate

Scatter or Point Plots



```
In [100]: macro = pd.read_csv('examples/macrodata.csv')

In [101]: data = macro[['cpi', 'm1', 'tbilrate', 'unemp']]

In [102]: trans_data = np.log(data).diff().dropna()

In [103]: trans_data[-5:]
Out[103]:
          cpi        m1  tbilrate     unemp
198 -0.007904  0.045361 -0.396881  0.105361
199 -0.021979  0.066753 -2.277267  0.139762
200  0.002340  0.010286  0.606136  0.160343
201  0.008419  0.037461 -0.200671  0.127339
202  0.008894  0.012202 -0.405465  0.042560
```



```
In [105]: sns.regplot('m1', 'unemp', data=trans_data)
Out[105]: <matplotlib.axes._subplots.AxesSubplot at 0x7fb613720be0>

In [106]: plt.title('Changes in log %s versus log %s' % ('m1', 'unemp'))
```

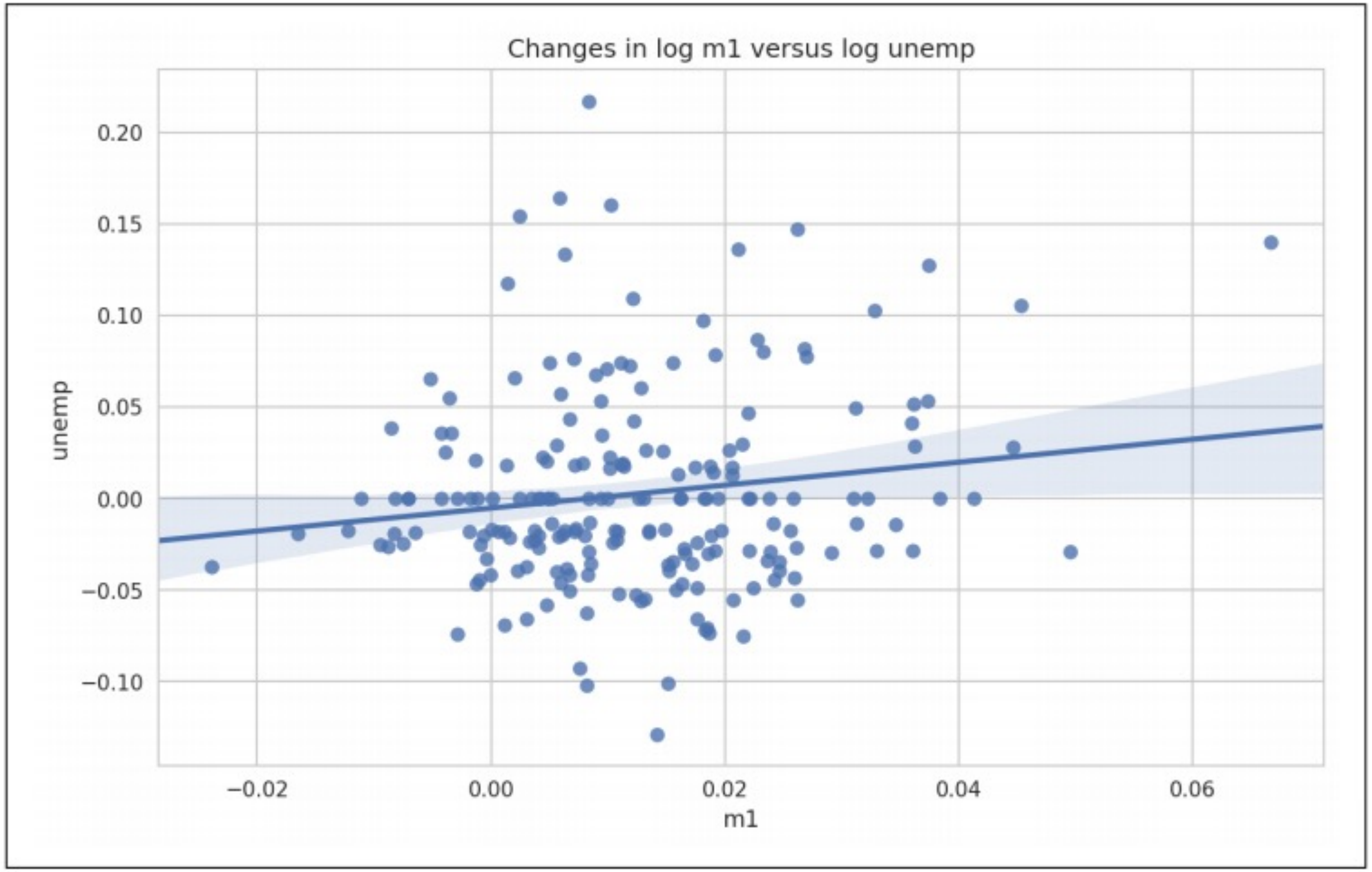


Figure 19: A seaborn regression/scatter plot

```
In [107]: sns.pairplot(trans_data, diag_kind='kde', plot_kws={'alpha': 0.2})
```

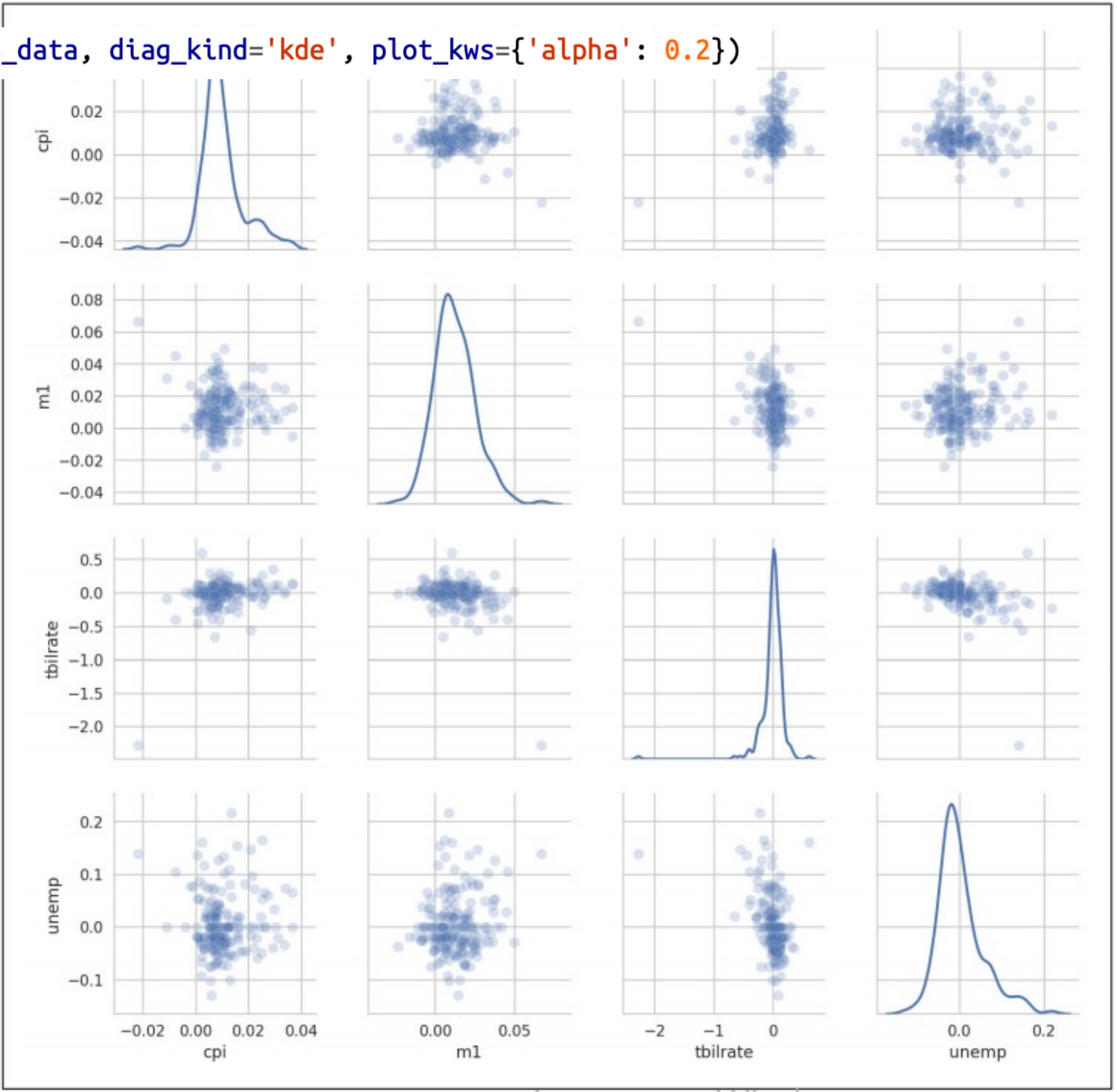
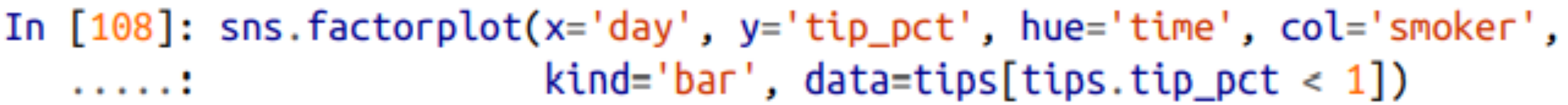


