

Inventory Optimization: A Necessity Turning to Urgency

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*Counter your supply chain uncertainties
with inventory optimization techniques
and technologies*

A key concern for global manufacturers today is reducing inventory and inventory driven costs across their supply and distribution networks [1]. Pressure to cut inventories continues to build for several reasons. Manufacturers no longer manage linear or stable supply chains. They juggle vast supply networks. Globalization of the supply network and supply base drive higher inventories and make cutting inventory more difficult. Globalization among consumers is putting pressure on product availability, prompting manufacturers, distributors and retailers to upgrade their stock keeping policies. Emerging market consumers are becoming as demanding as those in developed markets. These challenges are exacerbated by manufacturers' own product development decisions. The drive to innovate and increase the rate of new product introductions leads to high rates of new technology adoption for next generation products, putting enormous pressure

on inventory management across extended supply chains.

In this context, manufacturers have difficulty reducing inventory with traditional or even advanced inventory management techniques. Today's global manufacturers have largely hit limitations in leveraging material requirements planning and management processes and systems to cut inventories. Even advanced inventory management techniques, such as sales and operations planning or developing demand-pull replenishment systems with suppliers using Kanbans, have been either embraced or found to deliver less impact on overall inventory reduction than anticipated.

In the last few years a new paradigm has emerged: where one finds operations teams and planning teams of the manufacturer applying the latest techniques and technologies to improve inventory visibility, control and management across the extended supply network.

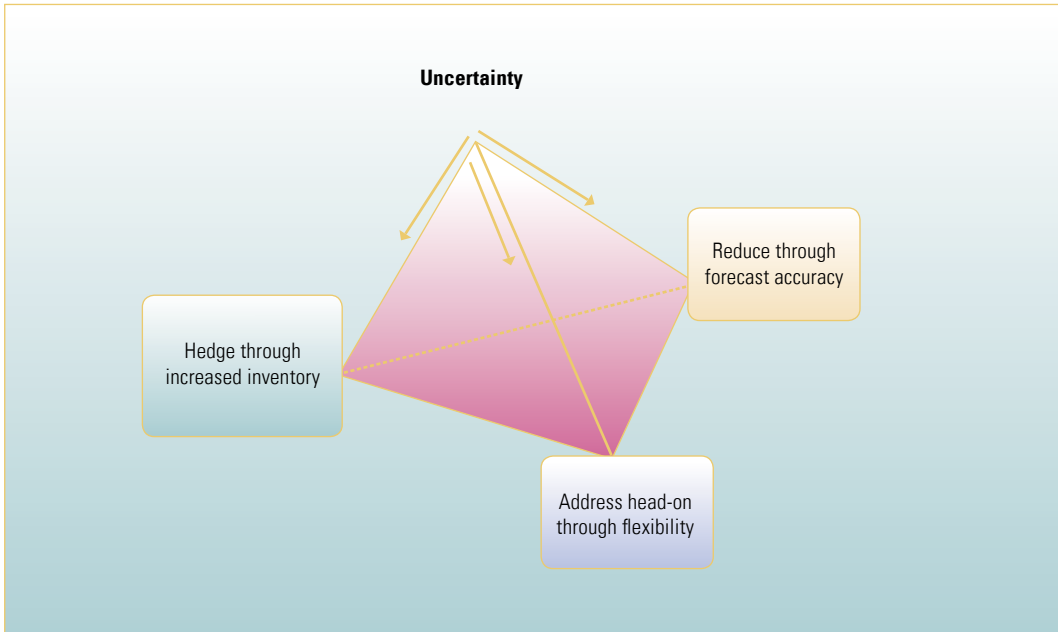


Figure 1: Addressing Uncertainty through IO Techniques

We call this collection of efforts as Inventory optimization. Inventory optimization helps discrete manufacturers control inventory driven costs and address today’s demand volatility and supply chain complexity.

We discuss several trends in inventory optimization including opportunities to apply this new technology to solve more than just high inventory costs. Inventory optimization can enable smarter product launches, lower direct material cost of goods and faster manufacturing and distribution execution.

