

How Rmarkdown changed my life

Rob J Hyndman
[@robjhyndman](https://twitter.com/robjhyndman)

Let's go back in time

Let's go back in time



Let's go back in time



Let's go back in time



Writing papers and reports

Wordstar 2000

DEMO.DOC Pg 1 Ln 1 Col 9 (0.80") Insert Horiz
POWER OF WordStar 2000 PLUS RELEASE 3 STUNS WORLD!

WordStar 2000 Plus Release 3 is

WORD PUBLISHING

Graphics and Text Integration
Unmatched Font Control
Page Preview
HPFont
True PostScript Support

WordStar 2000 plus release 3 is

→—S P E E D—→

WordStar 2000 Plus Release 3 is

WordPerfect

File Edit View Layout Tools Font Graphics Window Help

I actually liked WordPerfect 6.x, which had a nice graphical preview if you wanted. The white text on blue remained my favorite color combination, which Word for DOS also used.

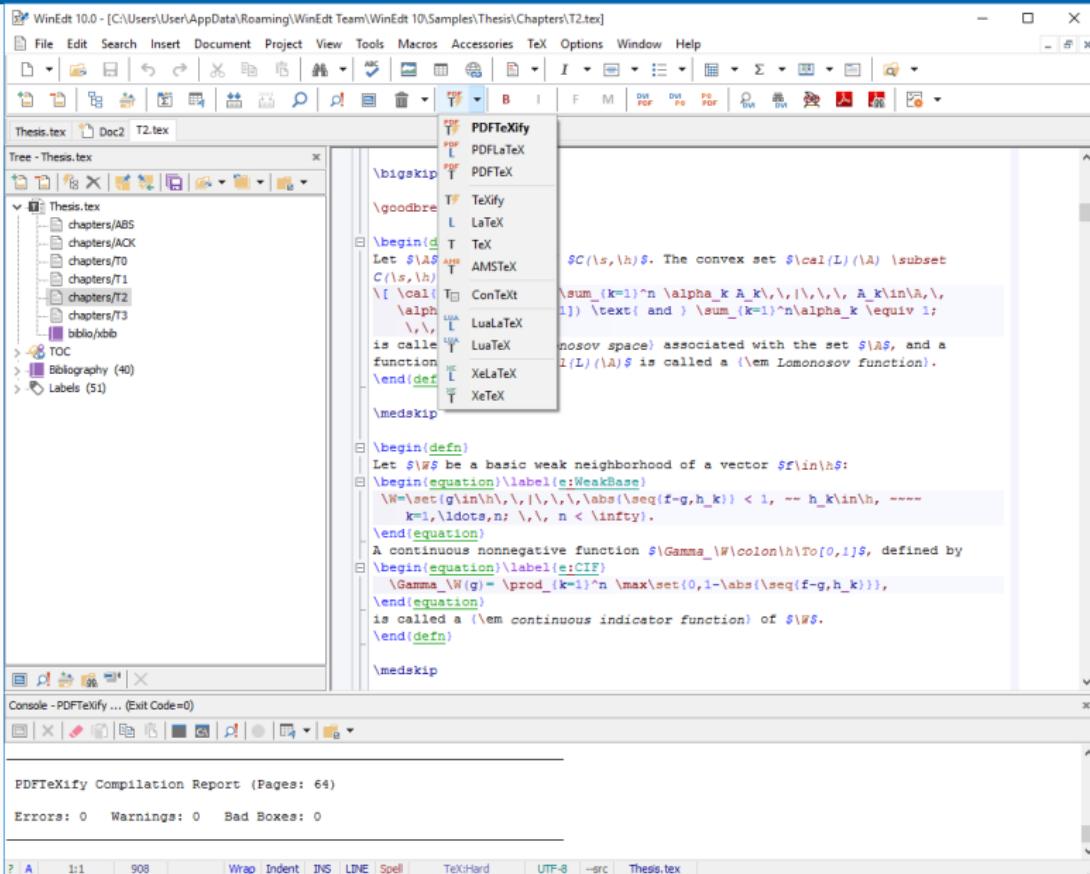
The familiar "Reveal Codes" command also continued to function and made the journey into WordPerfect for Windows. █

It is a shame WordPerfect has not evolved and was discontinued for the Apple Macintosh many years ago.

{ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ } ▲
[Bold On]The familiar "Reveal Codes" command also continued to function[SRT]
and made the journey into WordPerfect for Windows.[Bold Off][HRT]
[HRT]

It is a shame WordPerfect has not evolved and was discontinued[SRT]
Courier 12pt Bold Doc 1 Pg 1 Ln 1.83" Pos 6"

TeX/LaTeX



S

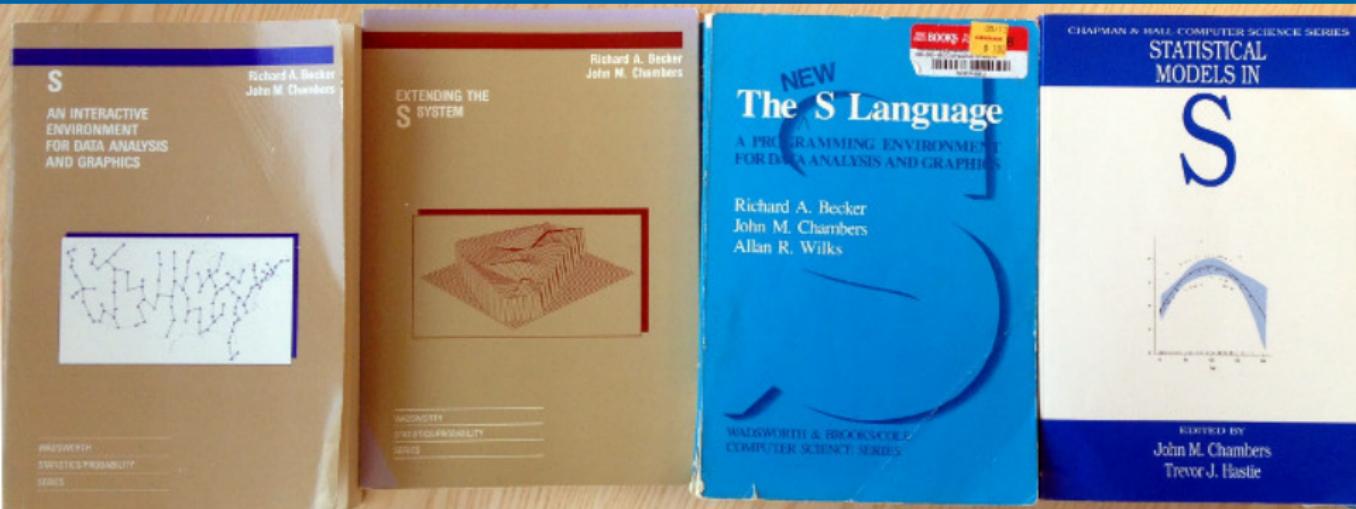


Photo credit: Rasmus Bååth

S-PLUS - OptionPricing.ssc - S-PLUS Workbench

File Edit Source Navigate Search Project Run Window Help

Navigator publish... run.Opt... simopti... pptscri... FameGAR... OptionPricing.ssc

```

1 OptionPricing <- function(sources.dir, results.dir, properties.list, par:
2
3   library(winjava)
4   source(paste(sources.dir, "simoptions.ssc", sep=""))
5
6   ## parameters
7   nsims<-1000 ## number of simulations
8
9   optiondays <- switch(as.character(parameter.list$Expiration),
10     "3 Months"=92, "1 Year"=250, "2 Years"=500) ## length of option
11
12   strike <- as.numeric(as.character(parameter.list$Strike))
13
14   vol<- 40 ## returns volatility, annualized (40 = 40%) [Should be ca.
15   startprice <- 100 ## option start price
16
17   method <- switch(as.character(parameter.list$Model),
18     "Gaussian"="gbm", "Mixture"="normmix") ## method to estimate opt:
19
20   ## read in data
21   print(properties.list)
22   filename=paste(properties.list@inputs.root,"/OptionPricing/SP500.xls")

