Considerations for categorical data

EXPLORATORY DATA ANALYSIS IN PYTHON



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Why perform EDA?

- Detecting patterns and relationships
- Generating questions, or **hypotheses**
- Preparing data for machine learning



[1] Image credit: https://unsplash.com/@simonesecci

Representative data

- Sample represents the population

For example:

- Education versus income in USA
  - Can't use data from France





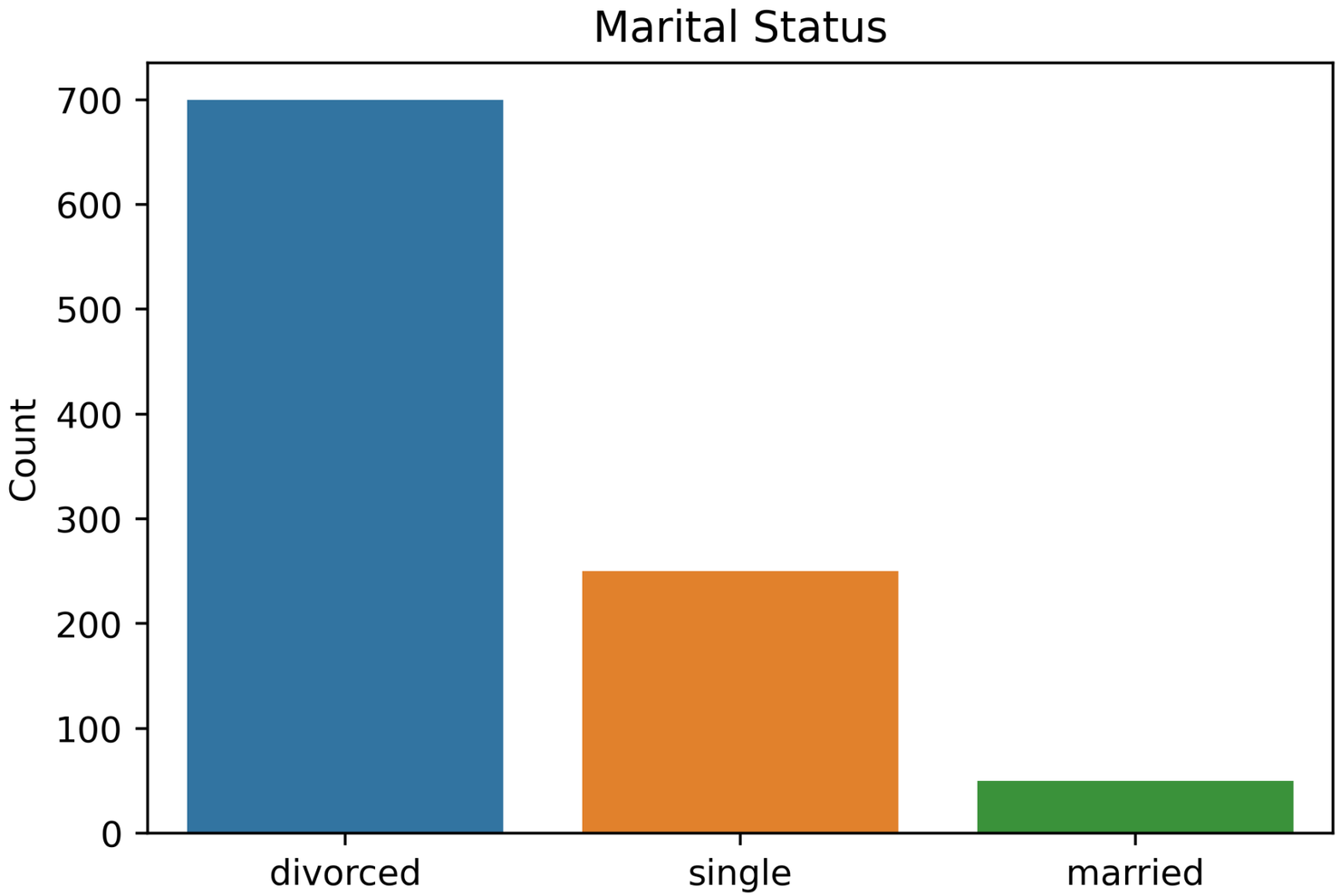
[1] Image credits: https://unsplash.com/@cristina_glebova; https://unsplash.com/@nimbus_vulpis

Categorical classes

- Classes = labels

- Survey people's attitudes towards marriage
  - Marital status
    - Single
    - Married
    - Divorced

Class imbalance



Class frequency

```
print(planes["Destination"].value_counts())
```

```
Cochin       4391
Banglore     2773
Delhi        1219
New Delhi     888
Hyderabad     673
Kolkata       369
Name: Destination, dtype: int64
```

Relative class frequency

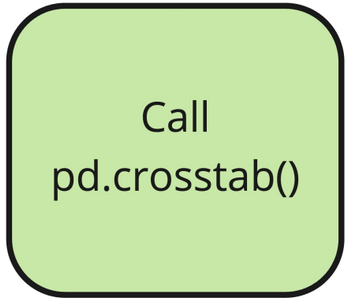
- 40% of internal Indian flights have a destination of Delhi

```
planes["Destination"].value_counts(normalize=True)
```

```
Cochin       0.425773
Banglore     0.268884
Delhi        0.118200
New Delhi    0.086105
Hyderabad    0.065257
Kolkata      0.035780
Name: Destination, dtype: float64
```

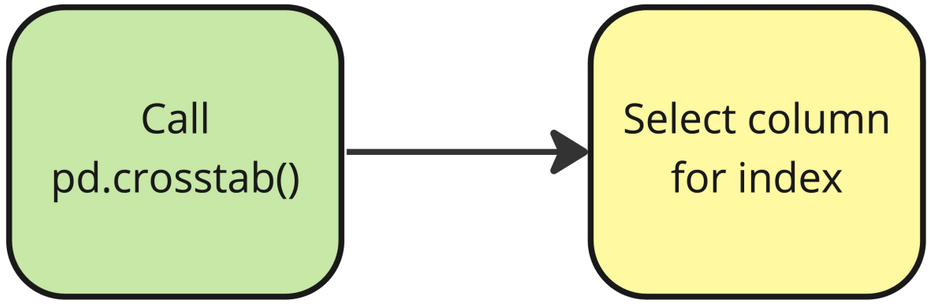
- Is our sample representative of the population (Indian internal flights)?

Cross-tabulation




```
pd.crosstab(
```

Select index




```
pd.crosstab(planes["Source"],
```

Select columns




```
pd.crosstab(planes["Source"], planes["Destination"])
```

Cross-tabulation

Destination	Banglore	Cochin	Delhi	Hyderabad	Kolkata	New Delhi
Source						
Banglore	0	0	1199	0	0	868
Chennai	0	0	0	0	364	0
Delhi	0	4318	0	0	0	0
Kolkata	2720	0	0	0	0	0
Mumbai	0	0	0	662	0	0

Extending cross-tabulation

Source	Destination	Median Price (IDR)
Banglore	Delhi	4232.21
Banglore	New Delhi	12114.56
Chennai	Kolkata	3859.76
Delhi	Cochin	9987.63
Kolkata	Banglore	9654.21
Mumbai	Hyderabad	3431.97

Aggregated values with pd.crosstab()

```
pd.crosstab(planes["Source"], planes["Destination"],
            values=planes["Price"], aggfunc="median")
```

Destination	Banglore	Cochin	Delhi	Hyderabad	Kolkata	New Delhi
Source						
Banglore	NaN	NaN	4823.0	NaN	NaN	10976.5
Chennai	NaN	NaN	NaN	NaN	3850.0	NaN
Delhi	NaN	10262.0	NaN	NaN	NaN	NaN
Kolkata	9345.0	NaN	NaN	NaN	NaN	NaN
Mumbai	NaN	NaN	NaN	3342.0	NaN	NaN

Comparing sample to population

Source	Destination	Median Price (IDR)	Median Price (dataset)
Banglore	Delhi	4232.21	4823.0
Banglore	New Delhi	12114.56	10976.50
Chennai	Kolkata	3859.76	3850.0
Delhi	Cochin	9987.63	10260.0
Kolkata	Banglore	9654.21	9345.0
Mumbai	Hyderabad	3431.97	3342.0

Let's practice!

