

How Rmarkdown changed my life

Rob J Hyndman

30 January 2020

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.

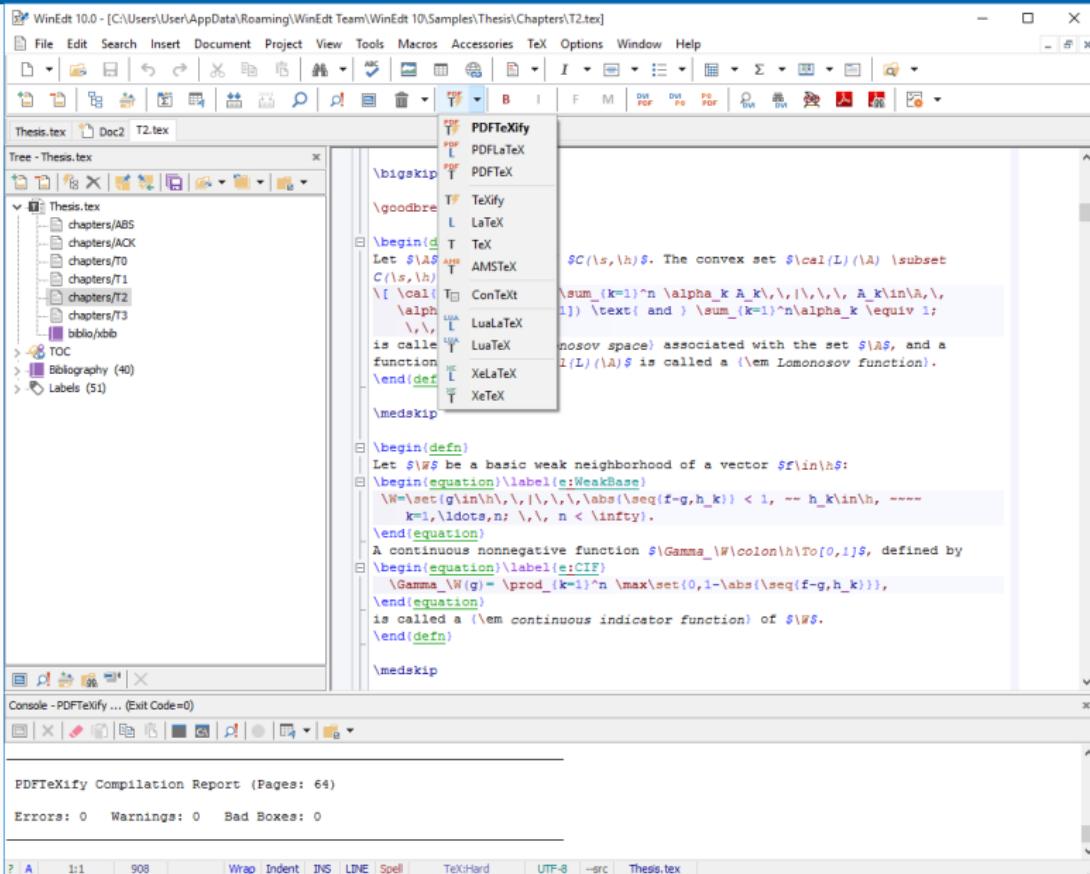
The familiar "Reveal Codes" command also continued to function and made the journey into WordPerfect for Windows. █

