TI

2023-04-01

Contents

R Markdown Cookbook, by Yihui Xie, Christophe Dervieux, Emily Riederer https://bookdown.org/yihui/rmarkdown-cookbook/

Happy Git and GitHub for the useR, by Jennifer Bryan https://happygitwithr.com/index.html

Qiita https://qiita.com/kamorits/items/6f342da395ad57468ae3

https://lbusett.github.io/insert_table/

This is a *sample* book written in **Markdown**. You can use anything that Pandoc's Markdown supports; for example, a math equation $a^2 + b^2 = c^2$.

0.1 Usage

Each **bookdown** chapter is an .Rmd file, and each .Rmd file can contain one (and only one) chapter. A chapter *must* start with a first-level heading: `# A good chapter`, and can contain one (and only one) first-level heading.

Use second-level and higher headings within chapters like: `## A short section` or `### An even shorter section`.

The `index.Rmd` file is required, and is also your first book chapter. It will be the homepage when you render the book.

0.2 Render book

You can render the HTML version of this example book without changing anything:

1. Find the **Build** pane in the RStudio IDE, and
2. Click on **Build Book**, then select your output format, or select "All formats" if you'd like to use multiple formats from the same book source files.

Or build the book from the R console:

```
bookdown::render_book()
```

To render this example to PDF as a `bookdown::pdf_book`, you'll need to install XeLaTeX. You are recommended to install TinyTeX (which includes XeLaTeX): https://yihui.org/tinytex/.

0.3 Preview book

As you work, you may start a local server to live preview this HTML book. This preview will update as you edit the book when you save individual .Rmd files. You can start the server in a work session by using the RStudio add-in "Preview book", or from the R console:

```
bookdown::serve_book()
```

Chapter 1

(PART*)

Chapter 2

1 ( )

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( ) https://www.datastadium.co.jp/news/information/2856

WBC 2023 2 19 https://www.nikkei.com/article/DGXZQODH1482H0U3A210C2000000/

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- “ ’’

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– 2

  - 2015/4/2 2 https://toyokeizai.net/articles/-/67103
  - ... https://www.tokyo-np.co.jp/article/234995
  - ... https://www.sankei.com/article/20230209-IZROVT6MY5CGLE4KEOUDEYKQBE/
  - https://cigs.canon/article/20220121_6483.html
  - https://www.jwa.or.jp/service/weather-and-data/weather-and-data-02/
  - https://www.konicaminolta.jp/business/solution/aisee/case/002.html
  - 23 https://www.nikkei.com/article/DGXZQOUB1940O0Z11C22A0000000/
  - https://business.nikkei.com/atcl/gen/19/00081/110200467/
  - 2021 8 https://www.tdb.co.jp/report/watching/press/p210807.html
-
-

  5 ( )

- GDP

  (2015)

  - 1% 1 GDP 0.24%
  - 1% 1 GDP 0.32%
  - (2015) %(http://www.esri.go.jp/jp/archive/e/_dis/e/_dis314/e/_dis314.pdf)

- https://www5.cao.go.jp/keizai1/mitoshi/mitoshi.html
  - https://www5.cao.go.jp/keizai1/mitoshi/2022/r05012 3mitoshi.pdf

  XX

- https://www.stat.go.jp/training/2kenkyu/pdf/rn/2-rn-002.pdf https://obamawhitehouse.archives.gov/blog/2013/06/11/what-great-gatsby-curve

  6

2.1

2.1.1

SSDSE https://www.nstac.go.jp/use/literacy/ssdse/

Figure 2.1: image of histogram

e-Stat https://www.nstac.go.jp/sys/files/static/SSDSE/data/2019/eStat-2019.pdf

- SSDSE e-Stat SSDSE e-Stat SSDSE

  https://www.nstac.go.jp/statcompe/index.html

2.1.2

Cracking The Mystery Of California's High Egg Prices https://www.hoover.org/research/cracking-mystery-californias-high-egg-prices

2.2

-
-

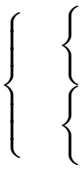
1	( )
2	( )
3	
4	
5	

Chapter 3

3.1

-

ID				···	GPA	( )
155001	3	S	A	···	3.67	45
155002	3	C	B	···	1.73	90
:	:	:	:		:	:



3.2

3.3 (Stem-and-Leaf)

( ) 50 ( )

|—|—|—|—|—|—|—|—|—|—|—| | 5 | 9 | 15 | 15 | 17 | 24 | 25 | 25 | 27 | 29 | |29 | 29 | 32 | 32 | 34 | 34 | 35 | 36 | 36 | 38 | |38 | 39 | 39 | 39 | 39 | 43 | 44 | 44 | 44 | 45 | |45 | 47 | 47 | 47 | 52 | 54 | 54 | 56 | 58 | 59 | |59 | 67 | 73 | 75 | 79 | 82 | 84 | 84 | 89 | 99 |

( )

- ( )
-

2 9
↑ ↑

10	1
0	59
1	557
2	4557999
3	2244566889999
4	344455777
5	2446899
6	7
7	359
8	2449
9	9

( ) 50

- 25
- 25
-

(, median) ,

3.4

( ) 50 ( )

0-9	2
10-19	3
20-29	7
30-39	13
40-49	9
50-59	7
60-69	1

70-79	3
80-89	4
90-99	1

frequency distribution class frequency

- – 10 2 90 1 30
- – – 100 10 5 ⇒ “ ’ ’

3.5

( ) 50 (histogram)

( )
50 (histogram)

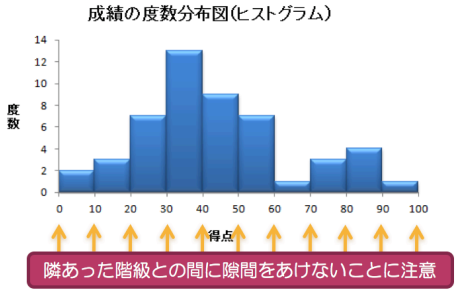


Figure 3.1: image of histogram

(Sturges)

1. m n m

$$m \approx 1 + \frac{\log_{10} n}{\log_{10} 2} \approx 1 + 3.32 \log_{10} n$$

≈ ($\log_{10} 2 \approx 0.301$)

2. c c

$$c \approx \frac{x_{\max} - x_{\min}}{1 + 3.32 \log_{10} n} = ——$$

- `(maximum)''` (minimum)’ ’
- “ (range)’ ’

( ) 50 ( ) 5 99 m c

1.

n	50
x_{max}	99
x_{min}	5

2. m

$$m \approx 1 + 3.32 \times \log_{10} \underset{\uparrow}{50}_{n} \approx 1 + 3.32 \times 1.699 \approx 1 + 5.64 = 6.64$$

3. c

$$c \approx \text{——} \approx \frac{99-5}{7} \approx 13$$

1.

2.

3.

   1.
   2.

