Raw Material Inventory Strategy for Make-to-Order Manufacturing

Authors: Vikash Chandra, Michael Tully
Advisor: Fredrik Eng Larsson

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Agenda

- Context
- Current Structure
- Approach
- Results
- Questions
High growth rate sustained for the last decade
The focus was market share

Make-to-Order manufacturer
  Short lead times
  High service level

Legacy inventory policies untouched
  Have worked reasonably well

High value of finished goods in comparison to raw materials

FMCG manufacturer
So why change inventory policies and why not do it the conventional way?

Suppliers' service levels are variable

- Supplier service levels (SSL) are variable and can greatly impact production
- The actual quality of the raw material is the problem
- Switching to another supplier not always practical

*Can Inventory policy changes mitigate the effect of SSL decline?*

Cost information not available

- Traditional inventory policy determination requires cost and/or service level information
- Trade-off information is needed in order to devise strategies
- An evaluation tool is more appropriate to help understand policy change effects

*Can a model for testing the effects of inventory policy changes be built without cost information?*
Current Structure

Two echelon, centralized inventory management

Consignment

 Expedited  Regular

 Transshipment

 Plant 1  Plant 2
Current Structure contd.

**Demand**
- Make-to-Order and forecast errors limit demand visibility
- Sudden spikes in demand can trigger the ordering cycle

**Replenishment**
- Decision based on days on hand (DOH)
- Different shipments have different DOH levels

**QA & Backorders**
- Packaging allows limited inspection
- Real check just before production
- Backorders completed as soon as possible

**Transportation**
- Regular shipments preferred
- Regular shipment cost is included in material costs
Approach

Understand current process
- The current processes are deeply embedded in organization
- Improve the process for practical application

Find cost substitutes
- Hard to put a cost to different shipments, inventory holding costs, etc.
- Number of events give a better understanding to management

Identify key metrics
- Key criteria is to meet production plan
- Production Fill Rate (PFR) is the measure of adherence to production planning
- In conjunction with shipments and inventory levels

Decide mathematical formulation
- Numerical model or simulation model?
- Flexibility and ease of future usage by sponsor main concerns
Shipment mode depends on requirement urgency and availability.

The consignment must have enough to ship.

To transship, the sending plant must hold back a certain amount to cover its own requirements. This level is the hold back level.

DOH sufficiency is measured.

Re-order point is 15 DOH inventory.

Order quantity is for further 15 days.

DOH can fluctuate suddenly because of quality failures.

Every effort is made to ensure full truckload shipment.
## Key metrics and cost factors

1. **Production Fill Rate**
   \[ \text{Production Fill Rate} = \frac{\text{Production quantity fulfilled on time}}{\text{Total production quantity}} \]

2. **Regular shipments**
   \[ \text{Regular shipments} = \text{Number of regular shipments in a year} \]

3. **Expedited shipments**
   \[ \text{Expedited shipments} = \text{Number of expedited shipments in a year} \]

4. **Transshipments**
   \[ \text{Transshipments} = \text{Number of transshipments in a year} \]

5. **Average inventory**
   \[ \text{Average inventory} = \frac{\text{Sum of daily starting inventory}}{365} \]

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**Note:** All metrics are averaged over two plants
### Which model to use?

<table>
<thead>
<tr>
<th>Numerical Model</th>
<th>Simulation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Provides the optimal solution</td>
<td>&gt; Does not provide optimal solution but can be a good <strong>evaluation tool</strong></td>
</tr>
<tr>
<td>&gt; Harder to formulate</td>
<td>&gt; Easier to implement</td>
</tr>
<tr>
<td>&gt; Without cost info, certain values cannot be deduced</td>
<td>&gt; Can work with number of events instead of costs</td>
</tr>
<tr>
<td>&gt; Less flexible</td>
<td>&gt; Flexible, modifications easier to implement</td>
</tr>
<tr>
<td>&gt; Future changes can be difficult to add</td>
<td>&gt; Easy to use within sponsor organization</td>
</tr>
</tbody>
</table>
**Solution approach**

- The possible combinations of parameters under various inventory policies is extremely high
- Need to reduce the number of combinations

**Phase-1**

- Decide the transshipment hold back level
- Test this hold back level at different SSL and standard deviations of demand
- Fix the chosen value for the use in next phase

**Phase-2**

- With the assigned hold back level, simulate for different combinations of the re-order point and re-order quantity \((R,Q)\) \((s,S)\)
- Record the results in terms of events
- Check the sensitivity of the different policies for various SSL and standard deviations of demand
In the absence of cost information, a comparison can be made between improvement in production plan adherence and the costs incurred in terms of events to achieve that performance.

