E2OPEN®

WHITE PAPER

2018 Forecasting and Inventory Benchmark Study

Executive Summary

Now in its eighth year, E2open's 2018 Forecasting and Inventory Benchmark Study is the most consistent, comprehensive and useful study of its kind. The study encompasses over $250 billion in annual sales from global manufacturers across a variety of industries, including food and beverage, consumer packaged goods, industrial manufacturing, chemicals, and oil and gas.

This public version of the study provides the "state of the nation" for forecasting and inventory performance in North America. By aggregating data in a standard format directly from E2open's Demand Sensing and Multi-Echelon Inventory Optimization applications, the study overcomes the pitfalls of self-reported information and creates a reliable benchmark to help companies in the pursuit of planning excellence.

The Limits of Traditional Planning

Pressure to raise productivity, reduce costs and improve service keeps climbing. The days of simply getting by on incremental improvements are over. Increasingly, CEOs are counting on the supply chain to go beyond delivering just products and become an engine for transformation, differentiation and profitability. Accuracy matters more than ever, because the quality of every business decision ultimately ties back to the quality of one or more forecasts.

Despite this pressure to perform, forecast accuracy and the value-added created by demand planning investments in people, processes and technology have remained essentially flat over the last five years, suggesting that companies have squeezed just about all the benefits they can out of traditional techniques. This performance falls short of even the most basic incremental improvement targets, let alone the loftier goals mandated by the board. It's time to look beyond traditional approaches.

Measured Benefits of Automation and Machine Learning

Rethinking what's possible in planning is especially relevant now that almost every company has some form of a digital transformation initiative under way. The term "digital transformation" means something different to everyone and varies from SAP® Advanced Planning and Optimization (APO) replacement strategies to the full convergence of planning and execution. Regardless of the definition, there is new interest across industries in smarter software that uses machine learning and automation to step up performance.

Other than E2open's Demand Sensing, there are not many proven scalable applications on the market yet, but this will surely expand because the benefits are so compelling. Case in point, while organizations struggle to eke out more from their investments in traditional demand planning, demand sensing provides a distinct step change in performance, cutting error by 36% and doubling forecast value-added (FVA).

Effect of Innovation on the Long Tail

Item proliferation continues to work against productivity, making planners' jobs more difficult and actually increasing costs. New product launches continue to be a top priority as a way to get ahead and stay ahead of the competition. However, 94% of introductions end up in the tail (slowest moving items) in their first year, and with few ever breaking out to become faster sellers, the high rates of innovation only make the long tail even longer.

Failure to promptly cut non-performing products has the detrimental effect of both fueling proliferation and reducing average sales per item. Over the last eight years, the growth in active items (after accounting for discontinuations) outpaced the rise in sales by a factor of two. This trend, though discomfiting, is just the tip of the iceberg. While the number of active items increased by 36%, the cumulative growth in unique items during this period more than tripled.

For management, understanding the true and often hidden costs of innovation is an important step in finding the right cadence for introductions. Not only are new products hard to forecast, but each new item — whether it represents a new category, a line extension or simply new packaging — adds complexity along with inventory and production changeover costs.

Dramatic Impact of the Long Tail on Inventory

To gain further visibility into the true costs of proliferation, this year's benchmark study has been expanded to address inventory. This provides a financial context for what are otherwise technical supply chain metrics. It's one thing to report that error is *two times higher* for items in the tail than top movers, but it's another to know what this means in terms of inventory costs and working capital. It turns out that the tail is not only long but expensive. For the same sales revenue, *three times more* inventory is carried for items in the tail than for high-velocity items.

Measured Value of Multi-Echelon Inventory Optimization

For anyone wondering whether it's time to step up from traditional single-echelon inventory management to multi-echelon inventory optimization (MEIO), this study is a must-read. Inventory reduction is commonly used to justify a wide range of initiatives, but it routinely disappoints to the point that many companies feel jaded. What's been missing is an objective industry reference to understand the true benefits of inventory optimization.