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Generating new features

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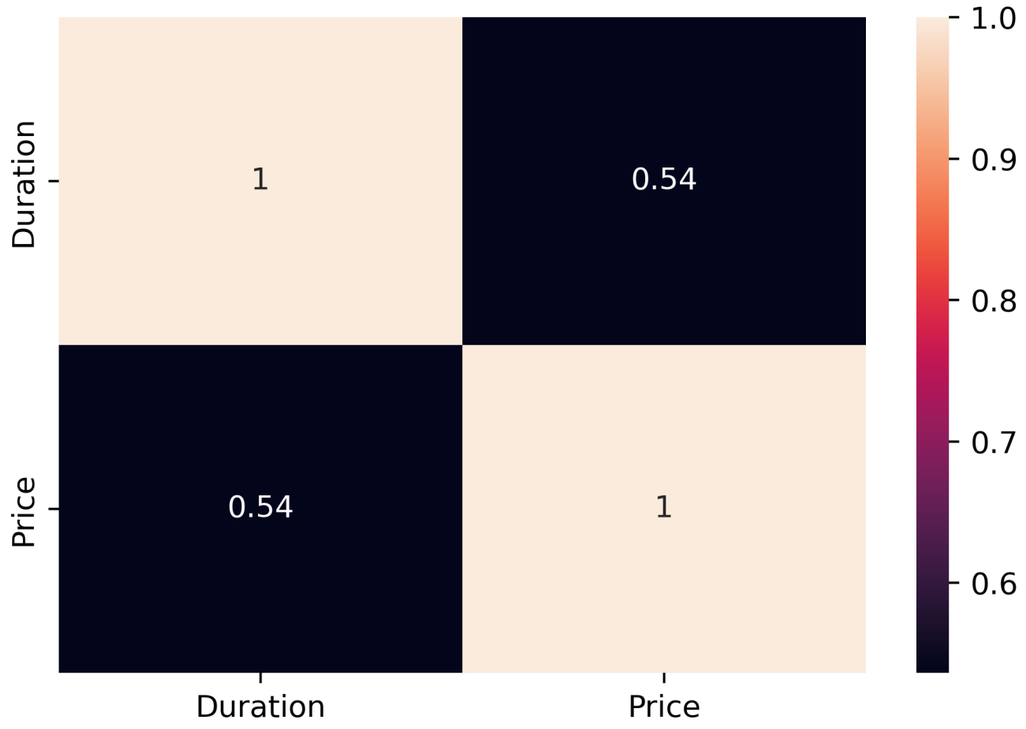
Correlation

```
sns.heatmap(planes.corr(), annot=True)
plt.show()
```



Viewing data types

```
print(planes.dtypes)
```

```
Airline                    object
Date_of_Journey    datetime64[ns]
Source                     object
Destination                object
Route                      object
Dep_Time           datetime64[ns]
Arrival_Time       datetime64[ns]
Duration                  float64
Total_Stops                object
Additional_Info            object
Price                     float64
dtype: object
```

Total stops

```
print(planes["Total_Stops"].value_counts())
```

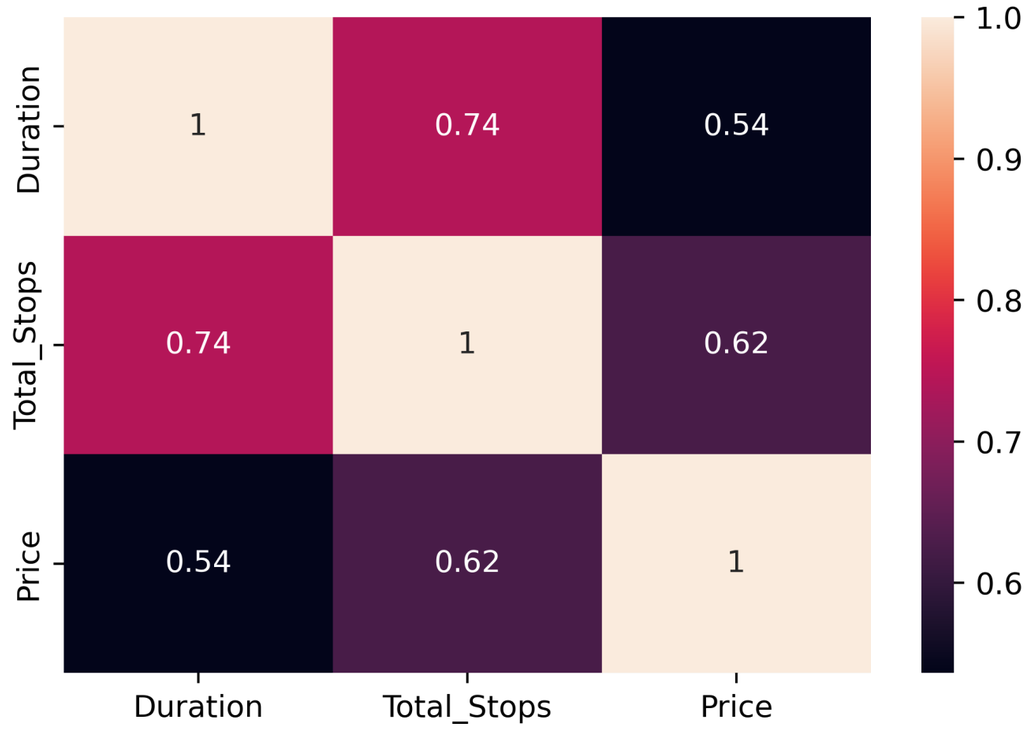
```
1 stop      4107
non-stop    2584
2 stops     1127
3 stops       29
4 stops        1
Name: Total_Stops, dtype: int64
```

Cleaning total stops

```
planes["Total_Stops"] = planes["Total_Stops"].str.replace(" stops", "")
planes["Total_Stops"] = planes["Total_Stops"].str.replace(" stop", "")
planes["Total_Stops"] = planes["Total_Stops"].str.replace("non-stop", "0")
planes["Total_Stops"] = planes["Total_Stops"].astype(int)
```

Correlation

```
sns.heatmap(planes.corr(), annot=True)
plt.show()
```



Dates

```
print(planes.dtypes)
```

```
Airline                    object
Date_of_Journey    datetime64[ns]
Source                     object
Destination                object
Route                      object
Dep_Time           datetime64[ns]
Arrival_Time       datetime64[ns]
Duration                  float64
Total_Stops                 int64
Additional_Info            object
Price                     float64
dtype: object
```

Extracting month and weekday

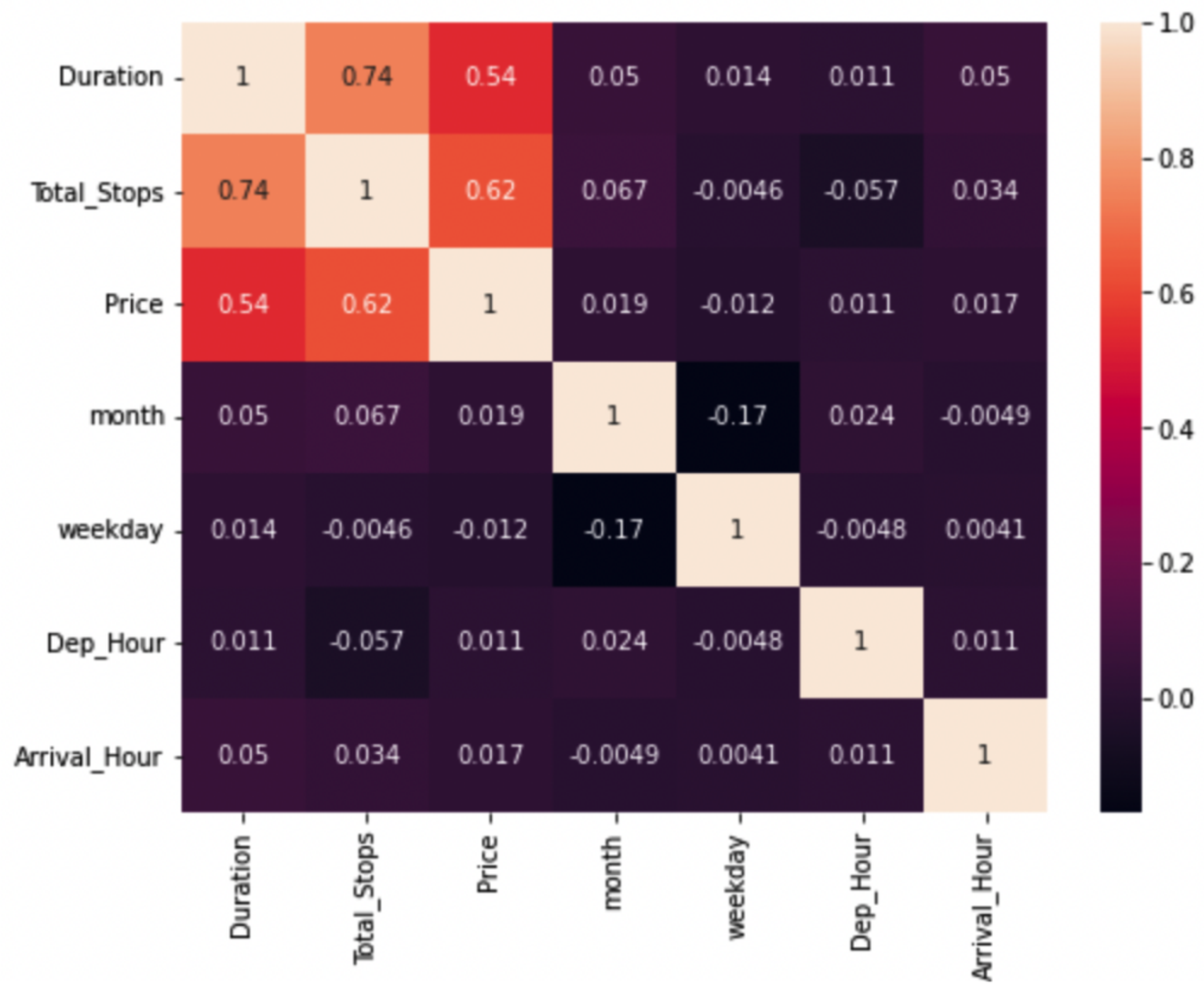
```
planes["month"] = planes["Date_of_Journey"].dt.month
planes["weekday"] = planes["Date_of_Journey"].dt.weekday
print(planes[["month", "weekday", "Date_of_Journey"]].head())
```

```
   month  weekday   Date_of_Journey
0      9         4        2019-09-06
1     12         3        2019-12-05
2      1         3        2019-01-03
3      6         0        2019-06-24
4     12         1        2019-12-03
```

Departure and arrival times

```
planes["Dep_Hour"] = planes["Dep_Time"].dt.hour
planes["Arrival_Hour"] = planes["Arrival_Time"].dt.hour
```