3.5.1

( )

1. 30
2. 30
3. 50
4. 50

1. 13 2. 26 3. 34 4. 68

( ) 31 40

30 $= \frac{30}{\text{———}} = \frac{13}{50} = 0.26$

( )	( )		
0-9	2	0.04	$\leftarrow 2/50$
10-19	3	0.06	$\leftarrow 3/50$
20-29	7	0.14	
30-39	13	0.26	$\leftarrow 13/50$
40-49	9	0.18	
50-59	7	0.14	
60-69	1	0.02	
70-79	3	0.06	
80-89	4	0.08	
90-99	1	0.02	
	50	1.00	

Chapter 4

( )5 1 2 3 4 5 ~
http://www.stat.go.jp/data/kakei/kaisetsu.htm

1966 1966 5 (%)

	1	2	3	4	5
1966	5.6	12.4	17.7	23.8	40.5

US Department of Commerce, Statistical Abstract of the United States

( ) 360 100

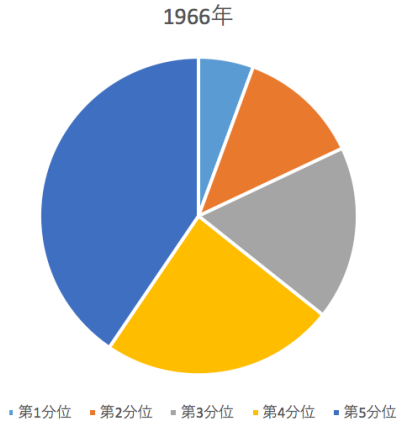


Figure 4.1: image of histogram

1966

	1966		
1	0.056	0.200	0.056
2	0.124	0.400	0.180
3	0.177	0.600	0.357
4	0.238	0.800	0.595
5	0.405	1.000	1.000

- 1 5.6%
- 6 (3) 4 (35.7%)
- 20% 4

1966 1966 (1) (2)

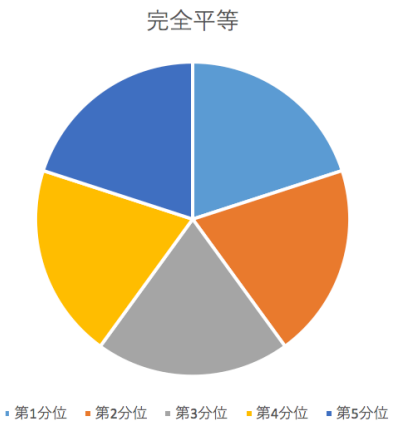


Figure 4.2: image of histogram

1966

(Lorenz curve) 1905 (M.O.Lorenz)

4.0.1

1. 1966
2.
3.

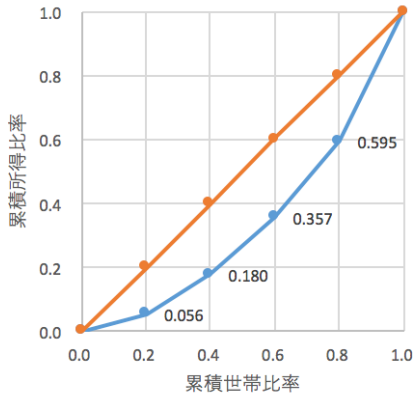


Figure 4.3: image of histogram

4.
5. 2 **2**

2005 2005

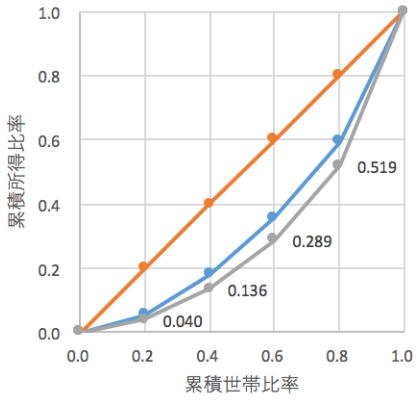


Figure 4.4: image of histogram

- 1969 2005
- 1966 2005

4.1

1. (Gini coefficient) ( )
2. **0 1** 0 1

1. (A) 0.5
2. B

$$= (\text{A} - \text{B}) \times 2 = 1 - \text{B} \times 2$$

3.

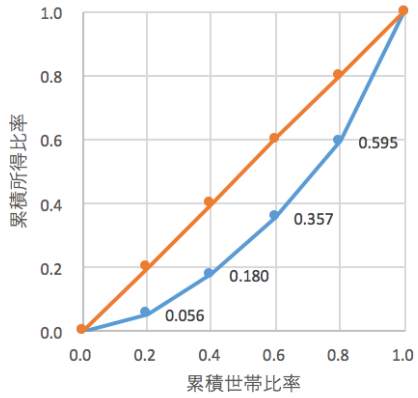


Figure 4.5: image of histogram

- 5

$$\begin{aligned}
&\frac{1}{2} \times \underset{\uparrow}{0.056} \times \underset{\uparrow}{0.2} \\
&+ \frac{1}{2} \times (0.056 + 0.180) \times 0.2 \\
&+ \frac{1}{2} \times (0.180 + 0.357) \times 0.2 \\
&+ \frac{1}{2} \times (0.357 + 0.595) \times 0.2 \\
&+ \frac{1}{2} \times (\underset{\uparrow}{0.595} + \underset{\uparrow}{1.000}) \times \underset{\uparrow}{0.2} \\
&= 0.3376
\end{aligned}$$

4. 1969

$$= 1 - 0.3376 \times 2 = 0.3248$$

5. B

- 5 20% “ ’’ 0.2
- $\frac{1}{2}$
-

$$\frac{1}{2} \times \underset{\uparrow}{0.2} \times \{0.056 + (0.056 + 0.180) + (0.180 + 0.357) + (0.357 + 0.595) + (0.595 + 1.000)\} = 0.3376$$

2005 2005

1. B

$$\text{B} = \frac{1}{2} \times \underset{\uparrow}{0.2} \times \{0.040 + (0.040 + 0.136) + (0.136 + 0.289) + (0.289 + 0.519) + (0.519 + 1.000)\} = 0.2968$$

2. 2005

$$= 1 - 2 \times 0.2968 = 0.4064$$

3. $0.3248(1969\ )$ $0.4064(2005\ )$

Chapter 5

	繊維工業		鉄鋼業	
従業員の規模(人)	事業所	従業員	事業所	従業員
5~9	4073	26359	1566	10548
10~19	2039	27256	1388	18892
20~29	711	16928	650	15713
30~49	523	19660	511	19421
50~99	375	26008	448	30542
100~199	165	22756	189	26937
200~299	37	9163	59	14175
300~499	16	5450	42	16310
500~999	5	3643	24	15310
1000~	3	3188	25	59589
総数	7947	160411	4902	227437

Figure 5.1: image of histogram

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-

    -
    -

  (0.5448 0.7003)
- “ ’’

	繊維工業		鉄鋼業	
従業員の規模(人)	事業所	従業員	事業所	従業員
	0.000	0.000	0.000	0.000
5~9	0.513	0.164	0.319	0.046
10~19	0.769	0.334	0.603	0.129
20~29	0.859	0.440	0.735	0.199
30~49	0.924	0.562	0.839	0.284
50~99	0.972	0.724	0.931	0.418
100~199	0.992	0.866	0.969	0.537
200~299	0.997	0.923	0.981	0.599
300~499	0.999	0.957	0.990	0.671
500~999	1.000	0.980	0.995	0.738
1000~	1.000	1.000	1.000	1.000

Figure 5.2: image of histogram

- ( )

