How Safety Stock Can Help You Manage Your Inventory Better

SKUVAULT

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SAFETY STOCK

What it is & why it's important

What is Safety Stock

Safety stock is simply defined as extra inventory beyond expected demand. Entrepreneurs and Operations Managers carry safety stock to prevent stockouts, caused by changes in customer demand, incorrect forecast, and variability in lead times for raw materials. Quantifying these variables makes it possible to accurately predict the amount of extra inventory to keep on hand in the event that you sell out of product.

Safety stock is calculated by a combination of mathematical formulas designed to quantify the different variables involved when managing inventory. When dealing with uncertainties and multiple variables, the best way to calculate safety stock is to use standard deviation for determining variations. Variables that need to be calculated can vary depending on the product and how distribution and order placement. While there are multiple ways to calculating safety stock the most widely accepted formula is as follows

Safety Stock = Service Factor (Z) × Standard Deviation of Lead Time Demand

Why Safety Stock is Important

Minimizing inventory while meeting the variability of customer demand is what makes safety stock so valuable. Preventing stockouts, overstocks, and wasted inventory space have significant impact on profits. Over time, stockouts result in loss of revenue, gross profit, customers, and market share. If you can not meet the demand of your customers they will find someone else who will. Taking the time to calculate safety stock not only saves you from these costs, but also increases the efficiency of your storage space. The result: increased revenue and higher service level.

GLOSSARY

Terms you need to know

Normal Distribution

Term used in statistical analysis to describe a distribution of numbers in which the probability of an occurrence, if graphed, would follow the form of a bell shaped curve. This is the most popular distribution model for determining probability and has been found to work well in predicting demand variability based upon historical data.

Standard Deviation

A quantity calculated to indicate the extent of deviation for a group as a whole.

Reorder Point

Inventory Level which initiates an order. Reorder Point = Lead Time Demand + Safety Stock

Demand History

A history of demand broken down into forecast periods. The amount of history needed depends on the nature of your business. Businesses with a lot of slower moving items will need to use more demand history to get an accurate model of the demand. Generally, the more history the better, as long as sales pattern remains the same.

Order Cycle

Also called replenishment cycle refers to the time between orders of a specific item. Most easily calculated by dividing the order quantity by the annual demand and multiplying by the number of days in the year.

Forecast

Consistent forecasts are also an essential part of the safety stock calculation. If you don't use a formal forecast, you can use average demand instead.

Forecast Period

The period of time over which a forecast is based. The forecast period used in the safety stock calculation may differ from your formal forecast periods. For example, you may have a formal forecast period of four weeks while the forecast period you use for the safety stock calculation may be one week.

Service Level

Desired service level expressed as a percentage.

Service Level Factor

Factor used as a multiplier with the Standard Deviation to calculate a specific quantity to meet the specified service level.

Lead Time

Highly accurate lead times are essential in the safety stock/reorder point calculation. Lead time is the amount of time from the point at which you determine the need to order to the point at which the inventory is on hand and available for use. It should include supplier or manufacturing lead time to initiate the purchase order or work order including approval steps, time to notify the supplier, and the time to process through receiving and any inspection operations.

Lead-Time Demand

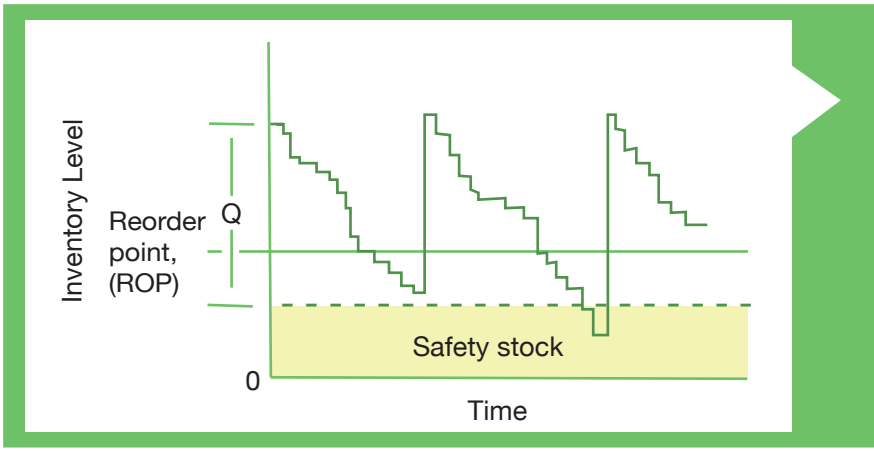
Forecasted demand during the lead-time period. For example, if your forecasted demand is 3 units per day and your lead time is 12 days your lead time demand would be 36 units.

