

# **ETC3550**

## **Applied forecasting for business and economics**

Revision

[OTexts.org/fpp3/](https://OTexts.org/fpp3/)

# Outline

- 1 Some case studies
- 2 Review of topics covered
- 3 Exam

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# CASE STUDY 1: Paperware company

**Problem:** Want forecasts of each of hundreds of items. Series can be stationary, trended or seasonal. They currently have a large forecasting program written in-house but it doesn't seem to produce sensible forecasts. They want me to tell them what is wrong and fix it.

## Additional information

- Program written in COBOL making numerical calculations limited. It is not possible to do any optimisation.
- Their programmer has little experience in numerical computing.
- They employ no statisticians and want the program to produce forecasts automatically



# CASE STUDY 1: Paperware company

## Methods currently used

- A** 12 month average
- C** 6 month average
- E** straight line regression over last 12 months
- G** straight line regression over last 6 months
- H** average slope between last year's and this year's values. (Equivalent to differencing at lag 12 and taking mean.)
- I** Same as H except over 6 months.
- K** I couldn't understand the explanation.

## CASE STUDY 2: PBS

- In 2001: \$4.5 billion budget, under-forecasted by \$800 million.
- Thousands of products. Seasonal demand.
- Subject to covert marketing, volatile products, uncontrollable expenditure.
- Although monthly data available for 10 years, data are aggregated to annual values, and only the first three years are used in estimating the forecasts.
- All forecasts being done with the FORECAST function in MS-Excel!

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**Problem:** How to do the forecasting better?

## CASE STUDY 3: Car fleet company

**Client:** One of Australia's largest car fleet companies

**Problem:** how to forecast resale value of vehicles?  
How should this affect leasing and sales policies?



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**Problem:** how to forecast resale value of vehicles?  
How should this affect leasing and sales policies?

### Additional information

- They can provide a large amount of data on previous vehicles and their eventual resale values.
- The resale values are currently estimated by a group of specialists. They see me as a threat and do not cooperate.

# CASE STUDY 4: Airline



## CASE STUDY 4: Airline

**Problem:** how to forecast passenger traffic on major routes?

### Additional information

- They can provide a large amount of data on previous routes.
- Traffic is affected by school holidays, special events such as the Grand Prix, advertising campaigns, competition behaviour, etc.
- They have a highly capable team of people who are able to do most of the computing.

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# 1. Introduction to forecasting and R

- ts objects
- seasonal periods
- frequency, start, end
- You don't have to write R code for the exam, but you do have to read and understand R code.

## 2. Time series graphics

- time plot
- season plot
- subseries plot
- lag plot
- ACF

### 3. The forecasters' toolbox

- Measures of forecast accuracy: MAE, MSE, RMSE, MAPE, MASE
- Training/test sets. Out-of-sample accuracy
- Problem of over-fitting.
- Time series cross-validation
- Box-Cox transformations to stabilize changing variance. Back-transformations after forecasting.
- Residual diagnostics: ACF, white noise, LB test.
- Simple methods: naive, seasonal naive, drift, mean.
- One-step prediction intervals based on RMSE

## 6: Time series decomposition

- Describing a time series: seasonality, trend, cycles, changing variance, unusual features.
- Difference between seasonality and cyclicity
- Moving averages
- Classical decomposition, X-12-ARIMA, STL: should know how to interpret.
- Seasonal adjustment
- Advantages/disadvantages of each method
- Forecasting and decomposition



## 7: Exponential smoothing

- Simple exponential smoothing.
- Holt's local trend method
- Damped trend methods
- Holt-Winters seasonal method (additive and multiplicative versions)
- ETS state space formulation
- Interpretation of `ets()` output in R.
- Computing forecasts by setting future  $\varepsilon_t$  to 0.
- Assumptions for prediction intervals
- Formula sheet provided

## 8: ARIMA models

- Stationarity.
- Differencing: first-differences and seasonal-differences. What to use when.
- White noise, random walk,  $AR(p)$ ,  $MA(q)$ ,  $ARMA(p,q)$ ,  $ARIMA(p, d, q)$ ,  $ARIMA(p, d, q)(P, D, Q)_s$ .
- Backshift operator notation
- ACF, PACF. Model identification.
- ARIMA models, Seasonal ARIMA models
- Order selection and goodness of fit (AICc)
- Interpretation of `Arima()` and `auto.arima()` output in R.

## 8: ARIMA models (cont'd)

- Expanding out an ARIMA model for forecasting
- Finding point forecasts for given ARIMA process
- Assumptions for prediction intervals
- One-step prediction intervals based on RMSE
- Effect of differencing on forecasts.
- Effect of a constant on forecasts.
- ARIMA vs ETS

## 5: Multiple regression

- Interpretation of coefficients as marginal effects
- Residual diagnostics: scatterplots of residuals vs predictors and residuals vs fitted values.
- Dummy variables, seasonal dummies, piecewise linear trends, interventions
- Splines
- Harmonic regression
- AIC, AICc, BIC,  $R^2$ , adjusted  $R^2$
- Matrix formulation
- Multicollinearity
- Interpretation of R output.

## 9: Dynamic regression models

- Regression with ARMA errors
- Using lagged predictors
- Difference between regression residuals and ARIMA residuals.
- When estimating, need to difference all variables if errors non-stationary
- Problems with OLS and autocorrelated errors
- Forecasting for regression models with ARMA errors
- Stochastic vs deterministic trends
- Dynamic harmonic regression
- Multiple seasonal series

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# Exam

- Five questions, all to be attempted.
- Q1: Short answers/explanations. Write about 1/4 page on four topics (out of six possible topics). Nuanced answers required.
- Q2: Describing a time series, choosing a forecasting method
- Q3: ETS models
- Q4: ARIMA model
- Q5: Dynamic regression.
- Formula page as for ETC3550 2017.

## Preparing for the exam

- 2015, 2016 & 2017 exams from ETC2450/ETC3550 to go on Moodle with solutions.
- Exercises. Make sure you have done them all!
- Identify your weak points and practice them.
- Write your own summary of the material covered.
- Practice explaining the material to a class-mate.



# Exam: 6 June am

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## Help available

See Puwasala in first instance.

See me at 11am-1pm on Wednesday 30th.

# Useful resources for forecasters

## Organization:

- International Institute of Forecasters.

## Annual Conference:

- International Symposium on Forecasting, Boulder. June 2018.

## Journals:

- International Journal of Forecasting
- Foresight

Links to all of the above at **[forecasters.org](http://forecasters.org)**

# Happy forecasting

Good forecasters are not smarter than everyone else, they merely have their ignorance better organised.