5.1

3

- 1

$$\sum_{i=1}^{n}(X_i + c) = \sum_{i=1}^{n} X_i + nc$$

- 2

$$\sum_{i=1}^{n} cX_i = c\sum_{i=1}^{n} X_i$$

- 3

$$\sum_{i=1}^{n}(aX_i + b) = a\sum_{i=1}^{n} X_i + nb$$

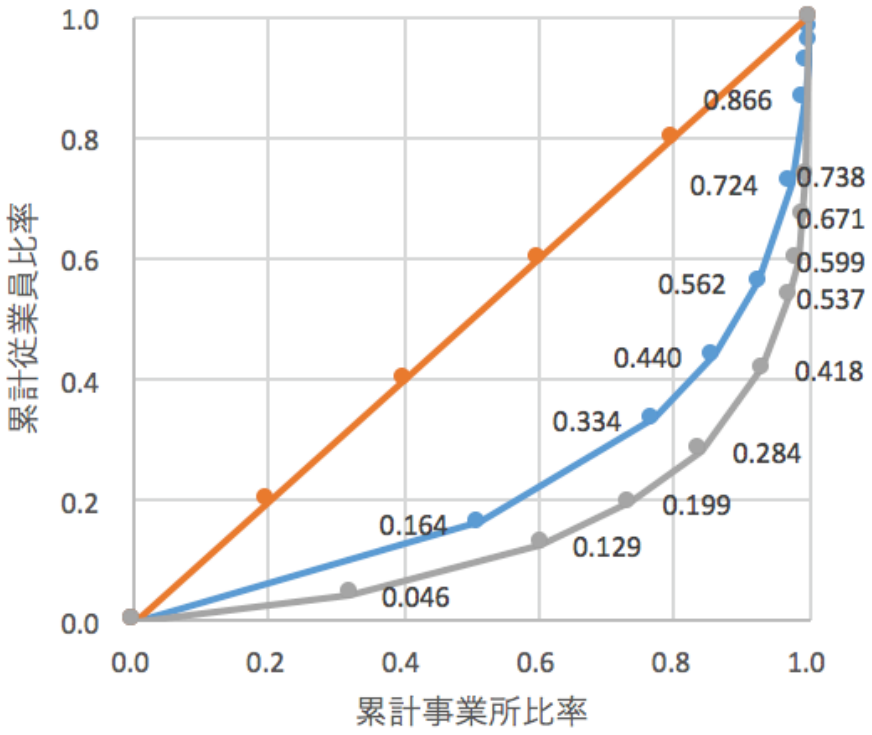

Figure 5.3: image of histogram

n $\{X_i\} = \{X_1, X_2, \cdots, X_n\}$ c $\{X_i + c\}$

$$\begin{aligned}\sum_{i=1}^{n}(X_i + c) &= (X_1 + c) + (X_2 + c) + \cdots + (X_n + c) \\ &= (X_1 + X_2 + \cdots + X_n) + \underbrace{(c + c + \cdots + c)}_{n\ c} \\ &= \sum_{i=1}^{n} X_i + nc \end{aligned} \tag{5.1}$$

n $\{X_i\} = \{X_1, X_2, \cdots, X_n\}$ c $\{cX_i\}$

$$\begin{aligned}\sum_{i=1}^{n} cX_i &= cX_1 + cX_2 + \cdots + cX_n \\ &= c(X_1 + X_2 + \cdots + X_n) \\ &= c\sum_{i=1}^{n} X_i \end{aligned} \tag{5.2}$$

(5.1) (5.2) n $\{X_i\}$ a b $\{aX_i + b\}$

$$\begin{aligned}\sum_{i=1}^{n}(aX_i + b) &= (aX_1 + b) + (aX_2 + b) + \cdots + (aX_n + b) \\ &= \underbrace{(aX_1 + aX_2 + \cdots + aX_n)}_{a(X_1 + X_2 + \cdots + X_n)} + \underbrace{(b + b + \cdots + b)}_{n\ b} \\ &= a\sum_{i=1}^{n} X_i + nb \end{aligned} \tag{5.3}$$

(Gini_Quintile2021.tex)

1. I II III IV V

I	Q_1	0.2	y_1
II	Q_2	0.4	y_2
III	Q_3	0.6	y_3
IV	Q_4	0.8	y_4
V	Q_5	1.0	y_5

3. Q_i i y_i i

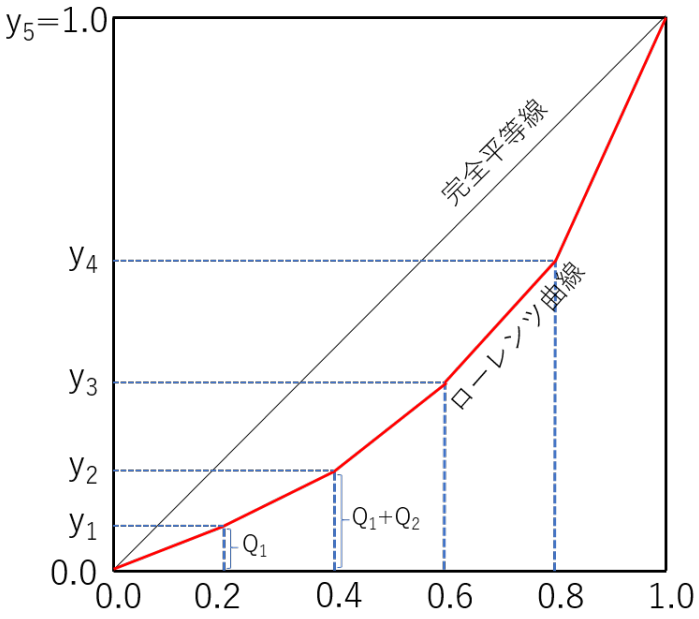

Figure 5.4: image of histogram

•

$$\begin{aligned} \mathrm{I} \quad &= \quad \times \quad \div 2 \\ &= y_1 \times 0.2 \times \frac{1}{2} = 0.1 \times y_1 \end{aligned}$$

$$\mathrm{II} \quad = (\quad + \quad) \times \quad \div 2 = (y_1 + y_2) \times 0.2 \times \frac{1}{2} = 0.1 \times (y_1 + y_2)$$

$$\mathrm{III} \quad = (y_2 + y_3) \times 0.2 \times \frac{1}{2} = 0.1 \times (y_2 + y_3)$$

$$\mathrm{IV} \quad = (y_3 + y_4) \times 0.2 \times \frac{1}{2} = 0.1 \times (y_3 + y_4)$$

$$\mathrm{V} \quad = (y_4 + y_5) \times 0.2 \times \frac{1}{2} = 0.1 \times (y_4 + 1)$$

- (B)

$$\begin{aligned}\text{B} &= 0.1 \times y_1 + 0.1 \times (y_1 + y_2) + 0.1 \times (y_2 + y_3) + 0.1 \times (y_3 + y_4) + 0.1 \times (y_4 + 1) \\ &= 0.1 \times \{y_1 + (y_1 + y_2) + (y_2 + y_3) + (y_3 + y_4) + (y_4 + 1)\} \\ &= 0.1 \times (2y_1 + 2y_2 + 2y_3 + 2y_4 + 1)\end{aligned}$$

