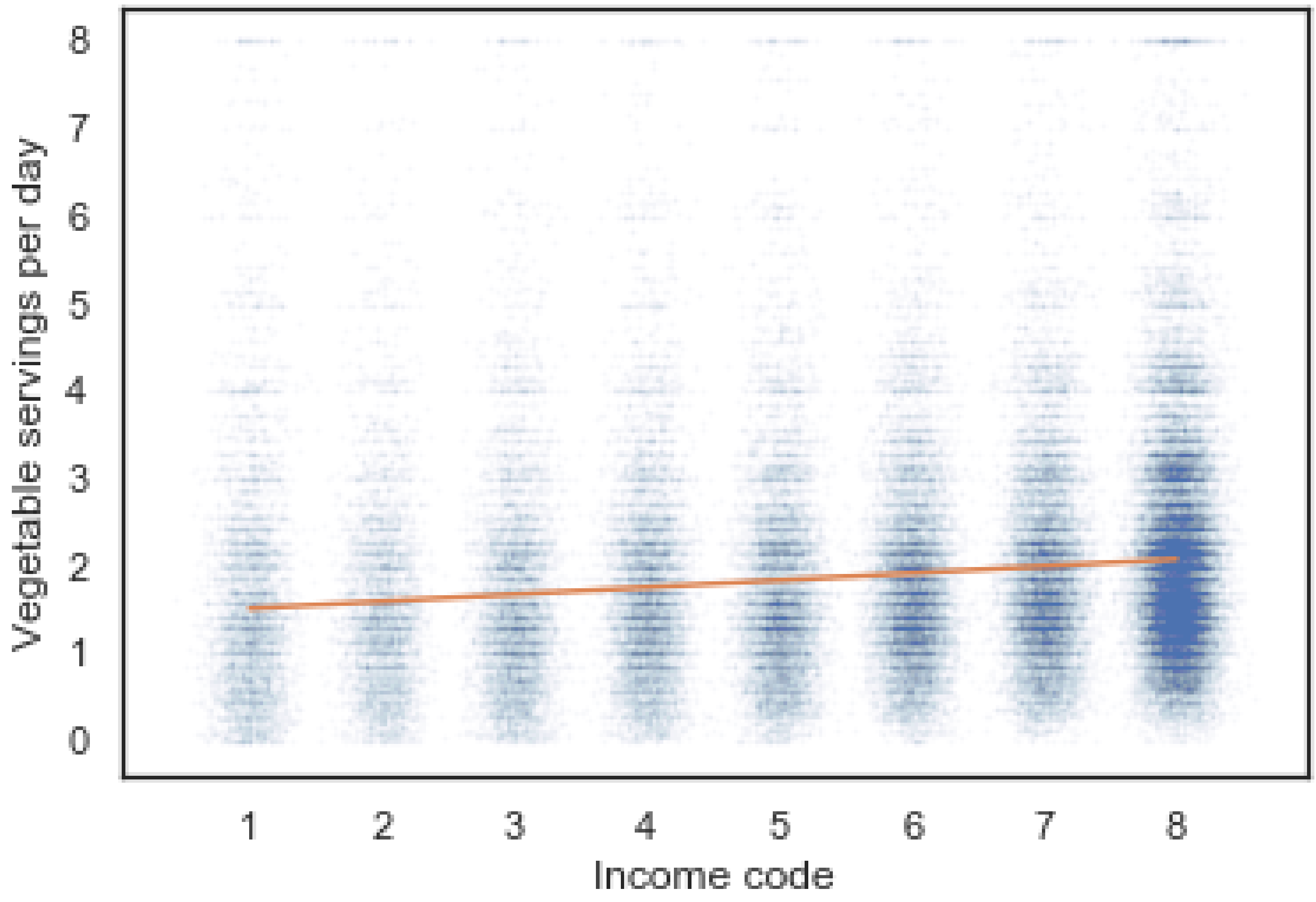
Limits of simple regression

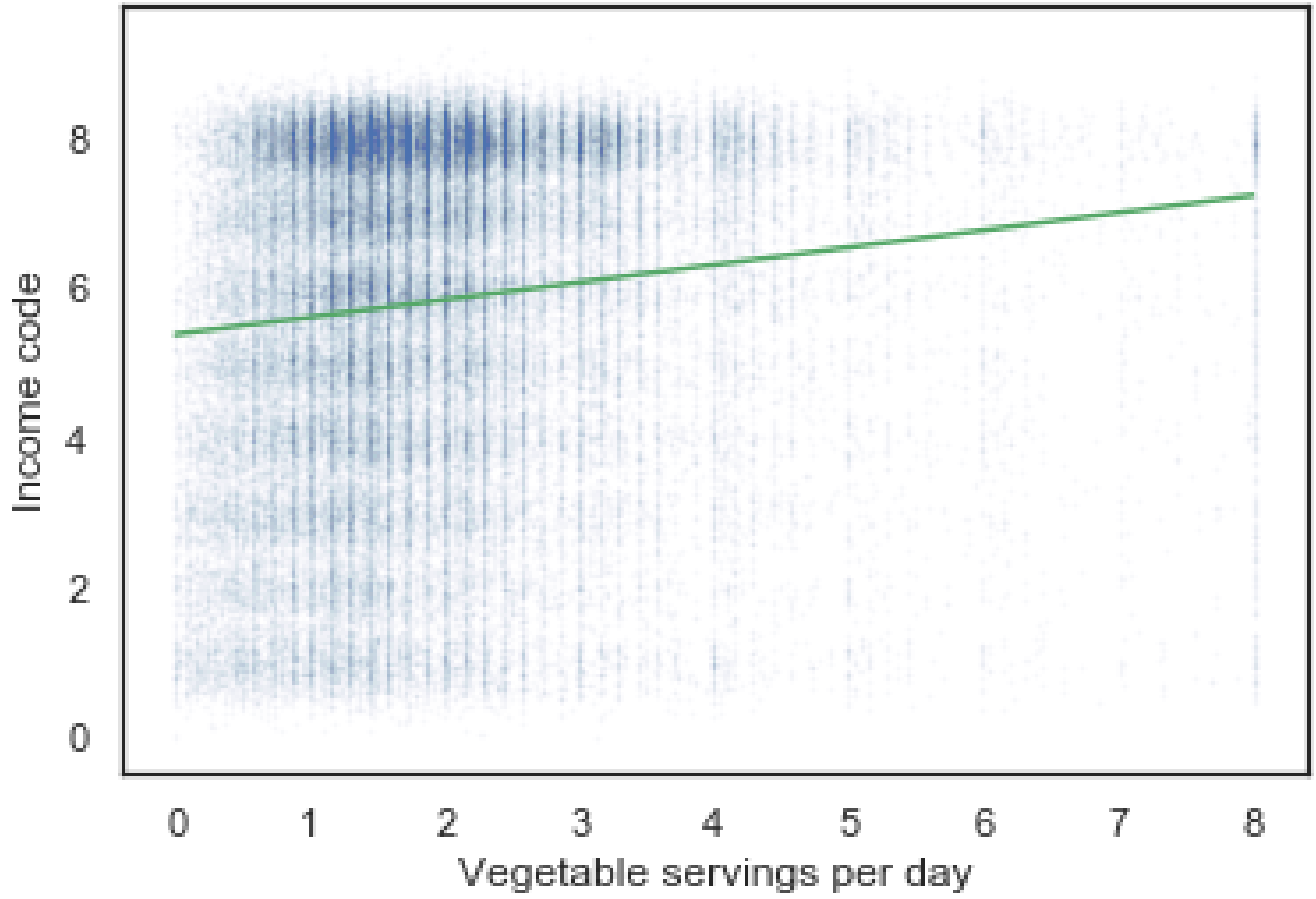
EXPLORATORY DATA ANALYSIS IN PYTHON

Allen Downey
Professor, Olin College

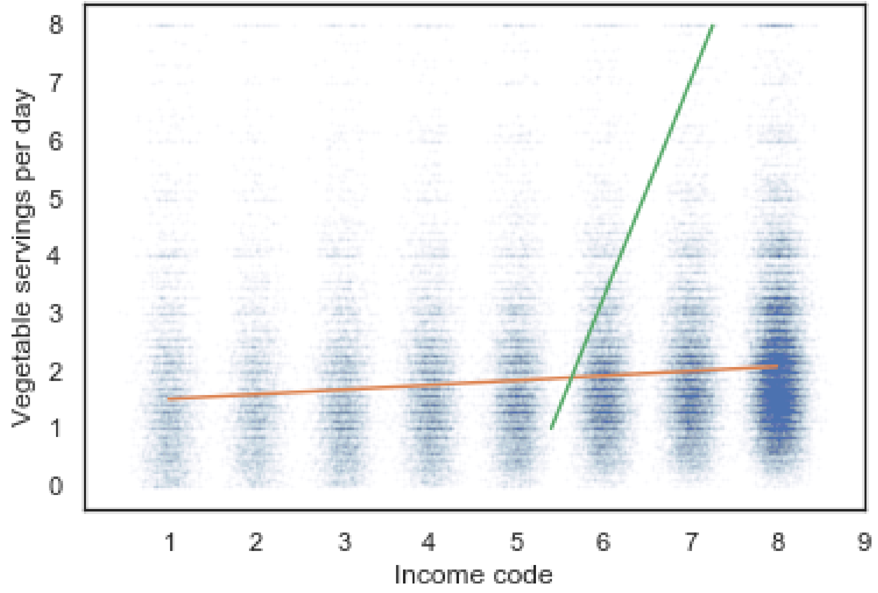
Income and vegetables

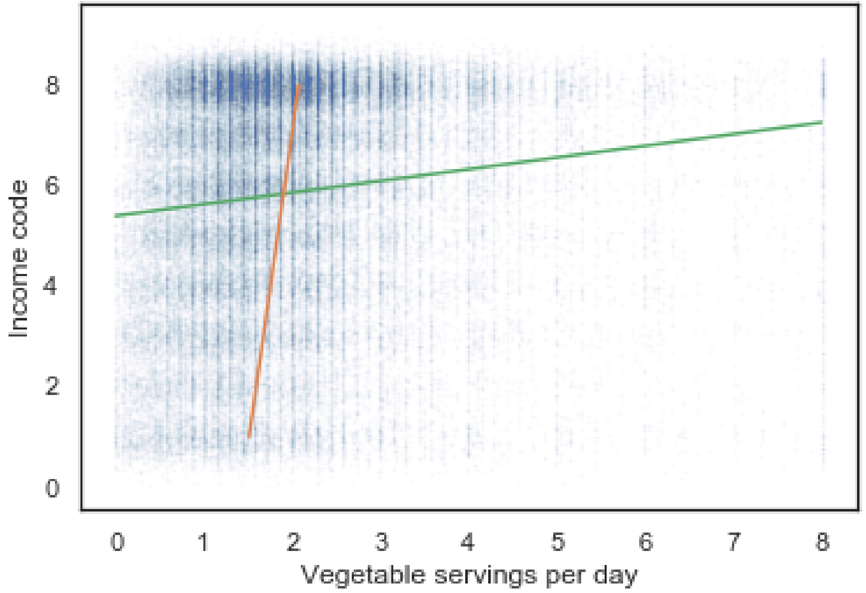


Vegetables and income

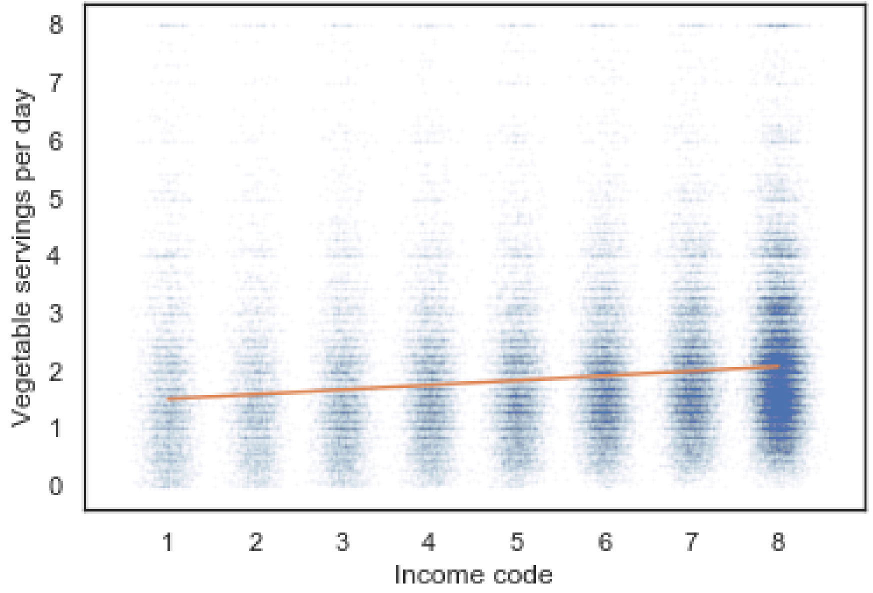


