Powering Your

with Data

AUTOMATED STATISTICAL ANALYSIS DRIVES INVENTORY MANAGEMENT EFFORTS

Thomas R. Willemain, PhD

SUPPLY CHAIN AND OPERATIONS management professionals recognize the importance of inventory management to both customer satisfaction and cost control. They also understand the inherent tension between the goals of customer satisfaction and cost control: In short, doing better on one puts a strain on the other. Easing this tension relies on finding the optimal balance point where customer service goals can be met with the lowest possible inventory investment.

To achieve this, it's necessary to exploit the available data about customer demand. This process involves three distinct but related tasks: measuring current performance, identifying the improvements that need to be made, and determining how to move from the current situation to something better.

Powering Your SKUs with Data

Measure current performance

Very few companies take the time to measure their inventory management performance. It is much more common to assess forecast accuracy—probably because it is easier to do. Imagine what it would be like to manually conduct a thorough audit of inventory performance. Employees would begin by picking a period of observation—say, 90 days. They would keep track, every day and for every stockkeeping unit (SKU), of not only item demand, but also on-hand inventory levels and related key performance indicators (KPIs). These would include service levels, fill rates, and ordering costs. Such a manual audit would be quite an effort, particularly if it involved thousands, or even tens of thousands, of SKUs. And it would all need to be done again every so often to track KPIs over time. In the end, people might know where the business stands, but would there be a clear path to improvement?

On the other hand, combining data collection with statistical modeling offers meaningful advantages compared with a manual performance audit. The key data input is something the firm probably already has: demand histories for all SKUs. Using this demand data, the estimation of KPIs can be done statistically, and those calculations would be automatic across as many SKUs as necessary. When new demand data arrives, all of the calculations can be updated as necessary, requiring the attention of only a few people. Plus, in contrast to a manual audit, the statistical approach lets employees examine what-if scenarios and predict the costs and benefits of changes in the way inventory is managed.

Identify improvement goals

Imagine that current KPIs have been measured, either manually or via statistical inference from each SKU's demand pattern. At a typical company, serious imbalances would be discovered. At the SKU level, the business would be over-invested in certain items and under-invested in others. At the overall (fleet) level, average KPI values also could be less than stellar. It is easy for inventory management to devolve into an imbalanced and unsatisfactory state. Frequently, reorder points have accreted through time like a coral reef, leaving a jagged collection of old decisions that are no longer suited to current market conditions. Sometimes they were made without any systematic thinking at all.

Order quantities also can be set incorrectly, often because they are subject to negotiation with—if not outright decreed by—suppliers. Meanwhile, misalignment of departmental goals can lead to misalignment of performance with those objectives. For instance, inventory managers might know precisely the best order quantity for every SKU, but purchasing agents deviate in order to strike deals with suppliers.

Making proper choices for reorder points and order quantities is a tactical job that can be done using statistical data analysis. The strategic task is to decide what targets to set for the various KPIs. Usually, this involves keeping an eye on the dollar investment represented by on-hand stock, treating the total investment as either a hard or soft constraint. It also involves setting targets for service levels, fill rates, and perhaps metrics such as inventory turns or annual number of orders. Choices for these non-financial measures may vary for different subsets of SKUs—for example, higher targets for critical customers, items with longer lead times from suppliers, higher-volume items, or higher-margin items.

Complicating matters is the fact that targets cannot be set for individual KPIs without attending to the consequences for all others. Performance metrics are linked, so setting targets for some without regard to others can trap employees into committing to a set of incompatible targets.

Automating the analysis of demand data can help by revealing the quantitative details of important trade-offs. For example, say it is decided that the service-level target on item X must be increased from 90 percent to 99 percent because that item is critical to an important customer and a big revenue generator. Statistical modeling can estimate

how much the increase in service level would cost in terms of an increase in dollarized on-hand inventory. As a byproduct, automation also will compute what reorder point would enable attaining the 99 percent target.

From now to better

The key levers for controlling inventory KPIs are reorder points and order quantities. Choosing values for this pair of control quantities for every SKU is a big job. Plus, the link between choices and the consequent levels of KPIs is difficult to see. Of the two, order quantity is usually more challenging to optimize because it often is subject to negotiation with suppliers. Or, as noted previously, inventory managers may know the best order quantity, but purchasing agents deviate. Reorder points are more directly under the control of inventory specialists and generally have a greater influence on KPIs such as service level and fill rate. A manual performance audit does not reveal how to move KPIs to their new target levels as effectively as

