# 2022/2023 MSCI 523 Forecasting Coursework - Part 2

**Coursework Information & Submission**

This is the second of two assignments. The first assignment, weighted 40%, required you to explore and understand a dataset as a group. Each one was assigned a single time series, which is also the data for the 2nd assignment. This 2nd individual assignment is weighted 60% and you may find it useful to apply insights from the first assignment to the second one. In this second assignment, you will forecast the same time series you analysed in assignment 1 with multiple forecasting algorithms and models.

Coursework deadline is **May 2nd 2023, 11:00 am**.

Standard departmental penalties will apply for late work unless you have been given an extension for exceptional reasons from the course administrator. All submissions will be checked by the plagiarism software. Coursework must be submitted online on Moodle. Submit your report PLUS all R scripts in the appendix in Moodle.

**Assignment: Forecast Model Building for a real-world time series**

Your task is to forecast and critically discuss the fit of your models based on the pattern(s) of a real-world time series. Document your findings comprehensively in a technical report, making adequate use of (readable and correctly labelled) graphs which you also critically discuss to support your arguments. Base your justification on evidence and document your iterative model building process, possibly transforming the time series and analysing the resulting patterns throughout. Your objective is to:

a) Develop the most accurate statistical forecasting models, demonstrating your modelling skills!
   - Build multiple potentially suitable forecasting models, including a suitable Exponential Smoothing, ARIMA, and Time Series Regression model to predict the 14 next values (2 weeks ahead)
   - Choose what you assume to be the "best" model from these models for a final submission, by assessing errors and comparing errors against a Naive and a Seasonal Naive benchmark models.

b) Document your forecasting process in a technical research report
   - Write a technical report to document your model building skills & to justify your choice of model
   - Critically discuss some findings and choices

**Marking Scheme & Hints**

**60 % of points – Forecast Model Building.**

- Build multiple potential contender models (each one suitable for the identified data properties), leading to (at least)
  - 1 good manually built Exponential Smoothing Model - in comparison to 1 automatically built
  - 1 good manually built ARIMA model - in comparison to 1 automatically built
  - 1 good manually built Time Series Regression model - in comparison to 1 automatically built
  - 1 good manually or automatically built Neural Network model
- Document the specification of each model
  - Document the specification process of model building, i.e. the iterative steps to build this final model, including the analysis of residuals of intermediate models that have led to better ones
  - Document the final model form and parameters to allow a complete replication of your experiments (i.e. specify what model forms or lags you selected, which transformations in which order & which parameters were used so that others could replicate what you did exactly only from your document).
- NOTE: For each contender model, one or more different model forms may be feasible to produce forecasts (i.e. for a seasonal time series with slight trend in Exponential Smoothing you may use multiplicative or additive seasonality, with or without trend, so 4 candidates that could perform well; for ARIMA you may consider models with seasonal differences or first differences or both; for regression models you may consider to capture seasonality as dummy variables, or as a seasonal autoregressive lag etc.). Where applicable, you should always consider multiple plausible candidate models, and must justify your choice of candidates in comparison to other potential models in each class of models (feel free to explicitly rule out implausible ones). To get high marks it will not be sufficient to build a single Exponential Smoothing model using an auto specification ZZZ or a single automatic ARIMA model and a single Regression model with stepwise, but rather require the development of a subset of potentially useful models which you compare and accept/reject. Base your justification on evidence and document your ITERATIVE modelling process throughout.

**20% of points – Discussion of expected Accuracy (Errors)**

- Determine suitable error metrics and compute the expected in-sample and out-of-sample errors of your recommended models and compare them. Comment on the suitability of the chosen metrics for this task.
- Select one "best" model to be used for forecasting the time series across all algorithm families, and provide your final out of sample forecasts.
- NOTE:

- To assess the future forecast accuracy of your models before the final future values become available, consider to create a hold-out dataset of equal or better larger size to the forecasting horizon and assess both in-sample and (quasi) out-of-sample errors
- Different error metrics are feasible. You should use at least two suitable error metrics for the assessment, and justify the use of each error metrics you are using
- To show improvements in accuracy of your methods to some objective benchmark, you should compare all to the Naive Level and a Naive Seasonal Model. Use tables to provide a suitable overview of different methods' accuracy and their uplift of accuracy on the 2 Naïve models.
- Comment on the accuracy and suitability of each of the methods for each of the time series. Which method would you recommend to use for each of the time series? Comment on why you think some methods perform better than others? Comment on the available data and number of origins for forecast evaluations on the withheld test set and given your fixed forecasting horizon.