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

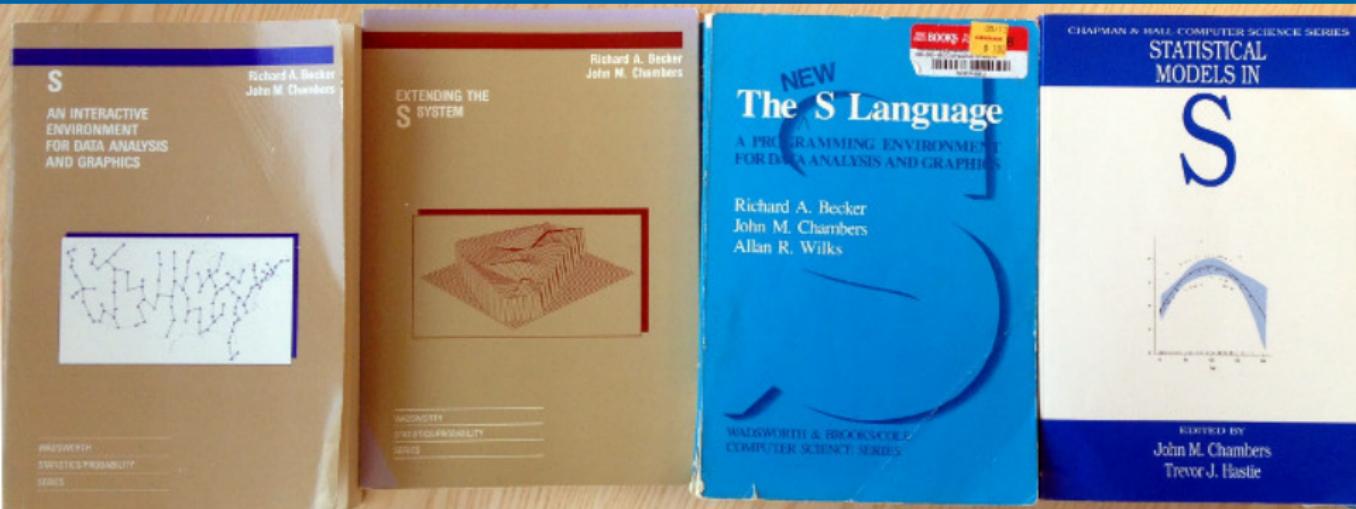


Photo credit: Rasmus Bååth

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"

