

Bachelor's / Master's Thesis

Thesis title

submitted by

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1. Advisor: Prof. A. First-Aid
2. Advisor: Prof. Z. Itwillbeallright

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Abstract

The abstract comes always first and should raise the readers interest in reading further.

The abstract summarizes, usually in one or two paragraph (here max. 1 page), the major aspects of the entire thesis in a prescribed sequence. This should include:

- the overall purpose of the study and the research problem(s) you investigated
- the basic design of the study
- the major findings or trends found as a result of your analysis
- a brief summary of your interpretations and conclusions.

Zusammenfassung

The thesis should always provide a German summary after the abstract, independent of the language of the main sections. Its content should not deviate from the abstract.

List of Abbreviations

You can provide a table of abbreviations in R Markdown syntax or \LaTeX syntax. But if you do the former, R will count this table and, consequently, the next actual table will start with the counter 2:

ATP	Adenosine Triphosphate
CoA	Coenzyme A
DNA	Deoxyribonucleic Acid
mtDNA	Mitochondrial DNA

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Settings in the YAML Header

This section provides an overview of the options and settings in the YAML (*YAML Ain't Markup Language*) header. You can delete this section later. The numbering of sections or chapters can be removed with a `{-}` after the heading (this is done here as well as in the abstract, summary, abbreviations, acknowledgements and declaration sections).

- This .Rmd file is the actual R Markdown file, which needs to be knitted to render the entire thesis. **It is important that you name this file ‘index.Rmd’, otherwise you’ll run into an error.** All other .Rmd file in this thesis folder (i.e. all the prelim and chapter files) **should not** be knitted!
- In the above YAML header (which none of the other .Rmd file have) all necessary settings are made including some dummy text for the title page, which you need to adjust to your thesis. Please note that if you run into knitting problems, spacing in the YAML header might be the cause.
- The list of references you cite in your thesis can either be copied into the ‘bib/references.bib’ file, which is provided above as default bibliography or you replace this file name with your own file(s). The reference style can defined by providing a .csl file. This template uses the **SAGE Harvard** reference style, provided by the ‘bib/sage-harvard.csl’ file. But you can replace this style file with any other .csl file. For more information see also [Citation and reference list].
- Hyperlinks: you can change the default colors for internal links (incl. ToC), external links, citation links, and linked URLs by adding the YAML fields `linkcolor`, `filecolor`, `citecolor`, or `urlcolor` and providing the name of a LaTeX color, e.g. `linkcolor: red`.
- The actual function to create this thesis is `UHHthesis::thesis_pdf_en`. It allows for a few more settings such as including or excluding a table of content (see also the function documentation). You can set them as follows:

```
output:
  UHHthesis::thesis_pdf_en:
    toc: true
    toc_depth: 5
    highlight: "default"
```

The default settings of `toc`, `toc_depth`, and `highlight` are shown here but don’t have to be set in the YAML header unless you want to change them. For further options that can be defined here see the documentation of the `bookdown::pdf_book` function, which is internally called.

The content of the section *Abstract*, *Zusammenfassung*, and *List of Abbreviations* has to be provided in individual .Rmd files located in the folder `prelim/`, i.e.

- 00-abstract.Rmd
- 00-zusammenfassung.Rmd
- 00-abbreviations.Rmd

All other chapters have their own .Rmd file within the `chapter/` folder:

- 01-intro.Rmd
- 02-methods.Rmd
- 03-results.Rmd
- 04-discussion.Rmd
- 96-references.Rmd
- 97-appendix.Rmd
- 98-acknowledge.Rmd
- 99-declaration.Rmd

The order of all sections and chapters is determined in the `_bookdown.yml` file. If you want to add more chapters, simply create a new .Rmd file in the `chapter/` folder following the same naming convention as the other files and add its file name to the `_bookdown.yml` file.

If you want to learn more on how to modify this template or about PDF books made with `bookdown` (which is the basis for this template) in general, I highly recommend the online book **bookdown: Authoring Books and Technical Documents with R Markdown!**

1 Introduction

The Bachelor and Master thesis can be written in German or English. The number of pages should correspond to the workload of the Bachelor (12LP) or Master (30LP) thesis (if necessary, consult your supervisor). The thesis is to be submitted in single copy (bound; no spiral binding) and as a PDF to the Academic Office via email or on a USB stick.

