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How to calculate safety stock for inventory management

Your guide to calculating safety stock using a range of formulas

Contents

The basics of safety stock

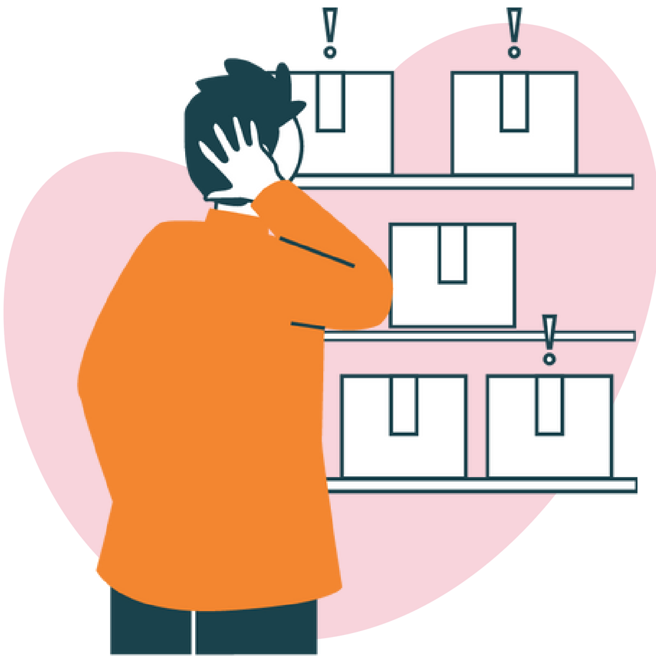
Determining appropriate stock levels is one of the most important and challenging tasks inventory managers face. If you carry too much, you tie up working capital. Carry too little, and you risk stockouts and unhappy customers.

You need to balance the right amount of capital invested in inventory with achieving service level targets (a measure of stock availability). One key challenge – and an essential piece in the puzzle – is calculating safety stock levels.

Safety stock, also called buffer stock, is essential at all stages of the supply chain.

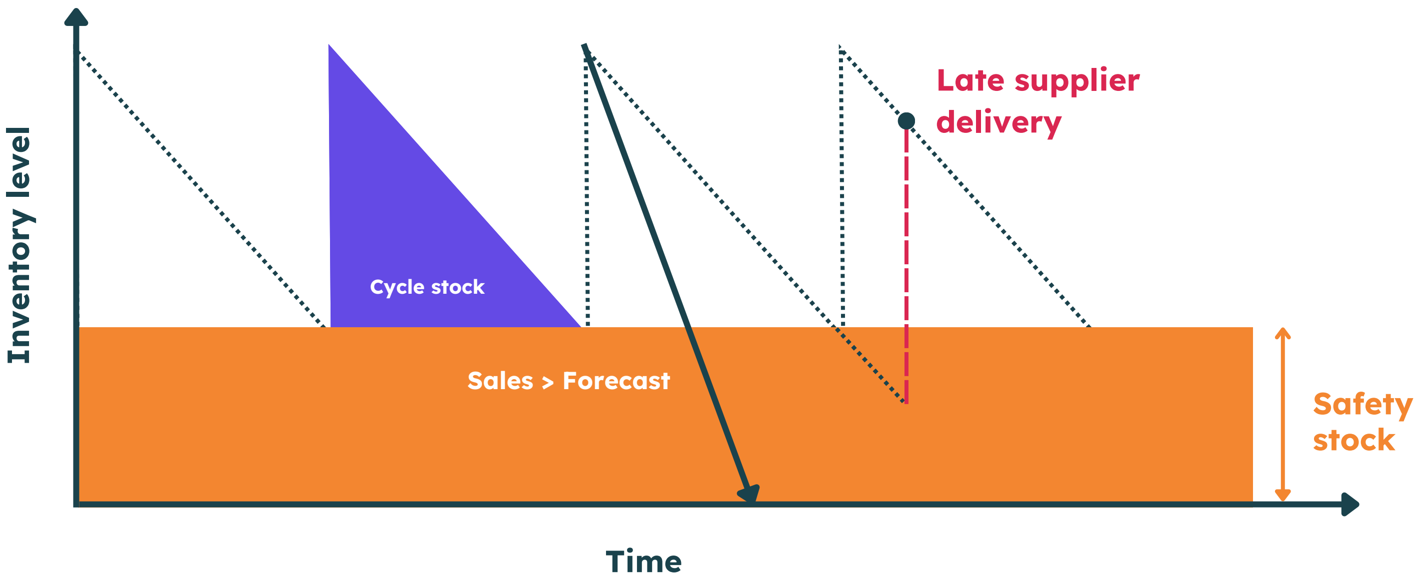
Safety stock is the items (raw materials or finished goods) businesses carry to mitigate the risk of run-out due to uncertainties in supply or demand. Safety stock prevents unforeseen changes in demand or supplier lead times from negatively impacting service levels.