Correlation



Creating categories

```
print(planes["Price"].describe())
```

```
count     7848.000000
mean      9035.413609
std       4429.822081
min       1759.000000
25%       5228.000000
50%       8355.000000
75%      12373.000000
max      54826.000000
Name: Price, dtype: float64
```

Range	Ticket Type
<= 5228	Economy
> 5228 <= 8355	Premium Economy
> 8335 <= 12373	Business Class
> 12373	First Class

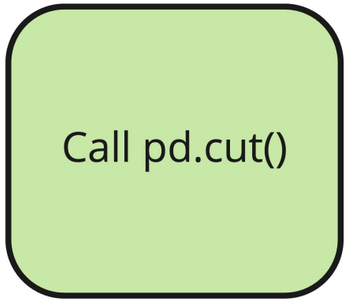
Descriptive statistics

```
twenty_fifth = planes["Price"].quantile(0.25)
median = planes["Price"].median()
seventy_fifth = planes["Price"].quantile(0.75)
maximum = planes["Price"].max()
```

Labels and bins

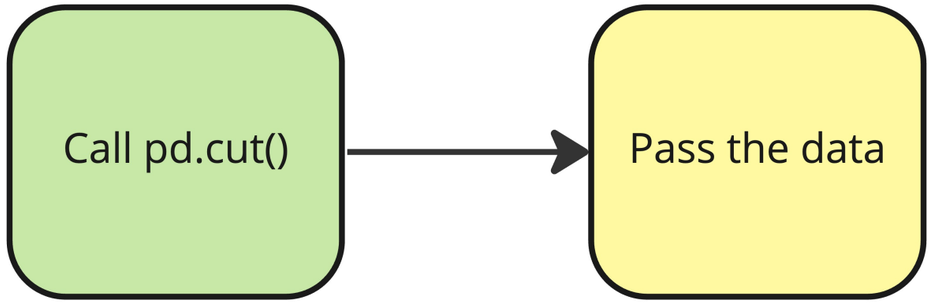
```
labels = ["Economy", "Premium Economy", "Business Class", "First Class"]
bins = [0, twenty_fifth, median, seventy_fifth, maximum]
```

pd.cut()




```
planes["Price_Category"] = pd.cut(
```

pd.cut()



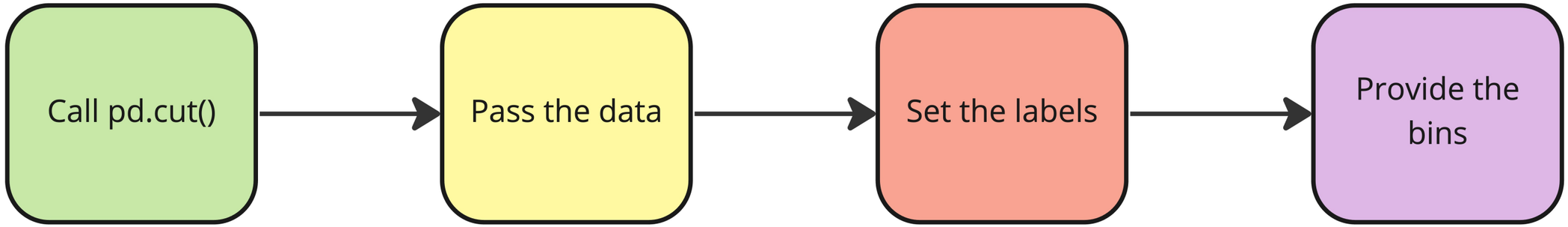

```
planes["Price_Category"] = pd.cut(planes["Price"],
```

pd.cut()




```
planes["Price_Category"] = pd.cut(planes["Price"],
                                  labels=labels,
```

pd.cut()




```
planes["Price_Category"] = pd.cut(planes["Price"],
                                  labels=labels,
                                  bins=bins)
```

Price categories

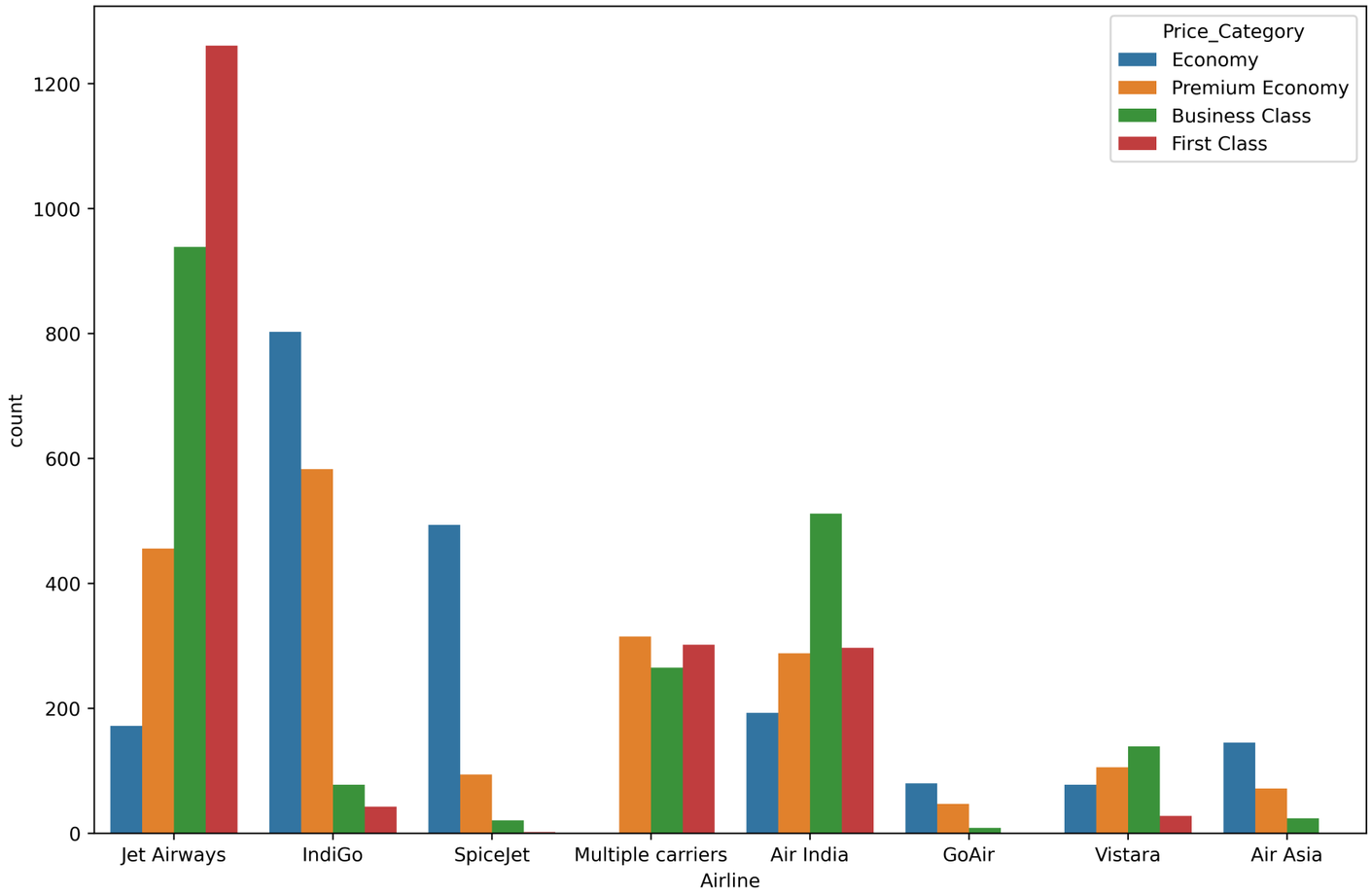
```
print(planes[["Price","Price_Category"]].head())
```

```
     Price   Price_Category
0  13882.0      First Class
1   6218.0  Premium Economy
2  13302.0      First Class
3   3873.0          Economy
4  11087.0   Business Class
```

Price category by airline

```
sns.countplot(data=planes, x="Airline", hue="Price_Category")
plt.show()
```

Price category by airline



Let's practice!