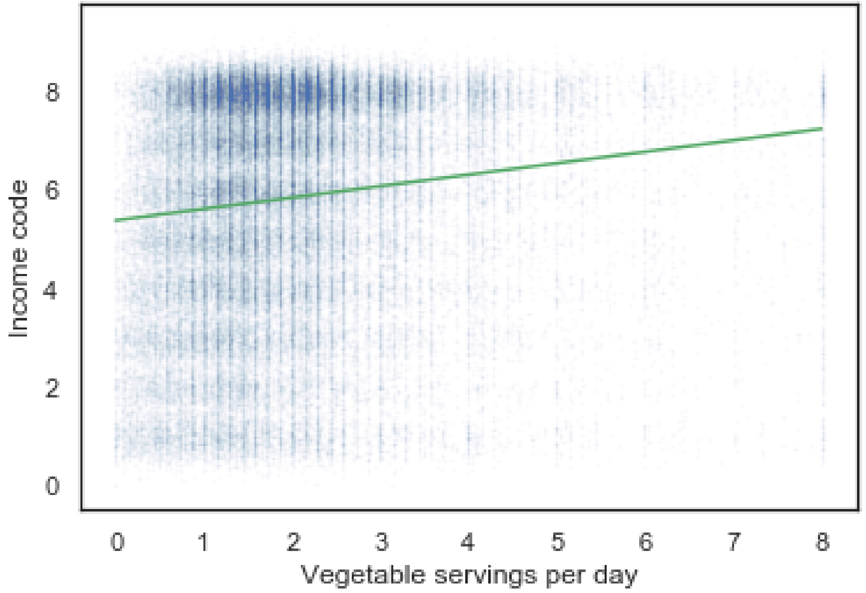
Regression is not symmetric





Regression is not causation





Multiple regression

```
import statsmodels.formula.api as smf
```

```
results = smf.ols('INCOME2 ~ _VEGESU1', data=brfss).fit()
results.params
```

```
Intercept     5.399903
_VEGESU1      0.232515
dtype: float64
```

Let's practice!