To this end, the 2018 benchmark study has been enhanced to include an aggregate measure of actual inventory reductions realized by companies using E2open Multi-Echelon Inventory Optimization. The study's fact-based, apples-to-apples comparison reveals that multi-echelon inventory optimization in conjunction with demand sensing reduces safety stock by 31% compared to traditional single-echelon inventory management. Interestingly, the use of multi-echelon inventory optimization alone without better forecasts from demand sensing only lowers safety stock by 13%.

The two takeaways are that multi-echelon inventory optimization works and that accuracy matters. The combination of optimization and sensing more than doubles the inventory reduction benefit of optimization on its own. Anyone serious about freeing up working capital should consider both.

Supply Chain Complexity

Each year, this study examines the state of supply chain complexity by evaluating item proliferation since 2010. The rapid pace of new item introductions makes forecasting and managing inventory more difficult, resulting in costs that are often not well understood. Understanding item proliferation is critical for addressing the challenges facing supply chains today.

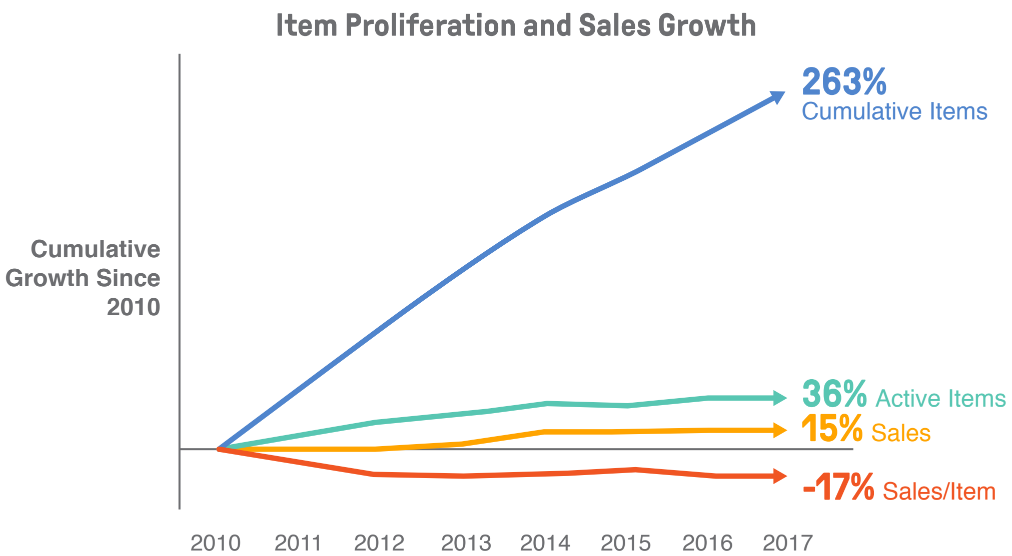
Item Proliferation and Turnover

“Growth-through-innovation” strategies continue to drive complexity faster than sales

With companies focusing on product innovation to drive sales growth, the high rate of item proliferation continues to be a challenge for supply chains. Since 2010, the growth in active items (total of all items net of discontinued items) outstripped sales by more than a factor of two. The number of active items was up 36%, compared to only 15% for sales. As a result, sales per item have dropped by 17%.

Cumulative items (total of all active and discontinued items) have increased 263% since 2010, which is even more alarming. The scale and pace of item turnover raise concerns about the hidden costs of growth-through-innovation strategies. Each introduction and discontinuation generates various supply chain costs, including manufacturing setup costs and the required inventory of raw materials, packaging and finished goods, as well as write-downs for obsolescence. Forecasting and managing inventory becomes more difficult because each planner is responsible for more items, and it is generally more difficult to plan for an increasing number of low-volume items than a smaller number of high-volume items. Some are phase-in and phase-out, but there are still significant costs for introducing them and risks of unused materials going to waste.

A bright spot in this year’s study is a slow-down in the growth of active items, which dipped very slightly. While perhaps a statistical quirk or noise, this could indicate manufacturers are more aggressively rationalizing product portfolios to rein in complexity.