1.1 Thesis structure and format

The thesis should consist of the following sections, which have already been outlined in this template:

1. **Title page** [is created automatically via the YAML header]
2. **Table of Contents** [is created automatically here]
3. **Summary** in English (i.e., the **Abstract**) and German [see files in the `prelim/` folder].
4. **List of Abbreviations** (optional) [see file in `prelim/` folder]
5. **List of Tables** and **List of Figures** (optional) [will be created automatically if YAML header `lot: true` and `lof: true` stops]
6. **Introduction** [see file in the `chapter/` folder].
7. **Material and Methods** [see file in the `chapter/` folder]
8. **Results** [see file in the `chapter/` folder]
9. **Discussion** [see file in the `chapter/` folder]
10. **References** [this section is automatically filled with references from the two files ‘references.bib’ and ‘packages.bib’ in the `bib/` folder, which must be explicitly specified in the YAML header; the ‘references.bib’ file must be manually filled with the cited literature sources, the file ‘packages.bib’, which contains the software references, is automatically created by the code snippet ‘generate-package-refs’ in the ‘index.Rmd’ file.]
11. **Appendix** (optional) [see file in the `chapter/` folder]
12. **Acknowledgement** (optional) [see file in `chapter/` folder]
13. **Declaration of Authorship** (obligatory) - don’t forget the date and signature here [see file in `chapter/` folder]

The following format should be followed: Font size 12 Times New Roman, line spacing 1.5, page margins each 2.5cm, upper margin 2.5cm, lower margin 2.0cm. This is already defined in this template so you don’t have to bother with!

1.2 Content of the introduction

The introduction consists of the problem definition, its relevance as well as the objectives and structure of the work. The introduction should start more broadly and then move to the more specific topics of your study. The following questions should be answered in brief form:

- What is the general topic?
- What is the specific question of the work, what is the goal? Why is the question important?
- How was the question dealt with in the literature so far?
- Which hypothesis is tested in the present work?
- How is the following text structured? (chain of argumentation, subproblems)

1.3 Literature

The selection and use of relevant academic literature is an important part of any thesis and scientific publication.

1.3.1 Literature research

When searching for literature, it is recommended to start with the given introductory literature and the references cited therein. Many titles can be easily searched and found via **Web of Science** or **Google Scholar**. The number of citations can provide a useful indication of the relevance of a certain publication. Note, that the Web of Science database can only be accessed from the university or from home via a **VPN** client.

Important literature sources are

1. reference books, standards
2. scientific articles
3. conference proceedings
4. university theses
5. technical reports, grey literature
6. online material

Further important literature databases in biology are among others

- the **Electronic Journals Library of the University of Hamburg** (ECB)
- the **Digital Library** of the Departmental Library of the UHH Biology
- the **Virtual Library of Biology** (vifabio) of the **University Library Johann Christian Senckenberg**
- the catalogues and databases listed in vifabio: <http://www.vifabio.de/howto/info/icatalogs.html>
- **ScienceDirect**

1.3.2 Citation and bibliography

The following applies to all scientific work: Wherever possible, reference should be made to other relevant publications instead of reproducing their content. A references must be given for all statements and representations that originate from publications. Whenever content from

external sources is paraphrased or literally interpreted, the source must be indicated at the text passage. It is not sufficient to include the source in the bibliography. Literal interpretations are to be put in quotation marks.

The program BibTeX is used here to create the bibliography. The advantage of BibTeX or any other literature database is that all citations and source references in the entire document are automatically detected and assigned to the corresponding reference in the literature database. The ‘references.bib’ file referred to in the YAML header represents this literature database. The file is a so-called plain-text file, which contains bibliographic entries in the following form:

```
@article{May1976,  
  author = {May, R. M.},  
  title = {Simple mathematical models with very  
    complicated dynamics},  
  journal = {Nature},  
  volume = {261},  
  number = {5560},  
  pages = {459-467},  
  ISSN = {0028-0836},  
  DOI = {10.1038/261459a0},  
  url = {<Go to ISI>://WOS:A1976BT72500018},  
  year = {1976},  
  type = {Journal Article}  
}
```

A single entry always starts with @type{, where the type can be an article, book, manual, techreport, inproceedings, phdthesis or misc (for e.g. multimedia types, computer programs). More information about the possible types as well as the individual fields such as author, title, etc. can be found at <https://de.wikipedia.org/wiki/BibTeX>. After the type and the curly opening bracket comes the ‘citation key’. To cite one of these entries or references the @ character is followed by this key, e.g.