EXPLORATORY DATA ANALYSIS IN PYTHON

Multiple regression

EXPLORATORY DATA ANALYSIS IN PYTHON

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Income and education

```
gss = pd.read_hdf('gss.hdf5', 'gss')
```

```
results = smf.ols('realinc ~ educ', data=gss).fit()
results.params
```

```
Intercept   -11539.147837
educ          3586.523659
dtype: float64
```

Adding age

```
results = smf.ols('realinc ~ educ + age', data=gss).fit()
results.params
```

```
Intercept   -16117.275684
educ          3655.166921
age             83.731804
dtype: float64
```

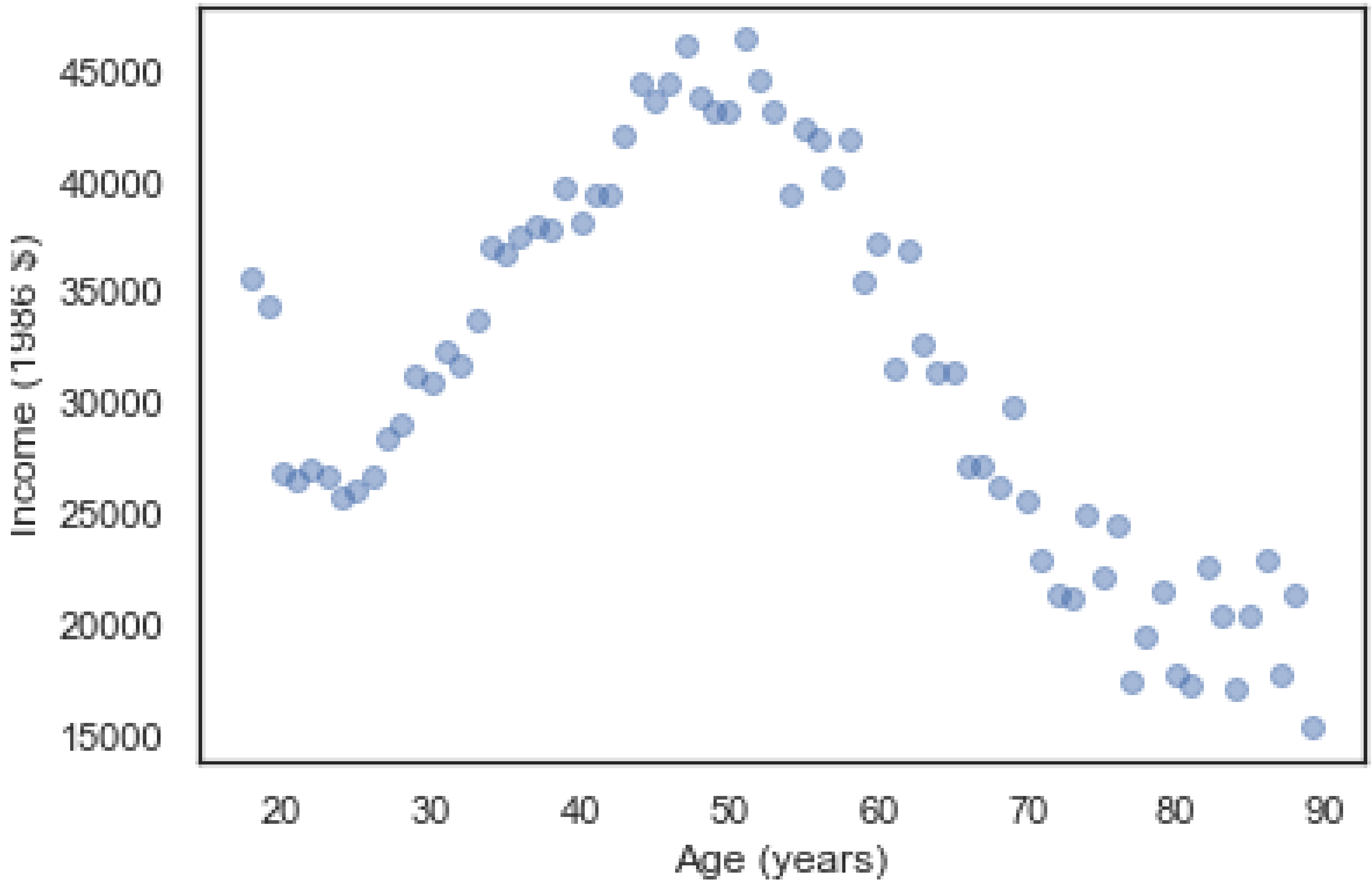
Income and age

```
grouped = gss.groupby('age')
```

```
<pandas.core.groupby.groupby.DataFrameGroupBy object
at 0x7f1264b8ce80>
```

```
mean_income_by_age = grouped['realinc'].mean()
```

```
plt.plot(mean_income_by_age, 'o', alpha=0.5)
plt.xlabel('Age (years)')
plt.ylabel('Income (1986 $)')
```


Income (1986 $)
45000
40000
35000
30000
25000
20000
15000
20
30
40
50
60
70
80
90
Age (years)

Adding a quadratic term

```
gss['age2'] = gss['age']**2
```

```
model = smf.ols('realinc ~ educ + age + age2', data=gss)
results = model.fit()
results.params
```

```
Intercept   -48058.679679
educ          3442.447178
age           1748.232631
age2           -17.437552
dtype: float64
```

Whew!

EXPLORATORY DATA ANALYSIS IN PYTHON

Visualizing regression results

EXPLORATORY DATA ANALYSIS IN PYTHON

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Modeling income and age

```
gss['age2'] = gss['age']**2
gss['educ2'] = gss['educ']**2
```

```
model = smf.ols('realinc ~ educ + educ2 + age + age2', data
results = model.fit()
results.params
```

```
Intercept   -23241.884034
educ          -528.309369
educ2          159.966740
age           1696.717149
age2           -17.196984
```

Generating predictions

```
df = pd.DataFrame()
df['age'] = np.linspace(18, 85)
df['age2'] = df['age']**2
```

```
df['educ'] = 12
df['educ2'] = df['educ']**2
```