In this eGuide, we'll look at ways to calculate safety stock from the simple to the more advanced statistical formulas.



The importance of safety stock

Safety stock manages demand or lead time uncertainty and guards against supply chain or fulfilment disruptions. Disruptions could be due to fluctuating demand, forecast errors or supplier lead time variations.



Safety stock is intended to cover any shortfall in cycle stock during the lead time. It is an important element of the reorder point formula:

ROP = (av. consumption x lead time) + safety stock

The challenges of calculating safety stock

The goal of safety stock is to minimise disruption to order fulfilment while investing the lowest possible amount of capital in inventory.

When demand for inventory items is consistent and lead times are reliable, it's fairly easy to set safety stock levels that will achieve this. When demand and supply fluctuate, many inventory planners find it much tougher to calculate safety stock accurately. They often use simple safety stock formulas that can't deal with their supply and demand challenges.

Why carry safety stock?

- To protect against demand and lead time variance.
- To compensate for forecast errors (when demand exceeds forecast).
- To fulfil demand if there are disruptions in production or deliveries.
- To avoid stockouts and backorders that can lead to lost sales and poor customer service.

3 Common methods for calculating safety stock

Here are three simple methods to calculate safety stock

01 Fixed safety stock

Many companies set a fixed level of safety stock for their inventory items, e.g., adding a 'best-guess' quantity to the reorder point to allow for any issues.

This number is often set at item group level and based on the judgment or assumptions of the inventory management team – without using formal calculations. For example, an inventory planner may decide to carry a week's worth of safety stock and use last month's highest week of sales as the safety stock figure.

Click here for a working example.

Pros/Cons:

While easy to set up and manage, this basic approach often leads to stock imbalances. This could mean investing an unnecessarily large amount of capital in excess stock while seeing frequent stockouts for other items.

02 Time-based calculations

A time-based safety stock calculation finds the average sales/demand over a fixed period and uses this value as the safety stock level. For example, it's simple to calculate average demand based on last month's consumption. In the case below, it would be 200 units.

Week	Quantity
One	300
Two	150
Three	250
Four	100

Safety stock for the forthcoming month would, therefore, be 200 units. For a working example, please click here.

Pros/Cons:
Fixed and time-based calculations take a "one-size-fits-all" approach. They assume that the forecasted demand will be accurate and that lead times will remain consistent. In reality, of course, this rarely happens.

For starters, calculating demand solely based on historical sales cannot account for demand variance, particularly items with erratic or intermittent demand. At the same time, lead times can be inconsistent due to various issues, such as production downtime or delivery delays.

Using a basic safety stock model can result in getting the right stock levels for some items, but others will see levels too high or too low.

03 Average/max calculation

A more prudent safety stock calculation uses an average/max formula, which accounts for when lead times rise and sales max out.

In our previous example, average sales were 200 units a week but rose to 300 and let's say the lead time is 1 week but can be as high as 1.5 weeks. Using the formula below, we can work out safety stock:

(max sales x max lead time) - (av. sales x av. lead time)

(300 x 1.5) - (200 x 1)

= 250 units

Pros/Cons:

Problems arise with this formula if the maximum lead time and sales are considerably higher than the average, as this significantly inflates safety stock levels.

While simple to use, a key drawback of all the formulas so far is that they fail to link back to service levels. Service levels are vital, as they are connected to how well you can serve your customers with on-time deliveries. Any out-of-stock item, even one SKU, will lead to an incomplete order, which can be detrimental to customer satisfaction. The service level KPI, therefore, closely correlates with customer service, acquisition, loyalty and retention.

