



MONASH University

This is my thesis

Susan Su

B.Sc. (Hons), University of Tangambalanga

A thesis submitted for the degree of Doctor of Philosophy at Monash University
in 2023

Department of Econometrics & Business Statistics

Contents

Copyright notice	v
Abstract	vii
Declaration	ix
Standard thesis	ix
Thesis including published works declaration	x
Acknowledgements	xiii
1 Introduction	1
1.1 Quarto	1
1.2 Data	1
1.3 Figures	2
1.4 Results from analyses	3
1.5 Tables	4
2 Literature Review	5
2.1 Exponential smoothing	5
Bibliography	7
Appendices	9
A Additional stuff	9

Copyright notice

© Susan Su (2023).

Delete following statement if not relevant.

I certify that I have made all reasonable efforts to secure copyright permissions for third-party content included in this thesis and have not knowingly added copyright content to my work without the owner's permission.

Abstract

The abstract should outline the main approach and findings of the thesis and must not be more than 500 words.

Declaration

Use only one of the following declarations.

Standard thesis

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Student name:

Student signature:

Date:

Publications during enrolment

Remove this section if you do not have publications.

The material in Chapter 1 has been submitted to the journal *Journal of Impossible Results* for possible publication.

The contribution in Chapter 2 of this thesis was presented in the International Symposium on Nonsense held in Dublin, Ireland, in July 2022.

Reproducibility statement

This thesis is written using Quarto with renv (Ushey, 2022) to create a reproducible environment. All materials (including the data sets and source files) required to reproduce this document can be found at the Github repository github.com/SusanSu/thesis.

This work is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](#).

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes ?? original papers published in peer reviewed journals and ?? submitted publications. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Department of Econometrics & Business Statistics under the supervision of ??

(The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.)

In the case of (??insert chapter numbers) my contribution to the work involved the following:

Thesis chapter	Publication title	Status	Nature and % of student contribution	Nature and % of coauthors' contribution	Coauthors are Monash students
2	The life cycle of Mongolian crickets	Submitted	Concept and data analysis, writing first draft: 60%	Shu Xu, input into manuscript: 25%; Eddie Betts, input into manuscript: 15%	Shu Xu: No; Eddie Betts: Yes

I have / have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

Student name:

Student signature:

Date:

Declaration

I hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor name:

Main Supervisor signature:

Date:

Acknowledgements

I would like to thank my pet goldfish for ...

In accordance with Chapter 7.1.4 of the research degrees handbook, if you have engaged the services of a professional editor, you must provide their name and a brief description of the service rendered. If the professional editor's current or former area of academic specialisation is similar your own, this too should be stated as it may suggest to examiners that the editor's advice to the student has extended beyond guidance on English expression to affect the substance and structure of the thesis.

Free text section for you to record your acknowledgment and gratitude for the more general academic input and support such as financial support from grants and scholarships and the non-academic support you have received during the course of your enrolment. If you are a recipient of the "Australian Government Research Training Program Scholarship", you are required to include the following statement:

"This research was supported by an Australian Government Research Training Program (RTP) Scholarship."

You may also wish to acknowledge significant and substantial contribution made by others to the research, work and writing represented and/or reported in the thesis. These could include significant contributions to: the conception and design of the project; non-routine technical work; analysis and interpretation of research data; drafting significant parts of the work or critically revising it so as to contribute to the interpretation.

Chapter 1

Introduction

This is where you introduce the main ideas of your thesis, and an overview of the context and background.

In a PhD, Chapter 2 would normally contain a literature review. Typically, Chapters 3–5 would contain your own contributions. Think of each of these as potential papers to be submitted to journals. Finally, Chapter 6 provides some concluding remarks, discussion, ideas for future research, and so on. Appendixes can contain additional material that don't fit into any chapters, but that you want to put on record. For example, additional tables, output, etc.

1.1 Quarto

In this template, the rest of the chapter shows how to use quarto. The big advantage of using quarto is that it allows you to include your R or Python code directly into your thesis, to ensure there are no errors in copying and pasting, and that everything is reproducible. It also helps you stay better organized.

For details on using Quarto, see <http://quarto.org>.