- 1/2 2

$$\begin{aligned}\text{Gini} &= \underbrace{2 \times 0.5}_{\text{A 2}} - \underbrace{2 \times 0.1 \times (2y_1 + 2y_2 + 2y_3 + 2y_4 + 1)}_{\text{B 2}} \\ &= 1 - (0.4y_1 + 0.4y_2 + 0.4y_3 + 0.4y_4 + 0.2) \\ &= 0.8 - 0.4 \times (y_1 + y_2 + y_3 + y_4) \qquad (5.4)\end{aligned}$$

- y Q

$$\begin{aligned}y_1 &= Q_1 \\ y_2 &= Q_1 + Q_2 \\ y_3 &= Q_1 + Q_2 + Q_3 \\ y_4 &= Q_1 + Q_2 + Q_3 + Q_4\end{aligned}$$

$$y_1 + y_2 + y_3 + y_4 = 4Q_1 + 3Q_2 + 2Q_3 + Q_4 \qquad (5.5)$$

- (5.4) (5.5)

$$\text{Gini} = 0.8 - 0.4 \times (4Q_1 + 3Q_2 + 2Q_3 + Q_4) \qquad (5.6)$$

1966 (5.6)

$$\begin{aligned}\text{Gini} &= 0.8 - 0.4 \times (4Q_1 + 3Q_2 + 2Q_3 + Q_4) \\ &= 0.8 - 0.4 \times (4 \times 0.056 + 3 \times 0.124 + 2 \times 0.177 + 0.238) \\ &= 0.8 - 0.4 \times (0.224 + 0.372 + 0.354 + 0.238) \\ &= 0.8 - 0.4 \times 1.188 = 0.8 - 0.4752 = 0.3248\end{aligned}$$

Barro, R.J. (1999), Inequality, Growth and Investment, NBER Working Paper 7038.

$\{X_i - \bar{X}\}$

n

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

1 $c = -\bar{X}$ (5.1) $\{X_i - \bar{X}\}$

$$\begin{aligned}\sum_{i=1}^{n}(X_i - \bar{X}) &= (X_1 - \bar{X}) + (X_2 - \bar{X}) + \cdots + (X_n - \bar{X}) \\ &= \underbrace{(X_1 + X_2 + \cdots + X_n)}_{\sum_{i=1}^{n} X_i} + \underbrace{\{(-\bar{X}) + (-\bar{X}) + \cdots + (-\bar{X})\}}_{n\ -\bar{X}}\end{aligned}$$

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad \sum_{i=1}^{n} X_i = n\bar{X}$$

$$\begin{aligned}\sum_{i=1}^{n}(X_i - \bar{X}) &= \underbrace{(X_1 + X_2 + \cdots + X_n)}_{\sum_{i=1}^{n} X_i} + \underbrace{\{(-\bar{X}) + (-\bar{X}) + \cdots + (-\bar{X})\}}_{n\ -\bar{X}} \\ &= \sum_{i=1}^{n} X_i - n\bar{X} \\ &= 0\end{aligned}$$

Chapter 6

6.1

1 5 100 300 600 900 1200 5

1	2	3	4	5
x_1	x_2	x_3	x_4	x_5

|–|–|–|–|–|–|–| | ( ) | 100 | 300 | 600 | 900 | 1200 |

$$= \frac{100 + 300 + 600 + 900 + 1200}{5} = 620(\quad)$$

- n $x_1, x_2, \ldots, x_n$

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

- x (1 x_1)

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5} = \frac{1}{5} \sum_{i=1}^{5} x_i$$

1.
   (a)
   (b)

(c)
(d)
(e) (=“ ”)

2.
(a) ( )
(b)

3.

-
-
-

2 10 10 30

24 12 80 16 28 16 32 16 52 24 ( )

* 30

6.2

- median
-

1. n $(n+1)/2$
2. n $n/2$ $n/2+1$

-

1.
2.

1.

- Outlier
-
-

2.

-
-

3 4 (A,B,C,D)

A: 3,4,5,6,7 B: 1,3,5,7,9
C: 0,4,5,6,10 D: 0,1,5,9,10

$\%(\bar{x}_A, \bar{x}_B, \bar{x}_C, \bar{x}_D)$ $\%(Me_A, Me_B, Me_C, Me_D)$

4

-
-

6.3

mode

1.

- Outlier
-

2.

-
-

5

-
-

6.4

(2016) [3] ( )

Chapter 7

1

2 (X Y) 2 100

- X A B 1m
- Y C D 5mm

2

X (A B) 1000m Y (C D) 1m

2

X (A B) 1000m Y (C D) 1m

- 1000m 1m 1m 5mm

$$\begin{aligned} \text{X} &= \frac{1}{1000} = 0.001 \\ \text{Y} &= \frac{5}{1000} = 0.005 \end{aligned}$$

(coefficient of variation)

$$(\text{CV}) = \frac{\text{sd}(x)}{\bar{x}} = \frac{x}{x}$$

0 0

3

1991 1 1996 1 ( ) ( )

%

-
-

-

6 ~( )

7

8 1 ~( )

9

-

$$\bar{x} = \frac{1}{6}(3 + 2 + 6 + 1 + 5 + 7) = \frac{24}{6} = 4$$

-

$$\begin{aligned} \text{MAD} &= \frac{1}{6}(|3-4| + |2-4| + |6-4| + |1-4| + |5-4| + |7-4|) \\ &= \frac{1}{6}(1 + 2 + 2 + 3 + 1 + 3) = \frac{12}{6} = 2 \end{aligned}$$

10

1. ( ) 2

$$\begin{aligned} &= \frac{1}{6}\{(3-4)^2 + (2-4)^2 + (6-4)^2 + (1-4)^2 \\ &\quad + (5-4)^2 + (7-4)^2\} \\ &= \frac{28}{6} = \frac{14}{3} = 4.66 \end{aligned}$$

2.

$$= \sqrt{\quad} = \sqrt{\frac{14}{3}} = \sqrt{4.66} = 2.16$$

11

1. $\frac{55}{10} = \frac{11}{2}$
2.

$$= \quad 2 \quad - \quad 2$$

$$= \frac{77}{2} - \left(\frac{11}{2}\right)^2 = \frac{33}{4} = 8.25$$

3.

$$= \sqrt{\ } = \sqrt{\frac{33}{4}} = \sqrt{8.25} = 2.872$$

12

4 ( ) ( )

1.
2.
3.

4 }

32 8 3

A: 56 , B: 28 , C: 32

$\bar{x}$ $\mathrm{sd}(x)$ “ ’’

$$= \frac{-}{\quad} = \frac{-\bar{x}}{\mathrm{sd}(x)}$$

1. 3

$$z_A = \frac{56-32}{8} = 3, \quad z_A = \frac{28-32}{8} = -0.5 \quad z_A = \frac{32-32}{8} = 0$$

5

3

}

$$= 50 + 10 \times$$

- 3

$$50 + 10 \times 3 = 80, \quad 50 + 10 \times (-0.5) = 45, \quad 50 + 10 \times 0 = 50$$

6

80 50

1.

