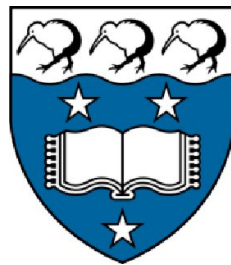


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# Time Series Visualisation for Auckland Air Quality



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# Contents

<b>Abstract</b>	<b>v</b>
<b>Acknowledgements</b>	<b>vii</b>
<b>Copyright notice</b>	<b>ix</b>
<b>Preface</b>	<b>xiii</b>
<b>1 Introduction (Template Demo)</b>	<b>1</b>
1.1 Rmarkdown . . . . .	1
1.2 Data . . . . .	2
1.3 Figures . . . . .	2
1.4 Results from analyses . . . . .	3
1.5 Tables . . . . .	3
<b>2 Literature Review (Draft)</b>	<b>5</b>
2.1 Exponential smoothing (Template Demo) . . . . .	5
<b>3 The Auckland Environmental Data</b>	<b>7</b>
3.1 Introduction . . . . .	7
3.2 Data Cleaning . . . . .	7
<b>A Additional stuff</b>	<b>9</b>
<b>Bibliography</b>	<b>11</b>



# Abstract

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



# Acknowledgements

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





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

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

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**Student signature:**

**Date:**

Thesis chapter	Publication title	Status (published, in press, accepted or returned for revision)	Nature and % of student contribution	Co-author name(s), nature and % of co-author's contribution	Co-author(s), Monash student Y/N
2	xx	xx	xx	xx	N
3	xx	xx	xx	xx	N
4	xx	xx	xx	xx	N
5	xx	xx	xx	xx	N



# Preface

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 2015.



# Chapter 1

## Introduction (Template Demo)

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 Rmarkdown

In this template, the rest of the chapter shows how to use Rmarkdown. The big advantage of using Rmarkdown is that it allows you to include your R 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 *R Markdown* see <http://rmarkdown.rstudio.com>.

## 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 command:

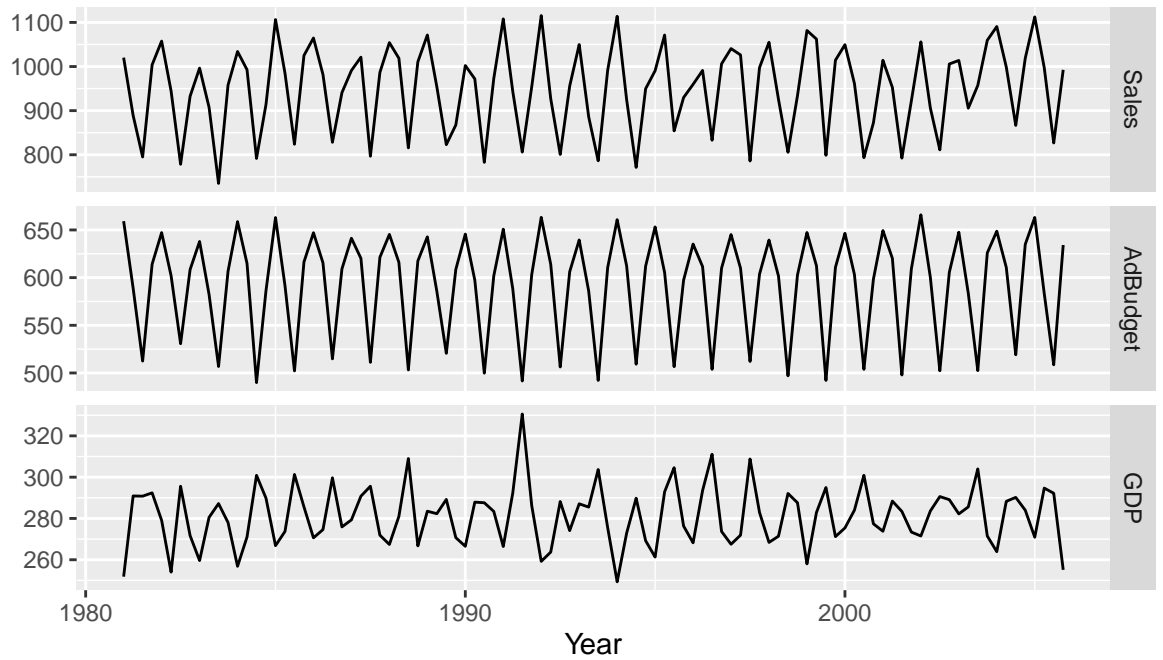
```
sales <- ts(read.csv("data/sales.csv"),[, -1], start = 1981, frequency = 4)
```