Statistical calculations for safety stock

Despite being more complicated to use, statistical safety stock calculations overcome many of the drawbacks we've just discussed. This is because they use probability distributions to model demand and account for variance, which produces more accurate results.

A probabilistic approach accepts that there is uncertainty when predicting future events, such as demand volume and frequency. It accommodates this by covering a percentage of all possible inventory requirements.

Statistical safety stock formulas are based on achieving a desired service level. Service level is the expected probability of satisfying all possible demand scenarios within a particular period.

For example, if you set a service level target of 99%, your safety stock levels will cover 99% of all probable requests. In other words, 99% of the time, you can give your customers what they want when they want it.

Examples of statistical safety stock formulas

Safety stock formula with demand uncertainty

Let's start with a basic statistical safety stock calculation. This formula assumes no supplier lead time variations and only considers demand variation.

$$SS = Z * \sigma\_d * \sqrt{LT}$$

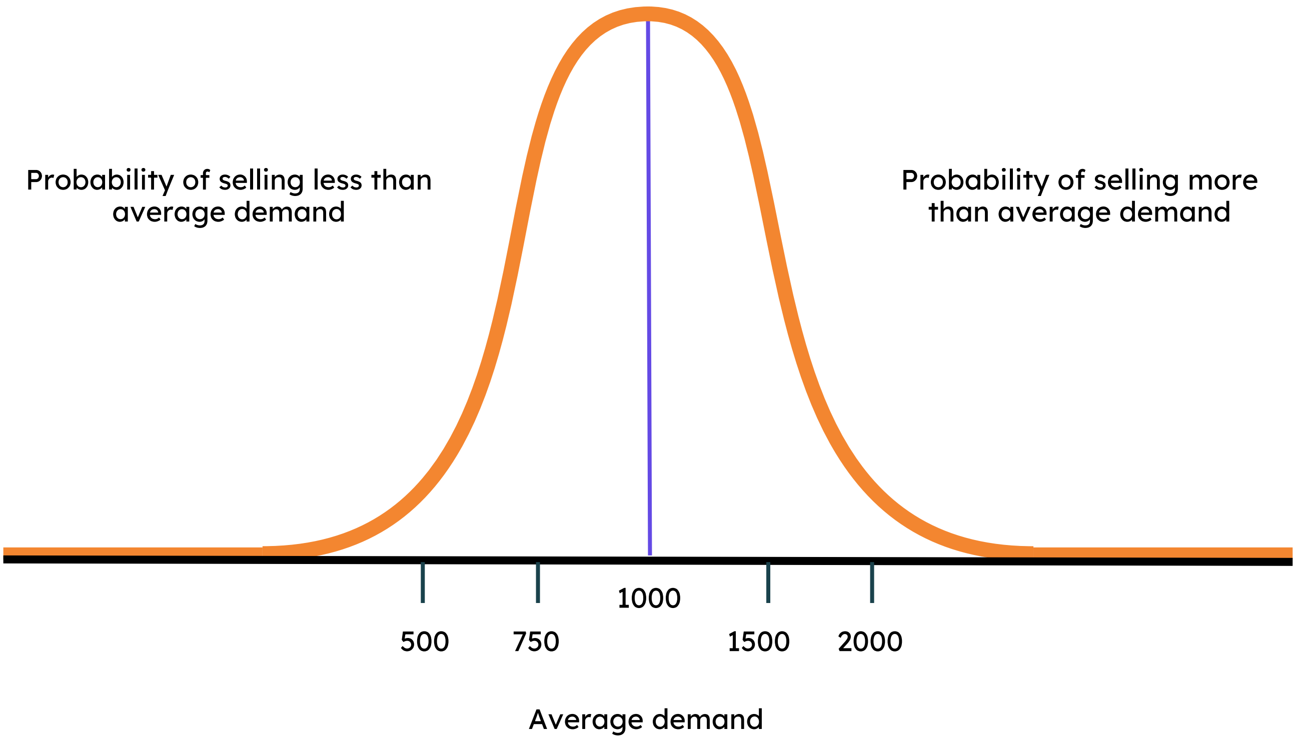
Key:
SS = Safety stock level
Z = Z-score
σd = Standard deviation of demand
LT = Average lead time

This formula introduces two statistical elements – the Z-score and standard deviation. Let's break down each element.