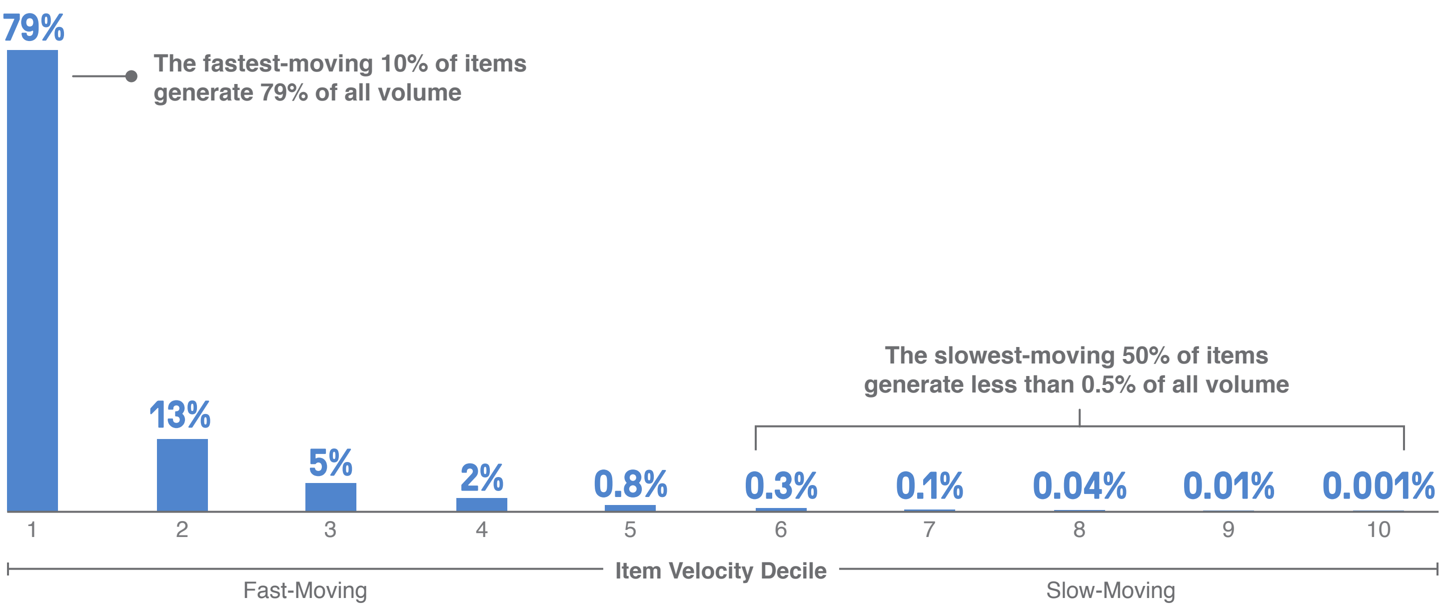
The Long Tail

The top 10% of items drive 79% of sales

To understand the impact of item proliferation, it is useful to look at how sales volume is distributed across product portfolios and quantify the size of the "long tail" — the large number of low-volume items that drives supply chain complexity. One method is to rank items by sales velocity, divide the items into deciles (where each decile represents 10% of the items) and then show the volume for each decile.

In the study, the top 10% of the items drive 79% of the sales volume, while the bottom 50% represents less than 0.5% of sales. Some people may argue that low-volume items are strategic or high-margin. While some of them are, it strains credibility that half of all items fit that description. Companies could probably cut most of these items and greatly reduce complexity and cost without significantly impacting sales.