2. 80

16 ( )}

3

1 2 3 ( )

( ) : $\mathrm{sd}(x) = \sqrt{\mathrm{Var}(x)} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$

1. 2( )

$$\mathrm{Var}(x) = \frac{1}{3}\{(1-2)^2 + (2-2)^2 + (3-2)^2\} = \frac{2}{3}$$

2. 1

$$\mathrm{sd}(x) = \sqrt{\frac{2}{3}} = 0.816(\ )$$

16 (( )) }

1

10,000 20,000 30,000 ( )

1. $y = 10000 \times x$

2. 20000( )

$$\mathrm{Var}(y) = \frac{1}{3}\{(10000 - 20000)^2 + (20000 - 20000)^2 + (30000 - 20000)^2\} = \frac{200000000}{3}$$

3. 1

$$\begin{aligned}\mathrm{sd}(y) &= \sqrt{\frac{200000000}{3}} = 8165(\ ) \\ &= 10000 \times \mathrm{sd}(x)\end{aligned}$$

x_i a b y_i

$$s_y = |a| s_x \mathrm{sd}(y) = |a| \times \mathrm{sd}(x)$$

- 1 1

Chapter 8

- n $x_1, x_2, \ldots, x_n$

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

-
-
-
-
-
- (=“ ’’)
-
-
-
-
- x (1 x_1)

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5} = \frac{1}{5} \sum_{i=1}^{5} x_i$$

}
-

-
-
-
-
- (=“ ’’)
-
-
-
-
-
-
-
-
- }
- median
-
- n $(n+1)/2$
- n $n/2$ $n/2+1$
-
-
-
- }
-
- Outlier
-
-
-
-
-
- }
- mode
- }

-
- Outlier
-
-
-
-

}

8.1 }

-
-
-
-

8.2

(“ ’ ’)}

- (range)

$$= x_{\max} - x_{\min}$$

} X Y

'' } ( ) ’ ’ ( )

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

(“ ’ ’)}

- (interquartile range)

$$\text{IQR} = Q_3 - Q_1$$

- 3
- Q_1, Q_2, Q_3 1 2 3

}

- (range) (outlier)

- 25% **50%** (outlier) “ (range)’’

  1 ~( )} 15 1

  24 12 14 24 11 18 19 14 18 32
  24 22 24 18 36 18 12 24 20 34

-
- 25( ) $(= 36 - 11)$
- $\mathrm{Q}_1 = \frac{1}{2}(14 + 18) = 16$ $\mathrm{Q}_3 = \frac{1}{2}(24 + 24) = 24$

$$= 24 - 16 = 8(\ )$$

}

-
- $\Rightarrow$“ ’’ Q_2
- 2 $\Rightarrow Q_1$
- 2 $\Rightarrow Q_3$

} 7 7 Q_2

1 2 3 4 5 6 7( )

} 10 10 $Q_1, Q_2, Q3$

1 2 3 4 5 6 7 8 9 10( )

- Q_2 2
- Q_1 2

}

- n

$$x_{(1)} \leq x_{(2)} \leq \cdots x_{(n)}$$

-
- 25% 50% 75%
- $100\alpha\%$ $n\alpha$ j g

$$\begin{cases} \frac{x_{(j)}+x_{(j+1)}}{2} & g=0 \\ x_{(j+1)} & g>0 \end{cases}$$

- $n=7$ 25% $j=1$ 2 50% 4 75% 6

}

7 7 2 (Q_1)

1 2 3 $\underset{\uparrow}{4}$ 5 6 7( )
Q_2

} 5 42

-
-

ISIZE 2011/5/4

}

- n

$$x_{(1)} \leq x_{(2)} \leq \cdots x_{(n)}$$

-
- 25% 50% 75%
- $100\alpha\%$ $n\alpha$ j g

$$\begin{cases} \frac{x_{(j)}+x_{(j+1)}}{2} & g=0 \\ x_{(j+1)} & g>0 \end{cases}$$

- $n=42$

25% $j=10$ 11 50% 21 22 75% 32

} % 42 ( )

$$= \underset{\uparrow}{11.4} - \underset{\uparrow}{4.9} = 6.5(\ )$$

$$= \underset{\uparrow}{7.5} - \underset{\uparrow}{6.2} = 1.3(\ )$$
Q_3 Q_1

(“ ’’)}

- (mean absolute deviation)

$$\text{MAD} = \frac{1}{n}(\underbrace{|x_1 - \bar{x}|}_{1} + |x_2 - \bar{x}| + \cdots + |x_n - \bar{x}|)$$
$$= \frac{1}{n}\sum_{i=1}^{n} |x_i - \bar{x}| =$$

-
- (=)

}

X 10 ( )

= 0.8( )

( )

-

8.2.1

-
-
-
-
-

K } K 5 42

$$= \underset{\uparrow}{11.4} - \underset{\uparrow}{4.9} = 6.5(\ )$$
$$= \underset{\uparrow}{7.5}_{Q_3} - \underset{\uparrow}{6.2}_{Q_1} = 1.3(\ )$$

}

}

- ( )
- (Box-whisker plot)
- Q_1 Q_3 Q_2 $\diamond$
- (1) 1.5 (2)
-

8.3 }

(weighted arithmetic mean)}

$$x_w = \frac{w_1x_1 + w_2x_2 + \cdots + w_nx_n}{\sum_{i=1}^{n} w_i}$$
$$= \underbrace{\left(\frac{w_1}{\sum_{i=1}^{n} w_i}\right)}_{1} x_1 + \cdots + \left(\frac{w_n}{\sum_{i=1}^{n} w_i}\right) x_n$$

1 } C-3 } 2006 3

2

-

$$(\ ) = \frac{47.1}{100} \times 145 + \frac{62.1}{100} \times 519 = \boxed{}$$

-

$$= \frac{68.295 + 322.299}{145 + 519} = \frac{390.594}{664} = 0.588 = 58.8\%$$

$$= \underbrace{}_{\smile} \times \quad + \underbrace{}_{\smile} \times$$
$$= \frac{\boxed{}}{664} \times 47.1 + \frac{\boxed{}}{664} \times 62.1$$
$$= 0.2183 \times 47.1 + 0.7816 \times 62.1$$
$$= 10.28 + 48.54$$
$$= 58.82\%$$

2 1 }

, 4 1 1 8

8 1 % .

$$G = \sqrt[8]{1.07 \times 1.28 \times 1.32 \times 1.21 \times 1.11 \times 1.09 \times 1.05 \times 1.01}$$
$$= \sqrt[8]{2.8068} \quad \leftarrow$$
$$= 1.137 \quad \leftarrow$$

1.14 14% \ (:~)

(geometric mean)}

- n (5% 1.05)
-

$$X_1 \times X_2 \times \cdots \times X_n$$

- n

$$G = \sqrt[n]{X_1 \times X_2 \times \cdots X_n}$$

2 1 } C-4 1 } , 4 1 1 2

2 1 % .