Z-score
The service factor, or Z-score, is based on your service level target – balancing inventory costs with the risk of a stock-out. The higher the desired service level, the more safety stock is required.

Once you set your service level target, you can work out your Z-score using a normal distribution table (see page 21).

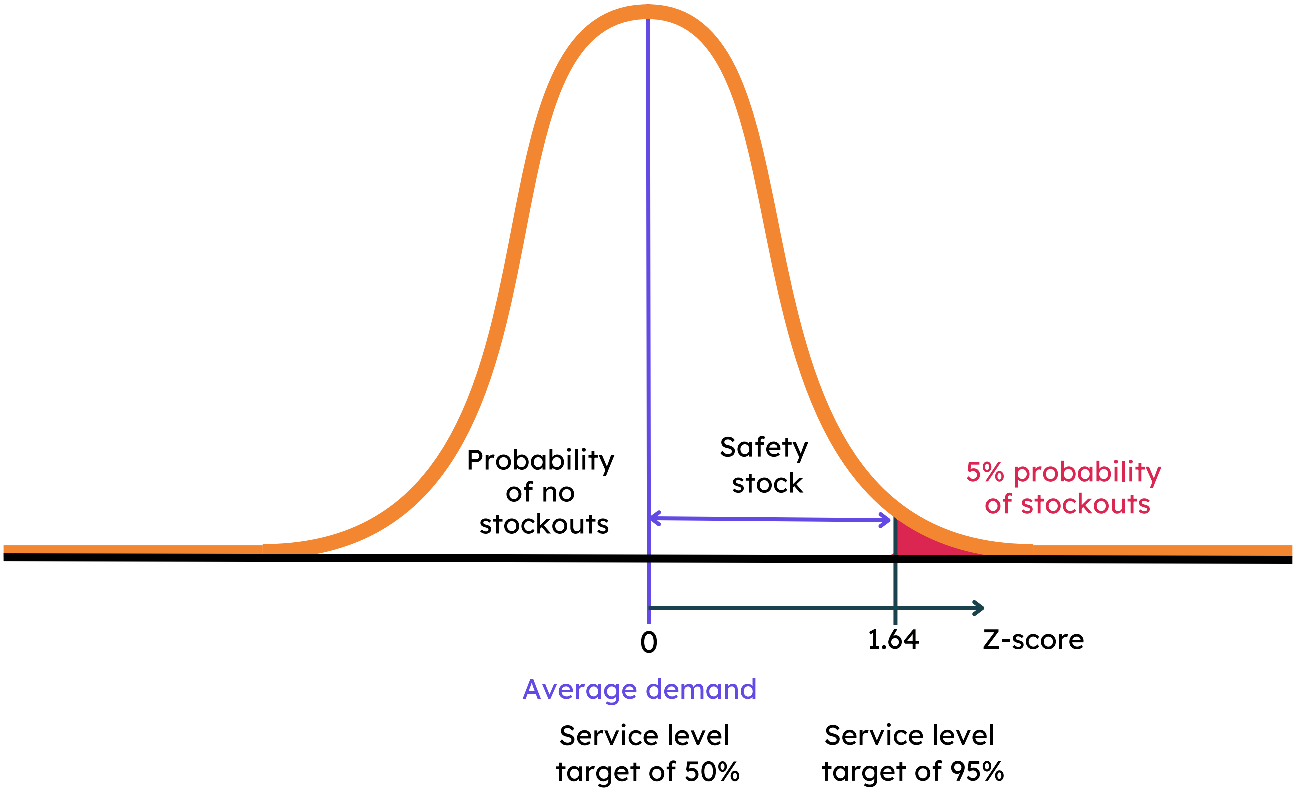
Normal distribution allows you to predict the probability of selling a certain quantity of stock. With normal distribution, the probability of an occurrence, if graphed, is a bell-shaped curve, where all data is equally spread out around a central value with no left or right bias.



For example, if you sell an average of 1000 units, you are as likely to sell more than 1000 next month as less than 1000. The probability decreases further from the centre of the curve, e.g. the probability of selling 2000 is lower than selling 1500, as is the probability of selling 500 over 750.