```

Outline History View

OptionPricing/sources.dir, results

- nsims
- optiondays
- strike
- vol
- 40
- startprice
- method
- filename
- SP500
- equityname
- SP500.price
- SP500.r
- SP500.ts
- dev.off
- ops

Console View Objects View Search Path View Output View Tasks Problems

```

> objects()
[1] ".Last.value"      ".Random.seed"      "OptionPricing"    "a.name"
[5] "attribute.vec"    "barrabata"       "dat"             "dl.str"
[9] "dnormix"          "file.vec"        "g.mod"          "grp.co"
[13] "grp.na"           "intra"          "keep"           "last.dump"
[17] "local.dir"        "lookback.len"   "lstdy"          "monthlyData"
[21] "msfit.ret"        "mu"              "parameter.list" "parameter.vec"
[25] "path.gbm"         "path.normix"   "pdata"          "pdnormix"
[29] "pred"              "pred.len"        "price"          "properties.list"
[33] "q_99"              "results.dir"    "ret"            "rng"
[37] "sd"                "server.dir"    "sim.option"    "sianormix"
[41] "source.vec"        "sources.dir"   "stk"            "stockData"
[45] "sys"               "tody"           "var.95"         "varData"
[49] "weeklyData"        "xx"             "xmax"          "xmin"
[53] "xx"                "ymax"

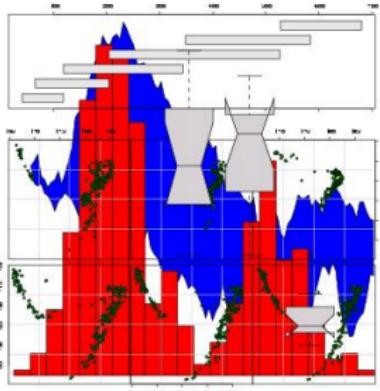
```

R (c.2000)



The R Project for Statistical Computing

(Web pages currently under construction!)



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R is 'GNU S' - A language and environment for statistical computing and graphics. R is similar to the award-winning S system, which was developed at Bell Laboratories by John Chambers et al. It provides a wide variety of statistical and graphical techniques (linear and nonlinear modelling, statistical tests, time series analysis, classification, clustering, ...).

R is designed as a true computer language with control-flow constructions for iteration and alternation, and it allows users to add additional functionality by defining new functions. For computationally intensive tasks, C, C++ and Fortran code can be linked and called at run time.

Makefiles

The screenshot shows a web browser window with the title 'Makefiles for R/TeX projects'. The address bar contains the URL 'robjhyndman.com/hyndsoft/makefiles/'. The page header includes the name 'Rob J Hyndman' and navigation links for 'Hyndsoft blog', 'Publications', 'Software', 'Seminars', 'Teaching', 'Research team', and 'About'. Below the header is a search bar and a set of small icons. The main content area features a large heading 'Makefiles for R/TeX projects'.

Makefiles for R/TeX projects

Hyndsoft

31 October 2012

computing, LaTeX, organization, productivity, R, reproducible research

Updated: 21 November 2012

`Make` is a marvellous tool used by programmers to build software, but it can be used for much more than that. I use `make` whenever I have a large project involving R files and LaTeX files, which means I use it for almost all of the papers I write, and almost of the consulting reports I produce.

If you are using a Mac or Linux, you will already have `make` installed. If you are using Windows and have Rtools installed, then you will also have `make`. Otherwise, Windows users will need to install it. One implementation is in GnuWin.

A typical project of mine will include several R files containing code that fit some models, and generate tables and graphs. I try to set things up so I can re-create all the results by simply running the R files. Then I will have a LaTeX file which contains the paper or report I am writing. The tables and graphs produced by R are pulled in to the LaTeX file. Consequently, all I need to do is run all the R files, and then process the tex file, and the paper/report

Makefiles

```
# Usually, only these lines need changing
TEXFILE= paper
RDIR= .
FIGDIR= ./figs

# list R files
RFILES := $(wildcard $(RDIR)/*.R)
# pdf figures created by R
PDFFIGS := $(wildcard $(FIGDIR)/*.pdf)
# Indicator files to show R file has run
OUT_FILES:= $(RFILES:.R=.Rout)
# Indicator files to show pdfcrop has run
CROP_FILES:= $(PDFFIGS:.pdf=.pdfcrop)

all: $(TEXFILE).pdf $(OUT_FILES) $(CROP_FILES)

# May need to add something here if some R files depend on others.

# RUN EVERY R FILE
$(RDIR)/%.Rout: $(RDIR)%.R $(RDIR)/functions.R
    R CMD BATCH $<

# CROP EVERY PDF FIG FILE
$(FIGDIR)%.pdfcrop: $(FIGDIR)%.pdf
    pdfcrop $< $< && touch $@

# Compile main tex file and show errors
$(TEXFILE).pdf: $(TEXFILE).tex $(OUT_FILES) $(CROP_FILES)
    latexmk -pdf -quiet $(TEXFILE)

# Run R files
R: $(OUT_FILES)

# View main tex file
view: $(TEXFILE).pdf
    evince $(TEXFILE).pdf &

# Clean up stray files
clean:
```

Makefiles

 **Yihui Xie** @xieyihui · Nov 21, 2012
@robjhyndman yihui.name/knitr/demo/chi... or another way of separating R from reports: yihui.name/knitr/demo/ext...

Q 1 ↗ ❤ 1 ⬆ ⬇

 **Rob J Hyndman**
@robjhyndman

Replies to [@xieyihui](#)

@xieyihui I know, but I reckon my way is simpler.
Does knitr have any real advantages over my approach with a Makefile?

3:47 PM · Nov 21, 2012 · Twitter Web Client

 View Tweet activity

1 Like

Q ↗ ❤ ⬆ ⬇

 **Yihui Xie** @xieyihui · Nov 22, 2012
Replies to [@robjhyndman](#)
@robjhyndman In fact I use Makefile frequently together with knitr. I'll elaborate later in a blog post.

