Aggregation in an Uncertain Production Environment: Secondary Forecasting to Align Production with Demand

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The Project

Human Centric Analytics

Ranyard & Fildes (2015)

Mortensen & Robinson (2015)
Methods & Methodology

**Analytics**
- Forecasting
- Simulation
- Visual analytics
- Data blending and mining
- Decision science

**Behavioural Operations**
- Path dependency
- Cognitive loading

**Action Research**
- Soft Systems Methodology
- Iterative development
Industrial project looking at variability reduction
Blending and visualising data sets has increased visibility of inventory points and markets.
Visualisation and rich data sets mainly used by managers.
New KPI’s such as days to sell, segmentation along export and domestic markets.
Coupled with Lean and ToC practices (continuous improvement 5Y’s) Savings so far: \textit{\textbf{4M reduction in inventory. Inventory turns increased by nearly 40%}}.
Next steps

- In order to reduce inventory further we must increase reliability of supply.
- Management have expressed a desire to level load production due stable demand at higher temporal aggregation.
- Problem domain is ill defined with high dimensionality.
- We are using participative simulation (Tako & Kotiadis 2015) to align production with demand.
Point of Discretisation

Initial packing and first point of discretisation

- Levelled, over two weeks, has dedicated scheduling software within that horizon.
- Fixed times, capacities and batch size choice limited.
- Continuous production.
- Variable yield.
- Long shelf life.
- Volatile BoM

- Levelled as much as possible, over one week.
- Variable short lead times, choice of fixed capacities and batch sizes. Variable process steps
- Liquid product made in batches
- Slight variability of yield/BoM
- Sets shelf life of final kitted product.

- Schedule set here that defines component 2 start.
- Other component parts required, occasional queueing for these.
- Variable WIP not defined as units at present.
- Variable process steps
- Clock is ticking on shelf life while product is here.
- Steps: prepare, test, review and sometimes investigate.

Figure 2
Cross sectional aggregation = to production level, at the quarterly temporal aggregation level = average lead time
Disaggregated at the quarterly level = average lead time
Disaggregated at the monthly level: Current forecast horizon and aggregation i.e. to SKU level
Disaggregated at the weekly level
Disaggregated at the daily level = reaction level
Proposed conceptual model

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<th>Demand</th>
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<td>Easy</td>
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<td>High batch frequency</td>
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<td>Medium batch f</td>
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Lead time and demand empirical distributions along grouped segmented items at each step.

May be able to group steps.

First model simple current system then add fail rates, repeat rates and component arrival rates. Then feedback effects.
Extensive data preparation: Alteryx

Heterogeneous data sources which also require blending across levels requires heavy wrangling
Analytics using R and visualisation using Tableau
One of the main factors driving variation that emerged from participative sessions:

• A back order predictor is driving reprioritisation across the process, driving this is;

1. Components not delivered on time
2. Fails at testing cause repeats and rework
3. Unexpected demand spikes fed through on a daily basis – the MRP runs every night.
Distribution Centers

Forecasting

Demand planners

Change, choose, leave

Master Production Schedule Planners

Dependent requirement Production orders

Material Resource Planning Planners

Allocate material

Manufacture Comp1

Test Comp1

Pass

Combination test

Dispense

Manufacture Comp2

Scrap

Change, leave, schedule

12 wk

24 to 36 m

4 to 6 wk

36 month

Ship

Assembly

Pass

Where the forecast is used
• Multiple Aggregation Predictive Algorithm (Korentzes, Petropoulos & Trapero, 2014)
  • To define what is and what is not suitable for smoothing i.e. aggregating.
  • Finding suitable aggregation volumes and the associated risk which goes with them

• Rolling window measure of variance and/or CV
  • Has been shown to be effective at predicting variance (Boylan & Babai, 2016)
  • CV is liked by the planners due to being normalised but blows up
  • Expected variance can also be used to group items

• Simple CV measure

• Distribution grouping of those with similar demand patterns
MAPA output with Minimum AL = 14wks = LT + plan and MAXL = 2 yr = average critical material stock
Time series with in sample forecast
Black line = forecasted daily, red circles = MAE
MAPA output with MAL = 31 wks and MAXL = 2 yr = average critical material Maximum MAE has increased by 40 per day but still sits at just over 100% of this items forecast.
MAE with MAPA run at MAL = 4wks and MAXL = 52wks the error increases
ecdf(Trial2.data$Sum_Quantity)
ecdf(Trial4.data$Sum_Quantity)
High seller with less erratic history.
MAPA at MAL = 31wks, MAXL = 52wks
Forecast output

MAE

MAE @ 50%
MAL = 26 wk
MAXL = 2 yr
MAE @ 50%
Forecast output

MAL = 14 wk
MAXL = 2yr
MAE @ 50%
Range and mean will be useful
Easier to interpret for the practitioner
Coefficient of Variation at a monthly aggregation @ 0.2 to 0.8
Coefficient of Variation at the daily level @ 0.5 to 2
Conclusions and next steps

- The MAPA can provide information regarding the behaviour of aggregated volumes. Benchmark and try different inputs.
- The groupings need to be decided through using these methods and the simulations run at the non-smoothed and smoothed.
- Using R and the MAPA plus good visual tools is providing valuable knowledge to the demand and planning team in the form of insights into temporal aggregation effects.
- Cross sectional and temporal aggregation needs to be built into decision tools for smoothing the demand input to ameliorate risk.
- The MAPA method has the potential to aid decisions regarding batch sizing.