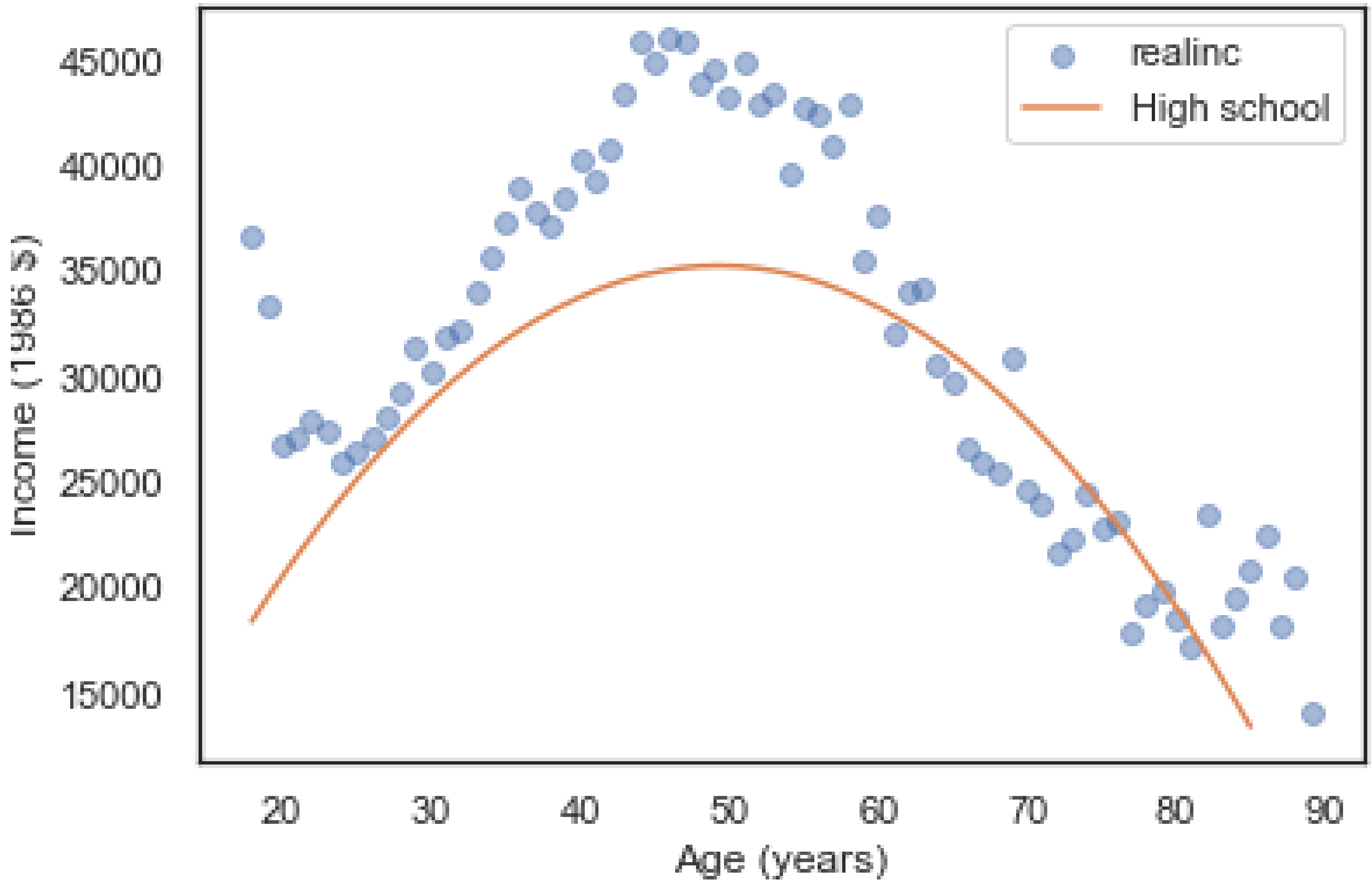
```
pred12 = results.predict(df)
```

Plotting predictions

```
plt.plot(df['age'], pred12, label='High school')
```

```
plt.plot(mean_income_by_age, 'o', alpha=0.5)
```

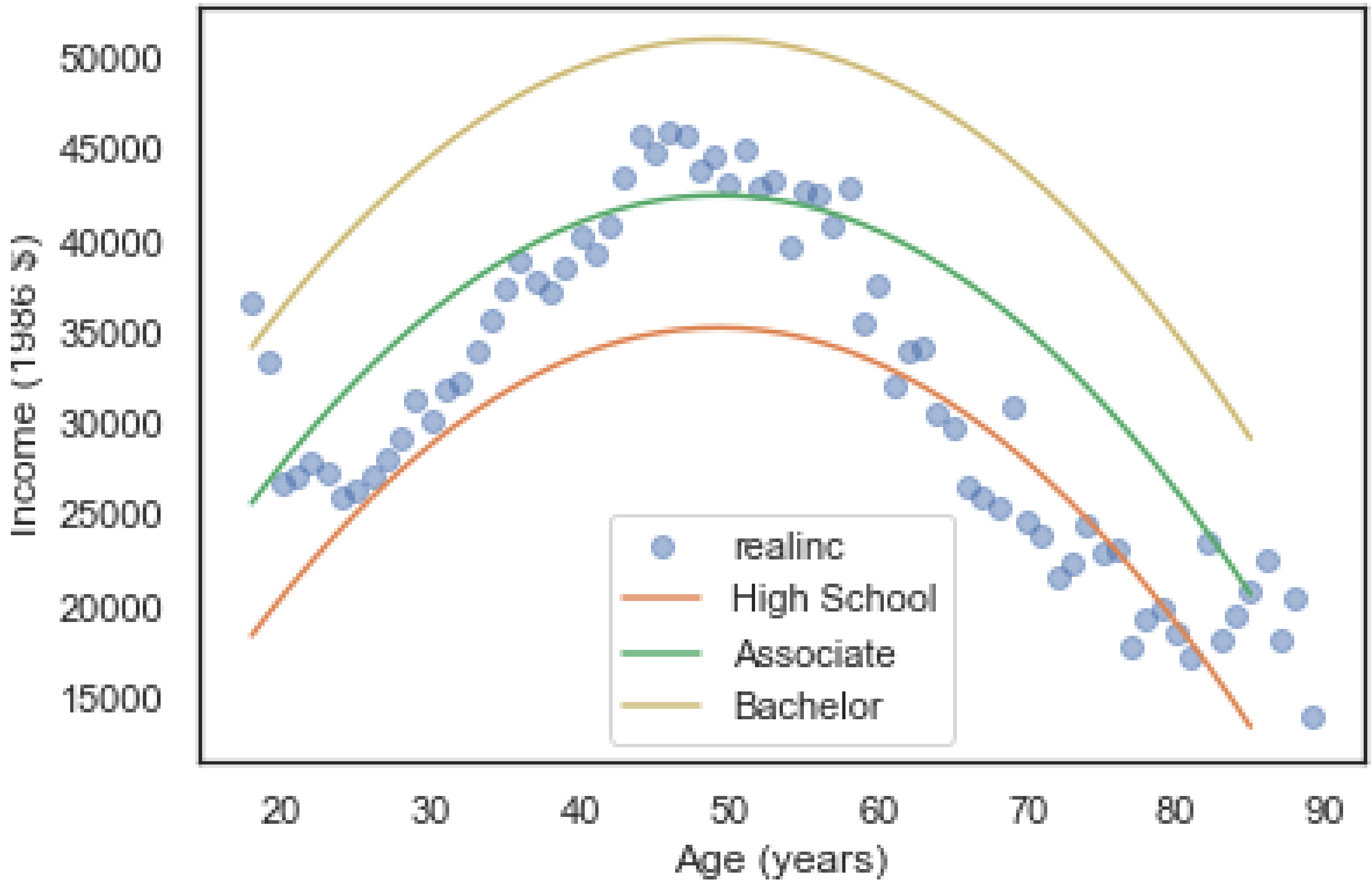
```
plt.xlabel('Age (years)')
plt.ylabel('Income (1986 $)')
plt.legend()
```


realinc
High school
45000
40000
35000
30000
25000
20000
15000
Income (1986 $)
20
30
40
50
60
70
80
90
Age (years)

Levels of education

```
df['educ'] = 14
df['educ2'] = df['educ']**2
pred14 = results.predict(df)
plt.plot(df['age'], pred14, label='Associate')
```

```
df['educ'] = 16
df['educ2'] = df['educ']**2
pred16 = results.predict(df)
plt.plot(df['age'], pred16, label='Bachelor'
```


Income (1986 $)
50000
45000
40000
35000
30000
25000
20000
15000
realinc
High School
Associate
Bachelor
20
30
40
50
60
70
80
90
Age (years)

Let's practice!

EXPLORATORY DATA ANALYSIS IN PYTHON

Logistic regression

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Categorical variables

- Numerical variables: income, age, years of education.
- Categorical variables: sex, race.

Sex and income

```
formula = 'realinc ~ educ + educ2 + age + age2 + C(sex)'
results = smf.ols(formula, data=gss).fit()
results.params
```

```
Intercept     -22369.453641
C(sex)[T.2]    -4156.113865
educ            -310.247419
educ2            150.514091
age             1703.047502
age2             -17.238711
```

Boolean variable

```
gss['gunlaw'].value_counts()
```

```
1.0    30918
2.0     9632
```

```
gss['gunlaw'].replace([2], [0], inplace=True)
```

```
gss['gunlaw'].value_counts()
```

```
1.0    30918
0.0     9632
```

Logistic regression

```
formula = 'gunlaw ~ age + age2 + educ + educ2 + C(sex)'
results = smf.logit(formula, data=gss).fit()
```

```
results.params
```

```
Intercept       1.653862
C(sex)[T.2]     0.757249
age            -0.018849
age2            0.000189
educ           -0.124373
educ2           0.006653
```

Generating predictions

```
df = pd.DataFrame()
df['age'] = np.linspace(18, 89)
df['educ'] = 12
```

```
df['age2'] = df['age']**2
df['educ2'] = df['educ']**2
```

```
df['sex'] = 1
pred1 = results.predict(df)
```