Q ↗ ❤ ⬆ ⬇

Rmarkdown templates



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Department of Econometrics and Business Statistics

<http://business.monash.edu/econometrics-and-business-statistics/research/publications>

FFORMA: Feature-based Forecast Model Averaging

Pablo Montero-Manso, George Athanasopoulos,
Rob J Hyndman, Thiyanga S Talagala

January 2019

Working Paper 19/18

Rmarkdown templates



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January 2019

Working Paper 19/18



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**Exploratory data analysis
for Huawei**

Mr Mitchell O'Hara-Wild
BComm (Hons)

Mr Justin Carmody
BSc, MBusA

Professor Rob J Hyndman
BSc (Hons), PhD, AStat

Dr Souhaib Ben Taleb
BSc, MSc, PhD

Report for
Huawei

26 March 2018

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Econometrics &
Business Statistics

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Rmarkdown templates



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**Exploratory data analysis
for Huawei**

Mr Mitchell O'Hara-Wild
BComm (Hons)

Mr Justin Carmody
BSc, MBUSA

Templates



[robjhyndman/MonashEBSTemplates](#)

- `MonashEBSTemplates::workingpaper`
- `MonashEBSTemplates::report`

Rmarkdown templates

```
1 ---  
2 title: "A brief history of forecasting competitions"  
3 author:  
4 - familyname: Hyndman  
5   othernames: Rob J  
6   address: Department of Econometrics & Business Statistics\nnewline Monash University, Clayton  
    VIC 3800, Australia  
7   email: Rob.Hyndman@monash.edu  
8 abstract: "Forecasting competitions are now so widespread that it is often forgotten how  
controversial they were when first held, and how influential they have been over the years. I  
briefly review the history of forecasting competitions, and discuss what we have learned about  
their design and implementation, and what they can tell us about forecasting. I also provide a  
few suggestions for potential future competitions, and for research about forecasting based on  
competitions."  
9 keywords: "evaluation, forecasting accuracy, Kaggle, M competitions, neural networks, prediction  
intervals, probability scoring, time series"  
10 wppnumber: 03/19  
11 jelcodes: C22,C45,C52,C53  
12 blind: false  
13 cover: true  
14 toc: false  
15 bibliography: references.bib  
16 biblio-style: authoryear-comp  
17 output:  
18   MonashEBSTemplates::workingpaper:  
19     fig_caption: yes  
20     fig_height: 5  
21     fig_width: 8  
22     keep_tex: yes  
23     number_sections: yes  
24     citation_package: biblatex  
25     includes:  
26       in_header: preamble.tex  
27 ---  
28  
29 ```{r setup, include=FALSE}  
30 knitr::opts_chunk$set(echo = FALSE, cache=TRUE, messages=FALSE, warning=FALSE)  
31 library(tidyverse)  
32```
```

Rmarkdown templates

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6   address: Department of Econometrics & Business Statistics,  
7     VIC 3800, Australia  
8   email: Rob.Hyndman@monash.edu  
9 abstract: "Forecasting competitions are now so widespread and controversial they were when first held, and how interestingly they have changed over time. This paper briefly reviews the history of forecasting competitions, their design and implementation, and what they can tell us about the future. It also provides a few suggestions for potential future competitions, and concludes with some final thoughts."  
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A brief history of forecasting competitions

Rob J Hyndman

March 2019

Working Paper 03/19



Rmarkdown templates

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16 biblio-style: authoryear-comp  
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A brief history of forecasting competitions

Rob J Hyndman

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Monash University, Clayton VIC 3800, Australia
Email: Rob.Hyndman@monash.edu

6 March 2019

JEL classification: C22,C45,C52,C53

Rmarkdown templates

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```

A brief history of forecasting competitions

Abstract

Forecasting competitions are now so widespread that it is often forgotten how controversial they were when first held, and how influential they have been over the years. I briefly review the history of forecasting competitions, and discuss what we have learned about their design and implementation, and what they can tell us about forecasting. I also provide a few suggestions for potential future competitions, and for research about forecasting based on competitions.

Keywords: evaluation, forecasting accuracy, Kaggle, M competitions, neural networks, prediction intervals, probability scoring, time series

Prediction competitions go back millennia; for example, rival diviners in ancient Greece competed to predict the future more accurately (Raphael 2013, p124). However, for general time series forecasting (i.e., predicting the future of regularly observed data over time), the history is much more limited and goes back only about 50 years. In fact, it wasn't until computers were widely available that it became feasible for forecasting competitions to be held at all.

Time series forecasting competitions have been a feature of the *International Journal of Forecasting* and the *Journal of Forecasting* since the journals were founded in the early 1980s. This strong emphasis on large scale empirical evaluations of forecasting methods, and the need to compare newly proposed methods against existing state-of-the-art methods, has played a large part in pushing researchers to develop new methods that can be shown to work in practice (Fildes & Ord 2002).

Researchers new to forecasting are often surprised to learn how controversial such competitions were when they were first conducted about 50 years ago. I review this controversy in section 1. The influential series of Makridakis competitions are discussed in section 2, and other forecasting competitions are described in section 3. Finally, I provide a few comments on the future of forecasting competitions, and research about forecasting competitions, in section 4. I do not cover forecasting competitions that are not based around time series data.

1 Early controversy

The earliest forecasting competitions were between methods rather than people. It was not feasible, given the communication tools available at the time, to conduct a large-scale forecasting competition involving many entrants spread around the world. So the first few competitions were by individual researchers comparing the accuracy of several methods applied to multiple time series. I only include the first two of these. From 1980 onwards, my scope is restricted to competitions involving multiple entrants.

Nottingham studies

The earliest non-trivial study of time series forecast accuracy was probably by David Reid as part of his PhD at the University of Nottingham (Reid 1969). Building on his work, Paul Newbold and Clive Granger conducted a study of forecast accuracy involving 106 time series (Newbold &

Evolution of a website

Evolution of a website

Rob Hyndman's Home Page

Hi. I am a Senior Lecturer in [Statistics](#) in the [Department of Mathematics](#) at [Monash University](#).

Subjects I am lecturing in 1997

[MAT1060: Statistical methods](#)

[MAT2061: Methods of Statistics](#)

[MAS3421: Time Series](#)

[S4082: Forecasting](#)

[S4122: Computer Intensive Methods in Statistics](#)

Administrative responsibilities

- I am Director of the [Key Centre for Statistical Science](#)
- I am [Book Review](#) Editor for the *Australian Journal of Statistics*.

Research Interests

- Time series analysis: particularly non-Gaussian time series, non-linear time series and time series with explanatory variables.
- Density estimation and smoothing: particularly estimating and visualizing conditional density estimates.
- Statistical computing.

A list of my published and unpublished [research papers](#) is available (including postscript copies for most of them).

Web resources

- [Statistical resources on the WWW](#).
- My [Time Series Data Library](#)
- My collection of [Time Series and Forecasting resources on the WWW](#)
- My [LaTeX](#) page.

Evolution of a website

Rob J Hyndman's Home Page

- [Teaching](#)
- [Statistical research](#)
- [Administrative tasks](#)
- [S-plus functions for Time Series](#)

Series

- [Forecasting book](#)
- [Web resources](#)
- [Religious interests](#)
- [Family](#)
- [How to contact me](#)

Hi. I am a Senior Lecturer in [Statistics](#) in the [Department of Mathematics and Statistics](#) at [Monash University](#).

Contact me by e-mail at Rob.Hyndman@sci.monash.edu.au or as follows.

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Monash University
Clayton VIC 3168
Australia

Phone: (03) 9905 4450
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- [Time Series Data Library](#)
- [S-plus functions](#)

- [Religious interests](#)
- [Family](#)
- [Miscellaneous](#)
- [Curriculum Vitae](#)

Hi. I am [Director of Consulting](#) and Associate Professor in the [Department of Econometrics and Business Statistics](#) at [Monash University](#).
I can be contacted as follows:

Associate Professor Rob J Hyndman
Department of Econometrics & Business Statistics
Monash University, VIC 3800, Australia.

E-mail: Rob.Hyndman@buseco.monash.edu.au .
Phone: (03) 9905 2358
Fax: (03) 9905 5474

If you visit, you will find me in Room 671 in the Menzies Building, Clayton campus.



Evolution of a website

Hi. You have reached the personal home page of Rob J Hyndman.

I am Professor of Statistics in the [Department of Econometrics and Business Statistics](#) at [Monash University](#).



