SUPPLY CHAIN SERVICES AUSTRALIA

DISCUSSION PAPER:

DEMAND PLANNING

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DEMAND PLANNING - INTRODUCTION

In this document we will discuss the basic demand planning framework and what to consider when deciding to implement forecasting software. Demand planning is more than just creating a forecast. Table A below gives an overview of the common demand planning framework.

The article addresses each headings from the table in Sections 1 to 4; in Section 5 we include a table that identifies all functional and non-functional requirements that should be taken into account when evaluating forecasting software.

Table A: Common Demand Planning Framework

1. Demand Planning Awareness
1.1 Understand the objectives of forecasting
1.2 Understand major relevant business conditions
2. Demand Planning Structures
2.1 Determine what to forecast
2.2 Structure products, customers, regions and time
2.2.1 Structure input and output
2.2.2 Aggregation, disaggregation and consistency
3. Demand Planning Process
3.1 Collect, correct and analyze input data
3.2 Determine appropriate forecasting techniques
3.3 Create forecast
3.4 Add human judgment
3.5 Collaborative forecasting
3.6 Plan dependent demand
3.7 Release the forecast
4. Demand Planning Control
4.1 Define and measure forecast error metrics
4.2 Aggregation rules for forecast accuracy metrics
4.3 Deal with forecasts errors and biases
4.4 KPIs and responsibility with incentives
4.5 Re-evaluate the process

1 DEMAND PLANNING AWARENESS

Before performing the forecasting itself, there is a need to understand the forecast implications on the company and have some organizational practices in place.

1.1 Understand the Objectives of Forecasting

Many decisions and planning activities in a supply chain can be based upon forecasts or be influenced by the forecasts. It is necessary to detect all of those decisions/planning activities as well as those who are responsible for performing them. All parties affected by a forecast should be aware of this link and this link should exist at the information system level. Creation of cross-functional or even cross-organizational teams may be required for this step. Completing this step will also provide insight into exactly what value increased forecast accuracy may bring to each stakeholder so that the concrete objectives of the demand planning process can be set.

1.2 Understand Major Relevant Business Conditions

Major business conditions relevant for a forecasting process can be on demand, supply or product side. On the demand side it is essential to bear in mind the difference between sales and actual demand.

- Demand can be said to equal sales when no “artificial” factors (like promotions or discounts, unmet demand because of stock outs etc.) are present.
- It is important to focus on meeting the ultimate customer demand i.e. the actual demand of the end user of the product.
- On the supply side the presence of substituting suppliers and suppliers’ lead times must be considered in order to find out the desired forecast accuracy.
- And on the product side there is a need to identify if there are any products which demand is correlated (e.g. they are substituting each other).

Taking into account all of the above will give the company a true/unconstrained **demand**. It is critical for companies to capture true unconstrained demand and this should replace the sales history as input to the forecasting tool.

2 DEMAND PLANNING STRUCTURES

This step deals primarily with the data required in demand planning process.

2.1 Determine What to Forecast

Once you know which organisational or inter-organisational functions are affected by the forecast, it should be possible to find out exactly what needs to be forecasted. A few things to consider:

- The correct time-series of the forecast
- Identify the dependent demand (i.e. parts of other products) which a company does not want to forecast since it can be computed using the forecast of independent demand and BOM’s.
- Make to stock vs make to order items

2.2 Structure Products, Customers, Regions and Time

Forecasting usually has three dimensions ie: **product**, **geographical region** and **time**. Each of the dimensions should be segmented, i.e. geographical regions (with corresponding customers), product groups and relevant time buckets.

2.2.1 Structure Input and Output

Having points 2.1 and 2.2 of the framework in place, makes it possible to find exactly what input data are required to run the desired forecasts and what output they should produce.

2.2.2 Aggregation, Disaggregation and Consistency

The dimensions of the forecasting system should be done in such a way that supports aggregation and disaggregation of forecasted data. The segmentation could have several hierarchy levels as indicated below.

Product: All products -> Category 1 -> Category 2 -> Product

Time: Year -> Quarter -> Month

Geography: Global -> Region -> Country -> Province/State -> City -> Customer

Aggregation to higher levels happens by simple summation. Disaggregation to lower levels is more problematic and can occur according to one of the following rules:

- *Even distribution*: Higher level items are distributed evenly to the lower level groups.
- *Existing quantities on lower level*: If lower level groups do already contain some item quantities, their distribution ratio is calculated, and the newly entered higher level items are distributed according to that ratio.
- *Some other time-series*: Higher level items are distributed according to some other time series/ratio, e.g. the one calculated from previous year demand for the same period.

The level-approach allows future forecast to fit different purposes during the demand planning process. It can be suitable for both financial planning (one-year planning horizon) or operational planning (one day planning horizon, e.g. how many items of this type to produce today).

3 DEMAND PLANNING PROCESS

3.1 Collect, Correct and Analyze Input Data

If not all data needed for forecasting is available through the current systems, it will have to be collected. It is highly likely that historical data will need to be corrected. This will entail removing or highlighting the influence of promotions and distinguishing between sales and actual demand.