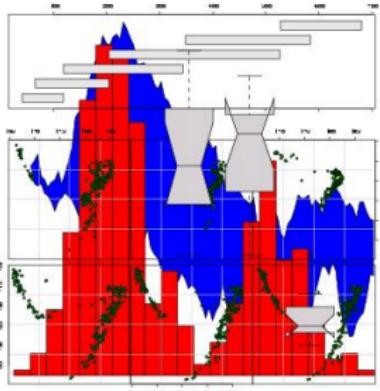
```

R (c.2000)



The R Project for Statistical Computing

(Web pages currently under construction!)



[About R](#)

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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 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.

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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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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Rob J Hyndman, Thiyanga S Talagala

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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Rmarkdown templates



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FFORMA: Feature-based Forecast Model Averaging

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



MONASH
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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`

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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Fax: (03) 9905 4435



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Rob J Hyndman's Home Page

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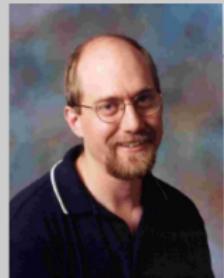
- [Religious interests](#)
- [Family](#)
- [Miscellaneous](#)
- [Curriculum Vitae](#)

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
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Phone: (03) 9905 2358

Fax: (03) 9905 5474

Office: Room 671, Menzies Building, Clayton campus.

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• [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](#)
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- [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](#)
- [Religious interests](#)
- [Links](#)
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Publications



Talks



New exponential
smoothing book



Forecasting
textbook



International
Journal
of Forecasting



Time Series
Data Library



R packages



LATEX

LATEX

Search for research



Research team



Evolution of a website

The screenshot shows the homepage of www.RobHyndman.info. At the top is a portrait of Rob J Hyndman, followed by his name in a large serif font and the website URL below it. A navigation bar below the portrait includes links for Home, Publications, Research, Library, Bible, and About me, along with a Search button. The main content area features a section titled "Website update" with a timestamp of Monday, 13 August 2007. It discusses the site's major upgrade and mentions new blogs and RSS feeds. Below this is a "Downtime" notice for Friday, 24 August 2007, explaining a server relocation. A sidebar on the left contains a menu with links to Home, Publications, Research, Library, Bible, and About me. At the bottom of the page are two book covers: "Time Series Data Library" and "FORECASTING METHODS AND APPLICATIONS".

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)

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!

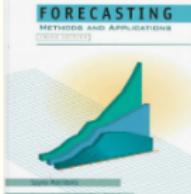
LAST UPDATED (FRIDAY, 24 AUGUST 2007)

Forecasting 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](#)
- [NEF-FOR: Forecasting papers](#)
- [Dandenong Bible Education Centre](#)
- [Bible answers blog](#)

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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Search this site

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

Evolution of a website

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.

[READ MORE...](#)

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 nights in thousands.

[READ MORE...](#)

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) FFORMA: Feature-based Forecast Model Averaging. *International Journal of Forecasting*, 36(1), 86–92. [ABSTRACT](#) [DOI](#) [PDF](#)

Recent and upcoming seminars

- ☞ Tidy time series & forecasting in R. (27 January 2020) [MORE INFO...](#)
- ☞ The journal game. (29 October 2019) [MORE INFO...](#)
- ☞ Tidy time series analysis in R. (27 September 2019) [MORE INFO...](#)
- ☞ Feature-based time series analysis. (27 September 2019) [MORE INFO...](#)
- ☞ Tidy time series analysis in R. (26 September 2019) [MORE INFO...](#)

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Rob J Hyndman

Hyndsoft blog

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Forecasts are always wrong

18 October 2019

forecasting, podcast

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[READ MORE...](#)

Tidy forecasting in R

29

2

Blogdown theme

The

als

re

la

da

th

 rbind/robjhyndman

(Adaptation of **hugo-finite** with
inspiration from Kieran Healy.)

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](#)
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Recent and upcoming seminars

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- Feature-based time series analysis. (27 September 2019) [MORE INFO...](#)
- Tidy time series analysis in R. (26 September 2019) [MORE INFO...](#)

robjhyndman.com

15

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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- [4 Simple regression](#)
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- [6 Time series decomposition](#)
- [7 Exponential smoothing](#)
- [8 ARIMA models](#)
- [9 Dynamic regression models](#)
- [10 Neural network models](#)
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- [12 Demand forecasting](#)
- [13 Using forecasting methods in practice](#)
- [Using R](#)
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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

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other words, the further ahead we forecast, the more uncertain we are.

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.

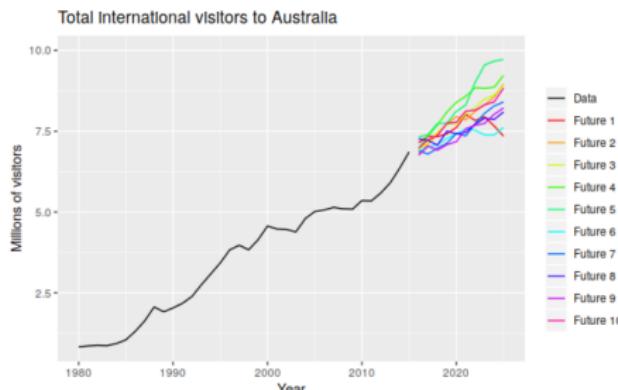


Figure 1.2: Total international visitors to Australia (1980–2015) along with ten possible futures.

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%.

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Forecasting: Principles and Practice

Preface

1 Getting started

1.1 What can be forecast?

1.2 Forecasting, planning and goals

1.3 Determining what to forecast

1.4 Forecasting data and methods

1.5 Some case studies

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1.7 The statistical forecasting perspe...

