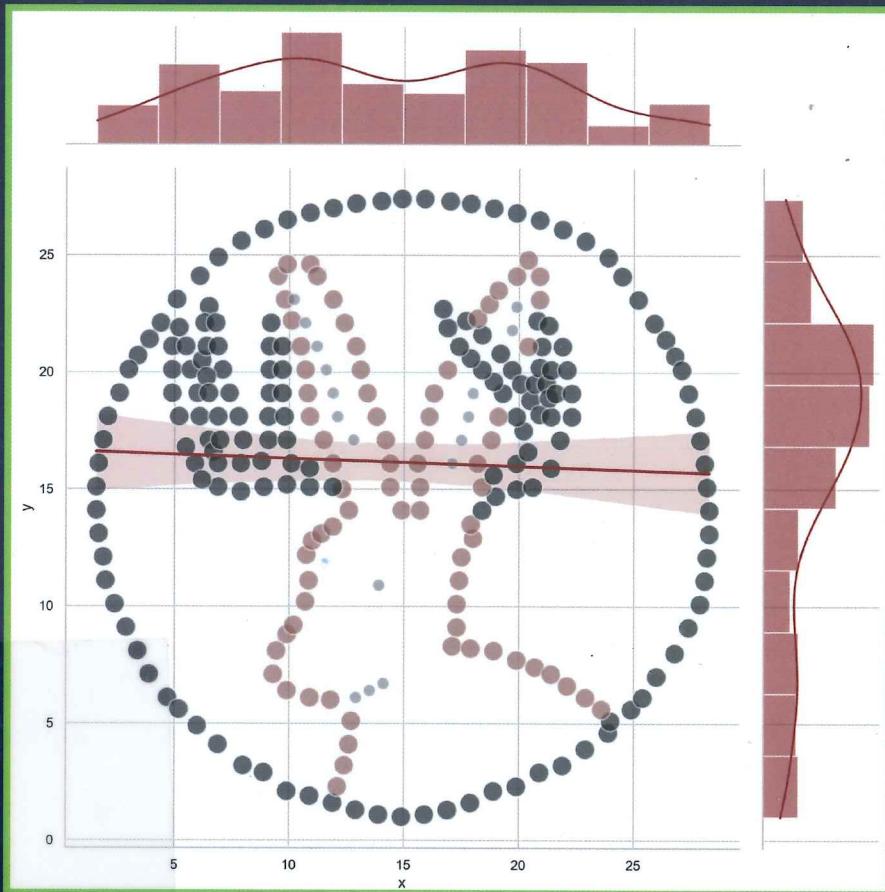


THE PYTHON SERIES

# STATISTICS AND DATA VISUALISATION WITH PYTHON



JESÚS ROGEL-SALAZAR



CRC Press  
Taylor & Francis Group

A CHAPMAN & HALL BOOK

สำนักหอสมุด มหาวิทยาลัยเชียงใหม่

b16704393  
0 12576451  
i 22684864

# Statistics and Data Visualisation with Python



Jesús Rogel-Salazar



CRC Press

Taylor & Francis Group

Boca Raton London New York

CRC Press is an imprint of the  
Taylor & Francis Group, an Informa business  
A CHAPMAN & HALL BOOK

# *Contents*

1	<i>Data, Stats and Stories – An Introduction</i>	1
1.1	<i>From Small to Big Data</i>	2
1.2	<i>Numbers, Facts and Stats</i>	10
1.3	<i>A Sampled History of Statistics</i>	14
1.4	<i>Statistics Today</i>	22
1.5	<i>Asking Questions and Getting Answers</i>	25
1.6	<i>Presenting Answers Visually</i>	30
2	<i>Python Programming Primer</i>	33
2.1	<i>Talking to Python</i>	35
2.1.1	<i>Scripting and Interacting</i>	38
2.1.2	<i>Jupyter Notebook</i>	41
2.2	<i>Starting Up with Python</i>	42
2.2.1	<i>Types in Python</i>	43

2.2.2	<i>Numbers: Integers and Floats</i>	43
2.2.3	<i>Strings</i>	46
2.2.4	<i>Complex Numbers</i>	49
2.3	<i>Collections in Python</i>	51
2.3.1	<i>Lists</i>	52
2.3.2	<i>List Comprehension</i>	60
2.3.3	<i>Tuples</i>	61
2.3.4	<i>Dictionaries</i>	66
2.3.5	<i>Sets</i>	72
2.4	<i>The Beginning of Wisdom: Logic &amp; Control Flow</i>	80
2.4.1	<i>Booleans and Logical Operators</i>	80
2.4.2	<i>Conditional Statements</i>	82
2.4.3	<i>While Loop</i>	85
2.4.4	<i>For Loop</i>	87
2.5	<i>Functions</i>	89
2.6	<i>Scripts and Modules</i>	94