- @May1976 → becomes May (1976)
- [@May1976] → becomes (May, 1976)

Note, when placing the citation key inside of square brackets, the name of the author appears in the round brackets together with the year.

In the R Markdown file, for example, you would write “@May1976 could show that simple population models can trigger complex chaotic dynamics”, which is translated in the PDF/LaTeX document to “May (1976) could show ...”. All references automatically get a hyperlink to the bibliography. If this is not desired, add link-citation: false to the YAML header.

Multiple cited references are separated with a semicolon, e.g. (Kamm, 2000; May, 1976; Post and Forchhammer, 2002).

The formatting of the bibliography is variable. The BibTeX style set in the document determines which information is displayed in which format. The style is defined in the YAML header via the .csl file. CSL stands for *Citation Style Language* and is an open XML-based language to describe the formatting of citations and bibliographies. Instead of the current **SAGE Harvard** style any other style can be used by replacing the .csl file in the YAML header. There is a repository on GitHub that provides a variety of .csl files for the different styles: <https://github.com/citation-style-language/styles>.

To facilitate the organization, sharing, and citation of scientific articles and PDF documents in this thesis as well as future research projects, it is recommended to use a literature management program or reference manager such as **Mendeley** or **Zotero** from the beginning. These programs easily create the needed .bib file for this thesis or other publications.

There is also the package **citr** which I highly recommend: `citr` provides functions and an RStudio add-in to search a BibTeX-file to create and insert formatted Markdown citations into the current document. If you are using Zotero the add-in can access your reference database directly.

2 Material and Methods

The structure of this chapter depends very much on the type of research study, whether it is a field, laboratory or modelling study or a literature review. For field studies, the typical subsections are the

- study site
- experimental set-up
- sampling design
- statistical analysis with information on the used computer program ¹

2.1 Study site

If you want to add external images here, e.g. to show the sampling site as in Fig. 1, use the `knitr::include_graphics()` function. You should always provide a figure legend, which you can define in the code chunk option `fig.cap` inside the curly brackets at the very beginning. If you want the image to take less then 100% of the page with use the option `out.width` as demonstrated here:

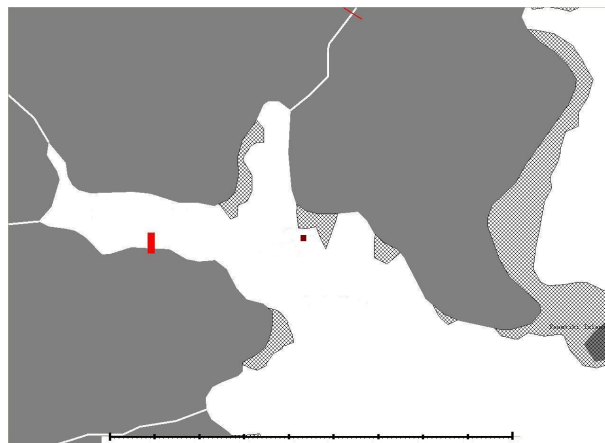


Figure 1: Location of sampling site....

2.2 Cross-references

External images and R figures can be referenced with `\@ref(fig:<label>)`, where `<label>` is the name of the code chunk (in the above example its *location*). These label names should **not contain underscores** to separate words, use hyphens here instead. Note that figures need to have a caption to be numbered and for cross-referencing, The caption is also set in the chunk option with `fig.cap='Your caption'`.

Cross-references to individual sections can simply be made by placing the name of the section into squared brackets, e.g. a link to the [Discussion](#) is made via `[Discussion]`.

¹ such as **R** - this is an example of a footnote

Tables require also a label and table caption for cross-referencing as figures. But here, the cross-reference contains a `tab: in \@ref(tab:<name>)` instead of a `fig:.` Also, captions of tables produced with R cannot be set in the chunk options as for figures but in the R functions directly (see examples in the [Results](#)).

This is for example a cross-reference to table 2 in the [Using the knitr and kableExtra packages](#) chapter.

Important note: Labels for tables produced with R Markdown syntax have to be set with \LaTeX notation, hence, the cross-reference has to be also in \LaTeX (see for an example [R Markdown table](#)).