Figure 20: Pair plot matrix of statsmodels macro data

Facet Grids and Categorical Data



```
In [108]: sns.factorplot(x='day', y='tip_pct', hue='time', col='smoker',
   .....:                kind='bar', data=tips[tips.tip_pct < 1])
```

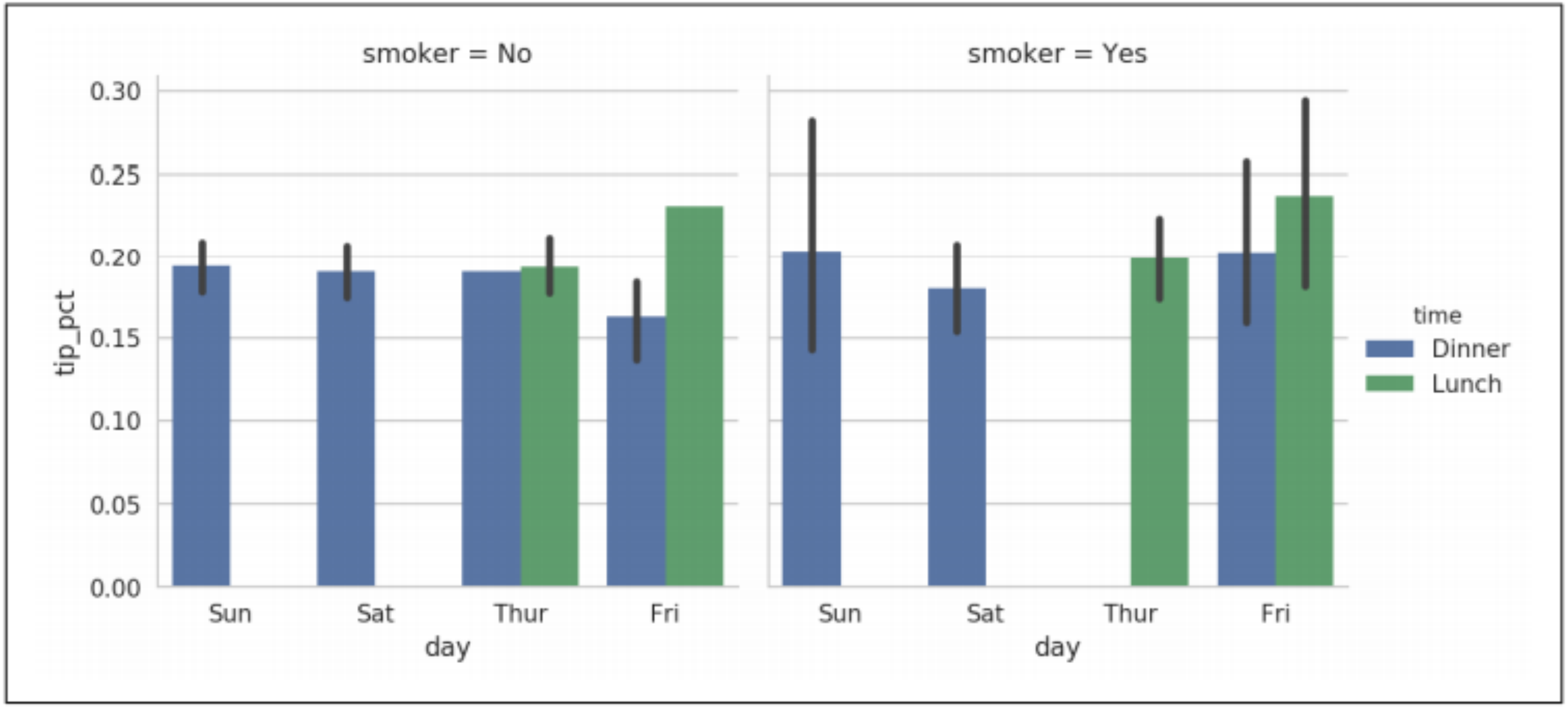
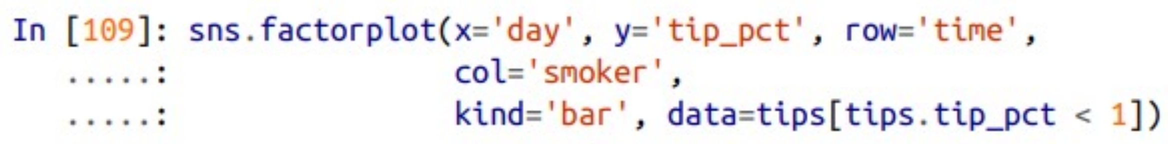


Figure 21: Tipping percentage by day/time/smoker



```
In [109]: sns.factorplot(x='day', y='tip_pct', row='time',
   .....:                col='smoker',
   .....:                kind='bar', data=tips[tips.tip_pct < 1])
```