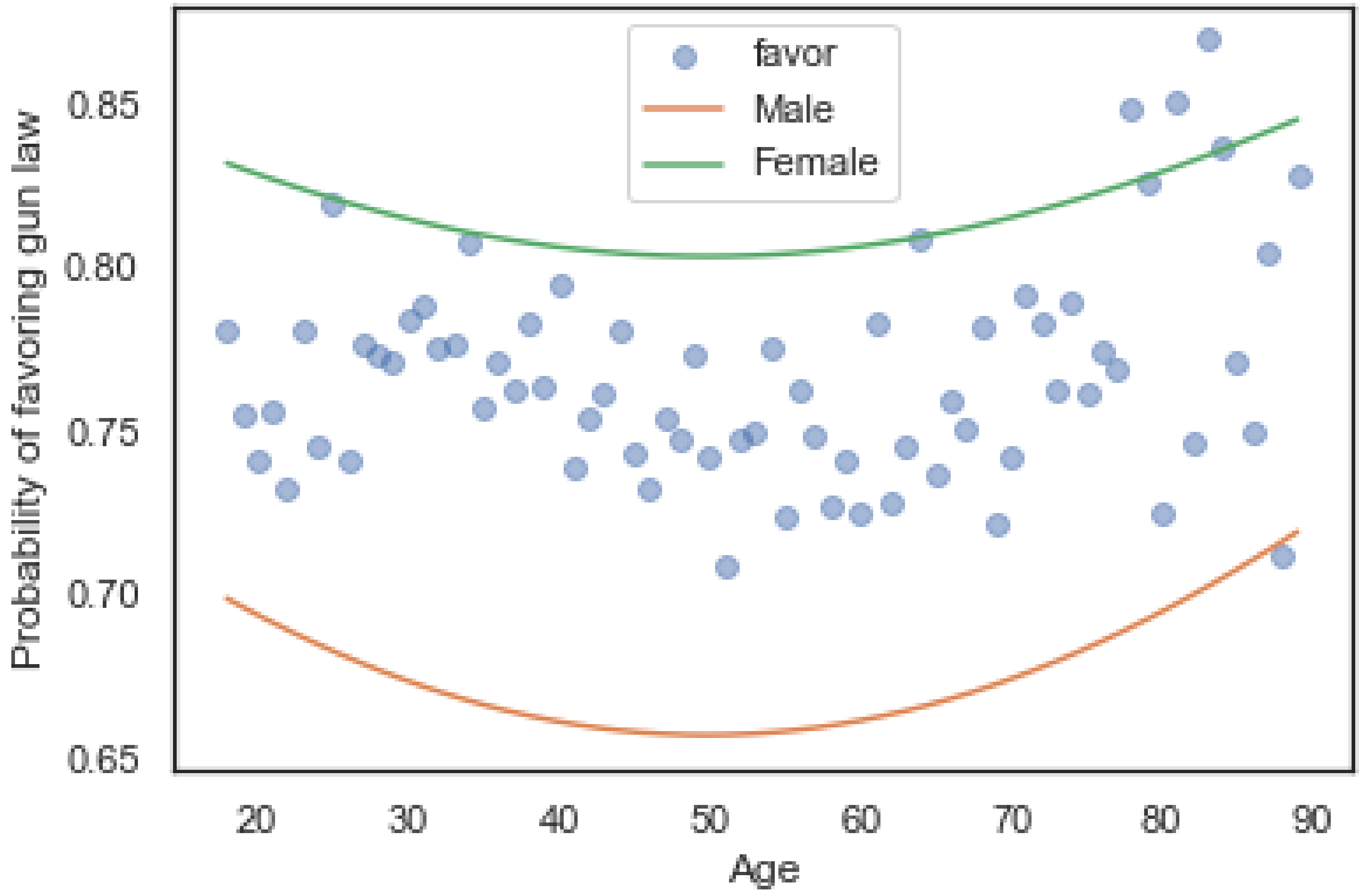
```
df['sex'] = 2
pred2 = results.predict(df)
```

Visualizing results

```
grouped = gss.groupby('age')
favor_by_age = grouped['gunlaw'].mean()
plt.plot(favor_by_age, 'o', alpha=0.5)
```

```
plt.plot(df['age'], pred1, label='Male')
plt.plot(df['age'], pred2, label='Female')
```

```
plt.xlabel('Age')
plt.ylabel('Probability of favoring gun law')
plt.legend()
```



favor
Male
Female
Probability of favoring gun law
0.85
0.80
0.75
0.70
0.65
20
30
40
50
60
70
80
90
Age

Let's practice!