(1)1.0%~~ (2)5.9%~~ (3)6.0%~~ (4)11.0%~~

(1)

$$G = \sqrt{1.01} \times 1.11$$
$$= \sqrt{1.1211}$$
$$= 1.0588(\quad 5 \quad)$$

1.059 5.9%

( ) $g(\%)$ 2

$$\left(1+\frac{g}{100}\right)^2 = \underbrace{1.1211}_{1.01\times 1.11}$$

$$\left(1+\frac{g}{100}\right) = \sqrt{1.1211} = 1.0588.$$

$$\frac{g}{100} = 0.0588$$

3 } C-5 } 1 (%)

-

(1) $\frac{1}{5}(4.2+12.5+6.3+7.3+13.4)$
(2) $\sqrt[5]{1.042\times 1.125\times 1.063\times 1.073\times 1.134}$
(3) $\sqrt[5]{0.042\times 0.125\times 0.063\times 0.073\times 0.134}$

- $\sqrt[5]{1.042\times 1.125\times 1.063\times 1.073\times 1.134}$
- $\sqrt[5]{0.042\times 0.125\times 0.063\times 0.073\times 0.134}$
- $\sqrt[5]{4.2\times 12.5\times 6.3\times 7.3\times 13.4}$

(2)

(3) } C-6 }

-
- ( )

(1) ∼∼ (2) ∼∼ (3)

- $G = \sqrt[5]{1.5162} = 1.087$ 8.7%
- $G = \sqrt[5]{\square} = \square$ 7.7%
- $G = \sqrt[5]{\square} = \square$ 9.7%

4 } C-7 } 2 (X Y) 2 100

- X A B 1m
- Y C D 5mm

(1)X ∼∼ (2)Y ∼∼

(4) } C-8 } X (A B) 1000m Y (C D) 1m

(1)X ~~ (2)Y ~~

- 1000m 1m 1m 5mm

$$\text{X} = \frac{1}{1000} = 0.001$$
$$\text{Y} = \frac{5}{1000} = 0.005$$

(coefficient of variation)}

$$(\text{CV}) = \frac{\text{sd}(x)}{\bar{x}} = \frac{x}{\text{---}}$$

0 0

5 } C-9 } 1991 1 1996 1 ( ) ( )

%

(1) ~~ (2) ~~ (3)

-
-
-

6 ~( )} 15

-

$$\bar{x} = \frac{870}{15} = 58(\ )$$

- 61( )

7 } 3 ( ) ( )

-
-
-

8 1 ~( )} 15 1

-
- 25(= 36 − 11)
- $Q_1 = \frac{1}{2}(14 + 18) = 16$ $Q_3 = \frac{1}{2}(24 + 24) = 24$

$$= 24 - 16 = 8$$

9 }

-

$$\bar{x} = \frac{1}{6}(3 + 2 + 6 + 1 + 5 + 7) = \frac{24}{6} = 4$$

-

$$\begin{aligned} \text{MAD} &= \frac{1}{6}(|3-4| + |2-4| + |6-4| + |1-4| + |5-4| + |7-4|) \\ &= \frac{1}{6}(1 + 2 + 2 + 3 + 1 + 3) = \frac{12}{6} = 2 \end{aligned}$$

10 }

- ( ) 2

$$\begin{aligned} &= \frac{1}{6}\{(3-4)^2 + (2-4)^2 + (6-4)^2 + (1-4)^2 \\ &\quad + (5-4)^2 + (7-4)^2\} \\ &= \frac{28}{6} = \frac{14}{3} = 4.66 \end{aligned}$$

-

$$= \surd = \sqrt{\frac{14}{3}} = \sqrt{4.66} = 2.16$$

11 }

- $\frac{55}{10} = \frac{11}{2}$
-

$$= \quad 2 \quad - \quad 2$$

$$= \frac{77}{2} - \left(\frac{11}{2}\right)^2 = \frac{33}{4} = 8.25$$

-

$$= \sqrt{} = \sqrt{\frac{33}{4}} = \sqrt{8.25} = 2.872$$

12 } 4 ( ) ( )

-
-
-

13 } 32 8 3

} $\bar{x}$ $\mathrm{sd}(x)$ “ ’’

$$= \frac{-}{\quad} = \frac{-\bar{x}}{\mathrm{sd}(x)}$$

- 3

$$z_A = \frac{56-32}{8} = 3, \quad z_A = \frac{28-32}{8} = -0.5 \quad z_A = \frac{32-32}{8} = 0$$

14 } 3

}

$$= 50 + 10 \times$$

- 3

$$50 + 10 \times 3 = 80, \quad 50 + 10 \times (-0.5) = 45, \quad 50 + 10 \times 0 = 50$$

15 } 80 50

-

- 80

  16 ( )}

  3

1 2 3 ( )

( ) : $\mathrm{sd}(x) = \sqrt{\mathrm{Var}(x)} = \sqrt{\dfrac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$

- 2( )

$$\mathrm{Var}(x) = \frac{1}{3}\{(1-2)^2 + (2-2)^2 + (3-2)^2\} = \frac{2}{3}$$

- 1

$$\mathrm{sd}(x) = \sqrt{\frac{2}{3}} = 0.816(\ )$$

16 (( )) } 1

10,000 20,000 30,000 ( )

- $y = 10000 \times x$
- 20000( )

$$\mathrm{Var}(y) = \frac{1}{3}\{(10000-20000)^2 + (20000-20000)^2 + (30000-20000)^2\} = \frac{200000000}{3}$$

- 1

$$\mathrm{sd}(y) = \sqrt{\frac{200000000}{3}} = 8165(\ ) = 10000 \times \mathrm{sd}(x)$$

} x_i a b y_i

$$\mathrm{sd}(y) = |a| \times \mathrm{sd}(x)$$

- 1 1

Chapter 9

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9.1 A section

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An unnumbered section

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Chapter 10

( )

- Q_1 Q_3 Q_2 $\diamond$
- (1) 1.5 (2)
-

Chapter 11

11.1 2

K

'' '' '' '' ,m^2

11.2 2

(Scatter Plot)}

- n

$$\{(x_1, y_1), (x_2, y_2), \cdots, (x_n, y_n)\}$$

$(y\ )$ $(x\ )$ xy

- 2
- x space( ) y rent( ) 42 42

11.3 2

(covariance)}

- x y

$$\mathrm{Cov}(x,y) = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$
$$\uparrow_{x} \qquad \uparrow_{y}$$

-
- 1 x

$$\mathrm{Var}(x) = s_x^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(x_i - \bar{x})$$

- 2 x, y $x_i - \bar{x}$ $y_i - \bar{y}$
  K }
- y x 5.0203

$$\begin{aligned} & \mathrm{Cov}(x,y) \\ = s_{xy} \quad & = \frac{1}{42}\sum_{i=1}^{42}(x_i - \bar{x})(y_i - \bar{y}) \\ & = 5.0203 \end{aligned}$$

-
  (correlation coefficient)}
  -

$$\begin{aligned} \mathrm{Corr}(x,y) &= \frac{\mathrm{Cov}(x,y)}{\mathrm{sd}(x) \times \mathrm{sd}(y)} \\ &= \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2}} \\ &= \frac{s_{xy}}{s_x s_y} \end{aligned}$$

-

1. -1 $1 \Rightarrow -1 \leq \mathrm{Corr}(x,y) \leq 1$
2. 2
3.