NEED FOR OPTIMIZING INVENTORIES

There are several reasons manufacturers are increasing focus on optimizing inventory by applying the latest tools and techniques for inventory control. Traditionally, competitive pressure has always driven manufacturers to seek enhanced capabilities to reduce inventory

levels; to enhance service levels and supply availability; and to establish the right product inventory mix and level in each geography and channel. Many manufacturers also focus on inventory as part of shifting their operations to achieve demand-pull replenishment across their supply network – hoping to achieve the performance demonstrated by leading manufacturers who have succeeded in this such as Dell, Procter and Gamble, Nokia, and Toyota Motor [2].

A key driver of the renewed focus on inventory lies in the recognition that traditional techniques are failing to reign in inventories in the wake of increased supply chain complexity. This complexity is characterized by increased uncertainty. Demand is more volatile and therefore less predictable. This is true not only for aggregate demand but for forecasting splits and volumes across channels and

markets. Traditionally, three strategies have been employed by manufacturers to address uncertainty: (a) increase inventory levels to hedge against uncertainty, (b) develop supply chain flexibility to be more responsive to uncertainty, (c) improve forecast accuracy so that less uncertainty propagates to the manufacturing floor. Inventory optimization techniques and technologies map to the flexibility and accuracy strategies [Fig. 1].

What is driving the dramatic increase in the complexity (and therefore uncertainty) of managing large supply and distribution networks? Globalization is one big driver, the evolution of emerging markets such as China and India present new challenges in effective product distribution with low inventory levels. Globalization of supply networks means that key functions such as R&D, product design and manufacturing are now geographically spread out, which hampers inventory reduction efforts, that are often best executed by a cross functional team working together very closely. Increased rates of new product introduction and product innovation are also driving complexity into supply networks. Finally, because increases in transportation and logistics options have made careful control and planning of in-transit or pipeline inventory difficult, manufacturers are tending instead to let inventory drift upwards.

INVENTORY OPTIMIZATION DEFINED

Inventory Optimization (IO) is the application of a range of latest techniques and technologies for improving inventory visibility, control, and management across an extended supply network. As we will illustrate later in this paper, these techniques and technologies are driving improvements beyond what traditional inventory management techniques – even advanced techniques – have been able to deliver.

IO Techniques

IO techniques apply rigorous and discrete analysis to analyzing inventory performance. They then use the analysis to identify product-specific changes to inventory stocking and replenishment policies; to identify the supply network configuration; or, to correlate inventory investments to item revenue or profit generation.

On the planning side, a key inventory optimization technique is profit-driven analysis, where the profit each individual product contributes is ranked; a pareto distribution is developed to separate high profit products from lower profit products; and inventory holding policies are adjusted to cut inventory on low ranked products and increase inventory on high ranked products, resulting in an intelligently applied net inventory reduction.

On the execution side, manufacturers are striving for IO by applying improvement concepts based on lean principles, and by expanding the use of collaborative and demand-pull replenishment schemes such as vendor- or supplier-managed inventory to drive highly precise replenishment and fulfillment activity. These techniques are also benefiting from improved supply chain planning and control. Lean seeks to optimize inventory by driving out non-value added inventory management tasks in the factory or warehouse and by improving planning and control at a granular level across each manufacturing or distribution step. Vendor- or supplier- managed inventory schemes seek to share risk and offload inventory ownership.

IO Technologies

A key inventory optimization technology is the IO engine. IO engines reveal opportunities to cut inventory by analyzing inventory performance holistically - looking at data from across the

“Classic” Inventory Management	“Advanced” Inventory Management	Inventory Optimization	Advantage of Inventory Optimization over prior methods
Material Requirements Planning (MRP)	Constraint based planning (APS)	IO Engine	Better characterizes demand uncertainty and lead time variability Advanced modeling Integrates with MRP and APS
Days of Supply rules for setting inventory levels	ABC Classification	Profit-Driven Analysis	Rationalizes inventory with minimal impact on revenue /profit
Cycle counting	Materials Management system	Closed loop planning and analytics with inventory control via exception management	Provides more predictable control over material flows Enables faster re-configuration of supply chain Supports smoother absorption and handling of unexpected supply or demand swings impact
No control over production Scheduling	Resorts to Chase techniques	Optimizes considering production and transportation batches	Better synchronization between Production and dispatch

Table 1: Different Types of Inventory Management and Control Techniques

Source: Infosys Research

extended supply network. They integrate with Advanced Planning and Scheduling systems and Material Requirements Planning systems to incorporate policy updates into the supply chain planning cycle. IO engines identify ‘smarter’ inventory holding rules and replenishment policies that increase overall supply chain planning accuracy. “Smarter” typically means applying these policies at a more discrete level, such as at an item /stock keeping location combination level instead of just at the item level.