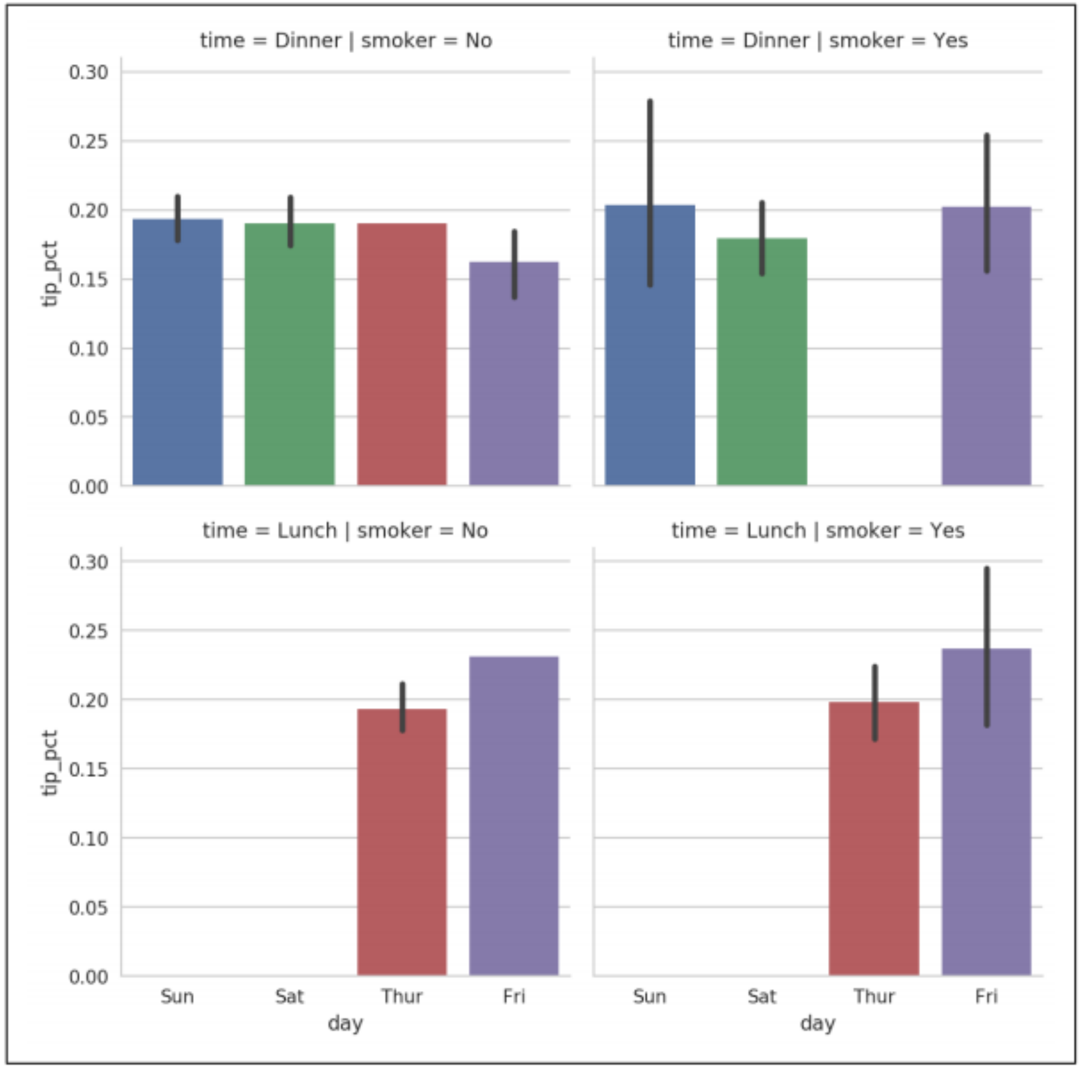
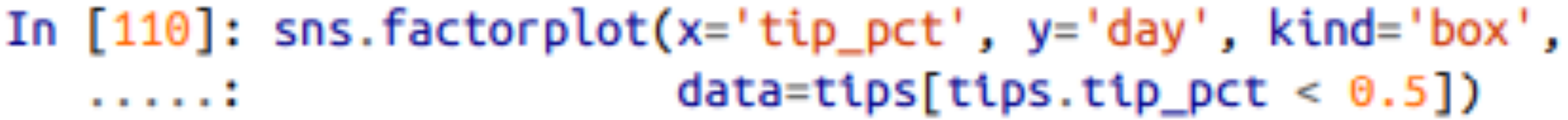


Figure 22: tip_pct by day; facet by time/smoker



```
In [110]: sns.factorplot(x='tip_pct', y='day', kind='box',
     .....:                data=tips[tips.tip_pct < 0.5])
```