PRODUCT INFO

What you need to know before calculating safety stock

Covering The Basics

When calculating safety stock, there is certain information you have to know about your product in order to accurately determine how much extra stock you will need. The formula for safety stock states that (Z) multiplied by the standard deviation determines the solution. Because we are dealing with standard deviation and averages, specific data is required to determine these numbers.



Standard Deviation

To calculate standard deviation (б), prior data for lead times must exist. Lead time data should have the amount of time it takes to order and restock a single product. When trying to determine safety stock for multiple items, data on each product's lead time will be required. The total time it takes between submitting a purchase requisition, approval time, emailing vendors, delivery time from vendor, incoming inspection time, and the time it takes to put on the shelf determine lead time. This data will be essential when determining the standard deviation of lead time.

Lead Time Demand

Data on demand history is necessary for calculating Lead Time Demand. Every product that you want to find the safety stock of will need to have an accurate demand history that accounts for how much of this product is sold each day. This information is helpful if you do not have an accurate forecast for Lead Time Demand. Find the average of products sold during the forecast period you want to service to find your Lead Time Demand. Safety stock will be more accurate the more data that you have. Keeping track of sales data of an item for several years, for example, is more accurate than sales data from a single year.

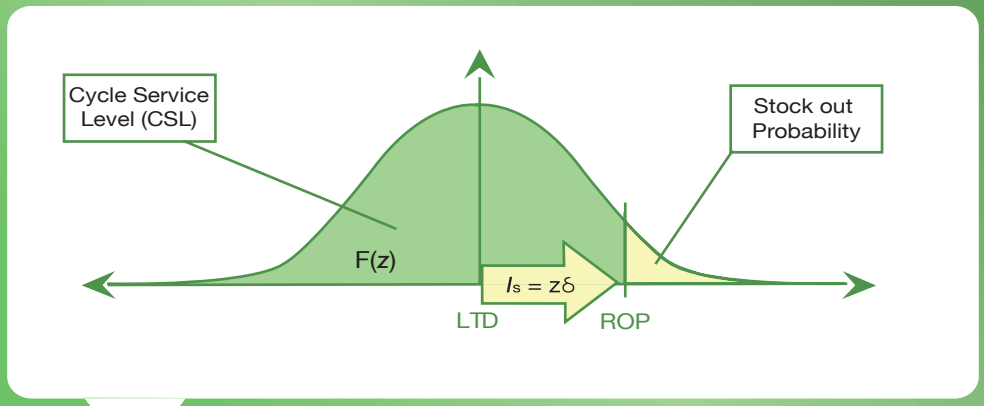
Warehouse Management Systems

Using a software management system, such as SkuVault, to keep detailed accounts of sales and ordering process increases the accuracy and ease of calculating safety stock. Warehouse management systems create sales reports and also keep track of when orders are fulfilled. Entrepreneurs and Operation Managers who understand their product and have data on past sales can expect higher inventory efficiency and higher revenue returns.

CALCULATING SAFETY STOCK

Learn how to use Safety Stock formula

The formula for safety stock in it simplest form is (Z) × Standard Deviation of Lead Time Demand. Each part of this equation has to be determined before you are able to actually calculate safety stock. While being able to determine what these numbers are is necessary, it is also important to understand why the sum of these numbers will give you your safety stock. The bell curve below highlights the factors that need to be considered to understand how normal distribution is factored as well as the role cycle service level and probability of a stock out plays.



When calculating safety stock a standard bell curve can be used to represent the normal distribution. The center line of the curve is the average amount that we use which is our Lead Time Demand (LTD). This is the amount of product we expect to use during the time an order is placed until the time the order is received. The bell curve defines our entire stock distribution, so we have to also account for the probability of a stock out which is highlighted in yellow on the graph.

What we need to do is find the amount of extra inventory we need on hand during times of stock out. So if the yellow area represents our probability of a stock out, the light green area represents the service level. The entire area under the bell curve is equal to one. Therefore, one minus the probability of a stock out equals the service level.

How to Use The Formula

Our lead time demand plus the safety stock will be the reorder point (ROP). Safety stock should be equal to the number of standard deviations (Z×6LTD) above the mean (LTD), so that LTD + safety stock = ROP. To calculate the safety stock we need to first multiply the Z score (Z) by the standard deviation of Lead Time Demand.