2.3 Mathematical equations

Use mathematics in R Markdown as usual using the dollar sign $\$$ at the beginning and end of the equation; either in **inline mode** with one dollar sign $E = mc^2$ or in **display mode** with two $\$$ $\$$:

$$E = mc^2$$

Important to note: do not leave a space between the $\$$ and your mathematical notation.

Alternatively, you can use \LaTeX for more control and when equations are more complicated. \LaTeX equations are also automatically numbered if you define a label within the equation environment, which is useful if you have many equations and want to cross-reference them. The equation label needs to be written with `\#eq:label` before the end of the equation (see eq. (1)):

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

Formulas and corresponding explanations should be integrated into the sentence and, thus, end with a comma or period. Here comes an example:

If the random variable Y follows a standard normal distribution, i.e. $Y \sim N(0, 1)$, its density function can be described with

$$f_Y(y) = \varphi(y) \stackrel{\text{def}}{=} \frac{1}{\sqrt{2\pi}} \exp\left\{-\frac{y^2}{2}\right\}, y \in \mathbb{R}. \tag{2}$$

π represents the circle number or Ludolph's number. The function

$$F_Y(y) = \Phi(y) \stackrel{\text{def}}{=} \int_{-\infty}^y \varphi(x) dx, \quad y \in \mathbb{R} \tag{3}$$

represents then the distribution function of (2).

The numbering of equations, as in (2), should only be done if they are referred to in the rest of the text. Especially if there are many equations in the thesis, the use of \LaTeX seems to make more sense.

2.4 Chemical formulas and equations

2.4.1 Generals

For chemical formulas the use of \LaTeX is also highly recommended. To avoid the automatic italicized typesetting in \LaTeX use the argument `$\mathrm{formula here}$` , with your formula inside the curly brackets.

(Notice the use of the backticks here which enclose text that acts as code purely for demonstration purposes.)

- So, $\mathrm{Fe}_2^{2+}\mathrm{Cr}_2\mathrm{O}_4$ is written `$\mathrm{Fe}_2^{\{2+\}\mathrm{Cr}_2\mathrm{O}_4}$` .
- Exponent or superscript: O^-
- Subscript: CH_4
- To stack numbers or letters as in Fe_2^{2+} , the subscript is defined first, and then the superscript is defined.
- Bullet: $\mathrm{CuCl} \bullet 7\mathrm{H}_2\mathrm{O}$
- Delta: Δ
- Reaction arrows: \longrightarrow
- Resonance arrows: \longleftrightarrow
- Reversible reaction arrows: \rightleftharpoons

2.4.2 Typesetting reactions

For more complicated formulas, use similar to mathematical equations the ‘equation environment’ that starts with `$\begin{equation}$` and ends with `$\end{equation}$` . \LaTeX will place the formula where it fits best and will number it if you provide a label. Here an example:



We can reference this combustion of glucose reaction via equation (4).

Another example with the use of the dollar signs instead of \LaTeX ’ equation environment (numbering is not possible then): $\mathrm{NH}_4\mathrm{Cl}_{(s)} \rightleftharpoons \mathrm{NH}_{3(g)} + \mathrm{HCl}_{(g)}$ (inline mode)

Display mode:



2.5 Software

This section should always come at the end of the method chapter. You should list here the R version you used and each package with its version number, including the reference. The following text creates everything necessary automatically. You only need to update the packages used:

All analyses were performed using the statistical software R (version 4.2.1) ([R Core Team, 2022](#)). This thesis, including tables, was generated using the packages ‘bookdown’ (version 0.27) ([Xie, 2022a](#)), ‘rmarkdown’ (version 2.14) ([Allaire et al., 2022](#)), ‘knitr’ (version 1.39) ([Xie, 2022b](#)), ‘kableExtra’ (version 1.3.4) ([Zhu, 2021](#)), and ‘xtable’ (version 1.8.4) ([Dahl et al., 2019](#)).

3 Results

The result chapter is of great importance in an empirical study and should comprise a good mix of text, tables and figures. Use your research questions and hypothesis for structuring this chapter to provide the reader some structure and to not lose the thread.

Figures and tables should be continuously numbered and referred to in the main text. \LaTeX places figures and tables automatically where they fit best, which is sometimes on the next page. This is fine since they are cross-referenced anyway.