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Generating hypotheses

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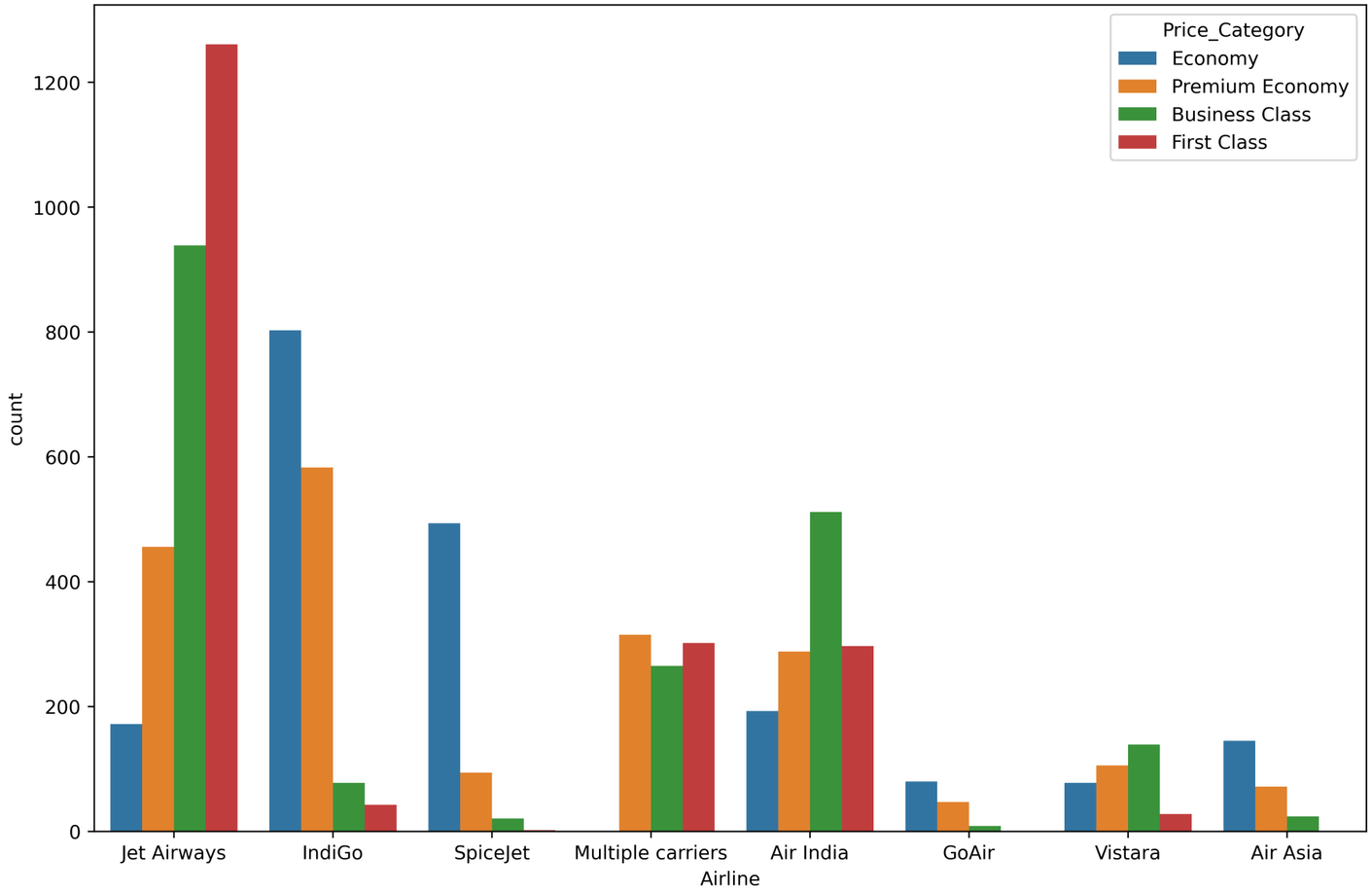
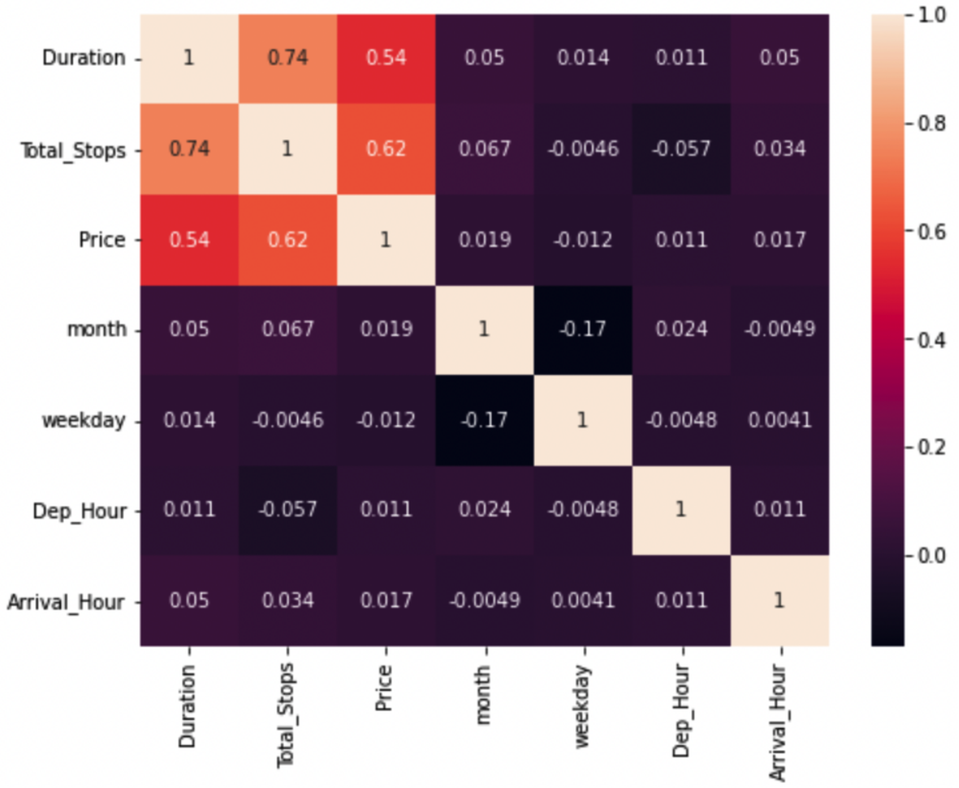
What do we know?



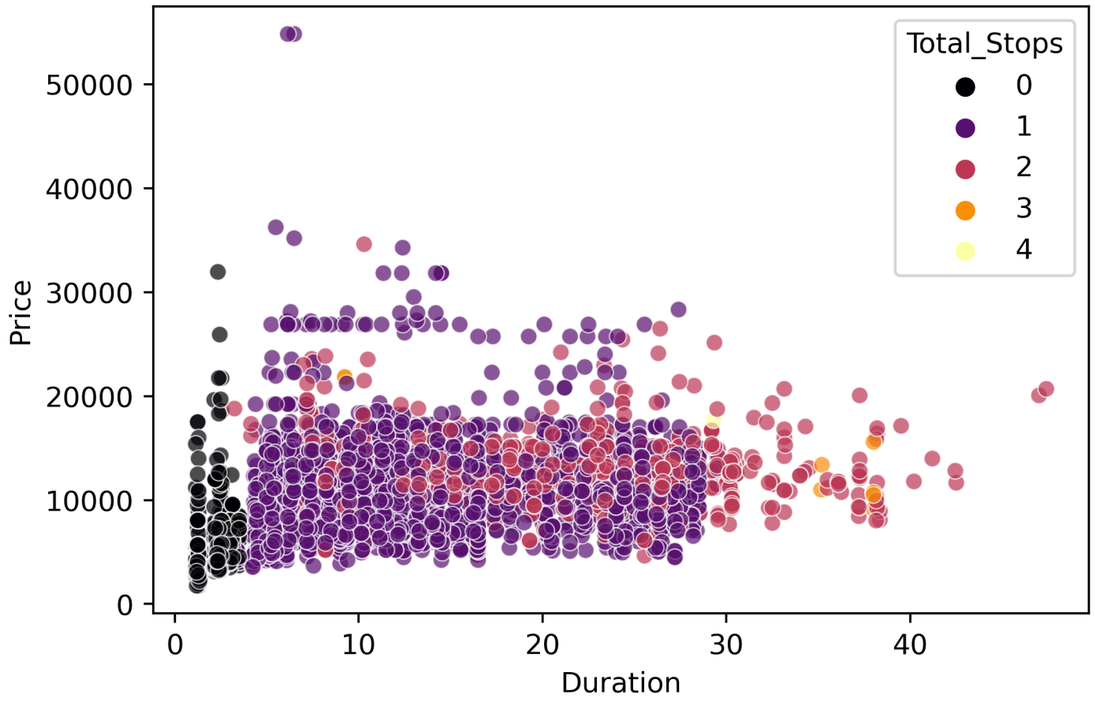
What do we know?

```
sns.heatmap(planes.corr(), annot=True)
plt.show()
```