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 outside of R. Any data munging should be scripted in R 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.

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:

$$y_t - y_{t-4} = \beta(x_t - x_{t-4}) + \gamma(z_t - z_{t-4}) + \theta_1 \varepsilon_{t-1} + \Theta_1 \varepsilon_{t-4} + \varepsilon_t \quad (1.1)$$

where  $\beta = 2.28$ ,  $\gamma = 0.97$ ,  $\theta_1 = NA$ , and  $\Theta_1 = -0.90$ .

## 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.

Again, notice the use of labels and references to automatically generate Table numbers. In this case, we need to generate the label ourselves.

Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
1000.2	947.7	1052.7	919.9	1080.5
1013.1	959.3	1066.8	930.9	1095.3
1076.7	1022.9	1130.6	994.4	1159.0
1003.5	949.7	1057.4	921.2	1085.8

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

The `knitLatex` package is useful for generating tables from R output. Other packages can do similar things including the `kable` function in `knitr` which is somewhat simpler but you have less control over the result. If you use `knitLatex` to generate tables, don't forget to include `results="asis"` in the chunk settings.

## Chapter 2

# Literature Review (Draft)

### 2.1 Exponential smoothing (Template Demo)

Exponential smoothing was 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 and 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, Koehler, and Snyder ([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.



## Chapter 3

# The Auckland Environmental Data

### 3.1 Introduction

### 3.2 Data Cleaning

The final data set is composed of two separate data sets, each with a different data structure. Cleaning and manipulation are needed for ensuring the consistency of format for combination. The desired structure of the final data consists of observations, each uniquely identified by the date-time and location serving as the index and key, with records of all parameters.

The environmental parameter data set is in long format, with each observation consisting of a single record of one parameter. In total, there are 7,461,261 records from 10 locations with 14 parameters in the data set. Preliminary inspection finds that 4,654 records (0.06% of total) have a missing time-stamp and 60,312 records (0.81%) have missing value. Besides, 104,332 records are found to have a negative value. Nevertheless, all pollutants are reported in units in the form of mass per unit volume, and other parameters except for temperature are only sensible if positive. Thus, 104,257 records of insensible negative values are removed. Of the 7,292,038 time-and-numerically sensible records, 239,374 (3.28%) are duplicate with 120,207 redundant records. Further checking reveals that 230,822 of the duplicates have inconsistent values. However, as the scale of the inconsistency of most duplicate records

is small, the first-appearing records of duplicates are kept. The cleaned data set consists of 7,171,831 (96.12%) valid records with 719,640 records (10.03%) of implicit time gaps.

The parameter wind direction is from a differently structured data set, with each observation consisting of wind direction records of all locations uniquely identified by a date-time stamp. Of the seven locations of interest (locations also in the environmental data set), the data set includes 940,632 records with 207,436 (22.05%) missing values but no implicit time gaps. It is worth noting that 39,193 records (4.17%) have an inconsistent format for their time-stamp.

The final data set consists of 1,138,535 observations and 18 variables (date-time as the index, location as the key, 15 original parameters and one derived parameter) from Jun 1, 2003, to Apr 30, 2021. The time range is different for each location, with Customs St as short as since Jan 1, 2020. Due to structural change of data, 9,173,003 records (53.71%) have missing values.

## **Appendix A**

### **Additional stuff**

You might put some computer output here, or maybe additional tables.

Note that line 5 must appear before your first appendix. But other appendices can just start like any other chapter.





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