Tables have generally a caption at the top, while figures have a caption at the bottom. This has to be considered in some of the R functions (see below).

3.1 Tables

3.1.1 R Markdown table

Table 1 is a R Markdown table including a caption and label for cross-referencing. The caption is set with **Table:** ... and can come before or after the table. You do not need to set a number as \LaTeX will care of the numbering as well as the placing. Also note that the caption requires no quotation marks.

The label is set **right after** the table caption with `\label{tab:name}`. **Note here** that this is \LaTeX notation, where brackets are **curly**, not round! Also when cross-referencing R Markdown tables use the \LaTeX notation `\ref{tab:name}` (i.e., no @ and curly brackets).

Table 1: This is a table written in R Markdown.

A	New	Table
left-aligned	center-aligned	right-aligned
\$123	\$456	\$789
<i>italics</i>	normal	boldface

3.1.2 Tables generated with R

Creating tables with R and packages like ‘knitr’ and ‘kableExtra’ is much easier (and protects against typing errors!) than manually entering values into a table by copying and pasting them into Excel or LaTeX. This shows once again how beautiful reproducible documents can be!

3.1.2.1 Using the `knitr` and `kableExtra` packages

Table 2 is an example when using `knitr::kable` to generate the table and `kableExtra` to modify it. `knitr::kable()` has an explicit argument named `caption` where you can place your caption text.

Table 2: This is a table produced with knitr and modified with kableextra.

	Group 5				Group 6	
	Group 1		Group 2		Group 3	Group 4
	mpg	cyl	disp	hp	drat	wt
Mazda RX4	21.0	6	160	110	3.90	2.620
Mazda RX4 Wag	21.0	6	160	110	3.90	2.875
Datsun 710	22.8	4	108	93	3.85	2.320
Hornet 4 Drive	21.4	6	258	110	3.08	3.215
Hornet Sportabout	18.7	8	360	175	3.15	3.440

Note:

Your comments go here.

3.1.2.2 The `xtable` package

`xtable` has become increasingly popular but is not as easy to use as `knitr::kable`. For instance, when using the default settings the table caption is placed *below* the table (see Table 3). Also, the label for cross-referencing has to be set inside the `xtable::xtable` function instead of the code chunk. And if you don't write `results='asis'` inside the chunk options, you get the \LaTeX code for the table instead of the actual table in your PDF output file! The

	mpg	cyl	disp	hp	drat	wt
Mazda RX4	21.00	6	160.00	110	3.90	2.62
Mazda RX4 Wag	21.00	6	160.00	110	3.90	2.88
Datsun 710	22.80	4	108.00	93	3.85	2.32

Table 3: This is a table made with 'xtable'.

advantage of the `xtable` package for the advanced \LaTeX user is that \LaTeX code can directly be incorporated (see Table 4), and also the `xtable::print.xtable` function allows various additional settings.

Table 4: This is a table made with 'xtable' and modified with \LaTeX Code and the `print.xtable` function.

	mpg	cyl	disp	hp	drat	wt
<i>Mazda RX4</i>	21.00	6	160.00	110	3.90	2.62
<i>Mazda RX4 Wag</i>	21.00	6	160.00	110	3.90	2.88
<i>Datsun 710</i>	22.80	4	108.00	93	3.85	2.32

3.2 Figures

Figures can directly be produced with R and displayed here. Similar to external images, figure captions and labels are placed inside the chunk options for cross-referencing (see Figure 2).