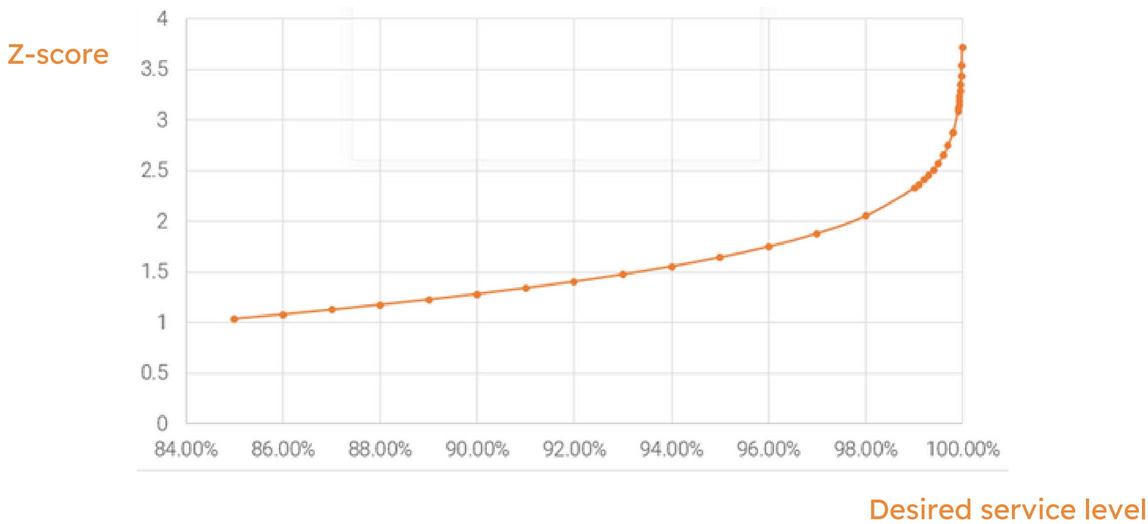
As the chart on the following page shows, if you set your service level target at 50%, you don't need safety stock because you have a 50/50 chance of selling more or less than the average next month.

However, if you want a service level of 95%, the normal distribution will give you a Z-score (a multiplier coefficient) of 1.64.



The Z-score can easily be determined using a service factor table (as shown on page 20), or you can use the Excel function NORMSINV to convert a service level percentage to a service factor.

The graph below shows the relationship between the target service level and the Z-score. The relationship is non-linear, e.g. higher service levels require disproportionately higher Z-scores and, therefore, disproportionately higher safety stock levels.



Standard deviation of demand

Standard deviation is used in statistics to measure how spread out a certain set of numbers is from the average. This allows the safety stock calculation to take into account demand variance.

Standard deviation of demand is calculated like this:

1. Determine the mean (average) of a set of numbers.
2. Determine the difference between each number and the mean.
3. Square each difference.
4. Calculate the average of the squares.
5. Calculate the square root of the average.

Let's take a working example. Mary works at The Plumbing Superstore. Below, you can see her forecasted demand for a line of showerheads. The average weekly demand is 525 units.

Period	Forecasted demand for shower head A	Difference between actual and forecasted demand	Difference squared
Week one	550	25	625
Week two	500	-25	625
Week three	650	125	15,625
Week four	400	-125	15,625
			32,500

- The total of the squared differences is 32,500 units.
- The average of 32,500 is 8125 units.
- The square root of 8,125 is 90.
- 90 units is the standard deviation of demand per week.

You can also use the Excel function STDEVPA to calculate the standard deviation. In safety stock calculations, the forecast quantity is often used instead of the mean in determining standard deviation.

Always ensure that you use the same unit of measurement for both the demand and lead time calculations. For example, if your standard deviation of demand is calculated in days, then calculate your average lead time in days, too.

Let's now combine these elements using The Plumbing Superstore as an example. Mary wants to achieve a service level for her showerheads of 95%. The service factor table (page 21) gives a Z-score of 1.64. The workings on the previous page show the standard deviation of demand is 90 units per week, and the average lead time is 3.5 weeks.

$$SS = Z * \sigma_d * \sqrt{LT}$$

$$SS = 1.64 * 90 * 1.87$$

$$SS = 1.64 * 90 * 1.87$$

Pros/Cons:

This formula will work well if your supplier lead times are fairly stable and you rarely have delivery delays. However, in practice, this is often unlikely, and you need to add factors to compensate for variance in your supply chain.