To determine the safety stock we are going to have to find (Z). (Z) is determined according to the service level. The service level has a service factor associated with it, which will be used as our z score. The service factor can be found by either using a normal distribution chart or Excel. Excel will calculate the probability of not having a stock out using NORMSINV formula to give the service factor. The normal distribution chart outlines the service factor that correlates to the service level. Look at the chart below for a complete normal distribution chart.

CALCULATING SAFETY STOCK

Continued

Service Level	Service Factor	Service Level	Service Factor
50.00%	00.00	90.00%	01.28
55.00%	00.13	91.00%	01.34
60.00%	00.25	92.00%	01.41
65.00%	00.39	93.00%	01.48
70.00%	00.52	94.00%	01.55
75.00%	00.67	95.00%	01.64
80.00%	00.84	96.00%	01.75
81.00%	00.88	97.00%	01.88
82.00%	00.92	98.00%	02.05
83.00%	00.95	99.00%	02.33
84.00%	00.99	99.50%	02.58
85.00%	01.04	99.60%	02.65
86.00%	01.08	99.70%	02.75
87.00%	01.13	99.80%	02.88
88.00%	01.17	99.90%	03.09
89.00%	01.23	99.99%	03.72

Looking at the normal distribution chart we can determine what our service factor is according to the service level we want to reach. For example, If you are trying to maintain a service level of 84% your service factor will be 00.99. This number will serve as your service factor, or (Z), in the equation.

Now that we know how to find the service factor, lets talk about how to solve for the Standard Deviation of Lead Time Demand (6LTD). Depending on the vendor service used, lead times can be constant or variable. Lead times are considered constant if the total time to reorder and restock are always the same. If lead time is constant, you have an established your 6LTD and can move on to the next stage in calculating safety stock. However, having such stability in lead time is rare. More often the lead time is variable, meaning that products production or delivery time are not always the same. It is because of this lack of consistency that we have to find the 6LTD.

Finding The 6LTD is a Four Part Process.

- First find the average of your lead time over the forecast period you are finding the safety stock for.
- Second add the average to each of the lead times for the forecast period. For example, if you restock once a week on a product, and your forecast period is a month, the lead time of each week becomes its own equation where the average is added to the lead times. In this example you have four lead times for each week of the month and will add the average to each lead time, which will give you for variances.
- Third add up the variances. Then take the sum of the variances and divide it by the sample proportion. In this example your sample portion is four since the samples are from each week during a month.
- Fourth add the solution form part three to the average. The sum amount will be your Standard Deviation of Lead Time.

At this point you should have both the service factor an the 6LTD. With both parts of the equation identified you are now able to solve for safety stock. Simply multiply the service factor and 6LTD and you will have your safety stock!

However, this equation only accounts for service level in the event of the stock out. There are other variables to consider to get the most from your safety stock calculations.

Variability

Calculating when dealing with uncertainties

When dealing with inventory there are often variables in supply and demand that makes it more difficult to find safety stock. Being able to calculate safety stock with variability really makes safety stock a valuable asset. Lets take a look at how to find these different variables and apply them to the safety stock formula.

Variability in Demand

Sometimes we know the lead time(LT), but the demand itself is variable. For this example lets assume that the lead time is constant and never changes. In this case, we must calculate the LTD and the бLTD. We have to find how much is the demand (R) and the standard deviation of demand (бR) for a given unit of time. Use these formulas to find LTD and бLTD

$$LTD = LT \times R \qquad бLTD = \sqrt{LT} \times бR$$

Example Problem

Ray is trying to figure out how much inventory of batteries to keep. During the past year demand per day was variable with a mean of 20 and a бR=3. Lead time was constant at five days. Ray would like to maintain a 90% service level.

- What is the recommended safety stock?
- What is the ROP?

Solution

R = 20, бR = 3, LT = 5

- $LTD = LT \times R = 5 \times 20 = 100$
- $бLTD = \sqrt{LT} \times бR = 2.236 \times 3 = 6.708$

Safety stock = (Z) × бLTD. Looking at the normal distribution chart will us that a service level of 90% equates to a service factor (Z) of 1.28. We also now know that бLTD is 6.708. So in this example safety stock = 1.28 × 6.708 which equals 8.6. And since you cannot have .6 of a product round up. So our safety stock is 9.
ROP = LTD + Safety stock = 100 + 9 = 109.