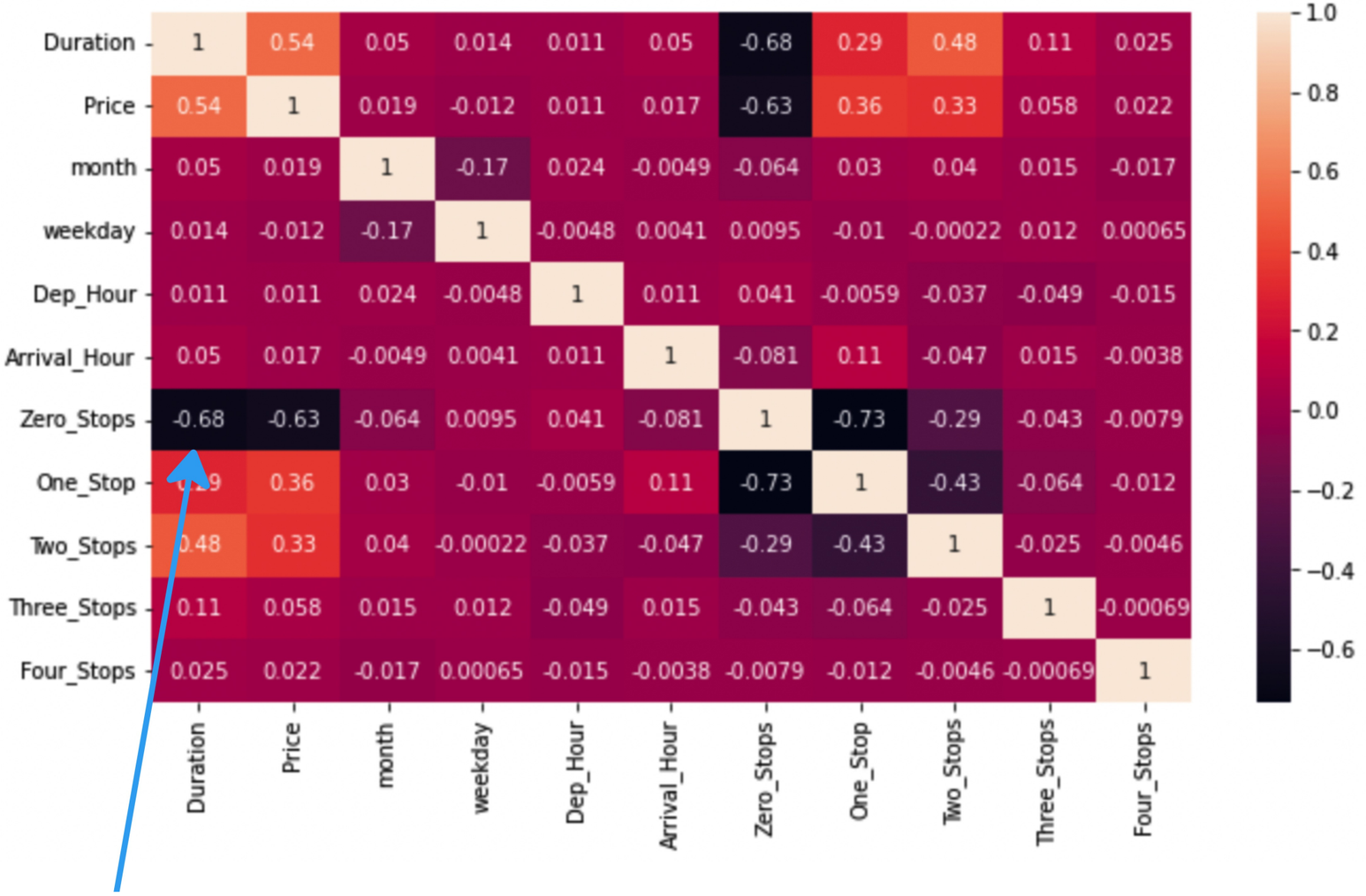


Spurious correlation

```
sns.scatterplot(data=planes, x="Duration", y="Price", hue="Total_Stops")
plt.show()
```



How do we know?



What is true?



- Would data from a different time give the same results?
- Detecting relationships, differences, and patterns:
  - We use **Hypothesis Testing**
- Hypothesis testing requires, prior to data collection:
  - Generating a hypothesis or question
  - A decision on what statistical test to use

[1] Image credit: https://unsplash.com/@markuswinkler

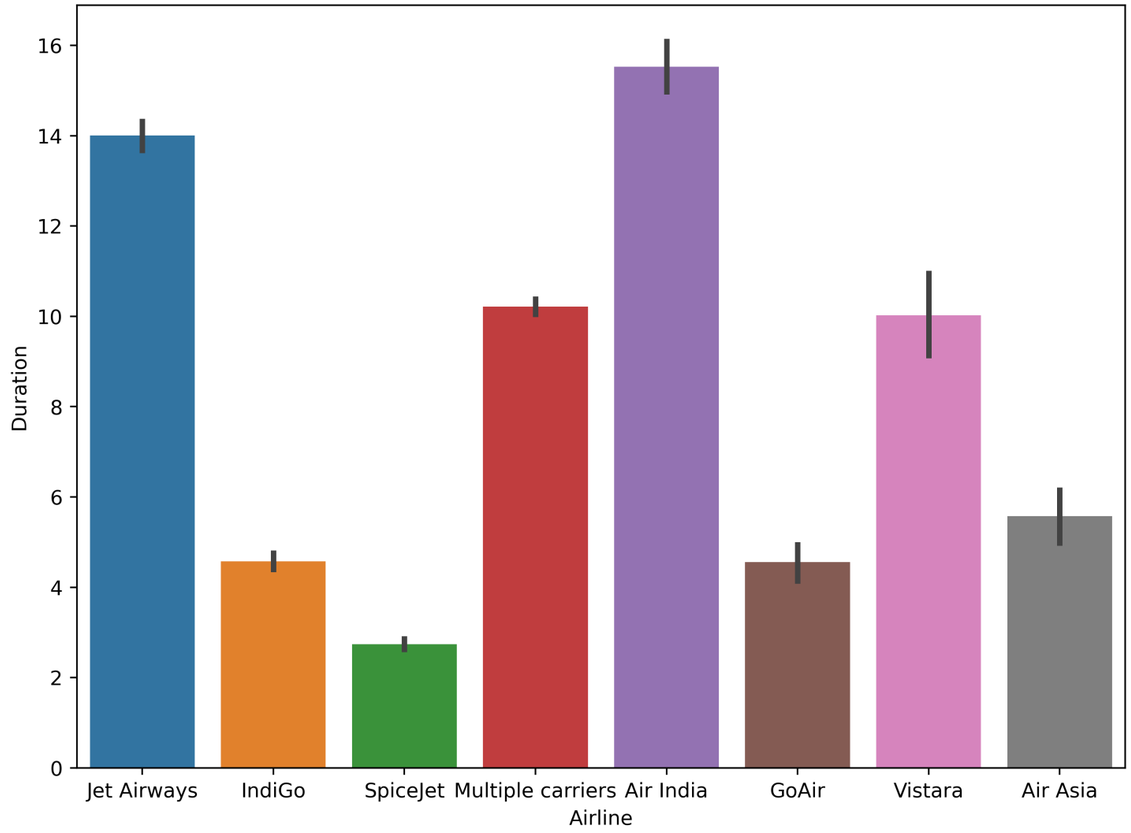
Data snooping





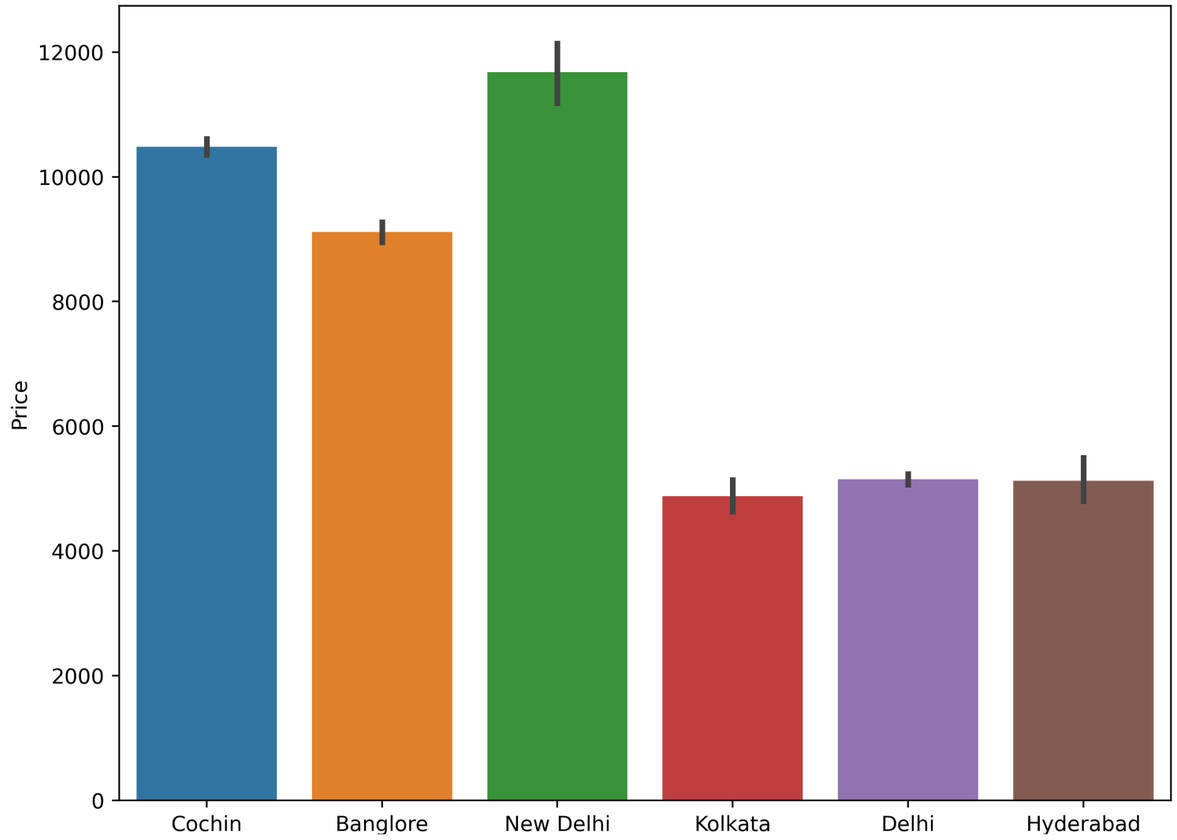
Generating hypotheses

```
sns.barplot(data=planes, x="Airline", y="Duration")
plt.show()
```



Generating hypotheses

```
sns.barplot(data=planes, x="Destination", y="Price")
plt.show()
```



Next steps

- Design our experiment
- Involves steps such as:
  - Choosing a sample
  - Calculating how many data points we need
  - Deciding what statistical test to run

Let's practice!