Contact details:

Professor Rob J Hyndman
Department of Econometrics & Business Statistics
Monash University, VIC 3800, Australia.

E-mail: Rob.Hyndman@buseco.monash.edu.au .

Phone: (03) 9905 2358

Fax: (03) 9905 5474

Office: Room 671, Menzies Building, Clayton campus.

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• [Links](#)

• [CV](#)

News articles on population forecasting and the elderly

- [Monash News \(May 2004\)](#)
- [Sunday Age \(16 May 2004\)](#)

Please note: This is a *personal* page; any material found here does not necessarily reflect the views of Monash University.

[Official disclaimer](#)

Evolution of a website



Rob J Hyndman

www.RobHyndman.info

- [Home page](#)
- [Publications](#)
- [Talks](#)
- [New exponential smoothing book](#)
- [Forecasting textbook](#)
- [International Journal of Forecasting](#)
- [Time Series Data Library](#)
- [R packages](#)
- [LaTeX](#)
- [Search for research](#)
- [Research team](#)
- [Dandenong Bible Education Centre](#)
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- [Links](#)
- [About me](#)

Publications



Talks



New exponential
smoothing book



Forecasting
textbook



International
Journal
of Forecasting



Time Series
Data Library



R packages



L^AT_EX

L^AT_EX

Search for research



Research team



Evolution of a website

The screenshot shows the homepage of www.RobHyndman.info. At the top, there is a portrait of Rob J Hyndman, a man with glasses and a beard, wearing an orange shirt. Below his name, the website URL is displayed. A navigation bar at the bottom includes links for Home, Publications, Research, Library, Bible, and About me, along with a Search button.

- Home
- Publications
- Research
- Library
- Bible
- About me

Website update

MONDAY, 13 AUGUST 2007

This website is undergoing its most major upgrade since its launch in 1993. There are two new blogs: one on [research issues](#) and one [answering Bible questions](#). There are also some new RSS feeds (look under Library/Useful news feeds). All of the old content is also here, but rearranged and repackaged. If you find anything that doesn't work properly, please [let me know](#).

LAST UPDATED (WEDNESDAY, 29 AUGUST 2007)

Time Series Data Library



Downtime

FRIDAY, 24 AUGUST 2007

This website will be down on Thursday 30 August from 5pm for up to four hours. This is to enable the server to be relocated. Sorry for any inconvenience!

LAST UPDATED (FRIDAY, 24 AUGUST 2007)

FORECASTING

METHODS AND APPLICATIONS

(SECOND EDITION)



Forecasting with exponential smoothing: the state space approach

SUNDAY, 12 AUGUST 2007



New research monograph to be published by Springer in 2008.

Evolution of a website



Rob J Hyndman

Home Publications Research Teaching Bible About me

Search

GO

Updated website

2009

In [News](#) [No Comments](#)

Jul This website has just undergone a major facelift. I've switched from Joomla to Wordpress, which will make it much simpler to maintain and develop. I hope you also find it easier to locate what you're looking for.

A few things have been removed including my link collections and feed collections. I decided these were not sufficiently useful and too difficult to maintain. The feeds are still available on the relevant webpages in any case. I will be adding some entries on the research tips blog about maintaining feed and link collections, so watch out for them.

Another area that has been removed is my collection of statistical quotations. This is now maintained by [Andrey Kostenko](#), and is available [here](#).

My Bible answers blog has moved to [BibleQ.info](#). Unfortunately, the extensive comments on some posts have been lost. Sorry about that.

Everything else should be here somewhere. Please [ask](#) if anything is broken, or if you can't find what you're after. Happy browsing!



MY OTHER WEBPAGES

- [International Journal of Forecasting](#)
- [Time series data library](#)
- [Forecasting textbook](#)
- [Exponential smoothing book](#)
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Rainbow plots, bagplots and boxplots for functional data

2009

In [Refereed papers](#)

Jul

Journal of Computational and Graphical Statistics (2010), to appear

ROB J HYNDMAN AND HAN LIN SHANG

Abstract: We propose new tools for visualizing large numbers of functional data in the form of smooth curves or surfaces. The proposed tools include functional versions of the bagplot and boxplot, and make use of the first two robust principal component scores, Tukey's data depth and highest density

Evolution of a website



Rob J Hyndman

Monash University, Australia

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Rob J Hyndman is Professor of Statistics in the [Department of Econometrics and Business Statistics](#) at Monash University, and Editor-in-Chief of the [International Journal of Forecasting](#).

He develops statistical models, algorithms and software for forecasting, analysing and visualizing data.

Rob has written more than 100 research papers and 5 books. He also maintains an active consulting practice, and has provided advice to hundreds of clients around the world.

He has won awards for his research, teaching, consulting and graduate supervision.



Recent activity

robjhyndman.com

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Rob J Hyndman Hyndsoft blog Publications Software Seminars Teaching Research team About

Forecasts are always wrong

18 October 2019

forecasting, podcast

Recently I was interviewed for the Monash Business School podcast “Thought Capital” on the topic of forecasting. You can listen to the episode [here](#) (or read the transcript).

Non-Gaussian forecasting using fable

17 October 2019

time series, graphics, statistics, R, tidyverts, forecasting

library(tidyverse) library(tsibble) library(lubridate) library(feasts) library(fable) In my previous post about the new fable package, we saw how fable can produce forecast distributions, not just point forecasts. All my examples used Gaussian (normal) distributions, so in this post I want to show how non-Gaussian forecasting can be done. As an example, we will use eating-out expenditure in my home state of Victoria. vic_cafe <- tsibbledata::aus_retail %>% filter(State == "Victoria", Industry == "Cafes, restaurants and catering services") %>% select(Month, Turnover) vic_cafe %>% autoplot(Turnover) + ggtitle("Monthly turnover of Victorian cafes") Forecasting with transformations Clearly the variance is increasing with the level of the series, so we will consider modelling a Box-Cox transformation of the data.

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Tidy forecasting in R

29 September 2019

time series, graphics, statistics, R, tidyverts, forecasting

The fable package for doing tidy forecasting in R is now on CRAN. Like tsibble and feasts, it is also part of the tidyverts family of packages for analysing, modelling and forecasting many related time series (stored as tsibbles). For a brief introduction to tsibbles, see this post from last month. Here we will forecast Australian tourism data by state/region and purpose. This data is stored in the tourism tsibble where Trips contains domestic visitor

Recent publications

- Earo Wang, Dianne Cook, Rob J Hyndman (2020) Calendar-based graphics for visualizing people's daily schedules. *J Computational & Graphical Statistics*, to appear. [ABSTRACT](#) [DOI](#) [PDF](#)
- George Athanasopoulos, Puwasala Gamakumara, Anastasios Panagiotelis, Rob J Hyndman and Mohamed Affan (2020) Hierarchical forecasting. *Macroeconomic forecasting in the era of big data*, ed. P. Fuleky, Springer, Chapter 21, pp.689–719. [ABSTRACT](#) [DOI](#) [PDF](#)
- Jeremy Forbes, Dianne Cook, Rob J Hyndman (2020) Spatial modelling of the two-party preferred vote in Australian federal elections: 2001–2016. *Australian and New Zealand Journal of Statistics*, to appear. [ABSTRACT](#) [DOI](#) [PDF](#)
- Earo Wang, Di Cook and Rob J Hyndman (2020) A new tidy data structure to support exploration and modeling of temporal data. *Journal of Computational & Graphical Statistics*, to appear. [ABSTRACT](#) [DOI](#) [PDF](#)
- Pablo Montero-Manso, George Athanasopoulos, Rob J Hyndman, Thiyanga S Talagala (2020) FFOMA: Feature-based Forecast Model Averaging. *International Journal of Forecasting*, 36(1), 86–92. [ABSTRACT](#) [DOI](#) [PDF](#)

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Tidy forecasting in R

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 [rbind/robjhyndman.com](https://github.com/robjhyndman)
(Adaptation of [hugo-finite](#) with inspiration from Kieran Healy)

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An online publishing venture

Online publishing

Forecasting: principles and practice

An online textbook by Rob J Hyndman and George Athanasopoulos



Preface Data Authors Using R Resources FAQ Search

Under construction.

