Introduction to Python

Tom Paskhalis

RECSM Summer School 2021, Linear Regression & Communicating Results, Part 5, Day 2

Anscombe's quartet

- 4 artificial datasets constructed by Anscombe (1973)
- All of them have nearly identical summary statistics
- But show dramatically different relationships between variables
- Designed to illustrate the importance of data visualization

Data for Anscombe's quartet

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In [1]:
```
import pandas as pd
anscombe_quartet = pd.read_csv('../data/anscombes_quartet.csv')
```

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```
import pandas as pd
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```

In [2]:
```
anscombe_quartet.head()
```

Out[2]:

	dataset	x	y
0	I	10	8.04
1	I	8	6.95
2	I	13	7.58
3	I	9	8.81
4	I	11	8.33

Summary statistics for Anscombe's quartet

Summary statistics for Anscombe's quartet

In [3]:
```
# Here we use `groupby` method to create summary by a variable ('dataset')
anscombe_quartet.groupby(['dataset']).describe()
```

Out[3]:

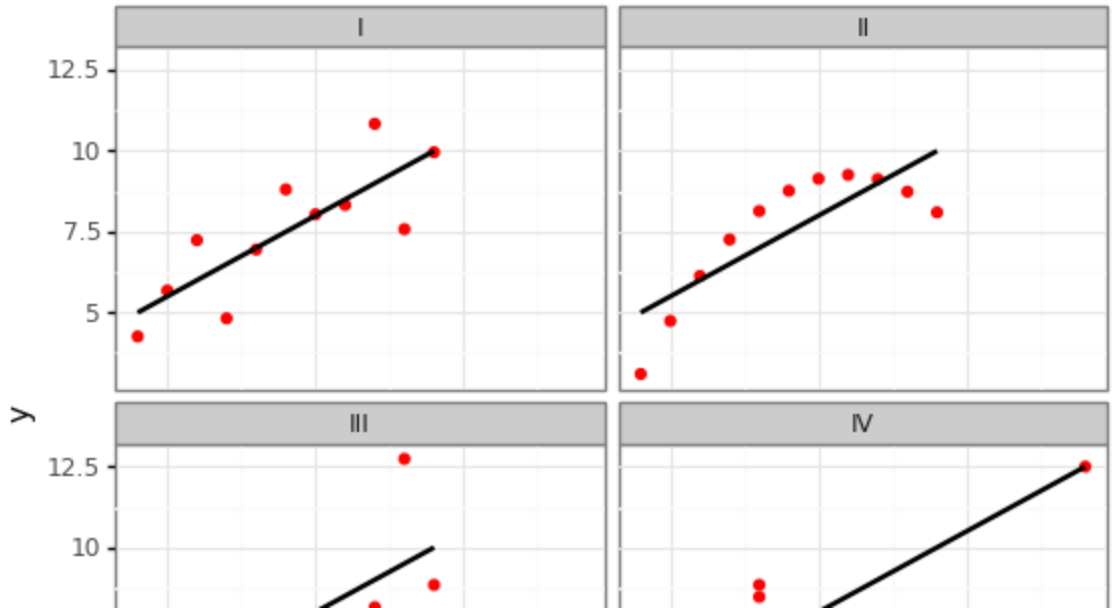
	x								y						
	count	mean	std	min	25%	50%	75%	max	count	mean	std	min	25%	50%	75
dataset															
I	11.0	9.0	3.316625	4.0	6.5	9.0	11.5	14.0	11.0	7.500909	2.031568	4.26	6.315	7.58	8.5
II	11.0	9.0	3.316625	4.0	6.5	9.0	11.5	14.0	11.0	7.500909	2.031657	3.10	6.695	8.14	8.9
III	11.0	9.0	3.316625	4.0	6.5	9.0	11.5	14.0	11.0	7.500000	2.030424	5.39	6.250	7.11	7.9
IV	11.0	9.0	3.316625	8.0	8.0	8.0	8.0	19.0	11.0	7.500909	2.030579	5.25	6.170	7.04	8.1

Plotting Anscombe's quartet

Plotting Anscombe's quartet

In [4]:
```
from plotnine import *

ggplot(anscombe_quartet, aes(x = 'x', y = 'y')) +\
    geom_point(colour = 'red') +\
    geom_smooth(method = 'lm', se = False) +\
    facet_wrap('dataset') +\
    theme_bw()
```



Linear regression

- Linear regression is the classical tool of statistical analysis
- It allows to estimate the degree of association between variables
- Typically, it is the association between one or more independent variables (IV) and one dependent variable (DV)
- The main quantities of interest usually are direction, magnitude of association and its statistical significance

Linear regression in Python

- As for tabular data and visualization we need external libraries for running regression
- `statsmodels` library provides tools for estimating many statistical models
- Another useful library is `scikit-learn`
- It is more focussed on machine-learning applications

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In [5]:
```
import statsmodels.api as sm
import statsmodels.formula.api as smf # Formula API provides R-style formula specif
```