EXPLORATORY DATA ANALYSIS IN PYTHON

Next steps

EXPLORATORY DATA ANALYSIS IN PYTHON

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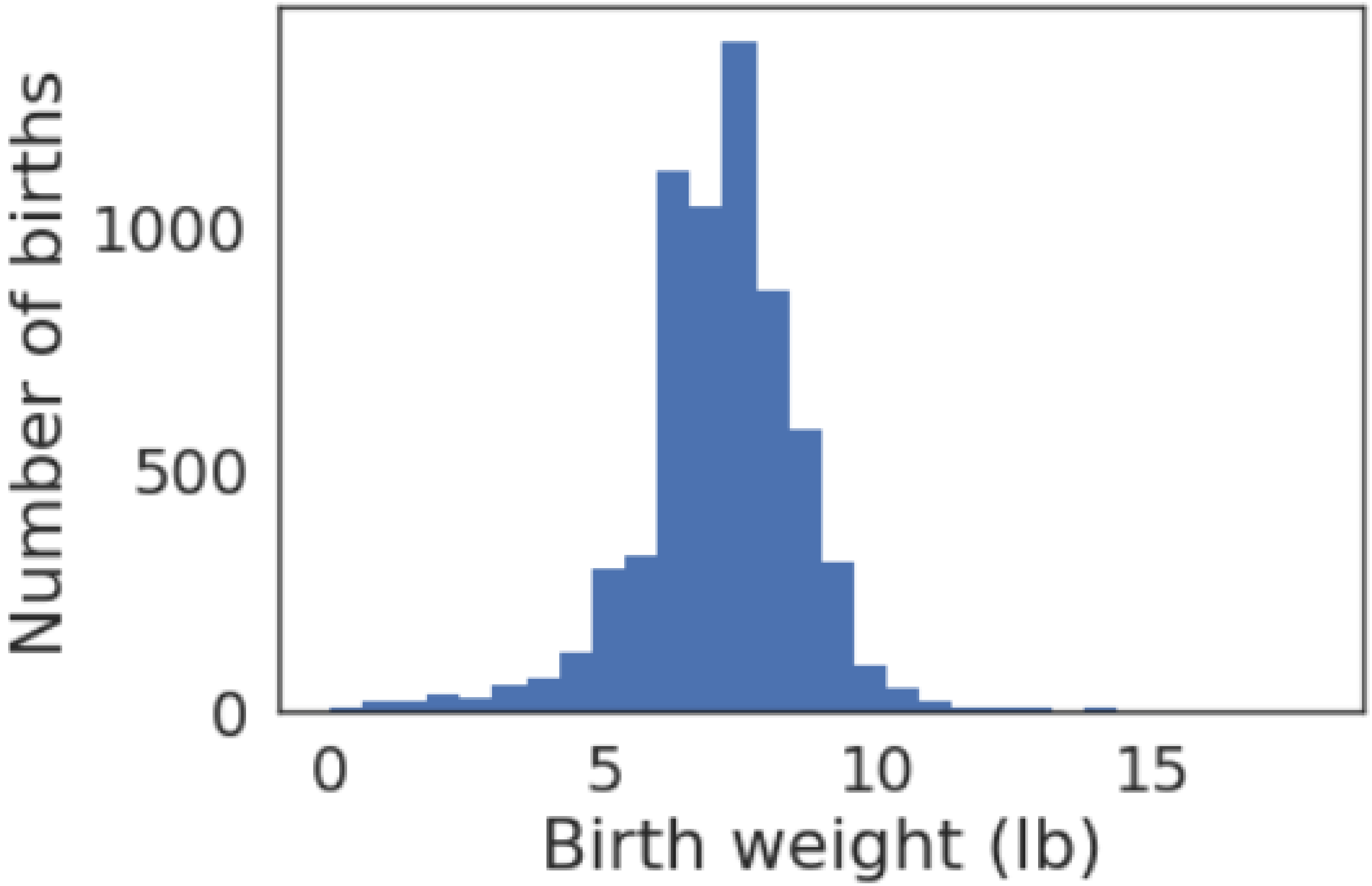
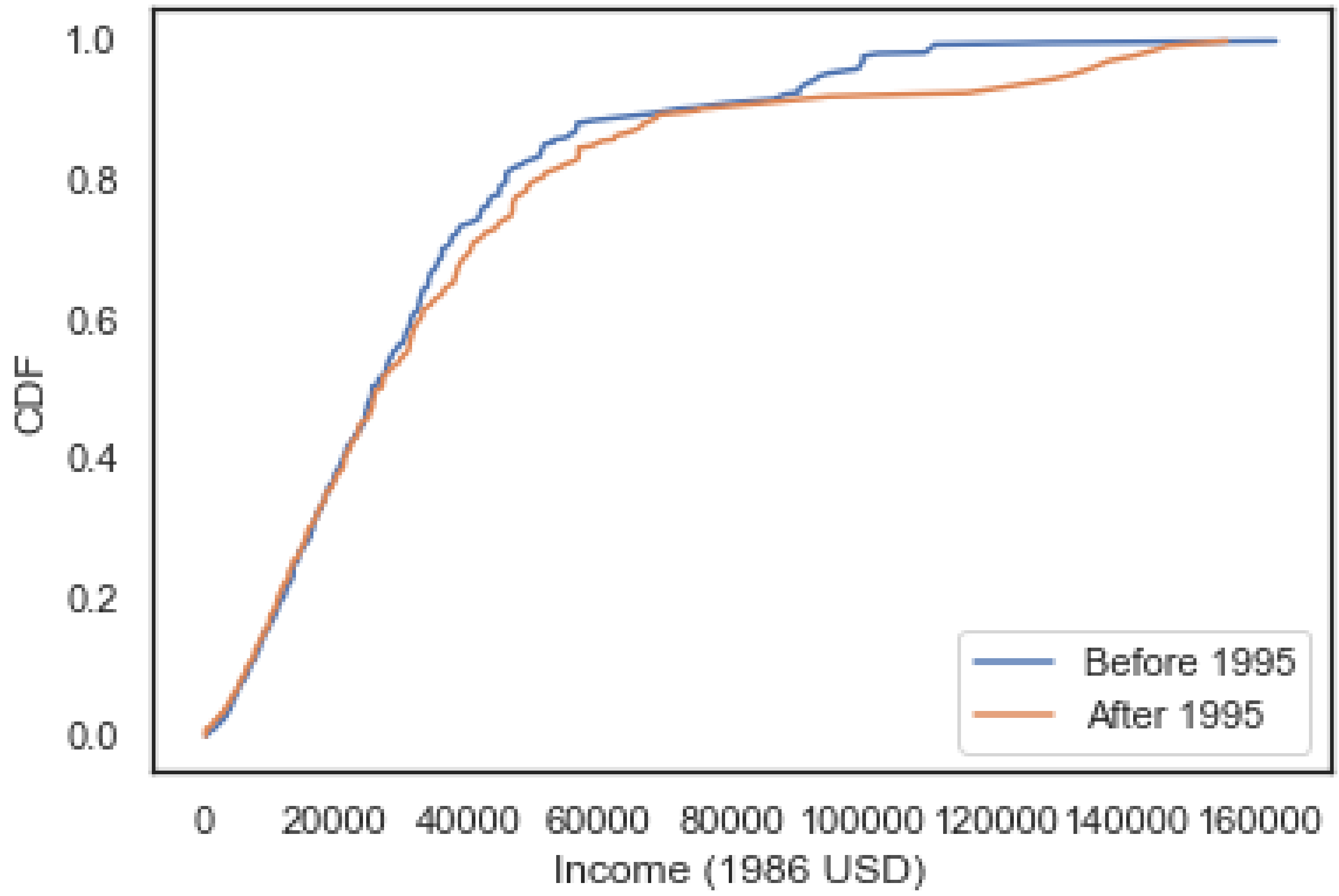
Exploratory Data Analysis

- Import, clean, and validate
- Visualize distributions
- Explore relationships between variables
- Explore multivariate relationships