IO engines characterize supply network uncertainty present in a variety of specific steps or links in manufacturing and distribution processes using advanced mathematical

(non-linear, algorithmic, etc.) models that are then solved to identify optimal inventory policies, stocking locations, or quantities. The uncertainties addressed by IO engines include: demand uncertainty (or forecast error), cycle time variability and replenishment lead time variability. The output of running an IO engine is fed back to the ERP, constraint based planning, or other discrete planning system, adjusting inventory policies as a finite level. IO engines have a range of applications, from modeling and optimizing safety stock across the supply chain to identifying optimal re-order point sizes in environments with highly erratic demand.

The rise in interest in IO engines is likely linked to their increased ease of use and

accessibility over time. In the last few years, a new generation of technology and related software vendor community has developed around IO engines [3]. The latest IO engines bring the computational horsepower to solve very large optimization problems quickly.

We make a distinction between inventory optimization engines as a new technology and a broader collection of concepts, techniques and technologies called inventory optimization.

In spite of the significant advantages available from the latest IO techniques and technologies, leveraging them effectively requires much more data than traditional or “advanced” inventory handling techniques. This is a valid concern some manufacturers express when planning to leverage these techniques. A second concern is frequently raised around the complexity of the calculations, formulae and mathematics employed. For traditional techniques and even for most advanced approaches, the computations required are limited to simple calculations and straightforward mathematical formulae, which are simple to communicate and explain to teams outside the supply chain function including upper management. For inventory optimization however, typically higher order calculations, including complex equations in algebraic or calculus forms, are used. Understanding and deriving meaningful results from these calculations requires a deeper mathematics background and greater computing power.

Despite all the complexity, IO techniques and technologies are gaining ground and finding more and more applications because of recent advances in information technology and far greater computational power available at the disposal of today’s supply chain architects. Similar advancements on the operations research front have also led to newer

ways to solve complex mathematical equations in acceptable time durations. This progress is a key reason for manufacturers to have applied IO techniques across a wide range of problems in their supply, manufacturing, and distribution networks.

APPLICATION AREAS

IO techniques and technologies are being applied within both supply chain planning and execution processes. Manufacturer are using these enhanced capabilities to cut inventory, enhance service levels and maximize return on investments by setting the right inventory levels in the right production lines and distribution channels.

Application of an IO approach depends on a deep understanding of the existing environment around the supply chain. An accurate knowledge of the various cost elements of the supply chain, along with a good understanding of existing lead time and demand variability is required to model the process correctly. Modeling also demands a proper and accurate definition of the optimization objective. Some suitable objectives can be minimization of costs, maximization of revenue or maximization of profit. One also needs to define business related constraints in unambiguous terms. Examples of such constraints are the process capacities of various plants, demand limitations of various customers and service time commitments between different chain partners.

A mathematical representation of these objectives and constraints represents the model for the subject supply chain. Typically, factors that drive the business constraints or the defined optimization objective, or both are nonlinear in nature. In addition, the optimized value of the IO objective function is point in time value that changes over time as component parameters in the function change. The same

is true for the constraints as well. For example, assume there is a constraint on total man hours available for production. As the number of production units increase, the man hour per unit shall decrease at some rate, resulting in non linearity in the constraint. Characterizing this dynamic is difficult using traditional analysis, inventory optimization is an ideal approach for the complex mathematics this entails. In addition, there is variability in demand and in fulfillment and replenishment cycle times which by themselves can be difficult to characterize. Thankfully, advancements on the mathematics and IT technology fronts have made it possible to capture these situations in great detail and solve them efficiently.

Inventory Reduction in Plant Operations / Assembly Lines

The production operations are subject to various process center capacities. In typical assembly line scenarios, the process capacities of successive work centers interact with each other in a complex fashion and have substantial impact on the quantities of WIP or staged component inventory for each such work center. To reduce inventory at each work center, one needs to optimize the inventory requirements across the processes in a holistic fashion keeping in mind the required manufacturing throughput rate and existing product availability /service commitments the manufacturer must achieve.