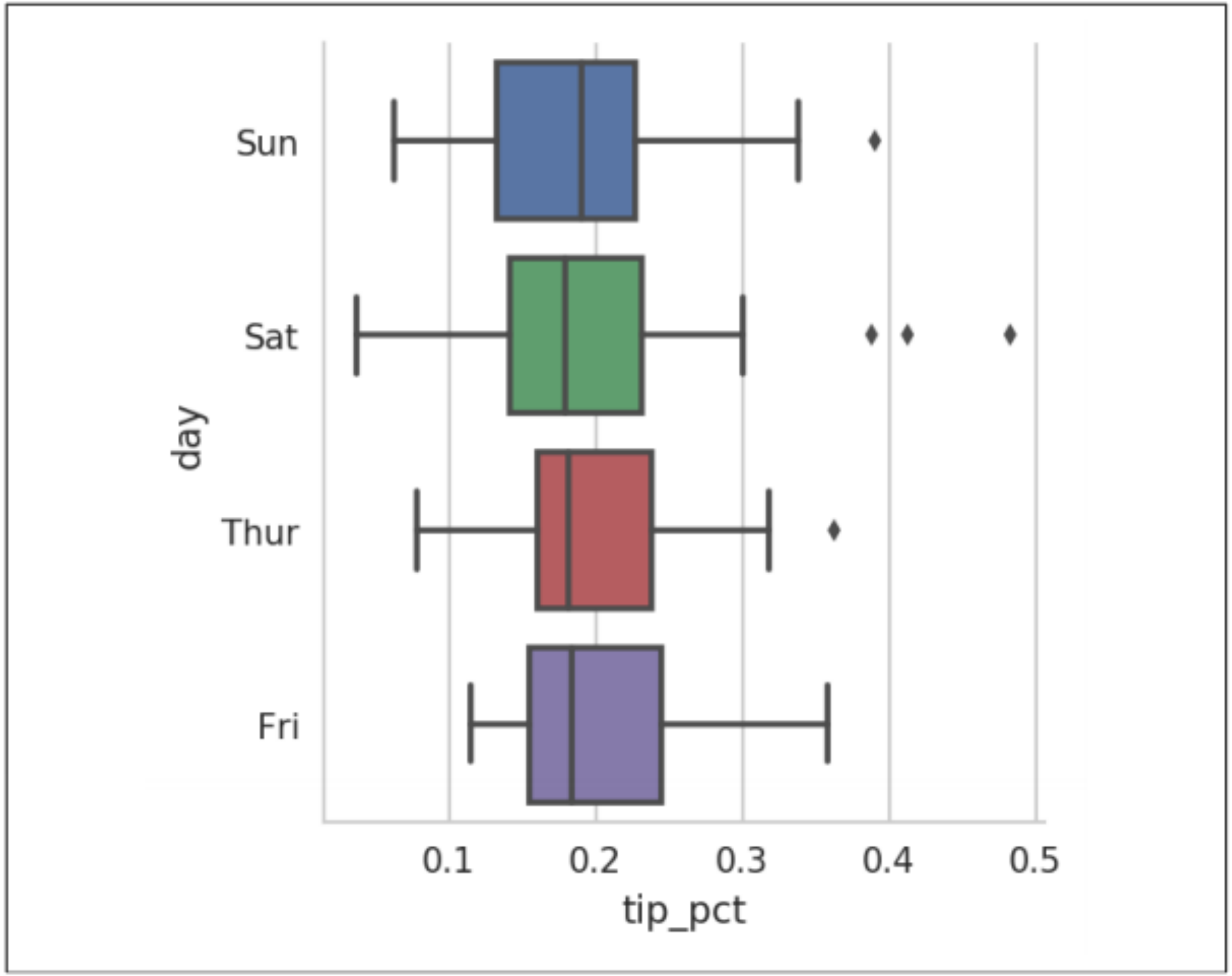


Figure 23: Box plot of tip_pct by day

Other Python Visualization Tools

- With tools like Bokeh and Plotly, it’s now possible to specify dynamic, interactive graphics in Python that are destined for a web browser.