### 3 *Snakes, Bears & Other Numerical Beasts: NumPy, SciPy & pandas* 99

3.1	<i>Numerical Python – NumPy</i>	100
3.1.1	<i>Matrices and Vectors</i>	101
3.1.2	<i>N-Dimensional Arrays</i>	102

3.1.3	<i>N-Dimensional Matrices</i>	104
3.1.4	<i>Indexing and Slicing</i>	107
3.1.5	<i>Descriptive Statistics</i>	109
3.2	<i>Scientific Python – SciPy</i>	112
3.2.1	<i>Matrix Algebra</i>	114
3.2.2	<i>Numerical Integration</i>	116
3.2.3	<i>Numerical Optimisation</i>	117
3.2.4	<i>Statistics</i>	118
3.3	<i>Panel Data = pandas</i>	121
3.3.1	<i>Series and Dataframes</i>	122
3.3.2	<i>Data Exploration with pandas</i>	124
3.3.3	<i>Pandas Data Types</i>	125
3.3.4	<i>Data Manipulation with pandas</i>	126
3.3.5	<i>Loading Data to pandas</i>	130
3.3.6	<i>Data Grouping</i>	136
4	<i>The Measure of All Things – Statistics</i>	141
4.1	<i>Descriptive Statistics</i>	144
4.2	<i>Measures of Central Tendency and Dispersion</i>	145
4.3	<i>Central Tendency</i>	146
4.3.1	<i>Mode</i>	147
4.3.2	<i>Median</i>	150

4.3.3	<i>Arithmetic Mean</i>	152
4.3.4	<i>Geometric Mean</i>	155
4.3.5	<i>Harmonic Mean</i>	159
4.4	<i>Dispersion</i>	163
4.4.1	<i>Setting the Boundaries: Range</i>	163
4.4.2	<i>Splitting One's Sides: Quantiles, Quartiles, Percentiles and More</i>	166
4.4.3	<i>Mean Deviation</i>	169
4.4.4	<i>Variance and Standard Deviation</i>	171
4.5	<i>Data Description – Descriptive Statistics Revisited</i>	176
5	<i>Definitely Maybe: Probability and Distributions</i>	179
5.1	<i>Probability</i>	180
5.2	<i>Random Variables and Probability Distributions</i>	182
5.2.1	<i>Random Variables</i>	183
5.2.2	<i>Discrete and Continuous Distributions</i>	185
5.2.3	<i>Expected Value and Variance</i>	186
5.3	<i>Discrete Probability Distributions</i>	191
5.3.1	<i>Uniform Distribution</i>	191
5.3.2	<i>Bernoulli Distribution</i>	197
5.3.3	<i>Binomial Distribution</i>	201
5.3.4	<i>Hypergeometric Distribution</i>	208
5.3.5	<i>Poisson Distribution</i>	216

5.4	<i>Continuous Probability Distributions</i>	223
5.4.1	<i>Normal or Gaussian Distribution</i>	224
5.4.2	<i>Standard Normal Distribution Z</i>	235
5.4.3	<i>Shape and Moments of a Distribution</i>	238
5.4.4	<i>The Central Limit Theorem</i>	245
5.5	<i>Hypothesis and Confidence Intervals</i>	247
5.5.1	<i>Student's t Distribution</i>	253
5.5.2	<i>Chi-squared Distribution</i>	260
6	<i>Alluring Arguments and Ugly Facts – Statistical Modelling and Hypothesis Testing</i>	267
6.1	<i>Hypothesis Testing</i>	268
6.1.1	<i>Tales and Tails: One- and Two-Tailed Tests</i>	273
6.2	<i>Normality Testing</i>	279
6.2.1	<i>Q-Q Plot</i>	280
6.2.2	<i>Shapiro-Wilk Test</i>	282
6.2.3	<i>D'Agostino K-squared Test</i>	285
6.2.4	<i>Kolmogorov-Smirnov Test</i>	288
6.3	<i>Chi-square Test</i>	291
6.3.1	<i>Goodness of Fit</i>	291
6.3.2	<i>Independence</i>	293