Safety stock formula with demand and lead time uncertainty

In the previous equation, safety stock was only used to mitigate demand variability. When variation in lead time is also a concern, the equation must be expanded. The formula below does just that:

$$SS = Z * \sqrt{(\sigma_d^2 * LT + x^2 * \sigma_{LT}^2)}$$

Key:
SS = Safety stock level
Z = Z-score
σd = Standard deviation of demand
LT = Average lead time
x = Average demand
σ_LT = Standard deviation of supplier lead time

Let's look at a working example of this formula using the Plumbing Superstore.

Mary still wants to provide a 95% service level for the showerheads.

- Average demand is 525 units per week
- The standard deviation from demand is 90 units
- The average supplier lead time is 3.5 weeks, but it can be as fast as 2.5 weeks and as slow as 4.5 weeks
- The standard deviation in lead time is 0.79 weeks (approx. 5.5 days stock)

$$SS = Z * \sqrt{(\sigma_d^2 * LT + x^2 * \sigma_{LT}^2)}$$

$$SS = 1.64 * \sqrt{(90^2 * 3.5 + 525^2 * 0.79^2)}$$

$$SS = 1.64 * \sqrt{(28350 + 172018)}$$

$$SS = 1.64 * 447.6$$

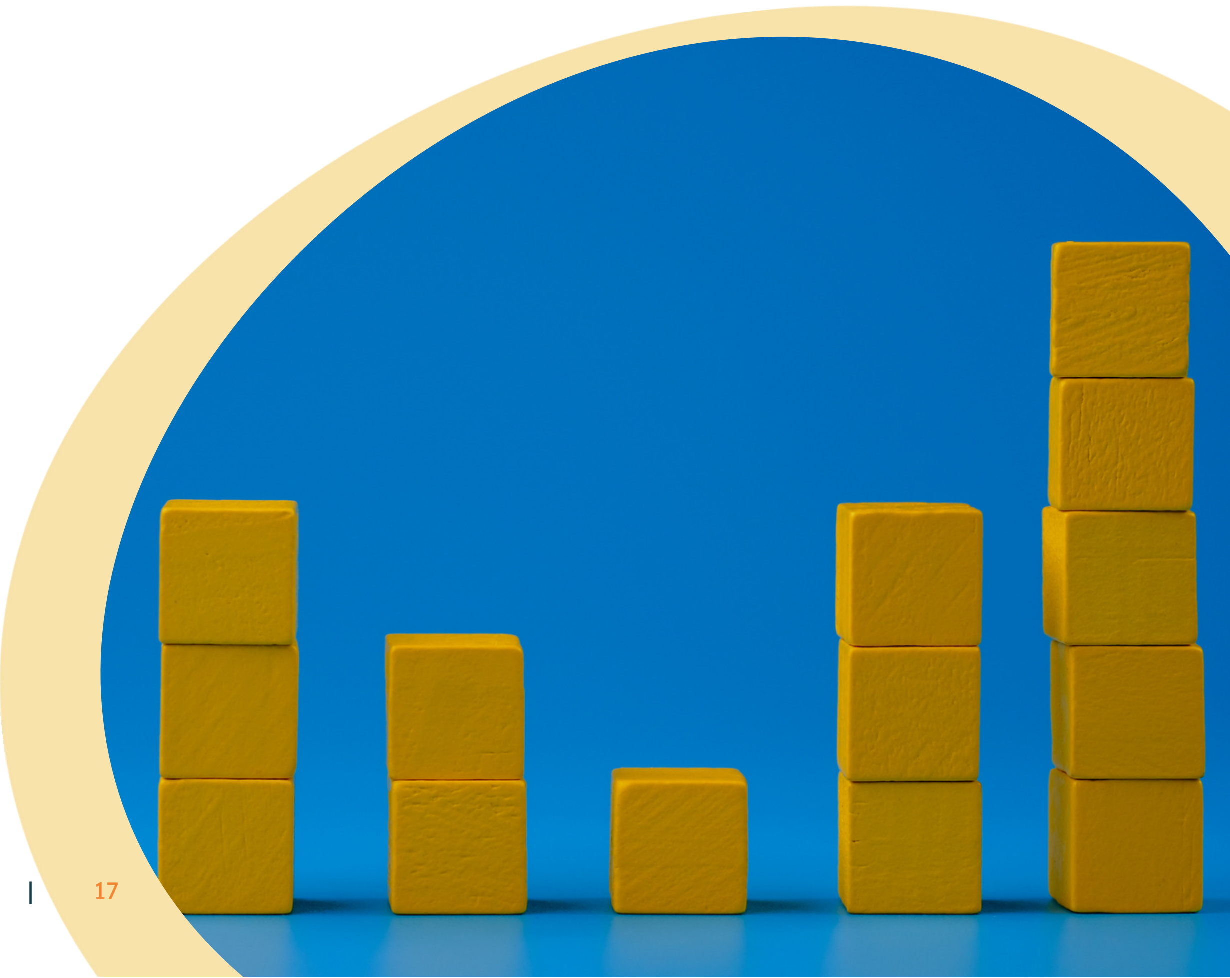
$$SS = 734 \text{ units}$$

As you can see, the safety stock level is now much higher, as lead time variance is also being considered.

Pros/Cons:

This formula assumes that the difference between the forecast and the actual demand follows a normal probability distribution. If the forecast error does not have a normal distribution, the quality of the result will be diminished.

For items with intermittent demand patterns, such as slow and lumpy demand, you'll achieve higher accuracy using Poisson distribution or negative binomial distribution.



Choosing the right safety stock model

Whichever safety stock calculation you use, it's essential to test it carefully before final implementation. This ensures it works correctly and analyses its impact on inventory levels and cash flow.

While more sophisticated models lead to more accurate safety stock levels, they also take time and resource to implement. Manual calculations are also frozen in time and virtually impossible to implement at SKU level.

A solution is to use software that automates this for you.

Dynamic safety stock

An inventory optimisation tool like EazyStock takes statistical safety stock calculations to the next level. It reduces the time involved in undertaking manual calcultions and avoids the risk and associated costs of humand error.

EazyStock sets safety stock levels at SKU level and considers several elements:

Demand type:

