KEY INSIGHTS

1. Stock levels are frequently set to achieve an off-the-shelf fill rate with inventory optimization software, while supply chain performance is measured by speed of service. Simulation can resolve this often costly disconnect.

2. The right inventory segmentation strategy can lower inventory investment in consumable parts as much as 20% while increasing performance on speed of service metrics.

3. To be successful, technical solutions and their implementation must be aligned. An internal review board that meets monthly, and an acquisition policy that provides quarterly funding, were each shown to degrade performance by unwittingly changing the review policy for stock levels.

Introduction

Heavy industries operate equipment having a long life to generate revenue or perform a mission. These industries must invest in the specialized service parts needed to maintain their equipment, because unlike in other industries such as automotive, there is often no aftermarket supplier. If parts are not on the shelf when needed, equipment sits idle while replacements are manufactured.

Consumable parts, often grouped by segment, are commonly optimized to fill rate targets. Supply chain performance is frequently gauged against a speed of service measure such as Order Fulfillment Lead Time (OFLT), the time from order placement to customer receipt. This research evaluates inventory segmentation strategies for consumable parts, as measured by OFLT and inventory investment, by analyzing an industry representative dataset.

Simple Strategy Segmenting Inventory on Cost

A simple strategy segments parts into A and B categories based on unit price, as shown in Figure 1. Each segment is optimized separately to a fill rate goal using a commercial inventory optimization model.¹ A business rule ensures that all parts are at least stocked to the Economic Order Quantity (EOQ) amount, ensuring a minimum 50% fill rate by part. This simple strategy is common in heavy industry.

Consumable parts for Segments A and B were ranked from lowest to highest unit price on the horizontal axis, compared to cumulative part count on the vertical axis, and graphed in Figure 1. Since an inventory optimization model uses a technique known as a “greedy heuristic” to select the lowest cost mix of spares required to achieve a given fill rate goal, this means that for Segment A, 1¢ parts are competing with $1,740 parts on “bang for the buck” to increase fill rate. Since this strategy achieves fill rate goals without stocking many expensive parts, the business rule was added in an attempt to better balance the mix of parts.

**Sophisticated Strategy Segmenting Inventory on Consumption**

A sophisticated strategy segments parts into ABCDE categories based on consumption (annual demand multiplied by unit price), as shown in Figure 2.

![Diagram of consumption vs. cumulative part count](image)

Figure 2 – **Sophisticated strategy** for inventory segmentation, segmenting consumable parts on consumption (top), and showing annual consumption vs. cumulative part count (bottom).

Decision rules for managing parts, when using an ABCDE strategy, balance an asset manager’s time against the benefit of in-depth analysis:

- **Class A** parts should be carefully tracked by asset managers. Instead of placing an order, could the asset manager transfer existing items to eliminate an imbalance of inventory between locations? Could the buyer reduce unit cost through competition among suppliers?
- **Class B** parts are in the mid-range, and should receive moderate attention, with management by exception rules flagging asset managers when close attention is warranted.
- **Class C** parts should be managed with simple decision rules. The value of an asset manager’s time in researching stockouts is greater than the holding cost incurred from high fill rates. These parts should be managed electronically to target stock levels, without human intervention.
- **Class D** parts cost from $1 to $25, and should be managed with simple decision rules to achieve high fill rates.
- **Class E** parts cost $1 or less, and should be managed with simple decision rules to achieve very high fill rates.

**Hypothesis**

This research tests the hypothesis that the sophisticated strategy, which segments consumable parts on consumption, will outperform the simple strategy, which segments on cost, when measured on both Order Fulfillment Lead Time and inventory investment.

**Methodology**

A previously published discrete-event simulation of warehouse operations was linked to a new Monte Carlo demand categorization and metrics simulation, resulting in the ability to predict tomorrow’s supply chain performance from today’s logistics data. The linked simulations analyze supply chain data from a representative industry dataset and historical orders from operating organizations maintaining equipment.

Required supply chain data includes the inputs (current on hand, due-in, and backorder inventory position, demand, condemnation rate, lead time, and price) and outputs (target stock level, reorder point, and reorder quantity) of commercial inventory optimization software. Also required are historical requisition data (part number, order quantity, and date), shipping performance data (days shipping delay by requisition, priority by requisition), performance (as reported within a company), and operational data, including equipment delivery schedule and future operating hours by period.