Non-linearity in factors that drive business constraints or optimization objectives call for the adoption of mathematics-intensive inventory optimization approach

Inventory optimization techniques can be applied to specific areas across a broad range of supply chain planning and execution activities. The needs, constraints, participation, process changes and benefits of each supply chain partner will vary depending on the industry and type of optimization problem. Some newly emerging and proposed applications of IO technology to specific operational issues and supply chain problems are explained in the following sections.

The following lists emerging areas of applying IO technologies to address complex supply chain and inventory issues:

Inventory requirement can be optimized by balancing the assembly line for a smooth work flow. One also needs to locate the most critical resource or bottleneck in the assembly line. This bottleneck defines the maximum throughput rate through the assembly line with minimum inventory requirements. The decision has the potential to influence the process batch size, transfer batch size and the buffer capacities for each work center. At a macro level, these decisions also impact the lot sizes that are required to be procured from suppliers and provided to the next stage in the supply chain.

Inventory Reduction Across Transportation Networks

Each stage in the supply chain has transportation options available with different cost structures. The choice of each transfer mode, or combination thereof, impacts the inventory needed to be carried in pipeline between those stages. A simultaneous optimization of the engagement of various transportation modes and the level pipeline inventories can have significant impact on the overall working capital invested in supply chain inventory at any given time. Trade offs are involved on two fronts while making the transportation decisions. On one hand,

to impact pipeline and safety stock inventory levels. Many procurement decisions and activities only indirectly drive inventory levels because decisions are made prior to actual sourcing execution or because of the longer cycle times associated with tactical procurement. While performing the source selection as a strategic initiative, little can be done on inventory optimization as a tactical exercise. The mix of procurement from various sources provides significant benefit if optimized along with the inventory requirement for each possible configuration of procurement mix from various suppliers.

From inventory reduction in plant operations to transportation networks, via sourcing policies to lot size optimization – inventory optimization technologies can address the most complex inventory issues

transportation costs are compensated against the pipeline inventory. On the other hand, transportation choices also impact customer responsiveness and thus the service level (product availability) commitments. A careful selection of the right configuration of modes, inventory holding in pipeline and service level commitments can optimize and improve the overall cost incurred in the chain.

Inventory Reduction via Changes to Sourcing Policies

Low cost country sourcing strategies open up several options for applying inventory optimization. The key is identifying which procurement decisions are significant enough

Inventory Reduction via Lot Size Optimization

Cycle inventories can be reduced by decreasing the lot sizes used in production and distribution replenishment. In production, optimal lot sizes depend on the fixed cost of forming the lots. A problem arises when different produced units have different optimal lot sizes for production but share the same work center resource or transportation resource. Considering these limitations and the cost structure in place, the lot sizes for different produced units can be optimized so as to utilize the available resources to the maximum. This concept can be applied across multiple manufacturing work centers and transportation resources via custom optimization routines that look across the supply

Application Area	Approach with Inventory Optimization	Advantages over traditional approaches	Incremental Value Realized
Inventory reduction in plants / assembly lines	Finding out the Critical resource and following the bottleneck approach	System runs at the maximum capacity without unnecessary inventory through out the line	Provides an effective tool for assembly line operations and a control mechanism for plant related inventory
Inventory reduction across transportation networks	Finding best configuration of transportation modes (and costs) along with required safety stocks, utilizing service times to optimum	Results in relatively lower safety stocks due to lesser lead times and proper exploitation of available transport modes	Reduces transportation and distribution costs Can increase actual product availability level with no net increase in pipeline inventories
Inventory reduction via changes to sourcing policies	Finding best configuration of sourcing options and quantities with safety stock requirements	Better utilization of available sourcing options. Easy to evaluate multiple sourcing policies	A comparatively longer term cost reduction technique that can simultaneously considers procurement and holding cost
Inventory reduction via lot size optimization	Finding joint lot sizes for a suitable group of products sharing similar resources and transportation schedules	Better overall reduction in inventory and transportation costs	An integrated inventory reduction approach for product families, Optimizes inventory with suitable MRP data
Risk Pooling	Finding right size of inventory by analyzing the demand patterns across geographies for group of items	Better overall reduction in inventory across geographies	A time tested approach, Emerges as an efficient technique for controlling inventory in distribution function
Inventory reduction via common component planning	Finding requirement schedule and quantities of components common to a group of products	Significant reduction in the component inventory across multiple finished products with common component parts	Value realized in the procurement of components for ATO or similar environment,
Inventory reduction via postponement	Postponing the product differentiation to later stages in chain by involving customer preferences at later stages	Allows mitigation or elimination of early WIP stage inventories No additional inventory needed to handle varying customer preferences	A trusted inventory reduction technique, casts drastic impact on supply chain complexity by reducing number of products