Figure 1: Diagnosis of current operations and assessment of two proposed changes

As-is service level versus cost	99 percent maximum service level	99 percent maximum service level and 80 percent minimum service level
Average service level: 84.78%	Average service level: 84.70%	Average service level: 87.96%
Average fill rate: 41.71%	Average fill rate: 41.68%	Average fill rate: 54.70%
Sum of inventory level: 1,670,747	Sum of inventory level: 1,123,009	Sum of inventory level: 1,528,357
Total inventory turns: 1.3 per year	Total inventory turns: 1.9 per year	Total inventory turns: 1.4 per year
Service-level distribution	**Service-level distribution**	**Service-level distribution**
100% = 74 items, 11.84%	100% = 0 items, 0.00%	100% = 0 items, 0.00%
95–99% = 85 items, 13.60%	95–99% = 161 items, 25.76%	95–99% = 152 items, 24.32%
90–94% = 126 items, 20.16%	90–94% = 122 items, 19.52%	90–94% = 96 items, 15.36%
80–89% = 166 items, 26.56%	80–89% = 181 items, 28.96%	80–89% = 377 items, 60.32%
70–79% = 114 items, 18.24%	70–79% = 97 items, 15.52%	70–79% = 0 items, 0.00%
60–69% = 28 items, 4.48%	60–69% = 32 items, 5.12%	60–69% = 0 items, 0.00%
50–59% = 11 items, 1.76%	50–59% = 11 items, 1.76%	50–59% = 0 items, 0.00%
<50% = 21 items, 3.36%	<50% = 21 items, 3.36%	<50% = 0 items, 0.00%
Fill-rate distribution	**Fill-rate distribution**	**Fill-rate distribution**
100% = 41 items, 6.56%	100% = 0 items, 0.00%	100% = 0 items, 0.00%
95–99% = 84 items, 13.44%	95–99% = 127 items, 20.32%	95–99% = 125 items, 20.00%
90–94% = 24 items, 3.84%	90–94% = 22 items, 3.52%	90–94% = 26 items, 4.16%
80–89% = 46 items, 7.36%	80–89% = 48 items, 7.68%	80–89% = 74 items, 11.84%
70–79% = 34 items, 5.44%	70–79% = 31 items, 4.96%	70–79% = 74 items, 11.84%
60–69% = 16 items, 2.56%	60–69% = 18 items, 2.88%	60–69% = 26 items, 4.16%
50–59% = 26 items, 4.16%	50–59% = 27 items, 4.32%	50–59% = 76 items, 12.16%
<50% = 354 items, 56.64%	<50% = 352 items, 56.32%	<50% = 224 items, 35.84%

statistical modeling of demand data. Such automation can expose that linkage.

An example

Figure 1 shows how statistical data modeling can be used to diagnose current operations and then assess the impact of proposed changes. The analysis pertains to a sample of 625 supply items at a medical center. The left column shows how current choices for reorder points play out in terms of service level, fill rate, inventory investment, and inventory turns. Averaging across all the items, the service level is approximately 85 percent, the fill rate is only 42 percent, and inventory turns average 1.3 per year. These overall average metric values may be deemed unimpressive on an inventory investment of almost $1.7 million.

Looking in more detail at the service levels across items, there are 74 items with essentially a 100 percent service level. In almost all cases, this indicates a gross overstocking, which amounts to a cost-saving or cost-shifting opportunity. At the other end of the scale, there are 21 items with service levels below 50 percent—worse than the odds of a coin flip. Things go downhill even more with regard to fill rates, where more than half of the items (354) have rates below 50 percent. These distributions illustrate that resources could be shifted around within the same budget. Alternatively, they suggest an increase in the budget or some combination of shifting and increasing.

The middle column shows the results of a proposed change characterized by setting 99 percent service-level targets for the 74 items currently running at 100 percent service levels. The resulting budget reduction amounts to a savings of about $500,000. This increases inventory turns from 1.3 to 1.9 each year, though it does essentially nothing for the items currently starved for investment. At the very least, this proposal looks like an improvement.

The right column shows the effect of going further: not only reducing the highest service levels to 99 percent, but also boosting all other items' service levels to at least 80 percent. Of course, this improves the average service levels and fill rates, but it does so at the cost of taking back some, but not all, of the budget savings. The net result of this set of changes is to improve customer service slightly while achieving a savings of about $100,000. The improvement is greatest for fill rate, where the average goes from 42 percent to 55 percent, and fill rate distribution, with the proportion of items with fill rates below 50 percent dropping from about one-half of the items to about one-third of them.

This example reveals how statistical data analysis of inventory demand can provide a diagnosis of current operations and an analysis of possible options for improvement. Of course, automated solutions cannot make strategic value judgments. Both of the proposed changes are attractive, but which is preferable?

Where forecasting fits in

Focusing on continuous improvement of forecasting accuracy is a good and necessary professional practice, and it benefits inventory management because the calculation of reorder points depends on, in part, good forecasts of an item's average demand, which will come in during its replenishment lead time. But two items with the same average demand and lead times can require very different reorder points. The key factor is the degree of demand volatility. Volatility is the enemy of customer service, as instability carries with it a greater risk of an uptick in demand that can strain supply, leading to stockouts and lost or backordered sales. Because forecasting almost always focuses on predicting the typical, and inventory management focuses on the atypical, good forecasting is not enough to ensure good customer service.

Inventory management requires a forecast that determines expected demand during the replenishment lead time. Unlike a longer-term business forecast, which might be a rolling 12-month view, the lead-time forecast is item specific and usually has a much shorter horizon—perhaps 1, 10, or 20 days. As a result, the lead-time forecast is not suited to the consensus-building process common to sales and operations planning. This is where automation can make a difference. The lead-time forecast can be combined with safety stock calculations to find, for every planned item, the reorder point that achieves the desired balance between availability and investment.

In this way, automation enables the statistical analysis of tens of thousands of items, the assessment of results at a portfolio level, and the strategic distribution of inventory dollars. And the outcomes are readily implemented, as returning the right-sized reorder points to the organization's material requirements planning or procurement application will implement the desired strategy. Best of all, measuring results monthly helps confirm that inventory management processes are on the right track.

Thomas R. Willemain, PhD, is senior vice president and cofounder of Smart Software and professor emeritus of industrial and systems engineering at Rensselaer Polytechnic Institute. He may be contacted at tomw@smartcorp.com.

To comment on this article, send a message to feedback@apics.org.