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Congratulations

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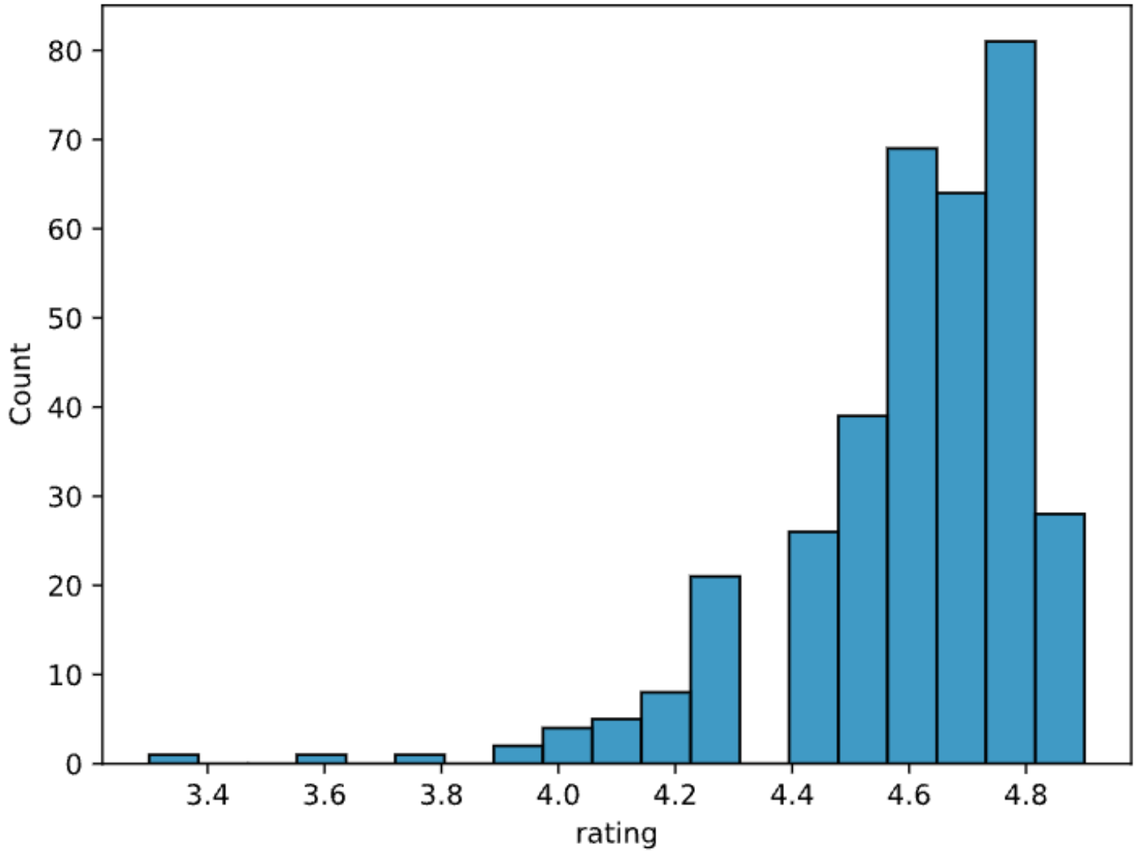
Inspection and validation




```
books["year"] = books["year"].astype(int)
books.dtypes
```

```
name       object
author     object
rating    float64
year        int64
genre      object
dtype: object
```

Aggregation

```
books.groupby("genre").agg(
    mean_rating=("rating", "mean"),
    std_rating=("rating", "std"),
    median_year=("year", "median")
)
```

genre	mean_rating	std_rating	median_year
Childrens	4.780000	0.122370	2015.0
Fiction	4.570229	0.281123	2013.0
Non Fiction	4.598324	0.179411	2013.0

Address missing data

```
print(salaries.isna().sum())
```

```
Working_Year              12
Designation               27
Experience                33
Employment_Status         31
Employee_Location         28
Company_Size              40
Remote_Working_Ratio      24
Salary_USD                60
dtype: int64
```

Address missing data

- Drop missing values

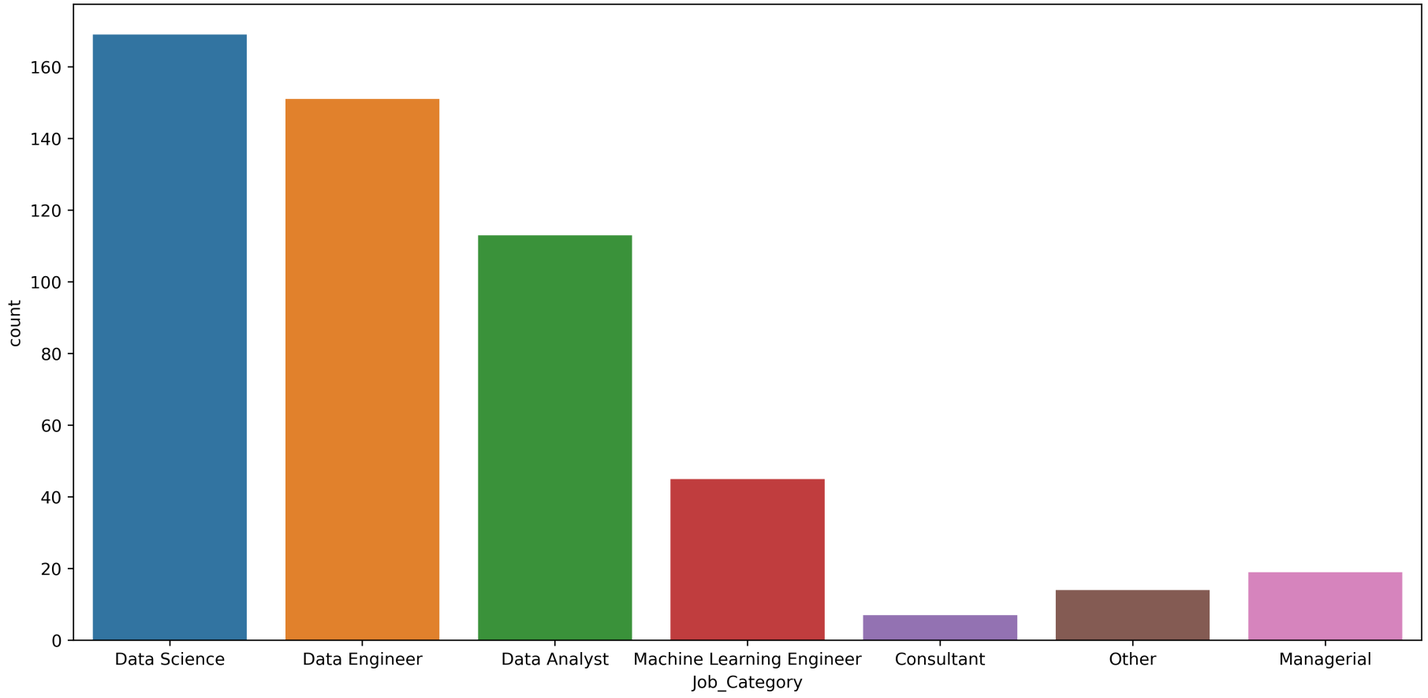
- Impute mean, median, mode

- Impute by sub-group

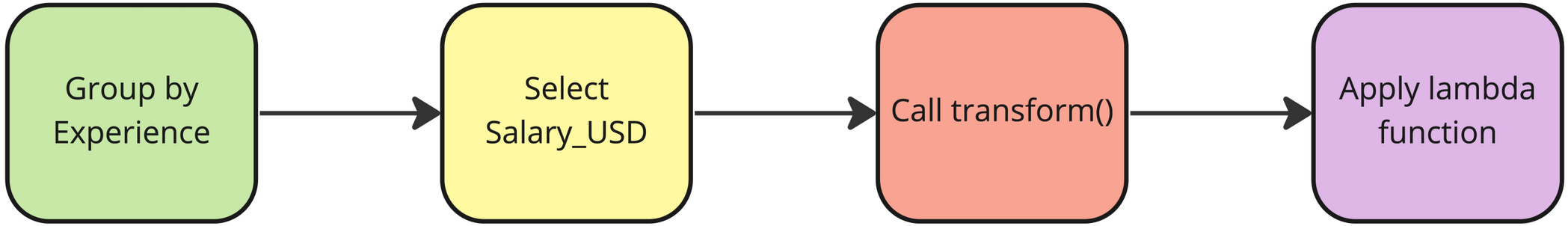
```
salaries_dict = salaries.groupby("Experience")["Salary_USD"].median().to_dict()
salaries["Salary_USD"] = salaries["Salary_USD"].fillna(salaries["Experience"].map(salaries_dict))
```

Analyze categorical data

```
salaries["Job_Category"] = np.select(conditions,
                                     job_categories,
                                     default="Other")
```



