OTM 714 – Supply Chain Analytics

Spring 2021

Time Series Forecasting Assignment

Individual Assignment

Due March 3, 2021, 11:59 pm

This assignment is based on two data sets – one from Shure, and one from Dish Network. We've already discussed Dish Network – here's some information on Shure.

> *Shure is dedicated to manufacturing microphones and audio electronics to help amplify, process, and mix sound. Perfectly. Transparently. Reliably.*
>
> *Our success is due to our belief that audio electronics are a means of self-expression for individuals worldwide. Since 1925, we've re-dedicated ourselves annually to the notion of being the audio tool of choice for personal expression, reminding ourselves that Shure is synonymous with "legendary performance."*
>
> *[…] From microphones to headphones to wireless gear, we make products that help users define their sound. We take equipment issues out of the audio equation, enabling customers to concentrate on their message or performance with confidence.*
>
> *Source: Shure company website: http://www.shure.com/americas/about-shure/company-overview*

I. Shure Data and Context:

The data set for this assignment, located in ShureData.xlsx, contains Shure's forecast and order history for a long-selling product line of microphones at Shure, Inc.

The CustOrders sheet contains the actual customer order history for 9 specific products within the product line, as well as the total for the whole line.

The ShureForecasts sheet contains the 3-month rolling forecast history from Shure's demand planning group for every product as well as for the total product line:

- For example, the number for product FLX012 on April 2015 indicates how many FLX012 orders they forecasted they would get in April 2015 as of January 2015 (i.e., 3 months earlier).
- Notice that we do not have forecast data going as far back as order data. Their system only had forecast data available starting in June 2014.

Some additional notes about this product line and supply chain:

- The different products represent different "configurations" of effectively the same product. All of these configurations cost roughly the same to make. The differences are

mainly cosmetic (e.g., differences in sizes of certain parts) or technical (e.g., wireless specifications).

- The reason why Shure's demand-planning team focuses on 3-month rolling forecasts in their sales and operations planning process is that they effectively face a 3-month lead time to make any changes to their production and delivery schedule from their overseas manufacturing location. (The main delay is due to shipping by freight).

Shure's Questions:

1. (*Performance Evaluation*) Shure currently makes a significant financial investment in their global forecasting team – both to make adjustments on the fly based on conversations with the sales team as well as to pay for forecasting packages used in their information system software. They would like an outside opinion as to how the forecasting team is doing. To address this question, do the following.
    a. Use an R script to construct forecasting models for each of the products and for the total (total of 10 models). Your model should forecast ahead 3 periods – similar to the example above, after observing January orders you should forecast April orders, after observing February orders you should forecast May orders, etc. For your training set, use the order data that is ***earlier*** than any of the Shure forecasts (i.e., May 2014 and earlier). For your test set use the months for which you do have Shure forecasts. For this question and all parts of this assignment, you should restrict each model to have smoothing parameters (alpha, beta and/or gamma) no less than 0.05 and no greater than 0.3. For each product and also for the total demand, try various models on the training set and choose the one you like best, then compute the performance of the chosen model vs. the validation set – using the RMSE as the metric.
    b. For the dates covered by the validation set, compare the performance of your forecasting models to the performance of Shure's forecasts. How do they compare? Would you say that Shure's forecasting team and investment in forecasting software are adding significant value?
    [Deliverable: Fill in table in template. Add a few sentences after the table to]

2. (*Lead Time Reduction Analysis*) One debate within Shure is whether they should be making investments to reduce the lead time (currently 3 months). Some within the company propose making a significant investment to reduce the lead time for all of their products to just 1 month. Others argue that the lead time doesn't matter and in fact they can save on the cost to manufacture by increasing the lead time to 5 months. However, nobody has any idea where to begin in terms of trying to quantify the (positive or negative) impact of these two potential changes. Therefore:
    a. Keep using the best models you found in question 1, but now compute the 1-month ahead forecasts and 5-month ahead forecasts. Compute the RMSE for each set of forecasts based on the test data. **[Deliverable: Fill in table in the template. Add a few sentences to comment on the differences in accuracies for different lead times.]**

b. Do some assessment of the inventory implications of different lead times. Recall that if Shure follows a base stock policy targeting a 95% fill rate, the amount of safety stock inventory they would need for an L-period lead time is approximately equal to the 95th percentile of a standard normal distribution times sqrt(L+1) times the standard deviation of the forecast error (your RMSE estimate). Put more directly: safety stock = 1.64*sqrt(L+1)*RMSE. **[Deliverable: Fill in table in template. Add a few sentences to comment on the inventory impact of different lead times, and relate that to the accuracy numbers in part a.]**

3. (*Postponement Analysis*) Another program being considered at Shure is to try to implement a kind of postponement strategy – delivering a semi-finished good to the US distribution center and then completing final configurations there (i.e., postponing the decision of which exact product to produce until later in the supply chain). Such a program would effectively mean that Shure can restrict attention to TOTAL demand for the whole product line (aggregated across all 9 products), not demand for the individual products (since final configurations could be completed very quickly). Therefore:
    a. Compare the inventory requirements between using and not using a postponement strategy, assuming that in both cases Shure wants a 95% fill rate and uses a 3-month forecast window. (Hint – you've done the necessary calculations in question 1 above.) **[Deliverable: Using the information you gathered in question 1, write a few sentences commenting on the inventory impact of going with postponement.]**

II. Dish Network Data

This problem uses the Dish Network data, which can be found on the course web site. Use R code to obtain a time series containing the total number of boxes (combining both return locations) returned each week for all the weeks in the data set. (Use Tableau to extract the weekly data and export or paste it into Excel. Then save the result in CSV format with file name DishWeekly.csv so it can be read into R.) Given the way the data were collected, some weeks will not contain "representative" values – i.e., the first several weeks and last several weeks have low returns because only outgoing shipments from January through June are counted. Use the week beginning January 26 as the initial "representative week", and the week beginning July 6 as your final week – discard the rest of the weeks. Split the remaining data into a "training" set consisting of the first 14 weeks and a "test" set consisting of the last 10 weeks. Then select an appropriate exponential smoothing model (simple exponential smoothing, smoothing with trend, Holt-Winters) to use on the data. Use that model to generate forecasts for the data set (after dropping the "non-representative" weeks), and report the RMSE that you get when applying your model (with one week ahead forecasts) to the "test" data. **[Deliverable: Fill in table in template.]**

Submitting your assignment: Put your deliverables in the assignment template. Submit that document, along with an R script in which you build your forecasting models, via Canvas by the due date.