Designing a Lean-Based Supply Chain Using Demand Pull
Designing a Lean-Based Supply Chain Using Demand Pull

By Manoj Nanda

Lean philosophy is popular as the basis for avoiding waste and enhancing operational efficiencies in manufacturing. Recently, services organizations have also successfully used Lean techniques. While Lean is more of a philosophy than a collection of tools, firms intelligently embracing some of those tools have gained considerable advantages.

One such tool is demand pull, which has tremendous advantages over push-based approaches. Firms still relying on push to set inventory and guide production planning should rethink their strategy and consider demand pull, which uses the consumption or shipment of goods rather than forecasting. The difference is akin to setting a fixed schedule to refuel your car every Monday (push) instead of monitoring the gas gauge and filling the tank when the level approaches empty (pull).

Does this somewhat minimalist approach to supply chain design stifle growth? Can a firm adopting this approach ramp up quickly enough to support a rapidly increasing demand? As the U.S. economy recovers, many organizations need to prepare for this scenario. While consumption-based planning might appear to be incapable of handling this eventuality, the beauty of pull-based planning is that it’s designed to handle uncertainty. The challenge, of course, is identifying how to incorporate and implement demand pull in your supply chain design.

Setting the Inventory for Pull

To illustrate how this is done, we’ll use the example of a high-tech OEM we recently worked with. Like many organizations, it was severely affected by the rapid movement and visibility of demand signal during the recent global recession. Their forecast-driven planning system could not reduce production quickly enough to avoid significant obsolete inventory, which then had to be written off.

In response, management adopted two measures to improve supply chain performance. First, it developed effective collaborative processes and invested in IT to expedite the movement and visibility of demand signal from end customers down to n-tier suppliers. Second, it implemented a Lean-based supply chain design by using demand pull.

The inventory of each item was set based on actual
consumption, and replenishment was triggered to maintain a set level. This level was just enough to support demand during lead time and equal to the average historical consumption of the item based on actual orders rather than a forecast during the lead time period.

To account for uncertainties in demand, a safety stock, also based on historical variability in consumption, was added. This inventory is identical to the traditional re-order point (ROP) with the difference being that historical consumption was used instead of a forecast in the calculation. In the language of Lean, we call this the Kanban. ROP was sized using the following formula:

\[
\text{ROP} = \text{Average Historical Consumption During Lead Time} + \text{Safety Stock}
\]

Figure 1, which is based on our sample company, illustrates an inventory level calculation for five weeks of demand under three different scenarios:

<table>
<thead>
<tr>
<th>Lead Time (LT) 7 Days</th>
<th>Days of Week</th>
<th>Demand During LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual Demand Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1: 5 4 2 6 7 1 3 28</td>
</tr>
<tr>
<td>Week 2: 5 3 4 7 6 2 4 31</td>
</tr>
<tr>
<td>Week 3: 7 11 4 8 4 6 5 45</td>
</tr>
<tr>
<td>Week 4: 7 11 5 8 10 4 2 47</td>
</tr>
<tr>
<td>Week 5: 6 8 6 7 10 12 5 54</td>
</tr>
</tbody>
</table>

Average Demand in LT (Average of the Numbers in Weeks 1-5) 42
Demand Variability (Standard Deviation of Numbers in Weeks 1-5) 11.07

<table>
<thead>
<tr>
<th>Customer Service Level</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>95%</td>
<td>97%</td>
<td>99%</td>
<td></td>
</tr>
<tr>
<td>Z-Score (Service Level Factor)</td>
<td>1.645</td>
<td>1.881</td>
<td>2.326</td>
</tr>
<tr>
<td>Safety Stock (Demand Variability x Z-Score)</td>
<td>19</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>Total Inventory (Average Demand in LT + Safety Stock)</td>
<td>61</td>
<td>63</td>
<td>68</td>
</tr>
</tbody>
</table>
Average Consumption During Lead Time

To estimate average demand, it is necessary first to ascertain lead time, which is the amount of time from the point at which a complete customer order is received to the point when the inventory is available for the customer’s use. Lead time includes: (1) order receipt and processing time; (2) supplier or manufacturing lead time; (3) inbound shipping time from the supplier or plant to the warehouse/distribution center; (4) outbound shipping time from the warehouse/distribution center to the customer location; and (5) time to process the material at receiving and inspection at the customer. Lead time for each item was meticulously calculated, stored in a database, and treated as master data.

All of the discrete shipments during the lead time were bucketed into a single number called consumption. (In Figure 1 that number is 28 in week 1). Then the average consumption for the previous two to four quarters was calculated. In Figure 1, ROP was calculated using demand for each day which was bucketed into lead time (seven days in Figure 1) for an average of five such weeks of data (42 days in Figure 1).