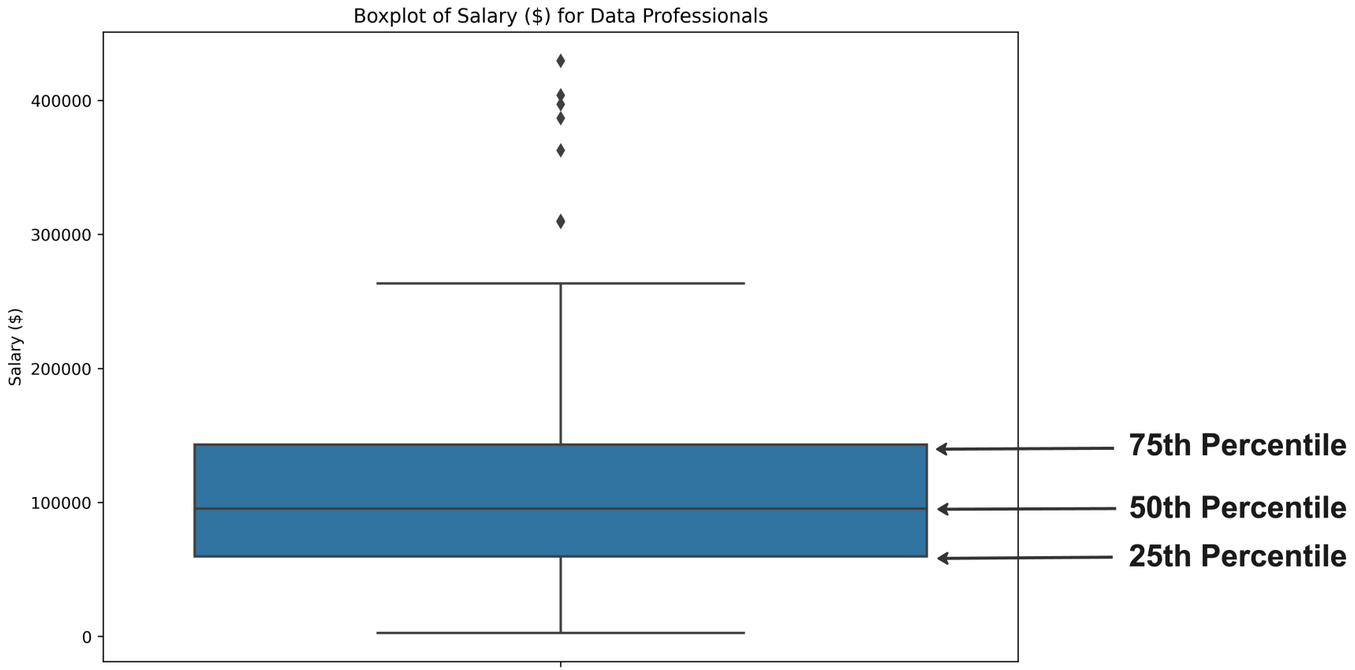
Apply lambda functions




```
salaries["std_dev"] = salaries.groupby("Experience")["Salary_USD"].transform(lambda x: x.std())
```

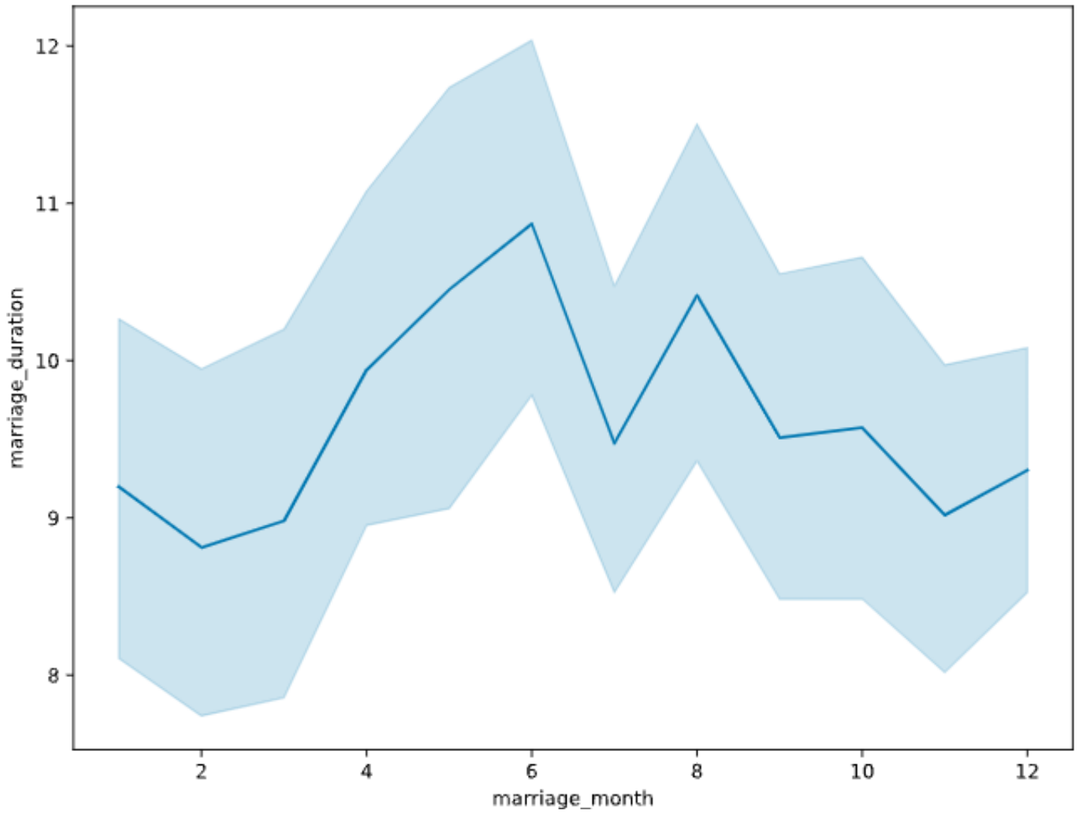
Handle outliers

```
sns.boxplot(data=salaries,
            y="Salary_USD")
plt.show()
```



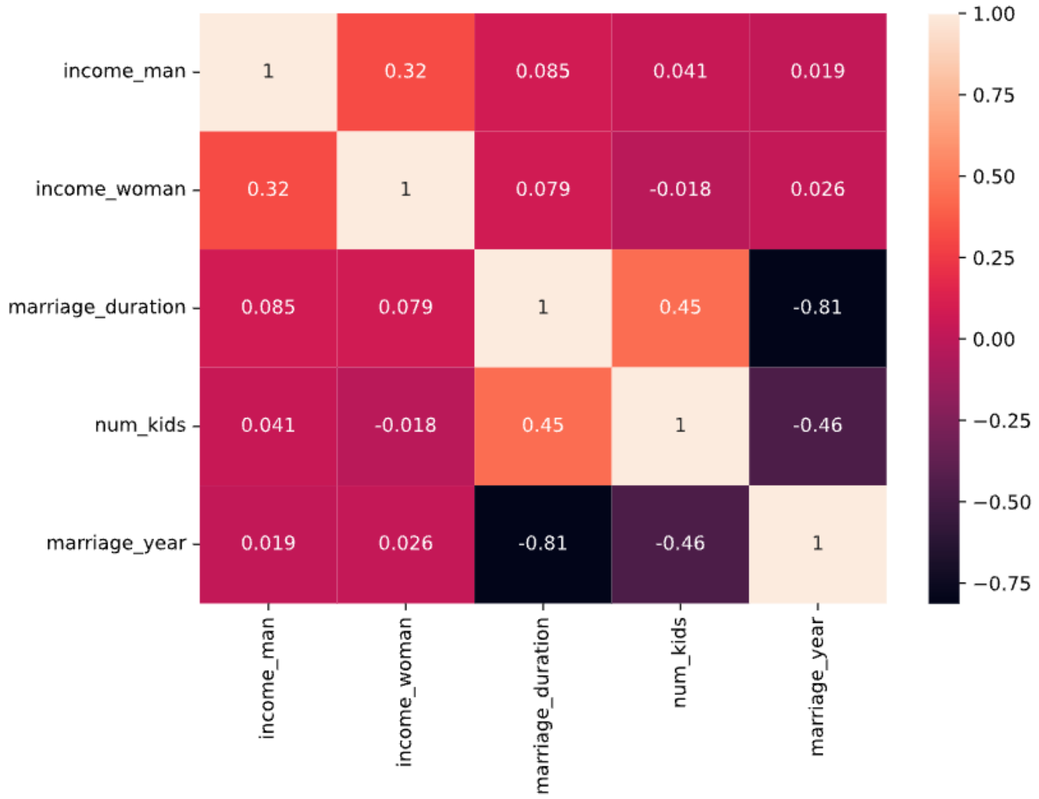
Patterns over time

```
sns.lineplot(data=divorce, x="marriage_month", y="marriage_duration")
plt.show()
```



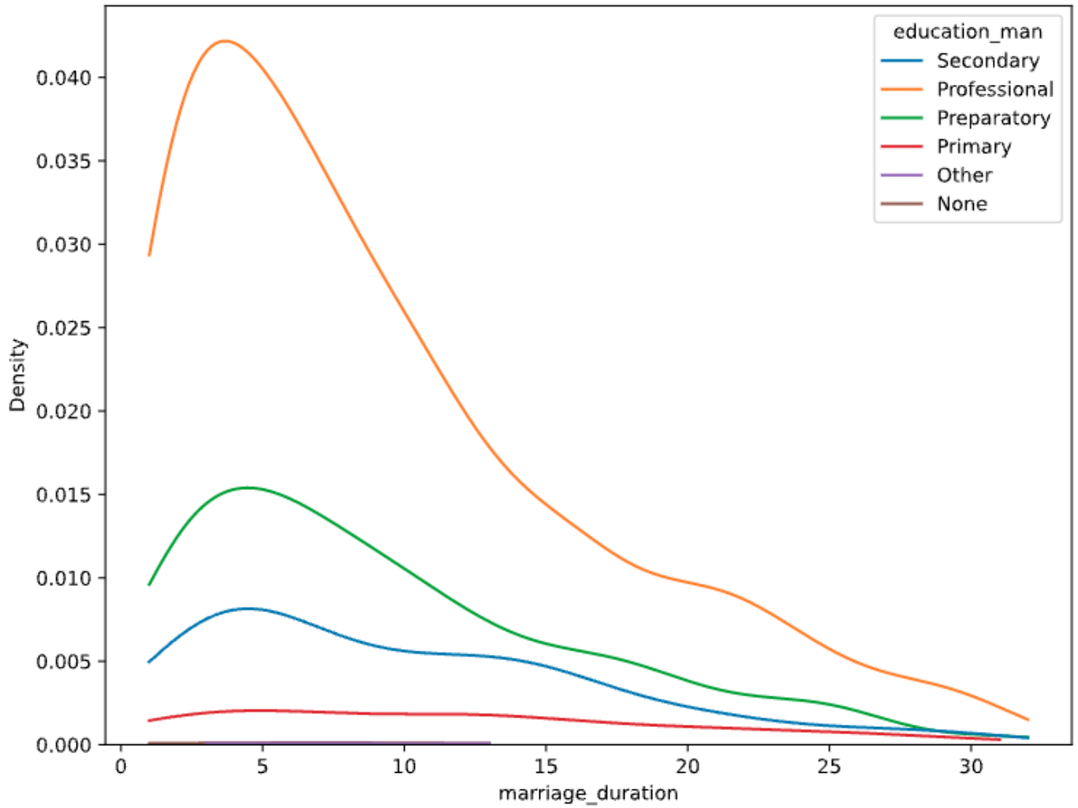
Correlation

```
sns.heatmap(divorce.corr(), annot=True)
plt.show()
```