**10% of points – Conclusions**
Conclude by recommending one (or multiple) suitable algorithm(s) and forecasting model form(s), and critically discuss your choice weighting the different options. As time series patterns are not always clear, there often are multiple suitable forecasting models for a time series. Please recommend all that are suitable.

**10% of points - General report writing skills**
General report writing skills include a critical discussion of findings, thoroughness of documentation, clarity of arguments, structure of the report, readability of the report (i.e. lack of spelling and grammatical mistakes etc.) in marking each section. Please see next page for some more technical considerations on report writing.

**SUM 100%**

We highly recommend using R, but you are free to use any external software but report the software used.



**Contact details:**

Questions regarding the coursework, R and workshops
Sven F. Crone
Room A53a
s.crone@lancaster.ac.uk

If you have any questions, please don't hesitate to contact us! Also consider in your enquiries that I cannot always react within a few hours, so don't leave questions to the last minute … start early!

Best of success!
Sven

PS. Please also consider the general recommendations on writing a technical report on the next page!

**General suggestions on writing a report**

The coursework requires you to document your analysis and critically discuss your chosen experimental design, modelling approaches and the results in a technical report. This technical report should be written as if tailored to an Analytics specialist (e.g. who has an MSc from Lancaster University and has taken the MSCI750 course, and who wants to evaluate your results AND your decision making process to determine your skills in modelling and whether you have missed anything). This means that you are not required to write a general description (i.e. a statistical test is, the ACF function is, Exponential Smoothing is ... ) as an Analytics expert would be aware of this! Consequently, the report should document the process of modelling, and allow an understanding of your choices and a replication of your experiments.

The report should contain an introduction and a summary with conclusions on your findings, numbered headings, list of figures and tables and an executive summary (tailored to senior management) indicating the most relevant findings. The report should display a logical and concise structure, be generally "readable" and support your argument using plots of time series, forecasts and /or accuracy. Make adequate use of graphs to show time series, model fit / predictions and residuals to support your arguments (for this graphs must be completely readable and with labels), as well as tables to compare results.

The page limit for the report is 10 pages (note this is a maximum to make your life easier - you can produce shorter reports! pages count only for main text incl. graphs and tables, but not for the cover sheet, executive summary, contents sheet or appendices). Reports of excessive length will be penalised by deducting 10 marks (i.e. 10% of 100) but only if they are including un-necessary material. For formatting, use single spacing, format normal text in times new roman font size 12, text in tables, figure and table headings in font size 10, and leave 2cm of margin left and right.

Excessive evidence (e.g. the complete information from statistical tests) may be placed in the appendix, but must be referenced directly at the corresponding place in the main the text, else it is not taken into consideration. Include any technical details and hardcopies that support your arguments in a set of appendices (i.e. the printouts from ADF tests in the appendix, with only the conclusion of significance / insignificance at a probability in the main text), which will not count towards the page limit. You must ensure the main text is readable and that your argument is coherent without needing to consult the appendices. All parts of the text supported by an appendix must cross-reference directly to the relevant part.