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1.9 Further reading

2 Time series graphics

2.1 t-s objects

2.2 Time plots

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2.4 Seasonal plots

2.5 Seasonal subseries plots

2.6 Scatterplots

2.7 Lag plots

2.8 Autocorrelation

2.9 White noise

2.10 Exercises

2.11 Further reading

3 The forecaster's toolbox

3.1 Some simple forecasting methods

3.2 Transformations and adjustments

3.3 Residual diagnostics

3.4 Evaluating forecast accuracy

3.5 Prediction intervals

3.6 The forecast package in R

other words, the further ahead we forecast, the less accurate our forecasts will be.

We can imagine many possible futures. Figure 1.2 shows the actual international visitors to Australia from 1980 to 2015. Also shown are ten possible future paths.

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

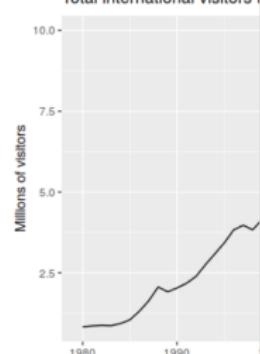


Figure 1.2: Total international visitors to Australia (1980–2015) along with ten possible futures.

When we obtain a forecast, we are estimating the range of values that the random variable could take. Often, a forecast will come with a prediction interval, which is the range of values the random variable could take with probability 95%. This means that 95% prediction interval contains a random variable with probability 95%.

24 FORECASTING: PRINCIPLES AND PRACTICE

Total international visitors to Australia

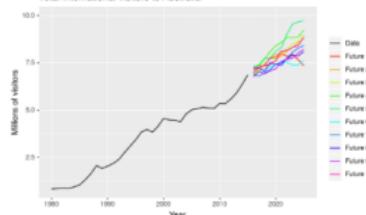


Figure 1.2: Total international visitors to Australia (1980–2015) along with ten possible futures.

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**.

Forecasts of total international visitors to Australia

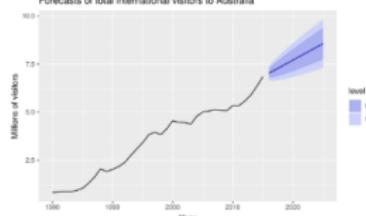


Figure 1.3: Total international visitors to Australia (1980–2015) along with 10-year forecasts and 80% and 95% prediction intervals.

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

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Bookdown theme

- Simple css styling

- Complicated LaTeX styling

other words, the further ahead we forecast, the more uncertain our forecast will be.

We can imagine many possible futures for the future Australian international visitors. Plotted in black in Figure 1.2 is the historical data up to 2015. Also shown are ten possible future paths.

Figure 1.2: Total international visitors to Australia (1980–2015)

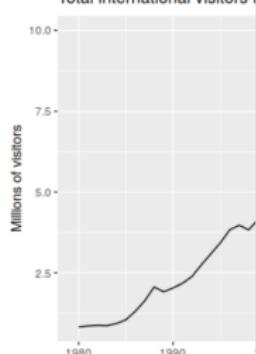


Figure 1.2: Total international visitors to Australia (1980–2015)

24 FORECASTING: PRINCIPLES AND PRACTICE

Total international visitors to Australia

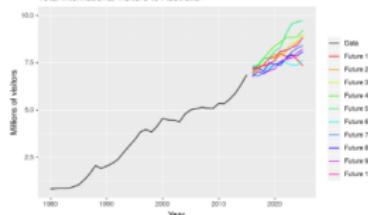


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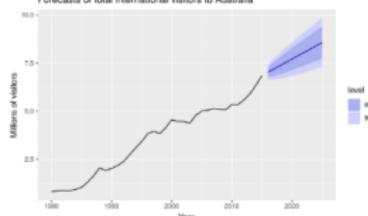


Figure 1.3: Total international visitors to Australia (1980–2015) along with 10-year forecasts and 80% and 95% prediction intervals.

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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:

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

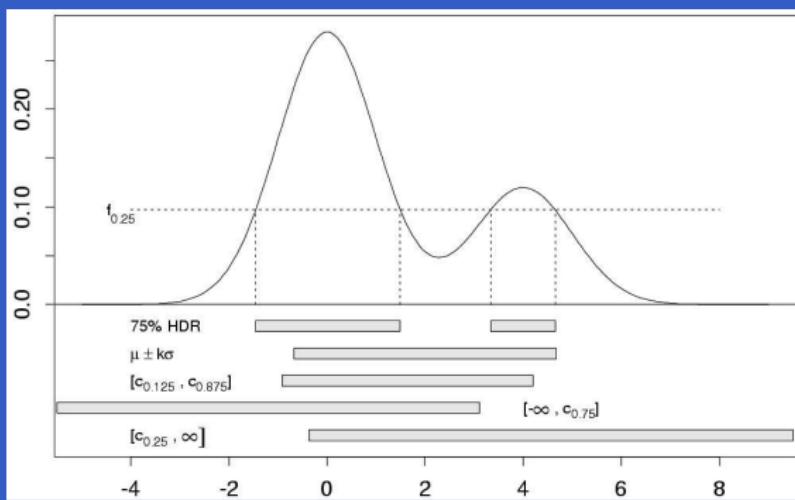
where h is the maximum lag being considered and n is the number of observations in the series.

- ◊ 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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Curriculum vitae

Curriculum vitae

Rob J Hyndman

Curriculum Vitae
December 2019

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Education and qualifications

1988 B.Sc.(Hons) University of Melbourne
1992 Ph.D. University of Melbourne
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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 Visiting Lecturer, Department of Mathematics and Statistics, Monash University
1995–1996 Lecturer, Department of Mathematics and Statistics, Monash University
1993–1994 Lecturer, Department of Statistics, University of Melbourne
1985–1992 Statistical consultant, Department of Statistics, University of Melbourne

Other positions

2011– Editor, *Journal of Statistical Software*
2001– Associate Editor, *International Journal of Forecasting*
2005–2010 Editor-in-Chief, *International Journal of Forecasting*
2005–2010 Director, International Institute of Forecasters
2001–2004 Theory and Methods Editor, *Australian & New Zealand Journal of Statistics*

Honours and awards

2016 KNWV Visiting Professor, TU/Eindhoven, Netherlands
2010 Dean's Award for excellence in innovation and external collaboration, Monash University
2008 Dean's award for excellence in research, Monash University
2008 Vice-Chancellor's award for postgraduate supervisor of the year, Monash University
2007 Kribbs Lecture, Statistical Society of Australia (ACT branch)
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
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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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Anomaly Detection in Streaming Time Series Data

A thesis submitted for the degree of

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Tutors and tutorials

Rob J Hyndman

11 June 2019

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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. p4-5. I had to read these pages a couple of times before 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).
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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?
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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.

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11. p38. The details of Holt (1957) are incorrect. The title was 'Forecasting trends and seasonal by exponentially weighted averages'. The 2004 version is correctly listed (with a different title).

References

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

Letters

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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



MONASH
BUSINESS
SCHOOL

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Template

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Exams

Exams



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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

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DESK NUMBER: _____

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

6 marks