   }

Chapter 12

(1)

12.1

•
• →

x y

(a)

$$y = \beta_0 + \beta_1 x$$

(b)2

$$y = \beta_0 + \beta_1 x + \beta_2 x^2$$

(b)3

$$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3$$

12.2

(,simple regression)

2 x y 1

$$y_i = \beta_0 + \beta_1 x_i + u_i, \qquad i = 1, 2, \ldots, n$$

(=)

- ( )
-

12.3 2 ( )

2

- ( )β_0, β_1 ( )
- 2 (Ordinary Least Square method: OLS)

$$\min_{\{\beta_0,\beta_1\}} \underset{\substack{\uparrow \\ S \\ \beta_0,\beta_1}}{S(\beta_0, \beta_1)} = \sum_{i=1}^{n} \underbrace{\{ \underset{\substack{\uparrow \\ y}}{y_i} - (\beta_0 + \underset{\substack{\uparrow \\ x}}{\beta_1 x_i})\}^2}_{i}$$

- 2 y_i 2 (2)

Excel

1. B C
2. C11 C12
3. D
4. E
5. F 2 F9

12.4 2 ( )

2 β_0 β_1

- 2

$$\min_{\{\beta_0,\beta_1\}} \underset{\substack{\uparrow \\ S \\ \beta_0,\beta_1}}{S(\beta_0,\beta_1)} = \sum_{i=1}^{n} \underbrace{\{ \underset{\substack{\uparrow \\ y}}{y_i} - (\beta_0 + \beta_1 \underset{\substack{\uparrow \\ x}}{x_i})\}^2}_{i}$$

- $S(\beta_0,\beta_1)$ β_0,β_1 (1) $\Rightarrow$ 2 2

$$\frac{\partial S(\beta_0,\beta_1)}{\partial \beta_0} = -2\sum_{i=1}^{n}(y_i-\beta_0-\beta_1 x_i) = 0 \qquad \Rightarrow \sum_{i=1}^{n} u_i = 0$$

$$\frac{\partial S(\beta_0,\beta_1)}{\partial \beta_1} = -2\sum_{i=1}^{n}(y_i-\beta_0-\beta_1 x_i)x_i = 0 \quad \Rightarrow \sum_{i=1}^{n} u_i x_i = 0$$

β_0, β_1

OLS

1. i $\{y_i-\beta_0-\beta_1 x_i\}^2$ β_0

$$2\{y_i-\beta_0-\beta_1 x_i\} \times (-1)$$

2. 1 n $=0$

$$\frac{\partial S}{\partial \beta_0} = -2\sum_{i=1}^{n}\{\underbrace{y_i-\beta_0-\beta_1 x_i}_{u_i}\} = 0 \Rightarrow \sum_{i=1}^{n} u_i = 0$$

3. i $\{y_i-\beta_0-\beta_1 x_i\}^2$ β_1

$$2\{y_i-\beta_0-\beta_1 x_i\} \times (-x_i)$$

4. 1 n $=0$

$$\frac{\partial S}{\partial \beta_1} = -2\sum_{i=1}^{n}x_i\{\underbrace{y_i-\beta_0-\beta_1 x_i}_{u_i}\} = 0 \Rightarrow \sum_{i=1}^{n} x_i u_i = 0$$

5. 1 ($\sum u_i = 0$)

$$\sum(y_i-\beta_0-\beta_1 x_i) = 0$$
$$\sum y_i - \sum \beta_0 - \sum \beta_1 x_i = 0$$
$$n\bar{y} - n\beta_0 - \beta_1 n\bar{x} = 0$$
$$\bar{y} - \beta_0 - \beta_1 \bar{x} = 0$$

$$\beta_0 = \bar{y} - \beta_1 \bar{x}$$

6. 2 ($\sum x_i u_i = 0$)

$$\begin{aligned}
\sum(x_i + \quad)u_i &= 0 \\
\sum(x_i - \bar{x})u_i &= 0 \\
\sum(x_i - \bar{x})(\underbrace{y_i - \beta_0 - \beta_1 x_i}_{u_i}) &= 0 \\
\sum(x_i - \bar{x})\{y_i - (\bar{y} - \beta_1\bar{x}) - \beta_1 x_i\} &= 0 \\
\sum(x_i - \bar{x})\{(y_i - \bar{y}) - \beta_1(x_i - \bar{x})\} &= 0
\end{aligned}$$

$$\beta_1 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2}$$

12.5 2

2

2 β_0, β_1 (2 , OLS estimator)

$$\hat{\beta}_0 = \bar{y} - \beta_1\bar{x} \qquad \hat{\beta}_1 = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2} = \frac{\mathrm{Cov}(x, y)}{\mathrm{Var}(x)}$$

- $\hat{\beta}_0, \hat{\beta}_1$ (=) β_0, β_1 “ ’’
- **(OLS estimate)**

Excel

- $= \bar{x}$
- $= \bar{y}$
- $= \sum_i^4 (x_i - \bar{x})(y_i - \bar{y})$
- $= \sum_i^4 (x_i - \bar{x})^2$

12.6

1. $(\hat{\beta}_0)$ $(\hat{\beta}_1)$

$\hat{\beta}_0 = 17.0$ $\hat{\beta}_1 = 30.0$

x_i `(fitted value)''` y ’’

$$\underset{y}{\hat{y}_i} = \hat{\beta}_0 + \hat{\beta}_1 x_i$$

2. x_i

$$\underset{\uparrow}{\hat{y}_i} = \hat{\beta}_0 + \hat{\beta}_1 x_i = 17.0 + 30.0 x_i \tag{12.1}$$

3. (12.1) 1.0(m)

$$17.0 + 30.0 \times 1.0 = 47.0(\text{kg})$$

4. (12.1) 1.1(m)

$$17.0 + 30.0 \times 1.1 = 50.0(\text{kg})$$

5. 0.1(m) 3.0(kg)

$$\begin{aligned} &\frac{1.1(\text{m}) \qquad - 1.0(\text{m})}{1.1(\text{m}) - 1.0(\text{m})} \\ &= \text{——} \\ &= \frac{50.0 - 47.0}{1.1 - 1.0} \\ &= 30.0 \qquad \leftarrow \qquad (\hat{\beta}_1) \end{aligned}$$

42 (m^2) ( )

$$\widehat{\text{rent}}_i = 3.172 + 0.209 \text{ area}_i, \qquad i = 1, \ldots, 42$$

1. 20m^2 XXX
2. 1m^2 XXX

1994 2005 12 (income) (cons)

$$\widehat{\text{cons}}_t = 13.44 + 0.5406 \text{ income}_t, \qquad t = 1994, \ldots, 2005$$

1. 0.5406 “ ’’
2. 1 XXX

(vegetable compound) 1907 1960 (54) 1000

$$\widehat{\text{sales}}_t = 488.8 + 1.434 \text{ advertisement}_t, \qquad t = 1907, \ldots, 1960$$

Palda, Kristian S. (1964). *The Measurement of Cumulative Advertising Effects.* Englewood Cliffs, N.J.: Prentice-Hall.

- 1000 XXX XXX

12.7 (2)

1.

$$\sum y_i = \sum \hat{y}_i$$

2. ( ) 0

$$\sum \hat{u}_i = \frac{1}{n} \sum \hat{u}_i = 0$$

3. x_i $\hat{u}_i$

$$\sum x_i \hat{u}_i = 0$$

Chapter 13

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13.1 A section

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Chapter 14

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14.1 A section

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Chapter 15

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15.1 A section

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Chapter 16

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16.1 A section

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Chapter 17

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17.1 A section

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Chapter 18

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18.1 A section

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An unnumbered section

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Chapter 19

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19.1 A section

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An unnumbered section

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Chapter 20

Cross-references

Cross-references make it easier for your readers to find and link to elements in your book.