Chapters 1–2, 4–8 are largely complete apart from exercises. We plan to finish the remaining chapters by the end of 2012. If you have any comments or suggestions on what is here so far, feel free to add them to the comments at the end of the [Preface](#).

Preface

Welcome to our new online textbook on forecasting. This book is intended as a replacement for [Makridakis, Wheelwright and Hyndman \(Wiley 1998\)](#).

The entire book is available online and free-of-charge. Of course, we won't make much money doing this, but textbooks never make much money anyway — the publishers make all the money. We'd rather create something that is widely used and useful, than have large publishers profit from our efforts.

Eventually a print version and a downloadable e-version of the book will be available to purchase on Amazon, but not until a few more chapters are written.

Contents

- [open all](#) | [close all](#)
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- [2 The forecaster's toolbox](#)
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- [11 Further forecasting methods](#)
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[Home](#) » Forecasting: principles and practice

Forecasting: principles and practice

Welcome to our online textbook on forecasting. This textbook is intended to provide a comprehensive introduction to forecasting methods and to present enough information about each method for readers to be able to use them sensibly. We don't attempt to give a thorough discussion of the theoretical details behind each method, although the references at the end of each chapter will fill in many of those details. The book is written for three audiences: (1) people finding themselves doing forecasting in business when they may not have had any formal training in the area; (2) undergraduate students studying business; (3) MBA students doing a forecasting elective. We use it ourselves for a second-year subject for students undertaking a Bachelor of Commerce degree at Monash University, Australia.

For most sections, we only assume that readers are familiar with algebra, and high school mathematics should be sufficient background. Readers who have completed an introductory course in statistics will probably want to skip some of [Chapters 2 and 4](#). There are a couple of sections which require knowledge of matrices, but these are flagged.

At the end of each chapter we provide a list of "further reading". In general, these lists comprise suggested textbooks that provide a more advanced or detailed treatment of the subject. Where there is no suitable textbook, we suggest

Book information



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Forecasting: Principles and Practice

Preface

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- 3 The forecaster's toolbox
 - 3.1 A tidy forecasting workflow
 - 3.2 Some simple forecasting methods
 - 3.3 Transformations and adjustments
 - 3.4 Fitted values and residuals
 - 3.5 Prediction intervals

The screenshot shows the 'Forecasting: Principles and Practice' textbook interface. The title page features the book's title 'Forecasting: Principles and Practice' in large, bold, dark blue font, followed by the authors 'Rob J Hyndman and George Athanasopoulos' and their affiliation 'Monash University, Australia'. Below the title page is the 'Preface' section, which includes a welcome message, a description of the book's purpose, and a summary of its content. To the right of the preface is a decorative graphic featuring a person looking at a chalkboard with a line graph.

Forecasting: Principles and Practice

Rob J Hyndman and George Athanasopoulos
Monash University, Australia

Preface

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Rob J Hyndman
George Athanasopoulos

FORECASTING PRINCIPLES AND PRACTICE

A comprehensive introduction to the latest forecasting methods using R. Learn to improve your forecast accuracy using dozens of real data examples.





We can imagine many possible futures, each yielding a different value for the thing we wish to forecast. Plotted in black in Figure 1.2 are the total international visitors to Australia from 1980 to 2015. Also shown are ten possible futures from 2016–2025.

Total International visitors to Australia

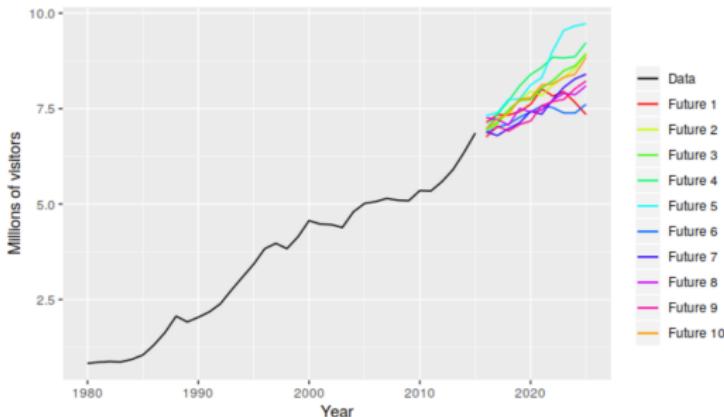


Figure 1.2: Total international visitors to Australia (1980–2015) along with ten possible futures.

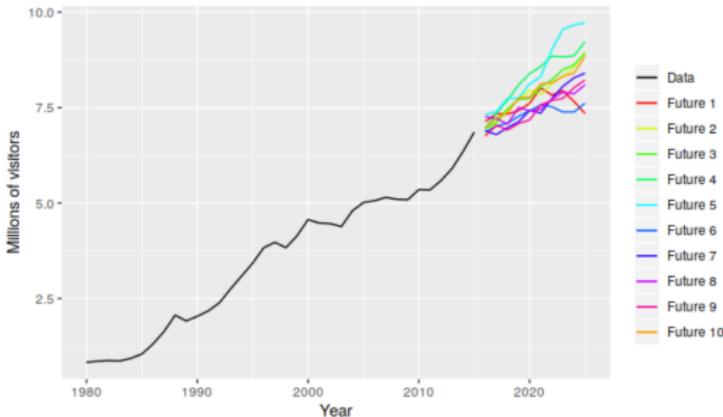
When we obtain a forecast, we are estimating the *middle* of the range of possible values the random variable could take. Often, a forecast is accompanied by a **prediction interval** giving a range of values the random variable could take with relatively high probability. For example, a 95% prediction interval contains a range of values which should include the actual future value with probability 95%.

Instead of plotting individual possible futures as shown in Figure 1.2, we usually show these



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Total International visitors to Australia



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OT

Forecasting: Principles and Practice

Preface

1 Getting started

1.1 What can be forecast?

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2.7 Lag plots

2.8 Autocorrelation

2.9 White noise

2.10 Exercises

3 The forecast package

3.1 Introduction

3.2 Data

3.3 Fitting models

3.4 Forecasting

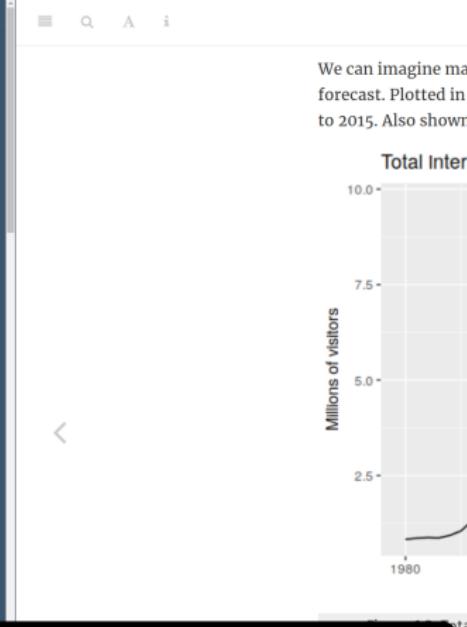
3.5 Evaluating forecasts

3.6 Exercises

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24 FORECASTING: PRINCIPLES AND PRACTICE

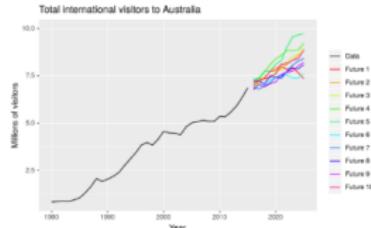


Figure 1.2: Total international visitors to Australia (1980–2015) along with ten possible futures.

interval contains a range of values which should include the actual future value with probability 95%.