Table 2: *Inventory Optimization vs. Traditional Approaches*

chain, producing a globally optimal result. An effective optimization function would consider local lot size optimality, the arrival rate of work in-process lots from each upstream process, and the storage or staging capacity at each resource.

Risk Pooling

Safety stocks across various geographies, over various time periods and for different product groups can be aggregated to reduce the total stock carried for providing a pre-

defined service level. Many companies like Dell, HP and Amazon practically optimized their safety stocks over different dimensions to exploit the benefit of risk pooling. If the demand patterns across geographies or product groups are independent, the variance for the aggregated demand will be less than the summation of individual variances. In this scenario, IO techniques and technologies are applied to identify (a) which geographies or product groups are optimal candidates for safety stock aggregation, (b) which inventory holding locations are optimal for risk-pooling from a cost standpoint, and (c) the level of safety stock inventory to hold in the risk-pooled location. The same explanation holds good for aggregation over various time periods and for different product groups as well.

Inventory Reduction via Common Component Planning

In a discrete manufacturing environment, a lot of inventory is held as components across various products. Thousands of components required for various products have significant commonality across products. Aggregation of such components is another form of pooling, with more relevance to high tech and discrete manufacturing environment. Since the same component is required for various products, the demand at the component level is more predictable and requires less safety stock as compared to a simple addition of safety stocks for the same component without considering commonality.

Inventory Reduction via Postponement

Postponement refers modifying a manufacturing process so that more of the operation is done closer to the customer and on more of a just-in-time basis.

This enables the organizations to check the impact of variations in the consumer demands for product variants, very early in the chain and thus avoiding the need to carry safety stocks for different variants in the initial stages of the supply chain. Both postponement and component commonality push the product differentiation towards downstream in the chain and facilitate aggregation till later stages.

Applying IO techniques here is similar to the Risk Pooling application. IO can identify (a) which products are optimal for postponement, (b) where postponement should take place physically for least cost, and (c) the level of postponement inventory to carry.

EXAMPLES OF MANUFACTURERS APPLYING INVENTORY OPTIMIZATION

These examples of manufacturers applying inventory optimization illustrate real world success with the concepts, technologies, and techniques.

One major manufacturer of personal communications devices is undertaking a broad initiative to enable sell-side supplier managed inventory for its major customers. This manufacturer's existing product fulfillment model is based on a classic multi-tier distribution channel. Before adopting inventory optimization techniques, the manufacturer's distribution network was unsynchronized and contained sequential layers of distribution leading to limited visibility, excess inventory, stock outs, cycle time delays and difficulty establishing new retail relationships.

In some markets, the manufacturer faced a 72% retail shelf stock-out rate. In addition, its forecasts did not adequately account for the potential demand if stock outs could be addressed.

To address these issues, the manufacturer, developed a supplier managed inventory (SMI) approach that eliminated distribution tiers, review cycles and order distortion and improved demand response. It also developed business and system models for collaborative inventory forecasting with channel partners and customers, including short, medium and long term forecasts of consumption, replenishment and aggregate sales.

The manufacturer approached IO by deploying replenishment planning and execution solution to support SMI with data shared across customers and channel partners allowing the company to simultaneously improve planning and execution processes. In addition, for each SMI replenishment process the manufacturer deployed, a replenishment lot size optimization was performed using several months of historical data.

After deploying its solution with several customers, the manufacturer realized significant benefits. With a single channel partner and distributor in Southeast Asia - the manufacturer was able to achieve:

- A \$31 million increase in revenues
- A \$40 million improvement in cash flow
- Recovery of demand lost due to retail stock outs - meeting this demand meant increased sales volume and market share.