1.2 Data

Included in this template is a file called `sales.csv`. This contains quarterly data on Sales and Advertising budget for a small company over the period 1981–2005. It also contains the GDP (gross domestic product) over the same period. All series have been adjusted for inflation. We can load in this data set using the following code:

```
sales <- readr::read_csv(here::here("data/sales.csv")) |>
  rename(Quarter = `...1`) |>
  mutate(
    Quarter = as.Date(paste0("01-", Quarter), "%d-%b-%y"),
    Quarter = yearquarter(Quarter)
  ) |>
  as_tsibble(index = Quarter)
```

Any data you use in your thesis can go into the data directory. The data should be in exactly the format you obtained it. Do no editing or manipulation of the data prior to including it in the data directory. Any data munging should be scripted and form part of your thesis files (possibly hidden in the output).

1.3 Figures

Figure 1.1 shows time plots of the data we just loaded. Notice how figure captions and references work. Chunk names can be used as figure labels with `fig-` prefixed. Never manually type figure numbers, as they can change when you add or delete figures. This way, the figure numbering is always correct.

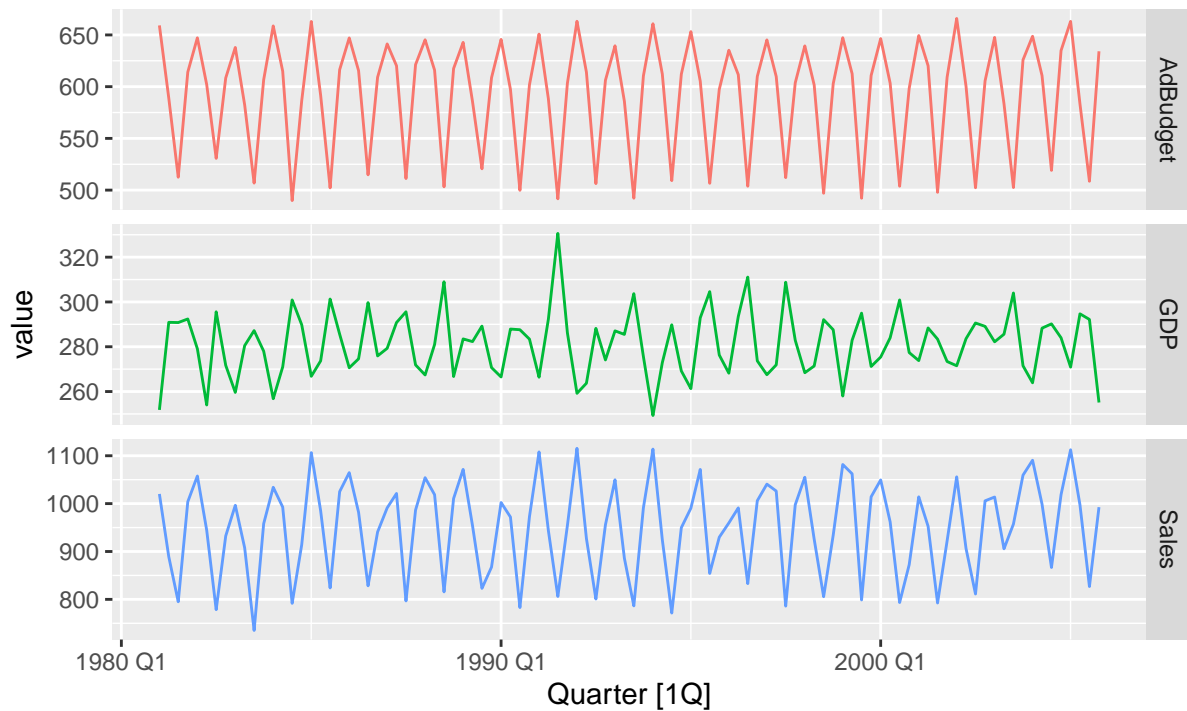


Figure 1.1: Quarterly sales, advertising and GDP data.

1.4 Results from analyses

We can fit a dynamic regression model to the sales data.