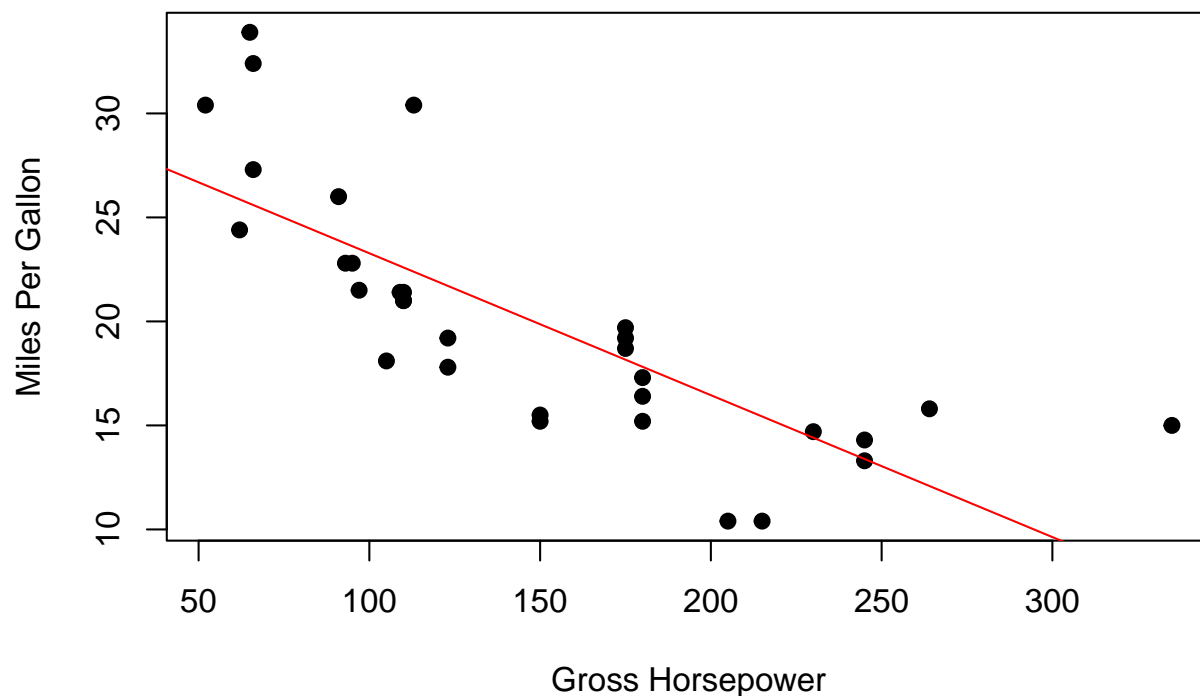


Figure 2: Relationship between horsepower and fuel economy.

Purely for demonstration purposes, figure 3 shows a boxplot with just half the width and centered:

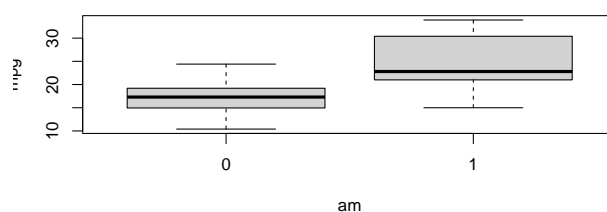


Figure 3: Fuel differences between transmission types (0 = automatic, 1 = manual).

4 Discussion

Providing strict guidelines and rules for a good discussion is difficult. But the following recommendations might be helpful:

- The discussion follows the opposite structure than the introduction and should move from the specific to the more general topics.
- Summary/recapitulation: You should start the discussion with a short summary of your main results and whether they support your hypothesis/hypotheses or not. Avoid here any statistical language as in the result section. You should again sketch out your line of argumentation in this section.
- Continue with the main messages of your empirical or theoretical study or your literature review: What are new insights from your results?
- Discussion of individual findings: expose results concisely and evaluate them critically.

Potential questions that could be addressed here:

- Are the findings convincing?
- In empirical studies: which conclusions about the problem studied can be drawn? What are the implications of your findings? Which theories and previous studies support your results, which are contradicting?
- In literature reviews: how many of the publications included in your analyses were high-quality and most recent? How many were outdated or had methodological flaws? Is there consensus across studies? Or are there group of studies that found different results?
- Which questions remain still unanswered? Which come out as important due to your findings?
- Point out the limitations of your study (assist reader in judging validity of findings). Are there any results that contradict your hypothesis and how can they be explained? Discuss to which extent your results can be generalized.

4.1 Conclusion

- Which *take home messages* do you like to give the reader? What is the relevance of your study for future research and potential applications? Suggest issues for future research.
- One *final sentence* to complete the thesis.

5 References

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- Xie Y (2022a) *Bookdown: Authoring Books and Technical Documents with r Markdown*. Available at: <https://CRAN.R-project.org/package=bookdown>.
- Xie Y (2022b) *Knitr: A General-Purpose Package for Dynamic Report Generation in r*. Available at: <https://yihui.org/knitr/>.
- Zhu H (2021) *kableExtra: Construct Complex Table with Kable and Pipe Syntax*. Available at: <https://CRAN.R-project.org/package=kableExtra>.