20.1 Chapters and sub-chapters

There are two steps to cross-reference any heading:

1. Label the heading: `# Hello world {#nice-label}`.
    - Leave the label off if you like the automated heading generated based on your heading title: for example, `# Hello world` = `# Hello world {#hello-world}`.
    - To label an un-numbered heading, use: `# Hello world {-#nice-label}` or `{# Hello world .unnumbered}`.
2. Next, reference the labeled heading anywhere in the text using `\@ref(nice-label)`; for example, please see Chapter 20.
    - If you prefer text as the link instead of a numbered reference use: any text you want can go here.

20.2 Captioned figures and tables

Figures and tables *with captions* can also be cross-referenced from elsewhere in your book using `\@ref(fig:chunk-label)` and `\@ref(tab:chunk-label)`, respectively.

See Figure 20.1.

```
par(mar = c(4, 4, .1, .1))
plot(pressure, type = 'b', pch = 19)
```

Don't miss Table 20.1.

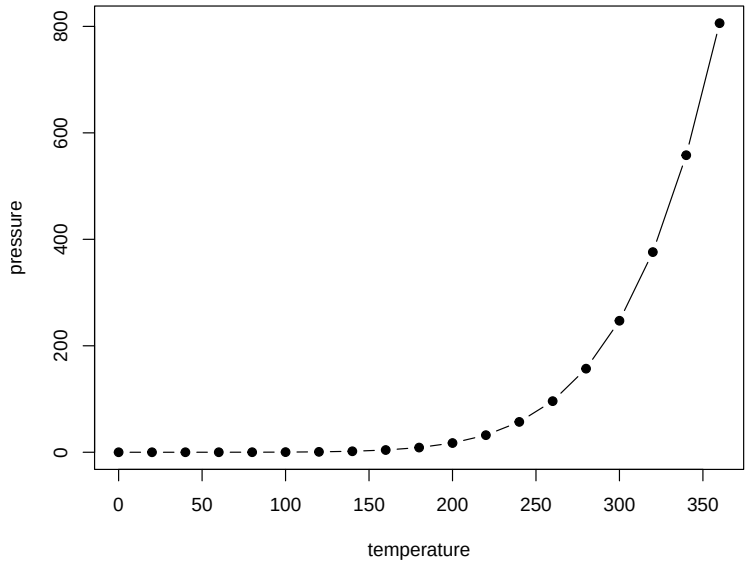

Figure 20.1: Here is a nice figure!

```
knitr::kable(
  head(pressure, 10), caption = 'Here is a nice table!',
  booktabs = TRUE
)
```

Table 20.1: Here is a nice table!

temperature	pressure
0	0.0002
20	0.0012
40	0.0060
60	0.0300
80	0.0900
100	0.2700
120	0.7500
140	1.8500
160	4.2000
180	8.8000

Chapter 21

Parts

You can add parts to organize one or more book chapters together. Parts can be inserted at the top of an .Rmd file, before the first-level chapter heading in that same file.

Add a numbered part: `# (PART) Act one {-}` (followed by `# A chapter`)

Add an unnumbered part: `# (PART\*) Act one {-}` (followed by `# A chapter`)

Add an appendix as a special kind of un-numbered part: `# (APPENDIX) Other stuff {-}` (followed by `# A chapter`). Chapters in an appendix are prepended with letters instead of numbers.

Chapter 22

Footnotes and citations

22.1 Footnotes

Footnotes are put inside the square brackets after a caret `^[]`. Like this one [1].

22.2 Citations

Reference items in your bibliography file(s) using `@key`.

For example, we are using the **bookdown** package (Xie, 2023) (check out the last code chunk in index.Rmd to see how this citation key was added) in this sample book, which was built on top of R Markdown and **knitr** (Xie, 2015) (this citation was added manually in an external file book.bib). Note that the `.bib` files need to be listed in the index.Rmd with the YAML `bibliography` key.

The `bs4_book` theme makes footnotes appear inline when you click on them. In this example book, we added `csl: chicago-fullnote-bibliography.csl` to the `index.Rmd` YAML, and include the `.csl` file. To download a new style, we recommend: https://www.zotero.org/styles/

The RStudio Visual Markdown Editor can also make it easier to insert citations: https://rstudio.github.io/visual-markdown-editing/#/citations

[1] This is a footnote.

Chapter 23

Blocks

23.1 Equations

Here is an equation.

$$f\left(k\right) = \binom{n}{k} p^k \left(1-p\right)^{n-k} \tag{23.1}$$

You may refer to using `\@ref(eq:binom)`, like see Equation (23.1).

23.2 Theorems and proofs

Labeled theorems can be referenced in text using `\@ref(thm:tri)`, for example, check out this smart theorem 23.1.

Theorem 23.1. *For a right triangle, if c denotes the* length *of the hypotenuse and a and b denote the lengths of the* ***other*** *two sides, we have*

$$a^2 + b^2 = c^2$$

Read more here https://bookdown.org/yihui/bookdown/markdown-extensions-by-bookdown.html.

23.3 Callout blocks

The `bs4_book` theme also includes special callout blocks, like this `.rmdnote`.

You can use **markdown** inside a block.

```
head(beaver1, n = 5)
#>   day time  temp activ
#> 1 346  840 36.33     0
#> 2 346  850 36.34     0
#> 3 346  900 36.35     0
#> 4 346  910 36.42     0
#> 5 346  920 36.55     0
```

It is up to the user to define the appearance of these blocks for LaTeX output.

You may also use: `.rmdcaution`, `.rmdimportant`, `.rmdtip`, or `.rmdwarning` as the block name.

The R Markdown Cookbook provides more help on how to use custom blocks to design your own callouts: https://bookdown.org/yihui/rmarkdown-cookbook/custom-blocks.html

Chapter 24

Sharing your book

24.1 Publishing

HTML books can be published online, see: https://bookdown.org/yihui/bookdown/publishing.html

24.2 404 pages

By default, users will be directed to a 404 page if they try to access a webpage that cannot be found. If you'd like to customize your 404 page instead of using the default, you may add either a `_404.Rmd` or `_404.md` file to your project root and use code and/or Markdown syntax.

24.3 Metadata for sharing

Bookdown HTML books will provide HTML metadata for social sharing on platforms like Twitter, Facebook, and LinkedIn, using information you provide in the `index.Rmd` YAML. To setup, set the `url` for your book and the path to your `cover-image` file. Your book's `title` and `description` are also used.

This `bs4_book` provides enhanced metadata for social sharing, so that each chapter shared will have a unique description, auto-generated based on the content.

Specify your book's source repository on GitHub as the `repo` in the `_output.yml` file, which allows users to view each chapter's source file or suggest an edit. Read more about the features of this output format here:

https://pkgs.rstudio.com/bookdown/reference/bs4_book.html

Or use:

```
?bookdown::bs4_book
```

Bibliography

Xie, Y. (2015). *Dynamic Documents with R and knitr*. Chapman and Hall/CRC, Boca Raton, Florida, 2nd edition. ISBN 978-1498716963.

Xie, Y. (2023). *bookdown: Authoring Books and Technical Documents with R Markdown*. R package version 0.32.