Safety Stock

Safety stock was calculated using the traditional formula of Demand Variability * Service Level. Once the demand data was bucketed into lead time, the variability was measured using the formula of standard deviation (11.07 in Figure 1). A customer service level (instances when an order is filled completely within the commit date) was selected and the corresponding service level factor was determined using the z-score. Standard deviation calculation based on last few quarters of data assumes that the numbers are coming from the same distribution.

For items having large unit growth, the growth was removed from the data before the calculation. Once the safety stock was calculated, it was added to consumption during lead time to determine the Kanban size (61 for a 95 percent service level in Figure 1).

Establishing Order Quantity and Determining When It's Time to Place an Order

Whenever total inventory dropped below Kanban a build signal was triggered and transmitted downstream to initiate the production or the replenishment of the item. The total inventory was calculated by adding the on-hand and on-order inventory. The order quantity depended on the set-up and capacity of the manufacturing process and the logistics operation, which can influence the package size. An Economic Order Quantity (EOQ) approach is unsuitable because the company did not have good estimates of holding and ordering costs, which are necessary inputs in the calculations. Instead, they used the larger of minimum production lot or an integral multiple of the minimum package quantity as the base estimate for order quantity.

Benefits

With this transformation, the OEM gained considerable tangible and intangible benefits. On-time shipments improved more than 2 percent and the penalties for delayed service were substantially reduced. The Customer Service Level increased from 92 to 93.5 percent, and Order Management was able to commit to customers without worrying about failure to deliver the items in time.

Inventory turns increased and associated working capital was released for more productive use. Quick inventory turnaround also reduced instances of components becoming obsolete. With less reliance on error-prone forecasts, the entire business
felt confident about the ability of the supply chain to deliver as promised.

Limitations to the Approach
As useful as this pull-based method is in smoothing out supply chain, it’s not a one-size-fits-all solution. It is critical to consider scenarios where this approach is not the most appropriate choice:

- **Supply Side Variability:** The safety stock takes care of variability in demand quantity; it is assumed that there is no variability in supply side, either in quantity or in lead time. In other words, when a company places a purchase order with one of its vendors, the assumption is that the full quantity is always delivered within the lead time period. Managers sometimes mistakenly assume that the safety stock is available to take care of any uncertainty in the supply chain. Of course it’s possible to modify this calculation to include supply side factors, but that would further increase the inventory.

  Supply side uncertainty is within the control of the company, and allocating safety stock to deal specifically for such variability can send a wrong signal to the vendors. It can potentially keep bigger supply chain problems from getting the immediate attention of management, including the issue of having a higher running balance of on-hand inventory because supply chain issues are increasingly buffered.

- **Known Variation:** The safety stock is meant to support only an uncertain change in demand. Hence any variation known in advance should be treated separately rather than as part of the safety stock calculation. For example, if seasonal variations in demand are predictable, production can be ramped-up in advance using a separate order. These inflated consumptions are eliminated temporarily from the data used to calculate the demand variability in the safety stock.

- **Minimum Safety Stock:** For items with large but very steady average demand, the calculated safety stock should be a small percentage of average demand, making the inventory vulnerable to an unexpectedly large demand variation. To avoid this, a minimum safety stock was proposed for these items. Initially this could be set at a fixed percentage (say, 30 to 40 percent) of average demand to make sure that when the calculated value of safety stock drops below this level, the minimum safety stock will kick in. Since this could adversely affect inventory turns, however, utmost care should be taken to identify items that need this support. Decisions about which items do and do not get this protection was left to experienced inventory planners.

- **Very Long Lead Time Items:** A very long lead time for an item can introduce significant supply side variability which can be difficult to manage. Whenever lead times are long, an effort should first be made to reduce them before switching the inventory to a pull-based design. Several approaches, including co-located JIT-hubs and switching to more regional suppliers instead of relying on global low-cost vendors, can be considered. In all cases, reducing lead time directly affects the inventory level and hence is one of the fundamental added values of Lean-based planning.

- **Customers with Highly Variable Demand:** Classic pull-based supply chain design is sometimes criticized for its inability to handle customers with a highly variable demand. Automobile manufacturers have tried to manage this problem by using pricing and incentive mechanisms through their vast network of dealers. Such flexibility,
however, may not be available to firms in the extremely price-sensitive high-tech industry. Having a consumption-based safety stock is one of the simplest and most effective ways to handle this. In situations where demand volatility is extremely high and cannot be reduced, this approach may not be suitable.

**Do We Still Need a Forecast?**

Many experts have suggested that the best supply chain planning system should mature to the extent that forecasting is not necessary. We disagree. We have found that a forecast is still the best guess predictor of long-term future demand and should continue to be generated. Here are a few important reasons why we recommend keeping it in a Lean environment:

- **Capacity Planning:** Investment decisions in manufacturing, logistics network, system resources, and manpower for a long horizon are dependent on capacity planning. Demand prediction plays a crucial role in deciding future capacity, and only an accurate forecast can effectively support this process.