EazyStock uses various statistical algorithms and probability distributions, e.g., normal, Poisson, empirical, and negative binomial distribution. The most appropriate algorithm is chosen based on each item's demand type. So whether an item's demand is fast, slow, lumpy or erratic, EazyStock calculates safety stock as accurately as possible.

Supplier lead times:

The dynamic lead time feature reviews purchase order history and alerts you when supplier lead times deviate from the norm.

You can then ask the system to automatically increase safety stock levels to help achieve target service levels.

Safety stock calculations are automatically reviewed and updated daily (when required) based on service level targets, demand variance, forecast accuracy, supplier lead times and order frequency. When these factors change, EazyStock updates safety stock algorithms dynamically and adjusts final safety stock levels accordingly.

With a tool such as EazyStock, you no longer need to calculate and update safety stock manually and enter this into your ERP. EazyStock does all the maths for you.

Summary

Today's marketplaces and supply chains are more dynamic and uncertain than ever. Demand and supply volatility is almost inevitable, making safety stock necessary for many businesses.

It's important to calculate safety stock levels as accurately as possible to balance inventory investment and stock availability, e.g., hitting your service levels.

Statistical safety stock calculations are much more accurate than fixed safety stock or time-based methods, as they allow for more demand and lead time variance. However, using these more complex formulas in manual spreadsheets is time-consuming and can lead to errors – especially if you manage a large number of SKUs.

Companies who really want to optimise their safety stock and inventory levels should consider an inventory optimisation software solution.

This will plug into existing ERP or stock control systems and automatically calculate forecasts, safety stock, service levels, and reorder points, giving operations teams the data and the time to make informed, strategic supply chain decisions.

Appendix 1 Service factor (Z-score) table

Target service level	Service factor (Z-score)
50	0
55	0.13
60	0.25
65	0.39
70	0.52
75	0.67
80	0.84
81	0.88
82	0.92
83	0.95
84	0.99
85	1.04
86	1.08
87	1.13
88	1.17
89	1.23

Target service level	Service factor (Z-score)
90	1.28
91	1.34
92	1.41
93	1.48
94	1.55
95	1.64
96	1.75
97	1.88
98	2.05
99	2.33
99.5	2.58
99.6	2.65
99.7	2.75
99.8	2.88
99.9	3.09
99.99	3.72

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