A Appendix

All relevant information has to be included in the main text. Irrelevant information as to be completely left out. Content that is related to the topic but not essential can be included in the appendix. Such could be the derivation of equations, additional information on statistical or laboratory analyses, source code of computer programs or any other comprehensive (data) material.

The appendix has to be similar to figures and tables cross-referenced and should **not** stand by itself. All figures and tables in the appendix should also have captions.

A.1 Figures

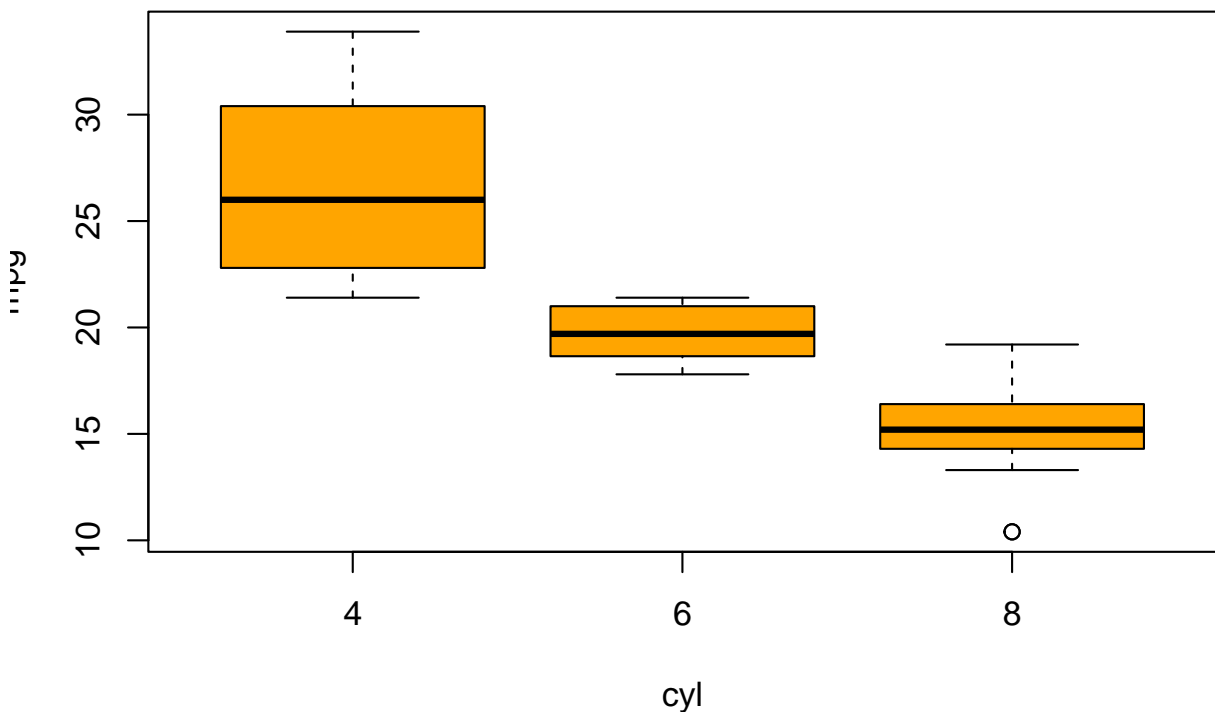


Figure 4: Fuel economy in cities, grouped by the number of cylinders.

A.2 Tables

Table 5: Descriptive statistics of

	3m	6m	1yr	2yr	3yr	5yr	7yr	10yr	12yr	15yr
Mean	3.138	3.191	3.307	3.544	3.756	4.093	4.354	4.621	4.741	4.878
Median	3.013	3.109	3.228	3.490	3.680	3.906	4.117	4.420	4.575	4.759
Min	1.984	1.950	1.956	2.010	2.240	2.615	2.850	3.120	3.250	3.395
Max	5.211	5.274	5.415	5.583	5.698	5.805	5.900	6.031	6.150	6.295
StD	0.915	0.919	0.935	0.910	0.876	0.825	0.803	0.776	0.768	0.762

Here is another variant of programming a table with \LaTeX syntax.

B Acknowledgements

I want to thank the following people ...

C Declaration of Authorship

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