6.4	<i>Linear Correlation and Regression</i>	296
6.4.1	<i>Pearson Correlation</i>	296
6.4.2	<i>Linear Regression</i>	301
6.4.3	<i>Spearman Correlation</i>	308
6.5	<i>Hypothesis Testing with One Sample</i>	312
6.5.1	<i>One-Sample t-test for the Population Mean</i>	312
6.5.2	<i>One-Sample z-test for Proportions</i>	316
6.5.3	<i>Wilcoxon Signed Rank with One-Sample</i>	320
6.6	<i>Hypothesis Testing with Two Samples</i>	324
6.6.1	<i>Two-Sample t-test – Comparing Means, Same Variances</i>	325
6.6.2	<i>Levene's Test – Testing Homoscedasticity</i>	330
6.6.3	<i>Welch's t-test – Comparing Means, Different Variances</i>	332
6.6.4	<i>Mann-Whitney Test – Testing Non-normal Samples</i>	334
6.6.5	<i>Paired Sample t-test</i>	338
6.6.6	<i>Wilcoxon Matched Pairs</i>	342
6.7	<i>Analysis of Variance</i>	345
6.7.1	<i>One-factor or One-way ANOVA</i>	347
6.7.2	<i>Tukey's Range Test</i>	360
6.7.3	<i>Repeated Measures ANOVA</i>	361
6.7.4	<i>Kruskal-Wallis – Non-parametric One-way ANOVA</i>	365
6.7.5	<i>Two-factor or Two-way ANOVA</i>	369

6.8	<i>Tests as Linear Models</i>	376
6.8.1	<i>Pearson and Spearman Correlations</i>	377
6.8.2	<i>One-sample t- and Wilcoxon Signed Rank Tests</i>	378
6.8.3	<i>Two-Sample t- and Mann-Whitney Tests</i>	379
6.8.4	<i>Paired Sample t- and Wilcoxon Matched Pairs Tests</i>	380
6.8.5	<i>One-way ANOVA and Kruskal-Wallis Test</i>	380
7	<i>Delightful Details – Data Visualisation</i>	383
7.1	<i>Presenting Statistical Quantities</i>	384
7.1.1	<i>Textual Presentation</i>	385
7.1.2	<i>Tabular Presentation</i>	385
7.1.3	<i>Graphical Presentation</i>	386
7.2	<i>Can You Draw Me a Picture? – Data Visualisation</i>	387
7.3	<i>Design and Visual Representation</i>	394
7.4	<i>Plotting and Visualising: Matplotlib</i>	402
7.4.1	<i>Keep It Simple: Plotting Functions</i>	403
7.4.2	<i>Line Styles and Colours</i>	404
7.4.3	<i>Titles and Labels</i>	405
7.4.4	<i>Grids</i>	406
7.5	<i>Multiple Plots</i>	407
7.6	<i>Subplots</i>	407
7.7	<i>Plotting Surfaces</i>	410
7.8	<i>Data Visualisation – Best Practices</i>	414

8	<i>Dazzling Data Designs – Creating Charts</i>	417
8.1	<i>What Is the Right Visualisaton for Me?</i>	417
8.2	<i>Data Visualisation and Python</i>	420
8.2.1	<i>Data Visualisation with Pandas</i>	421
8.2.2	<i>Seaborn</i>	423
8.2.3	<i>Bokeh</i>	425
8.2.4	<i>Plotly</i>	428
8.3	<i>Scatter Plot</i>	430
8.4	<i>Line Chart</i>	438
8.5	<i>Bar Chart</i>	440
8.6	<i>Pie Chart</i>	447
8.7	<i>Histogram</i>	452
8.8	<i>Box Plot</i>	459
8.9	<i>Area Chart</i>	464
8.10	<i>Heatmap</i>	468
A	<i>Variance: Population v Sample</i>	477
B	<i>Sum of First n Integers</i>	479
C	<i>Sum of Squares of the First n Integers</i>	481

D	<i>The Binomial Coefficient</i>	483
D.1	<i>Some Useful Properties of the Binomial Coefficient</i>	484
E	<i>The Hypergeometric Distribution</i>	485
E.1	<i>The Hypergeometric vs Binomial Distribution</i>	485
F	<i>The Poisson Distribution</i>	487
F.1	<i>Derivation of the Poisson Distribution</i>	487
F.2	<i>The Poisson Distribution as a Limit of the Binomial Distribution</i>	488
G	<i>The Normal Distribution</i>	491
G.1	<i>Integrating the PDF of the Normal Distribution</i>	491
G.2	<i>Maximum and Inflection Points of the Normal Distribution</i>	493
H	<i>Skewness and Kurtosis</i>	495
I	<i>Kruskal-Wallis Test – No Ties</i>	497
	<i>Bibliography</i>	501
	<i>Index</i>	511