**Demand Forecasting Model – Explanation and User’s Guide**

## Analysis of Product X1

Upon visual inspection, Product X1 demonstrates a consistent **upward trend** between 2014 and 2017, suggesting a steady increase in demand over time.

Additionally, there are distinct **seasonal fluctuations** within each year. This pattern repeats quarterly, for example, there is an slight increase from period 1-2, decrease from period 2 to 3, then significant increase from period 3 to 4. Predicting these seasonal variations can aid in inventory management and resource allocation to meet demands efficiently.

## Model Assumptions and Rationale

As identified above, Product X1 has both trend and seasonality components, and to fulfill the requirement of updating forecasts every quarter with new sales data, **updating Holt-Winters** **forecasting** **model** is the most suitable. Given that the seasonal variations change proportional to the series’ level, the **multiplicative method** is preferred in this context.

In assessing forecast accuracy, the **Root Mean Squared Error (RMSE) is employed** because it penalises larger errors more heavily, which means it is sensitive to outliers and reflects accuracy better. Additionally, RMSE is in the same units as the target variable (Sales), allowing for a more intuitive interpretation of forecasting errors.

For **model building**, there are 2 main steps

1. Build a **basic model** using the observed data for 2014-2016, by separating the trend and seasonality value and estimating the parameters (level, trend, seasonality).
2. Build the **updating model,** from 2017 onwards, taking into account the newest actual sales to update parameters.

Formulas for calculations:

|  |  |
| --- | --- |
| **𝐹𝑡+𝑚 = (𝐿𝑡 + 𝑚𝑏𝑡 ) 𝑆𝑡+𝑚−s**  A math equations on a white background  Description automatically generated | 𝐹𝑡+𝑚 is the 𝑚-step ahead forecast  𝐿𝑡 = the level of the series at time 𝑡  𝑏𝑡 is the trend at time 𝑡  𝑆𝑡 is the seasonal index at time 𝑡  𝑠 is the length of season in time periods  𝛼, 𝛽 and 𝛾: smoothing coefficients (values between 0 and 1) |

## User’s Guide

* 1. ***For IT staff***
* Two steps mentioned above are in 2 sheets “IT-base model” and “IT-updating model”, there are explanations in each sheet, along with suggested Macros for easy modifications and automatic maintenance.
* The steps used for Product X1 can be applied to other products in the same manner.
  1. ***For Non-IT users***
* There is a sample Dashboard to keep track of the actual and forecasted sales, customisation can be made according to users and availability of other products’ sales.
* How to interpret RMSE
  + Imagine you are predicting how many units of a product will be sold each quarter. RMSE helps you see how close your predictions are to the actual sales.
  + If your RMSE is, for example, 10 units, it means your sales predictions are off by about 10 units, on average. A lower RMSE shows your predictions are closer to the actual sales, while a higher RMSE means your predictions are further from what is actually being sold.