Series: Sales

Model: LM w/ ARIMA(1,0,0)(0,1,1)[4] errors

Coefficients:

	ar1	sma1	GDP	AdBudget
	0.2189	-0.9016	0.9742	2.2824
s.e.	0.1022	0.0715	0.4387	0.3930

sigma^2 estimated as 1677: log likelihood=-493.94

AIC=997.87 AICc=998.54 BIC=1010.69

If y_t denotes the sales in quarter t , x_t denotes the corresponding advertising budget and z_t denotes the GDP, then the resulting model is:

$$y_t - y_{t-4} = \beta(x_t - x_{t-4}) + \gamma(z_t - z_{t-4}) + \phi_1(y_{t-1} - y_{t-5}) + \Theta_1 \varepsilon_{t-4} + \varepsilon_t \quad (1.1)$$

where $\beta = 2.28$, $\gamma = 0.97$, $\phi_1 = 0.22$, and $\Theta_1 = -0.90$. We can reference this equation using Equation 1.1.

1.5 Tables

Let's assume future advertising spend and GDP are at the current levels. Then forecasts for the next year are given in Table 1.1.

Table 1.1: *Forecasts for the next year assuming Advertising budget and GDP are unchanged.*

Quarter	Sales forecast
2006 Q1	1000.2
2006 Q2	1013.1
2006 Q3	1076.7
2006 Q4	1003.5

Again, notice the use of labels and references to automatically generate table numbers.

Chapter 2

Literature Review

This chapter contains a summary of the context in which your research is set.

Imagine you are writing for your fellow PhD students. Topics that are well-known to them do not have to be included here. But things that they may not know about should be included.

Resist the temptation to discuss everything you've read in the last few years. And you are not writing a textbook either. This chapter is meant to provide the background necessary to understand the material in subsequent chapters. Stick to that.

You will need to organize the literature review around themes, and within each theme provide a story explaining the development of ideas to date. In each theme, you should get to the point where your ideas will fit in. But leave your ideas to later chapters. This way it is clear what has been done beforehand, and what new contributions you are making to the research field.

All citations should be done using markdown notation as shown below. This way, your bibliography will be compiled automatically and correctly.

2.1 Exponential smoothing

Exponential smoothing methods were originally developed in the late 1950s (Brown, 1959, 1963; Holt, 1957; Winters, 1960). Because of their computational simplicity and interpretability, they became widely used in practice.

Empirical studies by Makridakis & Hibon (1979) and Makridakis et al. (1982) found little difference in forecast accuracy between exponential smoothing and ARIMA models. This made the family of exponential smoothing procedures an attractive proposition (see Chatfield et al., 2001).

The methods were less popular in academic circles until Ord et al. (1997) introduced a state space formulation of some of the methods, which was extended in Hyndman et al. (2002) to cover the full range of exponential smoothing methods.

Bibliography

- Brown, R. G. (1959). *Statistical forecasting for inventory control*. McGraw-Hill, New York.
- Brown, R. G. (1963). *Smoothing, forecasting and prediction of discrete time series*. Englewood Cliffs, New Jersey: Prentice Hall.
- Chatfield, C., Koehler, A. B., Ord, J. K., & Snyder, R. D. (2001). A new look at models for exponential smoothing. *The Statistician*, 50(2), 147–159.
- Holt, C. E. (1957). *Forecasting trends and seasonals by exponentially weighted averages* (O.N.R. Memorandum No. 52/1957). Carnegie Institute of Technology.
- Hyndman, R. J., Koehler, A. B., Snyder, R. D., & Grose, S. (2002). A state space framework for automatic forecasting using exponential smoothing methods. *International Journal of Forecasting*, 18(3), 439–454.
- Makridakis, S., Anderson, A., Carbone, R., Fildes, R., Hibon, M., Newton, R. L. J., Parzen, E., & Winkler, R. (1982). The accuracy of extrapolation (time series) methods: Results of a forecasting competition. *Journal of Forecasting*, 1, 111–153.
- Makridakis, S., & Hibon, M. (1979). Accuracy of forecasting: An empirical investigation (with discussion). *Journal of Royal Statistical Society (A)*, 142, 97–145.
- Ord, J. K., Koehler, A. B., & Snyder, R. D. (1997). Estimation and prediction for a class of dynamic nonlinear statistical models. *Journal of American Statistical Association*, 92, 1621–1629.
- Ushey, K. (2022). *renv: Project environments*. <https://CRAN.R-project.org/package=renv> R package version 0.16.0
- Winters, P. R. (1960). Forecasting sales by exponentially weighted moving averages. *Management Science*, 6, 324–342.

Appendix A

Additional stuff

You might put some computer output here, or maybe additional tables. It is possible to have multiple appendices. Just list them in the appropriate place within `_quarto.yml`.