Unlike most supply chain simulations, which require an extended warm-up period and estimate only steady state conditions, these linked models take into account the existing state of the supply chain, due-in orders with scheduled delivery dates, and optimized stock levels and reorder points in order to estimate OFLT over time, as of the exact date of the data pull. By eliminating the warm-up period, these simulations extend the state of the art to provide short-term in addition to long-term predictions of performance to service metrics.

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Further, this methodology demonstrates how complex legacy simulation models can find new life by analyzing their results with companion simulations that measure contemporary metrics.

**Results:** Sophisticated Strategy Outperforms Simple Strategy

First, the null hypothesis -- that there is no difference between inventory segmentation strategies when measured on OFLT -- is rejected with a 95% level of confidence. At the start of the simulation, orders are placed to bring inventories for parts at or below reorder point up to the target stock level. Performance improves as these parts arrive in the warehouse after manufacturing lead time. Indeed, simulation results for high priority consumable parts indicate that by August 2013, the mean OFLT for the sophisticated strategy will achieve the desired goal, as indicated by the vertical dashed green line in Figure 3, unlike the simple strategy, which fails to meet goals.

![Figure 3](image)

*Figure 3 – Stock levels for consumable parts using the sophisticated strategy outperform the simple strategy, achieving Order Fulfillment Lead Time goals by August 2013 (dashed green vertical line). Imposing 30-day, 90-day, and 360-day resupply periods on the simple strategy degrades performance over time.*

Second, the sophisticated strategy also achieves a 20% reduction in investment compared to the simple strategy. This was unexpected, because the latter skews stock levels in favor of low unit price parts. A business rule requiring a minimum 50% fill rate by part was added to improve the parts mix, reducing the benefits of cost optimization in the simple strategy. Given the reduction in investment, another iteration of the sophisticated strategy, increasing Segment A parts to 92% fill rate and Segment B parts to 95%, should be evaluated to further improve performance and increase the margin for error.

**Stocking Policy**

Stocking policy, review policy, and acquisition policy go hand in hand. A continuous review stocking policy is appropriate for a flexible contract that funds purchases when stock levels fall to reorder points.

A review board that meets monthly to approve orders results in a de facto periodic review policy. Similarly, quarterly or annual funding cycles result in a periodic resupply contract. In these cases, the stocking policy must be changed from continuous review (with frequent buys to stock level) to periodic review (with monthly, quarterly, or annual buys to stock level). The appropriate review period must be added to the procurement lead time. The stock levels recommended by an inventory optimization model increase as the review period increases.

The key to understanding the impact of the review period and acquisition policy is realizing their effect on OFLT metrics, also shown in Figure 3. A monthly spares requirements review board imposes a 30-day delay on placing orders, resulting in about a five percentage point penalty on OFLT, sufficient to cause an organization to continuously miss goals. The 90-day delay incurred from a quarterly acquisition policy drops performance another few percent. The 360-day delay incurred from an annual acquisition policy degrades performance over time.

**Conclusions**

Heavy industry can achieve supply chain service metrics, lower inventory investment, and lower asset management costs by drawing inferences from this analysis. Based on results from the industry representative dataset:

1. Organizations that stock service parts can lower inventory investment in consumable parts by as much as 20% and increase performance on speed of service metrics using a more sophisticated segmentation approach.

2. Organizations must be cognizant that review policy and acquisition policy impact results. Automating the reorder of parts in the CDE Segments eliminates the pipeline stock required by the review period, and allows asset managers to focus their analysis on critical A and B Segments. Authorizing flexible funding eliminates the need to add additional months of pipeline stock to compensate for funding cycles.

3. Supply chain simulation not only can reveal whether service goals are achievable, but when, and with what confidence.

In summary, inventory segmentation is a straightforward technique for improving the mix of service parts which benefits heavy industry when aligned with review policy and acquisition policy. The maintainers servicing an organization’s heavy equipment receive the parts they need. The availability of equipment to generate revenue or perform a mission increases. It’s a winning strategy.