Instead of plotting individual possible futures as shown in Figure 1.2, we usually show these prediction intervals instead. The plot below shows 80% and 95% intervals for the future Australian international visitors. The blue line is the average of the possible future values, which we call the **point forecasts**.

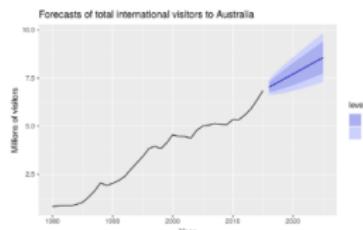


Figure 1.3: Total international visitors to Australia (1980–2015) along with 10-year forecasts and 80% and 95% prediction intervals.

We will use the subscript t for time. For example, y_t will denote the observation at time t . Suppose we denote all the information we have observed as \mathcal{I} and we want to forecast y_t . We then write $y_t|\mathcal{I}$ meaning “the random variable y_t given what we know in \mathcal{I} ”. The set of values that this random variable could

take individual possible futures as shown in Figure 1.2, we usually show these

Making slides

1.2 Portmanteau tests

Consider a *whole set* of r_k values, and develop a test to see whether the set is significantly different from a zero set.

Ljung-Box test:

$$Q^* = n(n + 2) \sum_{k=1}^h (n - k)^{-1} r_k^2$$

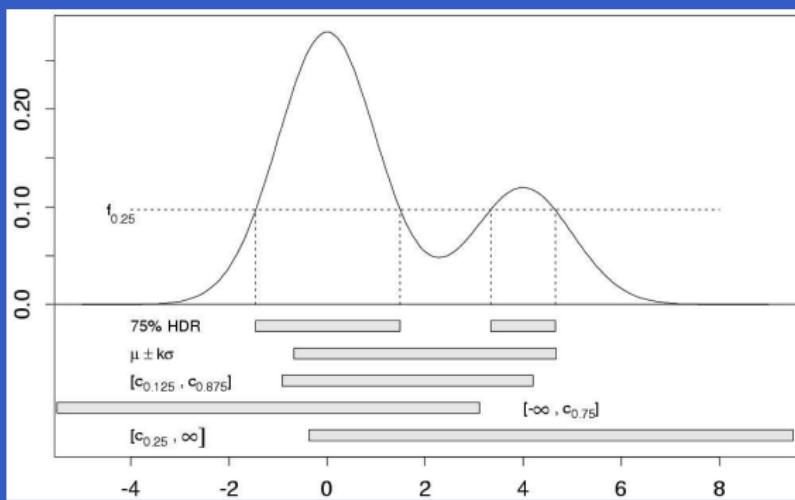
where h is the maximum lag being considered and n is the number of observations in the series.

- ◊ If each r_k close to zero, Q^* will be **relatively small**.
- ◊ If some r_k values large (positive or negative), Q^* will be **relatively large**.

:

Example: Density forecasting

Highest density regions



Forecasts

$$\mathbf{Y}_t = S\mathbf{Y}_{K,t}$$

Let $\hat{\mathbf{Y}}_n(h)$ be vector of independent (base) forecasts for horizon h , stacked in same order as \mathbf{Y}_t .

Write

$$\hat{\mathbf{Y}}_n(h) = S\beta_n(h) + \varepsilon_h$$

where

- $\beta_n(h) = E[\mathbf{Y}_{K,n+h} \mid \mathbf{Y}_1, \dots, \mathbf{Y}_n]$ is unknown mean of bottom level K
- ε_h has zero mean and covariance matrix Σ_h .

Idea: Estimate $\beta_n(h)$ using regression.

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Rob J Hyndman

30 January 2020

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Curriculum vitae

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Curriculum Vitae
December 2019

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Employment history

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Honours and awards

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2007 Moran Medal for Statistical Science, Australian Academy of Science
2006 Belz Lecturer, Statistical Society of Australia (Victorian branch)
1998 Award for excellence in teaching, Monash Science Society
1990 Finalist, Channel Ten Young Achiever Awards
1988 Dwights Prize in Statistics, University of Melbourne
1987 Norma McArthur Prize in Statistics, University of Melbourne
1986 Second Maurice H. Belz Prize in Statistics, University of Melbourne

Current memberships

- Elected Member, International Statistical Institute
- Member, International Institute of Forecasters
- Member, International Association for Statistical Computing
- Member, Statistical Society of Australia
- Member, International Society for Business and Industrial Statistics

Research

- Since 1991 I have authored 200 papers, chapters or books on statistical topics (listed on pages 4–12).
- My current research involves the analysis of large collections of time series, and includes visualization, forecasting, model selection, machine learning and causal inference.
- I currently supervise four PhD students and two post-doctoral research fellows. I have previously supervised another 25 PhD students and 3 Masters students.
- I publish the Hyndman blog on research issues which receives an average of about 2000 pageviews per day.
- I have produced 41 R packages as a result of my research (listed on pages 21–23).