The second example is that of a diversified industrial products manufacturer. The manufacturer has a range of industrial products that include industrial solvents and machine tools. It faced complexity in managing transition from the older generation product to its newer generation replacement. It frequently overbuilt its old generation product for several weeks after the new generation product was

introduced because it could not ramp up new product introduction fast enough. The manufacturer's overall goal was enabling higher actual product availability levels during new product introductions. It used the following approach to apply an IO engine to help determine how to properly stage pre-build and pipeline inventories:

- First, it identified a series of product lifecycle stages (Product launch phase, Ramp up phase, Maturity phase, End-of-Life phase), each with its own target service level. Demand characteristics for each phase were also identified, viz.,
 - Forecast accuracy
 - Demand growth
 - Demand variability (based on actual demand)
 - Demand price sensitivity
- Second, it developed a supply chain model that characterized these dimensions across timeframes corresponding to the expected duration of each lifecycle stage
- Finally it ran the IO engine to optimize inventory target settings to incorporate in planning and procurement policies for each product at key phases of its product lifecycle. For the old generation product, inventory targets were adjusted for its end-of-life phase. For the new generation product, inventory targets were adjusted for product launch and ramp-up phase.

By optimizing inventory targets and replenishment policies in this manner, the manufacturer was able to deliver minimum

cost and maximum distribution coverage for both products. By allowing service levels to vary with naturally occurring shifts in demand variability across lifecycle stages, the manufacturer was able to reduce inventory by more than 18% with no impact on product availability.

In yet another case, a power tools manufacturer leveraged an IO engine working along side Material Requirements Planning (MRP) and Advanced Planning and Scheduling (APS) systems to enable granular planning of WIP inventory positions (location, target buffer quantities, replenishment policies) throughout

and efforts to induce flexibility in the supply chain are still necessary but not sufficient to manage the growing multi-dimensional complexity. A suggested approach is to adopt inventory optimization concepts, techniques, and technologies.

Inventory optimization is a powerful problem solving approach backed by advanced technology. The concepts, techniques, and technologies of inventory optimization help model, characterize, and account for supply chain uncertainty. This uncertainty is a key reason manufacturers maintain higher than needed inventory levels. Inventory is a buffer

Inventory optimization is the new problem solving mantra for all supply chain related issues

its supply chain [5]. The IO engine determined a globally optimal placement of inventory, considering its cost at each stage in the supply chain and also the service level targets and replenishment lead times that constrain each inventory location.

CONCLUSION


The increased complexity of manufacturing and distribution among global manufacturers due to greater variability and uncertainty across the supply chain suggests that a new approach to controlling and reducing inventory levels is required. Pressures and trends impacting a manufacturer's ability to effectively manage inventory at a global level are increasing. Traditional methods such as accurate forecasting

against the uncertainty related to variable processing and replenishment lead times, erratic demand and forecast bias or error,

The key to effectively leveraging inventory optimization lies in viewing it as a problem solving approach. A specific set of constraints and parameters has to be identified and modeled to characterize supply chain behavior. An objective function is to be derived from the model to isolate the parameter requiring optimization. Finally, higher order mathematics are to be applied to solving the function, often aided by an IO engine or large scale computing capacity. Using this approach, changes can be effected to inventory planning, inventory stocking, replenishment, and transportation processes. Also this could lead to defining

the underlying operational policies at a very granular level.

REFERENCES

1. Sensing and Shaping Demand in a Consumer-driven Marketplace, Electronics Supply Chain Association Report, 2006.
 2. Kevin O'Marah, The Supply Chain Top 25: Supply Chain Leadership for the 21st Century, AMR Research, Nov 9, 2006.
 3. Beth Enslow, Are Your Inventory management practices Outdated, Aberdeen Group, March 2005.
 4. Matthew Menner and Dan Harmeyer, Developing Creative Supply Chain Strategies in Highly Competitive Markets" Conference Proceedings, presented by at the 2006 SCOR Supply Chain World North America Conference. Boston, MA USA. March 29, 2006.
 5. Sunil Chopra and Peter Meindl, Supply Chain Management' Third Edition, Prentice Hall, March 2006. 
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