- **Collaboration with Trading Partners:** Trading partners are key members of an extended supply chain and depend on each other for manufacturing, component supply, distribution, and logistics operations. Forecast collaboration allows every member in the chain to get visibility to the best possible demand signal in the future. That means the demand planning process should continue to generate the forecast and make it available for the partners down the supply chain.

- **Performance Management:** In outsourced manufacturing, trading partners usually use forecasts for their build planning. Their performance is often evaluated using some form of ‘build to plan’ metrics that use a forecast. In pull-based planning this is different. New performance evaluation criteria for the trading partners based on their ability to maintain inventory at ROP was established. This is a paradigm shift for many managers and therefore substantial priority should be given in change management to ensure that the new approach gets wide visibility and buy-in.

- **NPI and EOL Planning:** New product introduction (NPI) is always preceded by a process in which the supply pipeline is filled with inventory. This is required to sustain the demand generated immediately after product launch. Because of the lack of historical data, forecast is used for the planning. Similarly end-of-life (EOL) planning for an item is often an organized event in which firms try to consume their entire inventory. Previous consumption is not a good predictor since it tends to build unnecessary inventory, and forecasting is used to guide the inventory down to zero. Additionally, forecasting is used to run ‘what-if’ scenarios and perform risk assessments.

**How to Manage the New Process**

Since most of the data manipulation to achieve pulled-based demand is done outside the enterprise system, does it add unnecessary complexity to the operation? We’ve found that the benefits of demand pull are so overwhelming that a manual process used to adjust the parameter once per quarter is not a burden.

Unfortunately, popular enterprise management applications do not yet support the data manipulation capabilities required for pull-based design. The best current solution is to download both inventory and order quantity data into a spreadsheet for calculation. Then upload it into the ERP after determining the optimal inventory level, and automate the process of retrieval, data manipulation, calculation and uploading using advanced macros.
Depending on the firm’s growth rate, this does not need to be an onerous process. The frequency at which the OEM in our example re-adjusted its inventory depended on market dynamics. They started with once per quarter, which seemed adequate for a firm growing at roughly 15 percent in revenue for last several years. To avoid unnecessary churn in the supply chain, if the calculated inventory was within 5 percent of the existing setting they kept the old value. Recently a commercial application has been developed to communicate directly with the ERP to make this data manipulation functionality available.

**Using a Pull-Based Design to Improve the Bottom Line**

In spite of being very popular in many industries such as automotive and, recently, high-tech, most firms have yet to adopt pull-based supply chain management—even when they have embraced the Lean philosophy. But, as we’ve demonstrated with our example OEM, supply chain performance can be tremendously enhanced by using actual consumption instead of a forecast.

Using the simple analytical approach we’ve described, supply chain managers who adopt the Lean methodology of pull can master dealing with uncertainty—preventing costly excess inventory crises during economic downturns and helping to ramp up inventory acquisition as business improves. With a robust pull-based supply chain, organizations can improve on-time shipments, increase customer service levels, free working capital, reduce instances of components becoming obsolete, and improve supply chain dependability. It’s the essence of Lean.

Manoj Nanda is a Consulting Manager for Wipro Consulting’s Supply Chain Practice and is based in Dallas. He can be contacted at manoj.nanda@wipro.com.

**Notes**

1 This is a fundamental assumption for calculating standard deviation. Removing such trend is also known as de-trend in math parlance. For more information, please refer to a standard text in statistics.
About Wipro Consulting Services

Wipro Consulting Services helps companies solve today's business issues while thinking ahead to future challenges and opportunities. As a business unit of Wipro, one of the world's leading providers of integrated consulting, technology and outsourcing solutions, we bring value to our clients through end-to-end business transformation – think, build and operate. Our model for the 21st Century Virtual Corporation includes implementing lean process transformation, exploiting new technology, optimizing human capital and physical assets and structuring next generation partnering agreements that create value and win/win business outcomes for our clients. For information visit www.wipro.com/consulting or email wcs.info@wipro.com.

About Wipro Technologies

Wipro Technologies, the global IT business of Wipro Limited (NYSE:WIT) is a leading Information Technology, Consulting and Outsourcing company, that delivers solutions to enable its clients to do business better. Wipro Technologies delivers winning business outcomes through its deep industry experience and a 360° view of "Business through Technology" – helping clients create successful and adaptive businesses. A company recognized globally for its comprehensive portfolio of services, a practitioner's approach to delivering innovation and an organization wide commitment to sustainability. Wipro Technologies has 120,000 employees and clients across 54 countries. For information visit www.wipro.com or mail info@wipro.com.