Import, clean, and validate



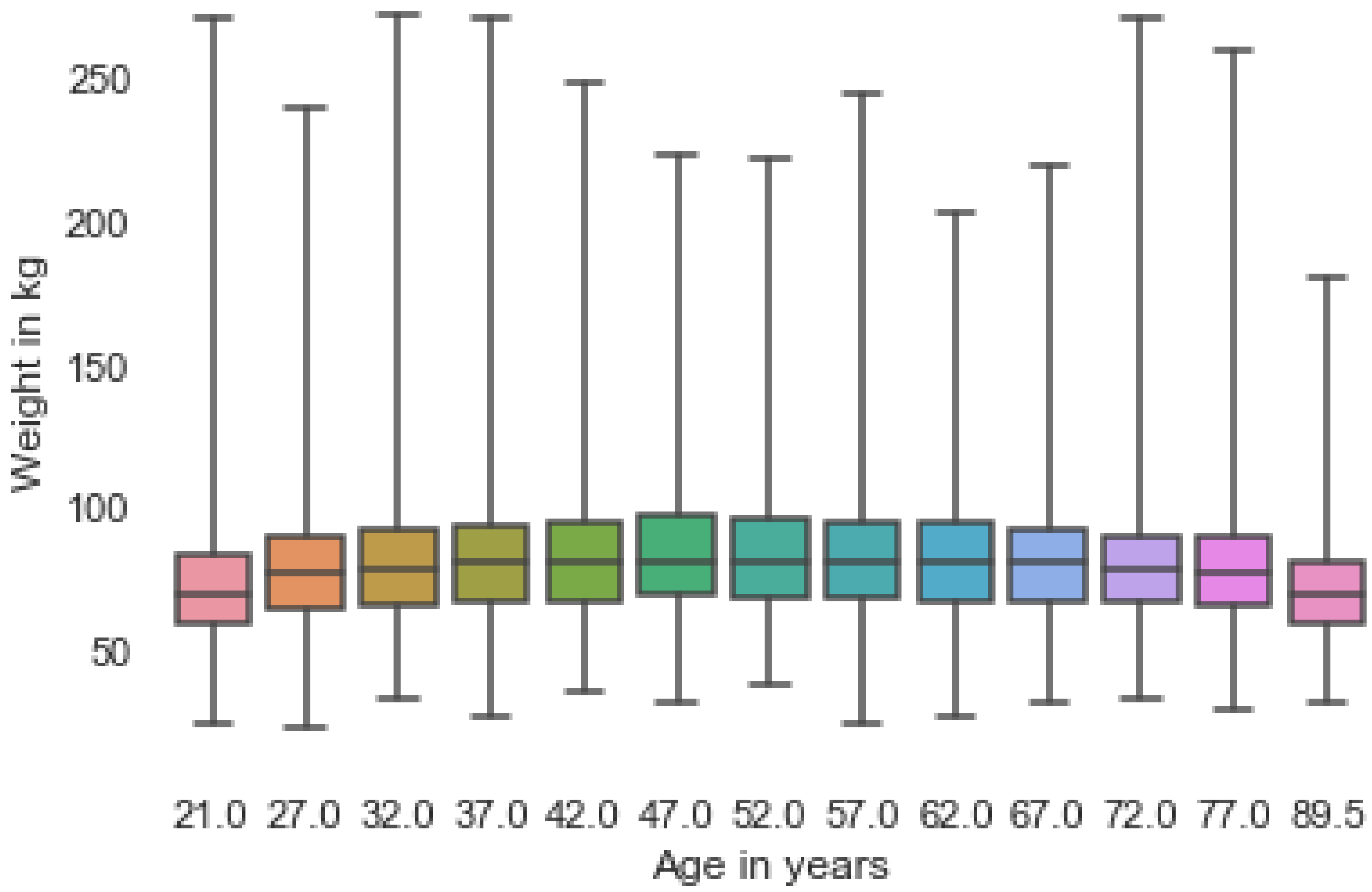
Visualize distributions



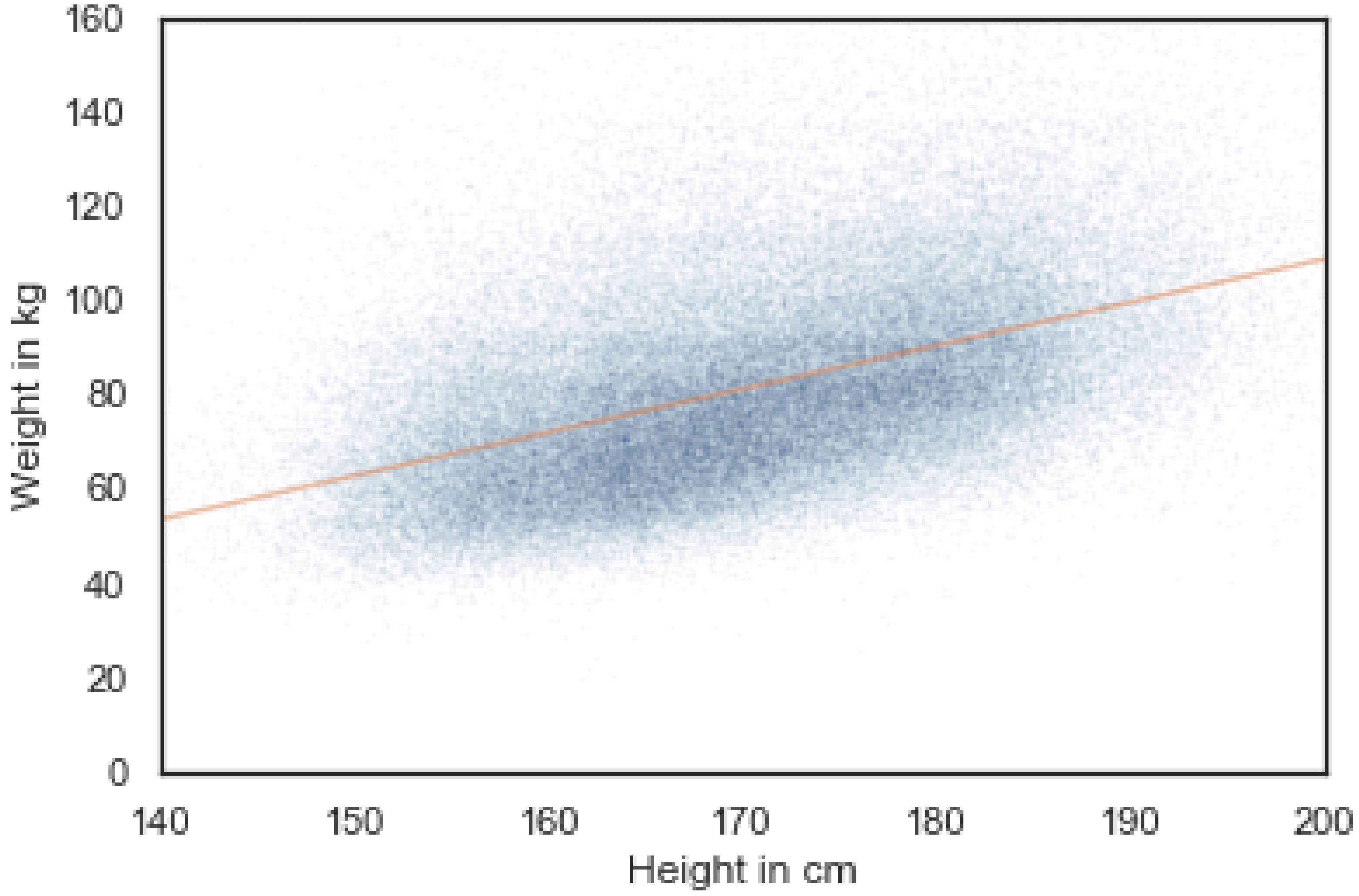
CDF, PMF, and KDE

- Use CDFs for exploration.
- Use PMFs if there are a small number of unique values.
- Use KDE if there are a lot of values.