3.2 Determine Appropriate Forecasting Techniques

User must be able to use different forecasting method(s). Sometimes forecasting software can pick the best-fit option and this will greatly automate the process. It is important to notice that different dimensions and various segments in a dimension may require different forecasting techniques.

3.3 Create Base Volume Forecast

In this step usually the Demand Planner will create a base volume forecast. This might be done automatically by the forecasting software; however, the demand planner will use his experience and different forecasting techniques to improve the forecast.

3.4 Add Human Judgment

The base volume forecast is shared with the relevant stakeholders. In this step the statistical and subjective perspectives are combined. Human corrections are only desired if they are based on information which is not been taken into account by the statistical method (i.e. upcoming promotion).

3.5 Collaborative Forecasting

The ultimate forecasting goal is to have a “one number” forecast. In this step all stakeholders have the opportunity to reach the final forecast where all exceptions and disagreements can be resolved.

This step can be achieved by having a final consensus or signoff meeting. In cases where consensus is not reached, one could implement a system of hierarchy forecasting where one party can overrule another party’s predictions. It is important that each party should contribute to the final forecast, but its contribution weight can be determined by the forecast accuracy improvements the party has achieved in the past.

3.6 Release the Forecast

The agreed forecast is released and other planning activities which are dependent on the forecast can now start or be corrected by the latest information.

4 DEMAND PLANNING CONTROL

The last step of the common framework is about controlling and improving the current demand planning process.

4.1 Define and Measure Forecast Error/Accuracy Metrics

It is important for a company to measure how accurate their forecasting is before basing important decisions on these figures. There are various ways of calculating the forecast error or accuracy. Below is an example of how forecast accuracy are calculated based on the MAPE (mean absolute percentage accuracy) calculation.

- MAPE is a relative metric and is often used for describing forecast accuracy as a percentage of demand.
- Forecast accuracy measurements should be available per sku, per month, country (agreed segments)
- Indicate the forecasting bias
- Forecast Accuracy is the converse of Error
- Formula for calculating MAPE

$$\mathrm{M} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

- Forecast accuracy example:

	Sku A	Sku B	Sku X	Sku Y
Forecast	75	0	25	75
Actual	25	50	75	74
Error	50	50	50	1
Error (%)	200%	100%	67%	1%
Accuracy (%)	0%	0%	33%	99%

Forecasting Bias:

One form of tracking signal is the ratio of the cumulative sum of forecast errors (the deviations between the estimated forecasts and the actual values) to the mean absolute deviation. The formula for this tracking signal is:

$$\text{Tracking signal} = \Sigma\,(a_t - f_t) \,/\, \text{MAD}$$

where a_t is the actual value of the quantity being forecast, and f_t is the forecast. MAD is the mean absolute deviation. The formula for the MAD is:

$$\text{MAD} = \Sigma\,|a_t - f_t| \,/\, n$$

where n is the number of periods. Plugging this in, the entire formula for tracking signal is:

$$\text{Tracking signal} = \Sigma\,(a_t - f_t) \,/\, (\Sigma\,|a_t - f_t| \,/\, n)$$

Alternative Forecast Accuracy Measurements:

Mean absolute error (MAE)	The mean absolute error (MAE) is a quantity used to measure how close forecasts or predictions are to the eventual outcomes.	$MAE = \frac{\sum_{t=1}^{N} \lvert E_t \rvert}{N}$
Mean Absolute Deviation (MAD)	The absolute deviation of an element of a data set is the absolute difference between that element and a given point. Typically the deviation is reckoned from the central value, being construed as some type of average, most often the median or sometimes the mean of the data set.	$MAD = \frac{\sum_{t=1}^{N} \lvert E_t \rvert}{N}$
Percent Mean Absolute Deviation (PMAD)	Percentage of Mean absolute deviation	$PMAD = \frac{\sum_{t=1}^{N} \lvert E_t \rvert}{\sum_{t=1}^{N} \lvert Y_t \rvert}$
Mean squared error (MSE) or Mean squared prediction error (MSPE)	The mean squared error (MSE) of an estimator measures the average of the squares of the "errors", that is, the difference between the estimator and what is estimated.	$MSE = \frac{\sum_{t=1}^{N} E_t^2}{N}$
Root Mean squared error (RMSE)	The root-mean-square deviation (RMSD) or root-mean-square error (RMSE) is a frequently used measure of the differences between value (Sample and population values) predicted by a model or an estimator and the values actually observed. Basically, the RMSD represents the sample standard deviation of the differences between predicted values and observed values.	$RMSE = \sqrt{\frac{\sum_{t=1}^{N} E_t^2}{N}}$
Forecast skill (SS)	Skill in forecasting (or skill score, forecast skill, prediction skill) is a scaled representation of forecast error that relates the forecast accuracy of a particular forecast model to some reference model.	$SS = 1 - \frac{MSE_{forecast}}{MSE_{ref}}$

4.2 Aggregation Rules for Forecast Accuracy Metrics

- The forecast data should be able to aggregate (point 2.2, section 2.2.2), so should the accuracy metrics.
- When viewing the forecast values at a certain level of aggregation, one should be able to find the forecast accuracy at exactly the same level.
- Thus, forecast accuracy calculation should be run along the same dimensions as the forecast itself.