Distributions

```
sns.kdeplot(data=divorce, x="marriage_duration", hue="education_man", cut=0)
plt.show()
```

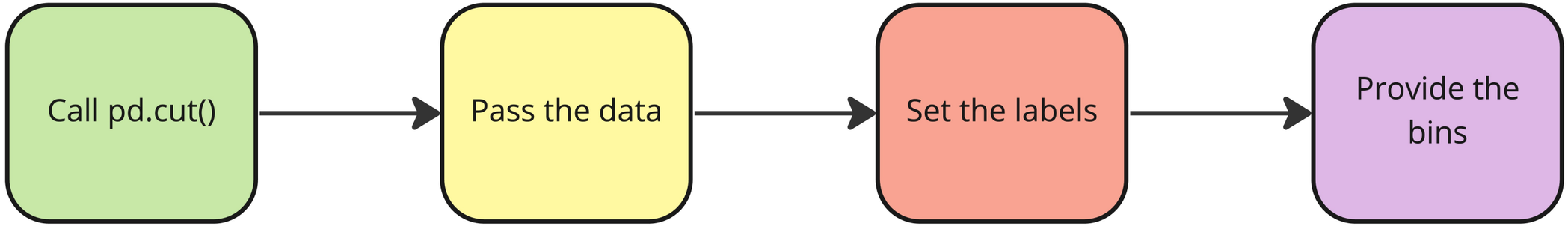


Cross-tabulation

```
pd.crosstab(planes["Source"], planes["Destination"],
            values=planes["Price"], aggfunc="median")
```

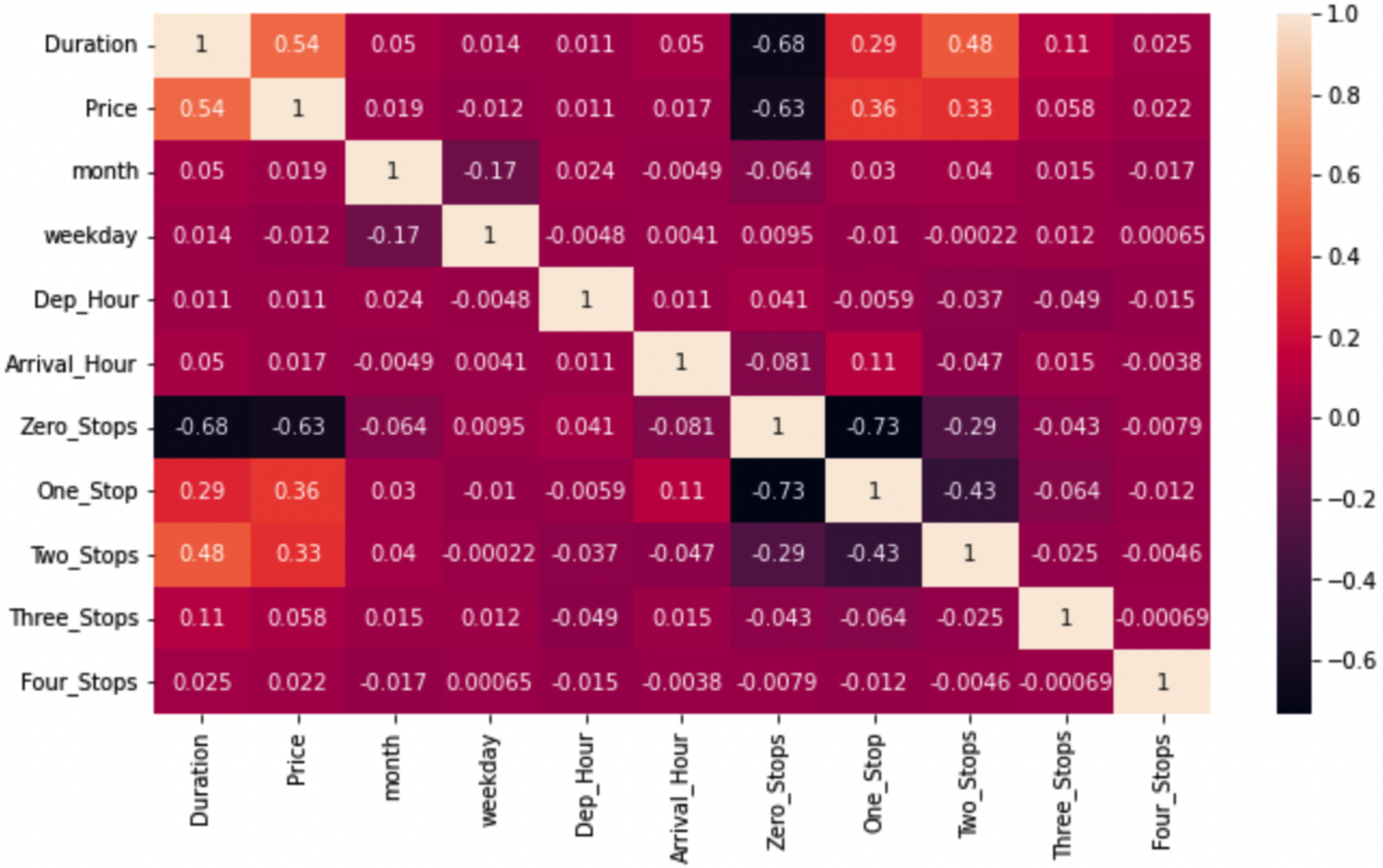
Destination	Banglore	Cochin	Delhi	Hyderabad	Kolkata	New Delhi
Source						
Banglore	NaN	NaN	4823.0	NaN	NaN	10976.5
Chennai	NaN	NaN	NaN	NaN	3850.0	NaN
Delhi	NaN	10262.0	NaN	NaN	NaN	NaN
Kolkata	9345.0	NaN	NaN	NaN	NaN	NaN
Mumbai	NaN	NaN	NaN	3342.0	NaN	NaN

pd.cut()



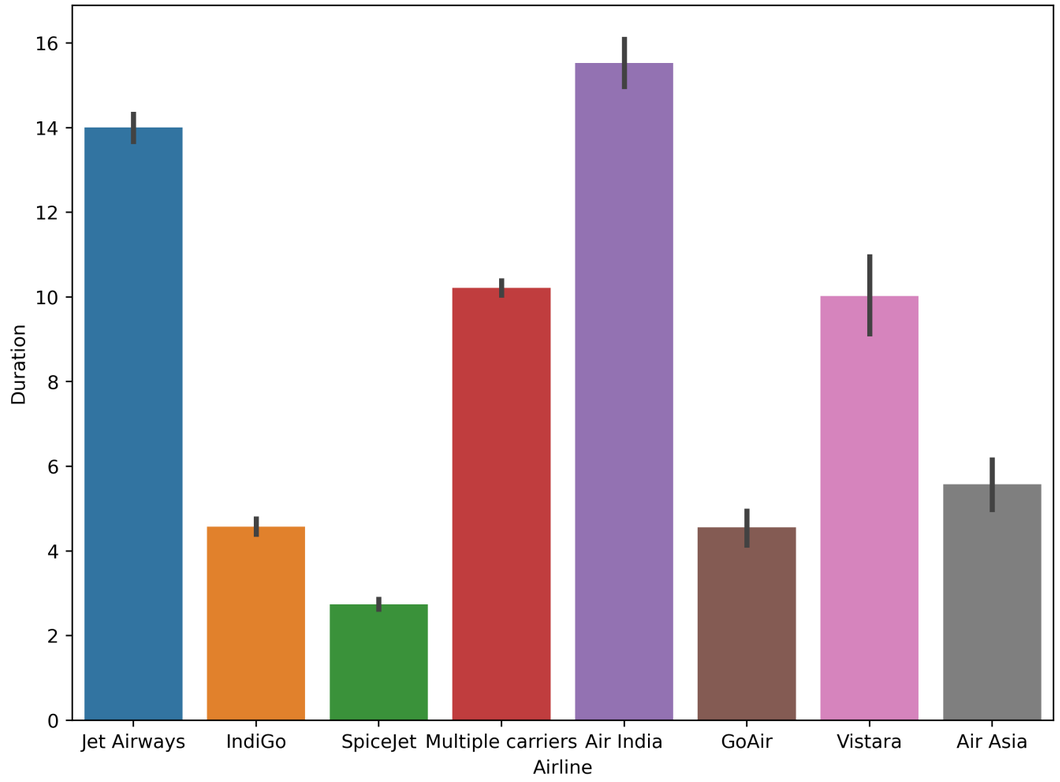

```
planes["Price_Category"] = pd.cut(planes["Price"],
                                  labels=labels,
                                  bins=bins)
```

Data snooping



Generating hypotheses

```
sns.barplot(data=planes, x="Airline", y="Duration")
plt.show()
```



Next steps

- Sampling in Python
- Hypothesis Testing in Python
- Supervised Learning with scikit-learn

Congratulations!

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