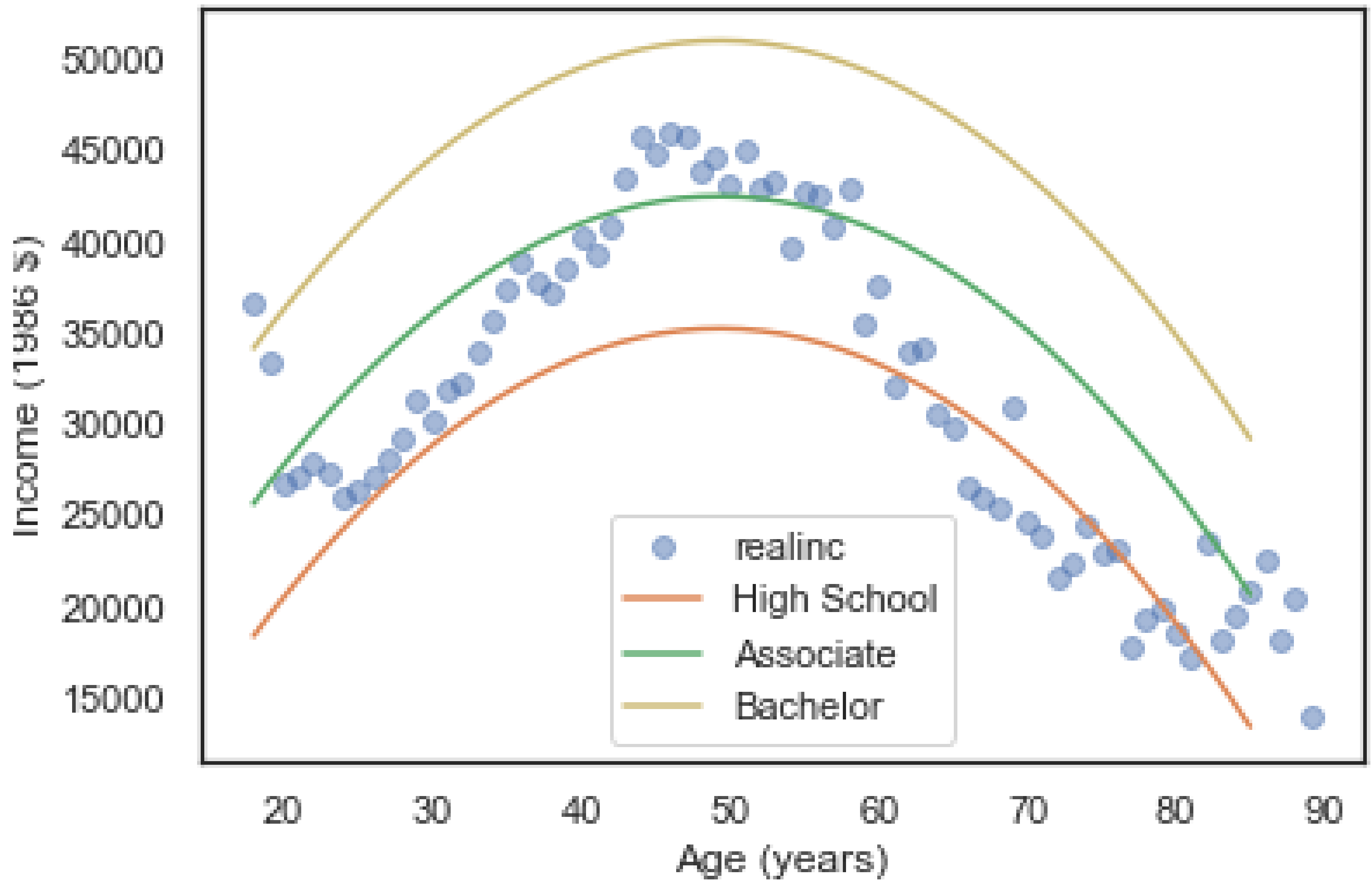
Visualizing relationships



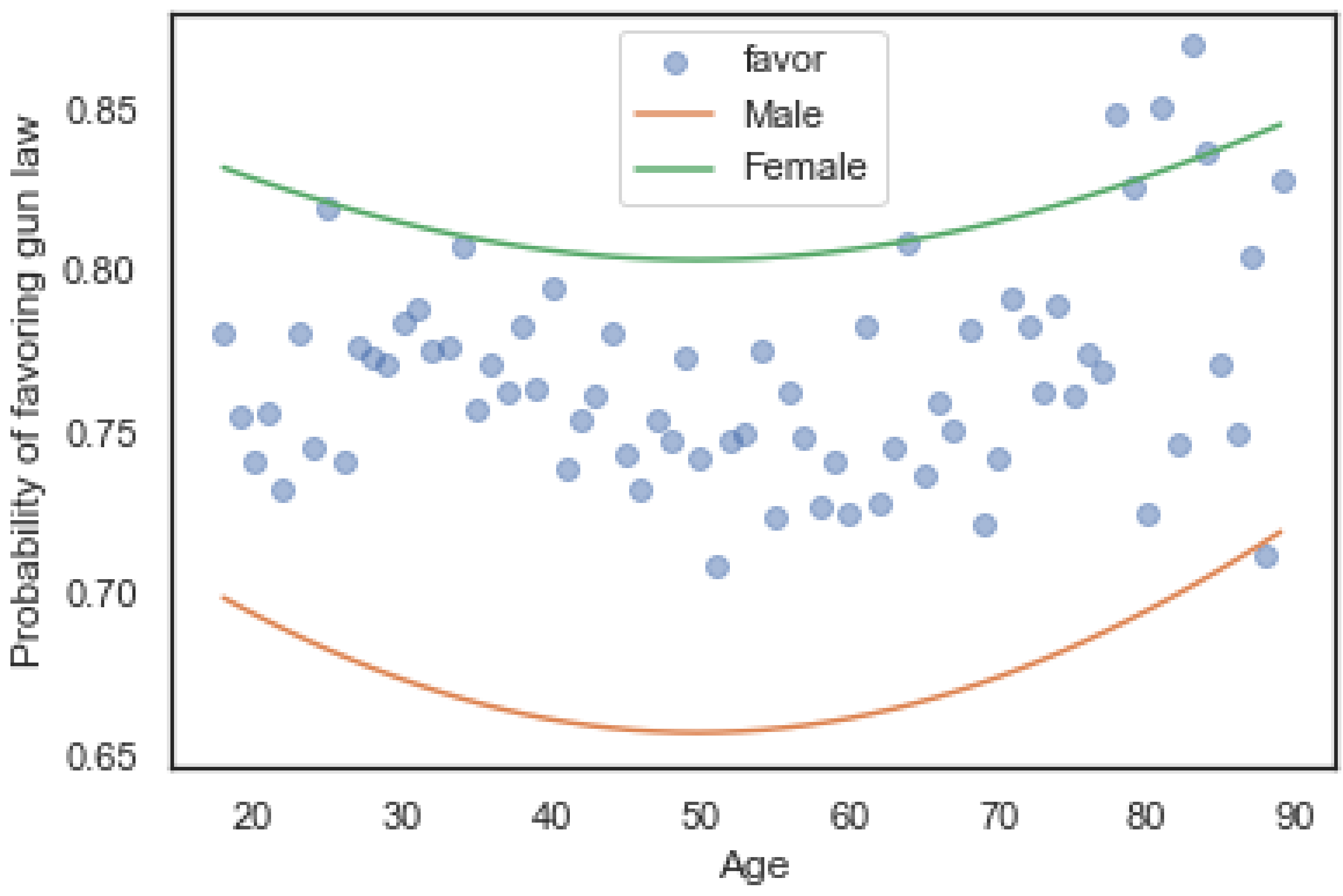
Quantifying correlation



Multiple regression



Logistic regression



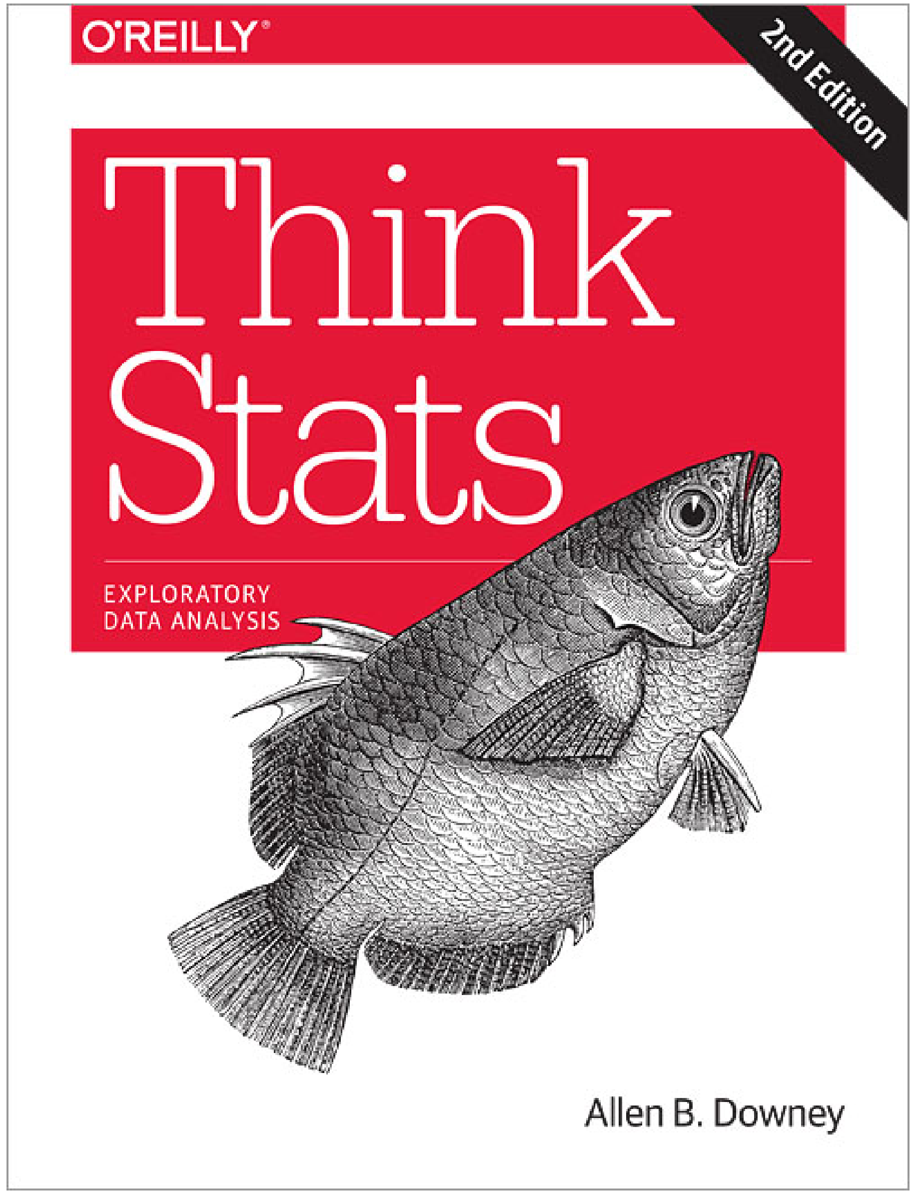
Where to next?

- Statistical Thinking in Python
- pandas Foundations
- Improving Your Data Visualizations in Python
- Introduction to Linear Modeling in Python

Think Stats

This course is based on *Think Stats*

Published by O'Reilly and available free from thinkstats2.com



Thank you!

EXPLORATORY DATA ANALYSIS IN PYTHON