Curriculum vitae

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Curriculum Vitae
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2 name: Rob J Hyndman  
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6 phone: +61 3 9905 5141  
7 email: "Rob.Hyndman@monash.edu"  
8 twitter: robjhyndman  
9 github: robjhyndman  
10 date: `r format(Sys.time(), '%B %Y')`"  
11 headcolor: "#000088"  
12 output:  
13   vitae::hyndman:  
14     keep_tex: yes  
15 ---
```

Template

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1987 Norma McArthur Prize in Statistics, University of Melbourne
1986 Second Maurice H. Belz Prize in Statistics, University of Melbourne

Current memberships

- Elected Member, International Statistical Institute
- Member, International Institute of Forecasters
- Member, International Association for Statistical Computing
- Member, Statistical Society of Australia
- Member, International Society for Business and Industrial Statistics

Research

- Since 1991 I have authored 200 papers, chapters or books on statistical topics (listed on pages 6–13).
- My current research involves the analysis of large collections of time series, and includes visualization, forecasting, reconciliation, modelling and anomaly detection.

Template

vitae::awesomecv



Curriculum vitae

Rob J Hyndman

Education and qualifications

1988B.Sc.(Hons)University of Melbourne
1992Ph.D. University of Melbourne
2000A.Stat. Statistical Society of Australia

Employment history

2019– Head, Department of Econometrics & Business Statistics, Monash University
2003– Professor, Department of Econometrics & Business Statistics, Monash University
2001–2003Associate Professor, Department of Econometrics & Business Statistics, Monash University
1998–2000Senior Lecturer, Department of Econometrics & Business Statistics, Monash University
1997–1998Senior Lecturer, Department of Mathematics and Statistics, Monash University
1995–1996Lecturer, Department of Mathematics and Statistics, Monash University
1993–1994Lecturer, Department of Statistics, University of Melbourne
1985–1992Statistical consultant, Department of Statistics, University of Melbourne

Other positions

2011– Editor, *Journal of Statistical Software*
2001– Associate Editor, *International Journal of Forecasting*
2005–2018Editor-in-Chief, *International Journal of Forecasting*
2005–2018Director, International Institute of Forecasters
2001–2004Theory and Methods Editor, *Australian & New Zealand Journal of Statistics*

Honours and awards

2016KNAW Visiting Professor, TU/Eindhoven, Netherlands
2010Dean's Award for excellence in innovation and external collaboration, Monash University
2008Dean's award for excellence in research, Monash University
2008Vice-Chancellor's award for postgraduate supervisor of the year, Monash University
2007Kuibis Lecturer, Statistical Society of Australia (ACT branch)
2007Moran Medal for Statistical Science, Australian Academy of Science
2006Belz Lecture, Statistical Society of Australia (Victorian branch)
1998Award for excellence in teaching, Monash Science Society
1990Finalist, Channel Ten Young Achiever Awards
1988Dwights Prize in Statistics, University of Melbourne
1987Norma McArthur Prize in Statistics, University of Melbourne
1986Second Maurice H. Belz Prize in Statistics, University of Melbourne

Current memberships

• Elected Member, International Statistical Institute

Template

vitae::latexecv



Curriculum vitae

ROB J HYNDMAN | RESUME

Department of Econometrics & Business Statistics, Monash University, VIC 3800, Australia
rob@hyndman.com

+61 3 9905 5541
03 1373 6666 (fax)

Education and qualifications

- 1988 B.Sc.(Hons) University of Melbourne
- 1992 Ph.D. University of Melbourne
- 2000 A.Stat. Statistical Society of Australia

Employment history

- 2019- Head, Department of Econometrics & Business Statistics, Monash University
- 2003- Professor, Department of Econometrics & Business Statistics, Monash University
- 2001-2003 Associate Professor, Department of Econometrics & Business Statistics, Monash University
- 1998-2000 Senior Lecturer, Department of Econometrics & Business Statistics, Monash University
- 1997-1998 Senior Lecturer, Department of Mathematics and Statistics, Monash University
- 1995-1996 Lecturer, Department of Mathematics and Statistics, Monash University
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Research

- Since 1991 I have authored 200 papers, chapters or books on statistical topics (listed on pages -).
- My current research involves the analysis of large collections of time series, and includes visualization, forecasting, reconciliation, modelling and anomaly detection.
- I currently supervise four PhD students and two post-doctoral research fellows. I have previously supervised another 25 PhD students and 3 Masters students.
- I publish the [Hyndman](#) blog on research issues which receives an average of about 2000 pageviews per day.
- I have produced 45 R packages as a result of my research (listed on pages -).

Grants

Template

vitae::moderncv



Theses

Theses

Anomaly Detection in Streaming Time Series Data

A thesis submitted for the degree of

Doctor of Philosophy

by

Priyanga Dilini Talagala

Supervised by

Professor Rob J. Hyndman

Professor Kate Smith-Miles



Department of Econometrics and Business Statistics

Monash University

Australia

July 2019

Theses

Anomaly Detection in Streaming Time Series Data

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Department of Econometrics and Business Statistics

Monash University

Australia

July 2019

Template

 robjhyndman/MonashThesis

Memos

Memos



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Tutors and tutorials

Rob J Hyndman

11 June 2019

Tutors are there to help in delivering a unit by running small group classes and with marking. Having a second person explaining things, in a different style in smaller groups, can be very helpful to students. Tutors are not meant to be delivering mini-lectures but instead should have content and exercises prepared for the tutorial that supports the lectures. They are there to answer student questions, explain any areas that have not been well understood, go over exercises, help with computer issues, etc.

Tutors will normally be provided for units with more than 25 enrolled students, with approximately one tutorial allocated for every 25 students (unless room constraints require a lower number). An exception is for honours units which do not have allocated tutorials, but have an additional lecture scheduled instead.

Guidelines to the appropriate use of tutors

- All activities undertaken by the tutors are to be prepared by the lecturer involved. This includes what happens in tutorials as well as all assessment tasks.
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- For each assessment task, lecturers are expected to provide tutors with a complete solution in addition to a marking scheme along with an estimate of the expected marking/assessment time.
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Head tutors

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 - managing student queries where appropriate;
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- The assigned work must fit within the hours allocated to the head tutor.

PhD students

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An Exponential Smoothing Model with a Life Cycle Trend

OPRE-2019-06-267

13 August 2019

This paper introduces a new model for life cycle trends which has some advantages over existing models. In particular, it is an extension of existing exponential smoothing models, it allows for full probabilistic forecasting, and it appears to be relatively accurate compared to the main competitor models.

A few minor comments follow.

1. p3, l11. The M4 competition required participants to make prediction intervals at a single forecast horizon, not rolling quantile forecasts. Also, the data were not all macroeconomic.
2. p4-51. I had to read these pages a couple of times realising that you were not saying the data follow a tilted-Gompertz distribution, but that the trend had a shape described by the tilted-Gompertz density function. This could be made clearer.
3. p6, eq (1). This model is numerically unstable due to the division by ε_{t-1} . See Ch 15 of Hyndman et al. (2008).
4. p7. There doesn't seem much benefit using the notation $1 + \varepsilon_t$ in [2] when you never use the ε_t s directly. Why not replace $[1 + \varepsilon_t]$ with ε_t^{γ} where ε_t is normally distributed.
5. p7. It is perhaps worth pointing out that setting $\gamma = 1$ leads to something similar to an ETS(M,M,M) model – the only difference being the log normal distribution rather than a normal distribution on the errors.
6. Section 2.3. The connection between the forecast function (7) and the tilted-Gompertz diffusion model is worth noting in passing, but it seems to get far more attention than it deserves. It is not clear to me how this connection leads to any insights or results that help in forecasting of life-cycle trends. If space is an issue, this is a section that could be reduced without losing the main value of the paper.
7. p19. It is a little odd to evaluate the median as a point forecast using RMSE or MAPE, neither of which lead to the median as the optimal point forecast. Since you are using pinball loss, why not average the pinball loss over a fine grid of quantiles to get something equivalent to CRPS?
8. p21. Surely the prior distributions for α and β^* are not identical for all 170 series? How do the authors explain this?
9. p23. In the simulation study, did you generate data for the full life-cycle, or a partial life-cycle? Only the latter gives useful results here as there is no need to forecast full life-cycles. Assuming you simulated partial life-cycles, how was the time of the last observation determined?
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References

- Hyndman, RJ, AB Koehler, JK Ord & RD Snyder (2008). *Forecasting with exponential smoothing: the state space approach*. Berlin: Springer-Verlag.

Memos



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Rob J Hyndman

11 June 2019

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```
1 ---  
2 title: Tutors and tutorials  
3 author: Rob J Hyndman  
4 branding: true  
5 output: MonashEBSTemplates::memo  
6 ---
```

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The final decisions on who tutu
(Clayton) and Charanjit Kaur

Template



robjhyndman/MonashEBSTemplates

■ MonashEBSTemplates::memo

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References

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Letters

Letters



Rob J Hyndman
BSc(Hons), PhD, AStat
Professor of Statistics and Head
Department of Econometrics & Business Statistics
 robjhyndman.com
 robj.hyndman@monash.edu
 +61 3 9905 5141

30 November 2019

Dr Caitriona Ryan
Senior Post-Doctoral Researcher
I-Form Advanced Manufacturing Research Centre
Maynooth University Hamilton Institute
Maynooth University, Maynooth, Co. Kildare, Ireland.