```
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
 $\log(\text{Count}) = \text{trend} + \text{season_year} + \text{remainder}$

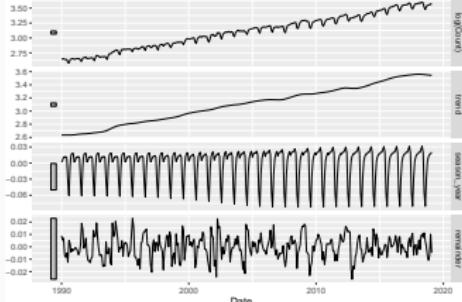


Figure 4:

(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(M,A_d,M).
- F. ARIMA(1,1,4).
- G. ARIMA(3,1,2)(1,1,0)₁₂.
- H. ARIMA(0,1,1)(2,0,0)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



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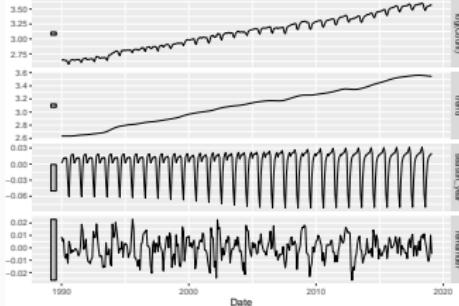


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2-
2-
th time and Fourier

10 marks

Total: 20 marks

Conclusions

What have I lost?

- The ability to write Makefiles

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What have I gained?

- Speed
- Simplicity
- Reproducibility
- Version control

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What's next?

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

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Thanks Yihui

