



**MONASH** University

# **This is my thesis**

Susan Su

B.Sc. (Hons), University of Tangambalanga

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Department of Econometrics & Business Statistics



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# **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.

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## 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](https://github.com/SusanSu/thesis).

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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

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## Declaration

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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.

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# Acknowledgements

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

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# 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)
```

New names:

Rows: 100 Columns: 4

-- Column specification

----- Delimiter: "," chr

(1): ...1 dbl (3): Sales, AdBudget, GDP

i Use 'spec()' to retrieve the full column specification for this data. i

Specify the column types or set 'show\_col\_types = FALSE' to quiet this message.

\* '' -> '...1'

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.



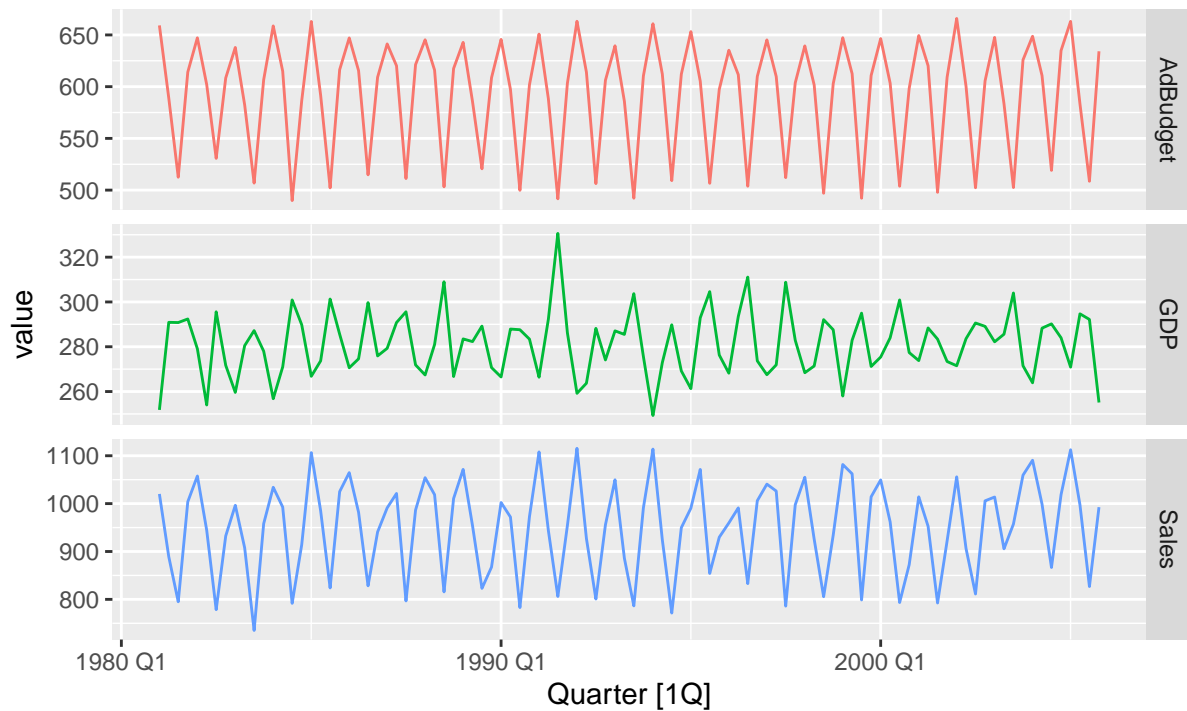


Figure 1.1: Quarterly sales, advertising and GDP data.

## 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.

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## **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`.