Dear Triona

I am writing to invite you to visit Monash University in 2020 to work on new statistical methods in advanced manufacturing with me and others in my research group. I understand you plan to visit Queensland University of Technology in Brisbane. We would be happy to cover the domestic flights between Brisbane and Melbourne, and accommodation in Melbourne for up to 5 nights.

As you know, I have been working on algorithms for anomaly detection in large collections of time series data. I hope we can join forces and work on some new algorithms designed for the type of data you analyse with the I-Form group.

If the timing suited, it would also be good to have you speak in our departmental seminar series in a topic of your choice.

Best wishes

A handwritten signature in black ink, appearing to read "Rob J Hyndman".

Letters



Rob J Hyndman
BSc(Hons), PhD, AStat
Professor of Statistics and Head
Department of Econometrics & Business Statistics
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Template

robjhyndman/MonashEBSTemplates
MonashEBSTemplates::letter

Letters



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Rob J Hyndman
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```
1 |--  
2 from: Rob J Hyndman  
3 fromqualifications: BSc(Hons), PhD, AStat  
4 fromtitle: Professor of Statistics and Head\nnewline Department of Econometrics \& Business  
Statistics  
5 fromWWW: robjhyndman.com  
6 fromemail: Rob.Hyndman@monash.edu  
7 fromphone: +61 3 9905 5141  
8 fromsignature: Sig  
9 toname: Dr Caitriona Ryan  
10 toaddress: Senior Post-Doctoral Researcher\nnewline I-Form Advanced Manufacturing Research  
Centre\nnewline Maynooth University Hamilton Institute\nnewline Maynooth University, Maynooth,  
Co. Kildare, Ireland.  
11 opening: Dear Triona  
12 closing: Best wishes  
13 spacing: 1.4  
14 output:  
15   MonashEBSTemplates::letter  
16 header-includes:  
17   - \usepackage[lf,t]{carlito}  
18 --
```

Template

robjhyndman/MonashEBSTemplates
MonashEBSTemplates::letter

Exams

Exams



MONASH University

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Semester One 2019
Examination Period

Faculty of Business & Economics

EXAM CODES: ETC3550

TITLE OF PAPER: Applied Forecasting for Business and Economics

EXAM DURATION: 2 hours writing time

READING TIME: 10 minutes

THIS PAPER IS FOR STUDENTS STUDYING AT: (tick where applicable)

- Caulfield Clayton Parkville Peninsula
 Monash Extension Off Campus Learning Malaysia South Africa
 Other (specify) _____

During an exam, you must not have in your possession any item/material that has not been authorised for your exam. This includes books, notes, paper, electronic device/s, mobile phone, smart watch/device, calculator, pencil case, or writing on any part of your body. Any authorised items are listed below. Items/materials on your desk, chair, in your clothing or otherwise on your person will be deemed to be in your possession.

No examination materials are to be removed from the room. This includes retaining, copying, memorising or noting down content for personal use or to share with any other person by any means following your exam.

Failure to comply with the above instructions, or attempting to cheat or cheating in an exam is a discipline offence under Part 7 of the Monash University [Council] Regulations, or a breach of instructions under Part 3 of the Monash University [Academic Board] Regulations.

AUTHORISED MATERIALS

OPEN BOOK

YES NO

CALCULATORS

Only HP 300+ or Casio FX82 (any suffix) calculator permitted

YES NO

SPECIFICALLY PERMITTED ITEMS

If yes, items permitted are:

YES NO

Candidates must complete this section if required to write answers within this paper

STUDENT ID: _____

DESK NUMBER: _____

Exams



MONASH University

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Semester One 2019 Examination Period

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OPEN BOOK YES NO

CALCULATORS

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SPECIFICALLY PERMITTED ITEMS

If yes, items permitted are: YES NO

Candidates must complete this section if required to write answers within this paper

STUDENT ID: _____

DESK NUMBER: _____

(b) Using the code below, describe what is plotted in Figure 4. Comment on the selection of window.

daycare <- STL(log(Count) ~ season(window = 21)) <- autoplot() +
ggtitle("Number of employees in child day care services in New York City")

Number of employees in child day care services in New York City
'log(Count)' ~ trend + season_year + remainder

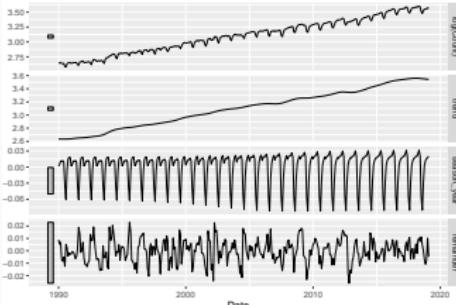


Figure 4:

(c) You are asked to provide forecasts for the next two years for the daycare series shown in Figure 1. Consider applying each of the methods and models below. Comment, in a few words each, on whether each one is appropriate for forecasting the data. No marks will be given for simply guessing whether a method or a model is appropriate without justifying your choice.

- A. Seasonal naive method.
- B. Drift method plus seasonal dummies.
- C. Holt-Winters additive damped trend method.
- D. Holt-Winters multiplicative damped trend method.
- E. ETS(A,M,M).
- F. ARIMA(1,1,4).
- G. ARIMA(3,1,2)(1,1,0)12.
- I. ARIMA(0,1,1)(2,0,0)12.
- J. Regression model with time and Fourier terms.

10 marks

Total: 20 marks

— END OF QUESTION 2 —

Exams

Template



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AUTHORISED MATERIALS

OPEN BOOK

YES NO

CALCULATORS

YES NO

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SPECIFICALLY PERMITTED ITEMS

YES NO

If yes, items permitted are:

Candidates must complete this section if required to write answers without a computer.

STUDENT ID:

DESK NUMBER:

robjhyndman/MonashEBSTemplates

MonashEBSTemplates::exam

```
daycare ~>< STL(log(count) - season(window = 21)) ~>< autoplot() +  
  ggtitle("Number of employees in child day care services in New York City")
```

```
Number of employees in child day care services in New York City
```

```
1 |---  
2 unitcode: ETC3550  
3 title: "Applied Forecasting for Business and Economics"  
4 clayton: true  
5 caulfield: false  
6 duration: 2 hours writing time  
7 reading: 10 minutes  
8 semester: Semester One 2019  
9 examperiod: Examination Period  
10 openbook: false  
11 calculators: true  
12 fontfamily: kpfonts  
13 output:  
14   MonashEBSTemplates::exam:  
15     fig_caption: true  
16     fig_height: 4  
17     fig_width: 7  
18     highlight: tango  
19     toc: no  
20     keep_tex: yes  
21     includes:  
22       in_header: preamble.tex  
23       after_body: tables.tex  
24 |---
```

Conclusions

What have I lost?

- The ability to write Makefiles

Conclusions

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What have I gained?

- Speed
- Simplicity
- Reproducibility
- Version control

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- Reproducibility
- Version control

What's next?

- Tennis club website
- Shopping list
- email, SMS, tweets, social media

Conclusions

What have I lost?

- The ability to write Makefiles

What have I gained?

- Speed
- Simplicity
- Reproducibility
- Version control

What's next?

- Tennis club website ✓
- Shopping list
- email, SMS, tweets, social media

Thanks Yihui



Slides and package links: robjhyndman.com/rmd2020