Results
### Phase-1 Fix hold back level

<table>
<thead>
<tr>
<th>Std Dev Multiplier / Policy / Policy Parameters</th>
<th>0.75 (s,S)</th>
<th>1 (s,S)</th>
<th>1.25 (s,S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFR (%)</td>
<td>95.69%</td>
<td>95.56%</td>
<td>95.11%</td>
</tr>
<tr>
<td></td>
<td>95.52%</td>
<td>95.54%</td>
<td>94.98%</td>
</tr>
<tr>
<td></td>
<td>95.57%</td>
<td>95.42%</td>
<td>95.00%</td>
</tr>
<tr>
<td></td>
<td>95.35%</td>
<td>95.29%</td>
<td>95.05%</td>
</tr>
<tr>
<td></td>
<td>95.48%</td>
<td>95.22%</td>
<td>94.90%</td>
</tr>
<tr>
<td></td>
<td>95.35%</td>
<td></td>
<td>95.06%</td>
</tr>
</tbody>
</table>

**Hold back level**

- Current value of 15 can be improved
- Lower hold back levels enable more transshipments, especially with low SSL
- Better distribution of raw materials
- Improves the PFR slightly and generally gives better results

**SSL = 97%**
**Results contd.**

<table>
<thead>
<tr>
<th>Std Dev Multiplier / Policy / Policy Parameters</th>
<th>PFR</th>
<th>SSL = 91%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0.75 (s,S)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>74.46%</td>
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</tr>
<tr>
<td>73.69%</td>
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<tr>
<td>72.74%</td>
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<tr>
<td>73.02%</td>
<td>73.02%</td>
<td></td>
</tr>
<tr>
<td>71.23%</td>
<td>71.23%</td>
<td></td>
</tr>
<tr>
<td>71.00%</td>
<td>71.00%</td>
<td></td>
</tr>
<tr>
<td>70.66%</td>
<td>70.66%</td>
<td></td>
</tr>
<tr>
<td><strong>1 (s,S)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>73.02%</td>
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<td>71.23%</td>
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<td>71.00%</td>
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</tr>
<tr>
<td>70.66%</td>
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<tr>
<td><strong>1.25 (s,S)</strong></td>
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</tr>
<tr>
<td>70.10%</td>
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<tr>
<td>68.85%</td>
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<tr>
<td>68.87%</td>
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<td>68.14%</td>
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<tr>
<td>69.12%</td>
<td>69.12%</td>
<td></td>
</tr>
<tr>
<td>68.35%</td>
<td>68.35%</td>
<td></td>
</tr>
<tr>
<td>67.51%</td>
<td>67.51%</td>
<td></td>
</tr>
</tbody>
</table>
## Results contd.

### Phase-2 Vary inventory policy specifics and record events

**Policy / Policy Parameters**

<table>
<thead>
<tr>
<th>Phase-2</th>
<th>Vary inventory policy specifics and record events</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R,Q)</td>
<td>[Graph showing varying percentages]</td>
</tr>
<tr>
<td>(s,S)</td>
<td>[Graph showing varying percentages]</td>
</tr>
</tbody>
</table>

**SSL = 97%**

**Shipment Type**
- Transshipments
- Expedited Shipments
- Regular Shipments
Results contd.

Sensitivity Checks - SSL

- PFR is highly sensitive to SSL changes.
- A 2 percentage points reduction in SSL can have up to 5 percentage points reduction in PFR.
- The number of shipments will need to be much higher to meet the old PFR requirements.
Sensitivity Checks – standard deviation

Sensitivity to standard deviation changes

> PFR is comparatively stable to standard deviation changes
> Same policy can be applicable over a wide range of SKUs

SSL = 97%
**Can inventory policies offset SSL decline?**
No, but it can help mitigate the damage. To a certain extent, PFR can be recovered.

**What to do immediately?**
Reduce the hold back level for transshipment. This will help the PFR improve slightly.

**The current system not good enough?**
The current system places large order constraints on the consignment which then needs to be replenished itself.

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**Results**
- Increase reorder point
- Reduce reorder quantity
- Increase frequency of shipments
- Analyze event-based tradeoffs

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**Long term recommendations?**
Increase the re-order point and decrease the order quantity. This will improve PFR but will increase costs elsewhere.

**Change the supplier?**
To overcome the drop in PFR due to low SSL, the ultimate solution is to find a better supplier

**Can’t change supplier?**
Incentivize the supplier to increase the SSL. It will probably be money well spent.

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**Results contd.**
Thank You!