# Department of Management Science
# 2023 MSCI523 Assignment 2 Feedback

| Participant ID: | MARK: | Max | Yours |
|---|---|---|---|
| **Task II: Coursework assignment 2 - Forecasting** | | **100** | |
| **Model building & Forecasting with Exponential Smoothing** | | **10** | |
| - Documentation of correct modelling process (steps taken) & info on final model (spec./pars.) | | 4 | |
| - Insightful residual analysis making good use of graphics and statistical tests | | 2 | |
| - Evidence of iterative model building process (analysis of residuals, refinement of model etc.) | | 2 | |
| - Critical discussion of all plausible contender models (in case multiple models are adequate) | | 2 | |
| **Model building & Forecasting with ARIMA models** | | **20** | |
| - Documentation of correct modelling process (steps taken) & info on final model (spec./pars.) | | 8 | |
| - Insightful residual analysis making good use of graphics and statistical tests | | 4 | |
| - Evidence of iterative model building process (analysis of residuals, refinement of model etc.) | | 4 | |
| - Critical discussion of all plausible contender models (in case multiple models are adequate) | | 4 | |
| **Model building & Forecasting with (dynamic) Regression Models** | | **20** | |
| - Documentation of correct modelling process (steps taken) & info on final model (spec./pars.) | | 8 | |
| - Insightful residual analysis making good use of graphics and statistical tests | | 4 | |
| - Evidence of iterative model building process (analysis of residuals, refinement of model etc.) | | 4 | |
| - Critical discussion of all plausible contender models (in case multiple model are adequate) | | 4 | |
| **Model building & Forecasting with artificial Neural Network Model** | | **10** | |
| - Documentation of correct modelling process (steps taken) & info on final model (spec./pars.) | | 4 | |
| - Insightful residual analysis making good use of graphics and statistical tests | | 2 | |
| - Evidence of iterative model building process (analysis of residuals, refinement of model etc.) | | 2 | |
| - Critical discussion of all plausible contender models (in case multiple model are adequate) | | 2 | |
| **Evaluation of Accuracy across models (discussion → analysis → description → none)** | | **20** | |
| - Use and justification of an unbiased error metric (e.g. sMAPE, not MAPE or RMSE, MSE) | | 4 | |
| - Compare errors of all model & against Naive to Recommend “best” model for competition | | 4 | |
| - Compute expected multiple-step ahead errors of models (in sample and out-of-sample) | | 8 | |
| - Provide final forecasts for selected model | | 4 | |
| **Conclusions** | | **10** | |
| - Summary of findings | | 4 | |
| - recommendation of one (or multiple) final models | | 6 | |
| **General Report Writing** | | **10** | |
| - Including relevant report parts (cover, execsum, intro, contents, graphs, tables, appendix) | | 4 | |
| - General report writing structure & style (see below) | | 6 | |
| **Sub-total Task I** | | **100** | |
| **Proficient Use of R** | | | |
| **- Late hand-in (-10% of 100 = -10 pts)** | | | |
| **- Exceeds page limit (-1% of 100 for each page, e.g. 10 pages = -10 pts)** | | | |
| **TOTAL** | | **100** | |

General issues considered in the marks given in each section

- Structure: coherence, logical sequencing of parts, distinct self-contained paragraphs
- Writing Style & presentation: clarity, precision, conciseness, grammar, spelling, punctuation, language
- Analysis / argument: Understanding of concepts; clarity of arguments; critical approach to concepts and theories
- Evidence: Relevance & depth in conceptual support/empirical evidence; avoiding unsupported assertion, claims& repetition
- Relevance: Addressing and interpreting the requirements of the question; keeping the question in focus
- Scope / breadth of approach: Adequate coverage of parts of the question; balance of different elements of question

Common mistakes

- no adequate use of plots in report (or in appendix with explicit link to appendix) to discuss time series, model fit, forecast & residuals
- no use & clear identification of ex-ante out of sample performance metrics (use of in-sample errors)
- no discussion of pros/cons of SMAPE error measure versus others; no identification of a single error measure used to id the "best" method
- no discussion of discrepancies in method performance (i.e. relative ranks) across series, across origins & across different error measures
- detailed discussion of each algorithm - not required, systematic analysis of data and developing models using graphs, tests & error metrics
- no evidence of iterative model building, i.e. starting with simple mode, analyzing residuals, then refining model type & parameters further
- no evidence of residual analysis for checking model adequacy, contrasting this with errors (often contradictory or supporting evidence)
- no evidence of critical discussion of lab exercises for ETS nor Regression models, poor discussion of error (no data exploration asked)