4.3 Deal with Forecasts Errors and Biases

- The demand planner will use the forecast error to change the forecasting methods, i.e. it is consistently over - or under forecasting the demand.
- Sales team will evaluate forecast accuracy in order to assist with collaborative forecasting
- The forecasting error and bias will be used in the following instances:
    - Baseline forecasting - demand planner can assess the statistical forecast bias and decide to increase or decrease the forecast. He will also use the forecast error to direct him to sku's that needs more attention than others.
    - Field intelligence forecast – Will give the sales staff an indication of their overrides

4.4 KPI's and Responsibility with Incentives

One can use mean absolute percentage error (MAPE) to measure if a contribution to a forecast actually added value, i.e. measure the participants override value. This will give you each contributor a "forecast value add" score. Having this mechanism in place it is possible to find out the contribution of each human correction and assign targets and incentives for the contributors as well as to estimate the relative weight of their contributions in the consensus meetings.

4.5 Re-Evaluate the Process

Finally, the whole processes should constantly be evaluated, analysed and improved. The demand planning process can be complicated and difficult to implement across organisational silos.

5 DEMAND PLANNING MODULE REQUIREMENTS SPECIFICATION

This section contains a table that identifies all functional and non-functional requirements that should be taken into account when evaluating forecasting software. Each requirement references the framework above as to where it is needed. The two columns **Exist?** and **Priority** can be used by the evaluator to decide if a certain functionality exists and how crucial this will be to their application.

Red – Show stopper
Yellow – Needs to be in place
Green – Nice to have

#	Requirement	Comments/Explanation	Source	Exist?	Priority
Functional requirements					
User Grouping					
Users	Different user groups	Different permissions and functionality for different user groups	3.5		
	User groups hierarchy	Different capabilities to overrule other's forecasted based on organisational hierarchy and/or dynamic weighting factors	3.5		
Data Analysis					
Data	Graphical presentation of historical demand data	Visualisation of data to assist manual demand pattern recognition	3.1		
	Classification of products	ABS classification of products. Products with dependent and independent demand	3.2 and 3.6		
	Segmentation of products	All products - category 1 - category 2 - product	2.2		
	Segmentation of geographical regions	Global - country - region	2.2		
	Segmentation of time periods	Year - Quarter - month	2.2		
	Aggregation along all 3 dimensions		2.2.2		
Forecasting, Error Reporting and Human Involvement					
Forecasting	Several forecasting algorithms available		3.3		
	Error measures and calculation of forecast error	Allows seeing how effective forecasting in this case is. Critical for improving forecast accuracy.	4.1		
	Forecasting and displaying forecast values and errors along all 3 dimensions at different aggregation levels	System usefulness for different planning levels	4.2		
	Opportunity to use different forecasting methods for different product and market groups and for different time buckets	More customised and therefore more accurate forecast fitting for different planning levels	4.3		
	Computation of dependant demand	Based on independent demand forecast and BOM	3.6		

Forecasting, Error Reporting and Human Involvement					
Forecasting	Generate forecast error report	Based on forecast error metrics and actual observed demand when available	4.1		
	Highlighting forecasts with a tracking signal greater than 6 or lower than -6	Pointing attention to biased forecast	4.3		
	Graphical presentation of forecasting error data on the same plot as actual observed demand data	Allows seeing the forecasting accuracy graphically	4.3		
	Best-fit function	Automatic suggestion of best-fit forecasting method for a given historical time-series based on the calculated forecast error	3.2		
	What-if analysis/simulation	Assist planning of campaigns and promotions.			
	Human correction of statistical forecast	Correct the statistically computed forecast values	3.4		
	Human insertion of forecasts	Directly type in anticipated forecast values when no computed value available	3.4		
	Traceability of all the human corrections and insertions		3.5		
	Ability to store different forecast values for the same item when forecasts come from different sources	So that it can be agreed on a joint value afterwards. Until a joint value is agreed upon, the forecast made by the party with highest permission level/weighting factor is considered the main value	3.5		
	Overview screen showing different forecast values entered by different parties with the functionality to edit these values or choose the final value if appropriate permissions are granted to the viewer	Support for collaborative forecasting	3.5		
	Weighting factor calculation based on FVA	Calculation of forecast accuracy of each human correction and assigning respective weighting factor to that user/user group	4.4		
	Immediate propagation of changes	Run aggregation of entered forecast values and report conflicts immediately after insertion	2.2		
Non-Functional Requirements					
Interoperability and Integration					
Integration	Import and export of Excel files	Interoperability with other software			
	Integration capabilities with other software via internet	Critical for cross-organisational integration and collaboration			