Variability In Lead Time And Demand

Sometimes both the lead time and the demand are variable. Once again, we must calculate the LTD and the бLTD in order to solve for both variables.

$$LTD = LT \times R \qquad бLTD = \sqrt{LT бR^2 + R^2 бLT^2}$$

Example Problem

Ray is trying to figure out how much extra inventory of boxes of imported candies to keep. During the past year, the demand per week was variable with a mean of 6 weeks and бLT = 2. Ray would like to maintain a 90% service level.

- What is the recommended safety stock?
- What is the ROP?

Variability Continued

Solution

R = 85, 6R = 12, LT = 6, 6LT = 2

- LTD = LT × R = 85 × 6 = 510
- 6LT = √LT6R2+R26LT2 = 6LTD = √6(12)2+(852)22 = 172.52

Safety stock = (Z) × 6LTD. Looking at the normal distribution chart will us that a service level of 90% equates to a service factor (Z) of 1.28. We also now know that 6LTD is 172.52. So in this example safety stock = 1.28 × 172.52 which equals 221.1. And since you cannot have .6 of a product round up. So our safety stock is 222.
ROP = LTD + Safety stock = 510 + 222 = 732.

Other Variables

There is not a general agreement on the formulas for safety stock; calculating for other variables can be a bit of a challenge. Other variables to consider in safety stock are lead-time factor, order cycle factor, forecast-to-mean-demand factor, minimum reorder point, and lead-time variances. I suggest you test these factors with your numbers and see if they meet your needs. To include these variables try this formula: Safety stock = (standard deviation)*(service factor)*(lead-time factor)*(order cycle factor)*(forecast-to-mean-demand factor).

Lead-time factor: This is necessary to compensate for the differences between lead time and forecast period. The standard deviation was based on the forecast period, a factor is necessary to increase or decrease the safety stock to allow for this variance. A formula you can try is lead time factor = square root (lead time/forecast period).

Order cycle factor: Since longer order cycles result in an inherent higher service level you will need to use a factor to compensate for this. A formula you can try is Order cycle factor = square root (forecast period/order cycle). This is a simple calculation that works sometimes, but I typically use a more complex calculation (different logic completely)for this factor.

Forecast-to-mean-demand factor: Remember that the original statistical model was based upon the mean of the distribution. Substituting a forecast for the mean in the calculation of standard deviation creates a problem if the forecast mean and the actual demand mean are not close and also if the forecast varies between forecast periods (seasonality, sales growth). Sorry but I don't have a canned formula for this one that I feel confident enough with to publish. The actual formula used will vary based upon the types of variances and the method for standard deviation calculation used.

Minimum Reorder Point: For slow moving products and especially if the lead time is short, you may want to program in a minimum reorder point which is the equivalent of one average sale.

Lead-time Variances: You may have noticed that I have only discussed demand variations in this model. While you can use this model for predicting variations in supply, I have found that supply variations tend to be far too random and unpredictable. Supply problems tend to be related more to a vendor than an item and the severity of the variations do not fall into the pattern of a normal distribution. The safety stock calculated for demand variation will also cover for some supply variations, however, the best way to deal with variable supply is to have a high level of communication with the vendor and not to count on safety stock. You may find that certain items which are critical to your operation may require a safety stock calculation based upon the nature of the supply chain of the specific item.

Conclusion

Terms you need to know

Overall, this formula is great for forecasting inventory and calculating variable changes in supply and demand. Understand that safety stock calculations are designed to help Operations Managers avoid stockouts when ordering inventory. Remember, there are more variables that go into the ordering process than just safety stock. Safety stock simply calculates the amount extra stock that should be added to overall inventory and gives indication on when to reorder.

Calculating safety stock correctly can save considerable amounts of money otherwise missed from stockouts or wasted in overstocked inventory. Using a software management system, such as SkuVault, to keep detailed accounts of sales and ordering process increases the accuracy and ease of calculating safety stock. Entrepreneurs and Operation Managers who understand their product and have data on past sales can expect higher inventory efficiency and higher revenue returns.

You've read the white paper - now let us show you what SkuVault can do!

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About The Author

Dominique Robinson is a content marketer who works at SkuVault, a warehouse management systems software company. Dominique's passion for helping people discover better ways to improve their business manifest in his coverage of management operations. His ability to relay the most up to date coverage of news and trends in the industry has helped provide readers with a targeted platform to meet their needs.

Works Cited

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