Data transformation

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In [6]:
```
kaggle2020 = pd.read_csv('../data/kaggle_survey_2020_responses.csv', skiprows = [1]
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In [7]:
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# Let's give more intuitive names to out variables
kaggle2020 = kaggle2020.rename(columns = {
                    'Q1': 'age',
                    'Q2': 'gender',
                    'Q3': 'country',
                    'Q4': 'education',
                    'Q24': 'compensation'})
```

Data transformation

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```

In [8]:
```
kaggle2020['compensation'].head()
```

Out[8]:
```
0                  NaN
1      100,000-124,999
2        15,000-19,999
3      125,000-149,999
4                  NaN
Name: compensation, dtype: object
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Data transformation

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Pandas and linear regression

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In [10]:
```
kaggle2020['compensation'] # Level of compensation (in USD) - our DV
```

Out[10]:
```
0             NaN
1        112499.5
2         17499.5
3        137499.5
4             NaN
             ...
20031         NaN
20032         NaN
20033       499.5
20034       499.5
20035       499.5
Name: compensation, Length: 20036, dtype: float64
```

Pandas and linear regression

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```

In [11]:
```
# Formula specification allows to write 'DV ~ IV_1 + IV_2 + ... + IV_N' as model sp
results = smf.ols('compensation ~ age + gender + education', data = kaggle2020).fit
```

Model summary

Model summary

In [12]:
```
results.summary()
```

Out[12]:

OLS Regression Results

Dep. Variable:	compensation	**R-squared:**	0.116
Model:	OLS	**Adj. R-squared:**	0.115
Method:	Least Squares	**F-statistic:**	70.41
Date:	Tue, 29 Jun 2021	**Prob (F-statistic):**	1.98e-268
Time:	02:49:14	**Log-Likelihood:**	-1.3352e+05
No. Observations:	10729	**AIC:**	2.671e+05
Df Residuals:	10708	**BIC:**	2.672e+05
Df Model:	20		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	1.536e+04	2847.115	5.396	0.000	9781.101	2.09e+04
age[T.22-24]	-1016.3138	3232.489	-0.314	0.753	-7352.593	5319.965
age[T.25-29]	9158.0382	3101.900	2.952	0.003	3077.739	1.52e+04
age[T.30-34]	2.694e+04	3173.713	8.489	0.000	2.07e+04	3.32e+04
age[T.35-39]	3.526e+04	3285.667	10.731	0.000	2.88e+04	4.17e+04
age[T.40-44]	4.699e+04	3449.386	13.624	0.000	4.02e+04	5.38e+04

Markdown - a language of reports

- Markdown is a markup language for formatting text with simple syntax
- The key goal of Markdown is readability
- Only a limited set of formatting options is supported
- Markdown is used in online documentation, blogging and instant messaging

Formatting text in Markdown

- For *italics* `*one star on each side*`
- For **bold** `**two stars on each side**`
- For ~~strikethrough~~ `~~two tildes on each side~~`

Lists in Markdown

For bulleted or unordered list of items:

```
- Just add a dash first and then write a text.
- If you add another dash in the following line, you wi
l have another item in the list.
  - If you add four spaces or use a tab key, you will c
eate an indented list.
```

For numbered or ordered list of items:

```
1. Just type a number and then write a text.
2. If you want to add a second item, just type in anoth
r number.
1. If you make a mistake when typing numbers, fear not,
```

Headers in Markdown

Headers or section titles are created with hashes(`#`)

```
# This is a first-tier header
```

```
## This is a second-tier header
```

```
### This is a third-tier header
```

Images and links in Markdown

- To add an image you can write `![some text](image_path)`
- To add a link you can write `[some text](URL)`
- For more complex cases HTML code can be used

Tables in Markdown

- Tables in Markdown can be created using the following syntax (there are a few variants)

```
| Header1 | Header2 |
|:--------|:--------|
| content | content |
```

- `:---` produces left-aligned text in cells
- `---:` produces right-aligned text in cells
- `:--:` produces centered text in cells

Markdown tables in pandas

- Pandas can generate Markdown tables from DataFrame

Markdown tables in pandas

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In [13]:
```
# Let's revisit the summary statistics of Anscombe's quartet
anscombe_quartet.groupby(['dataset']).describe().iloc[:,0:3]
```

Out[13]:

	x		
	count	mean	std
dataset			
I	11.0	9.0	3.316625
II	11.0	9.0	3.316625
III	11.0	9.0	3.316625
IV	11.0	9.0	3.316625

Markdown tables in pandas

- Pandas can generate Markdown tables from DataFrame

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IV	11.0	9.0	3.316625

In [14]:
```
print(anscombe_quartet.groupby(['dataset']).describe().iloc[:,0:3].to_markdown(inde
```

```
|    ('x', 'count') |    ('x', 'mean') |    ('x', 'std') |
|------------------:|-----------------:|----------------:|
|                11 |                9 |         3.31662 |
|                11 |                9 |         3.31662 |
```

The end