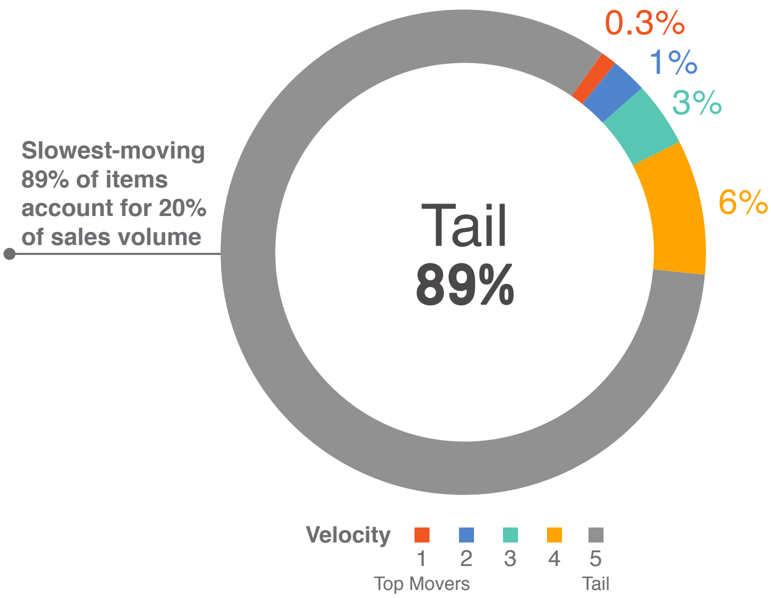
Percent Volume by Item Velocity Decile



Companies could cut complexity in half without significantly impacting sales.

Viewing the distribution of items across sales volume quintiles provides a different perspective of the tail. Items are ranked by velocity and divided into five groups of equal sales volume, with the fastest-selling items in quintile 1 (top movers) and the slowest in quintile 5 (the tail). In this analysis, the top 0.3% of items drive 20% of the sales, the top 11% of items drive 80% of sales and the bottom 89% of items — labeled “Tail” in the circle graph — account for just 20% of sales. This demonstrates again that a huge amount of complexity and cost is driven by a small portion of the business.

Percent of Items by Sales Volume Quintile



(Each band in the graph is 20% of sales volume.)

How long is the long tail? The answer is a shocking 89% of all items.

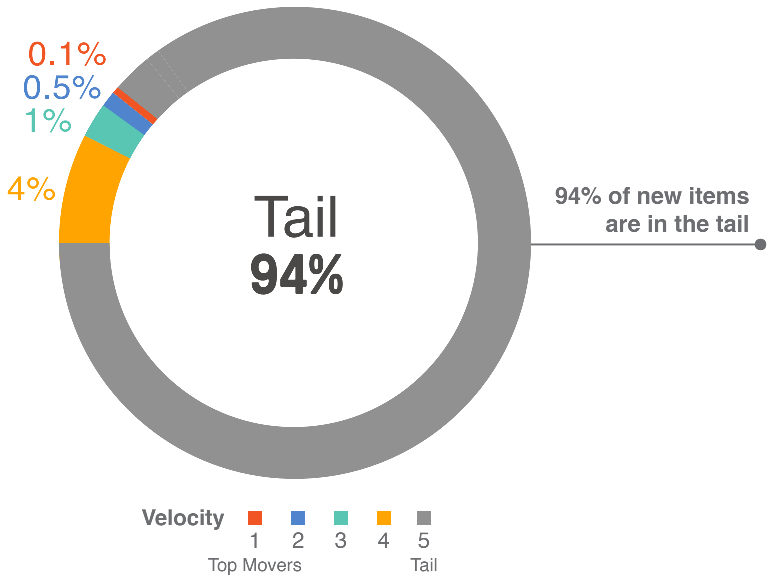
The Impact of Innovation

New items contribute disproportionately to the long tail

What makes the long tail so long? The short answer is that it is fueled by innovation and a reluctance to cut poorly performing items. An analysis of product introduction data reveals that only one in a thousand new items becomes a top mover. The vast majority — 94% of all new products — ends up in the tail.

A new item could be an entirely new product in a new category, a line extension or simply a minor tweak to an existing product. For the purposes of this study, the items associated with any new base code — typically a Universal Product Code (UPC) or Global Trade Item Number (GTIN) — are considered new. As such, some new items could be top movers from day one simply because they are replacing a very similar established product. For example, if there is a sheet count change on a roll of paper towels requiring a new UPC, the resulting item is considered new. This means that the success rate for truly new items is even lower than indicated by the data.

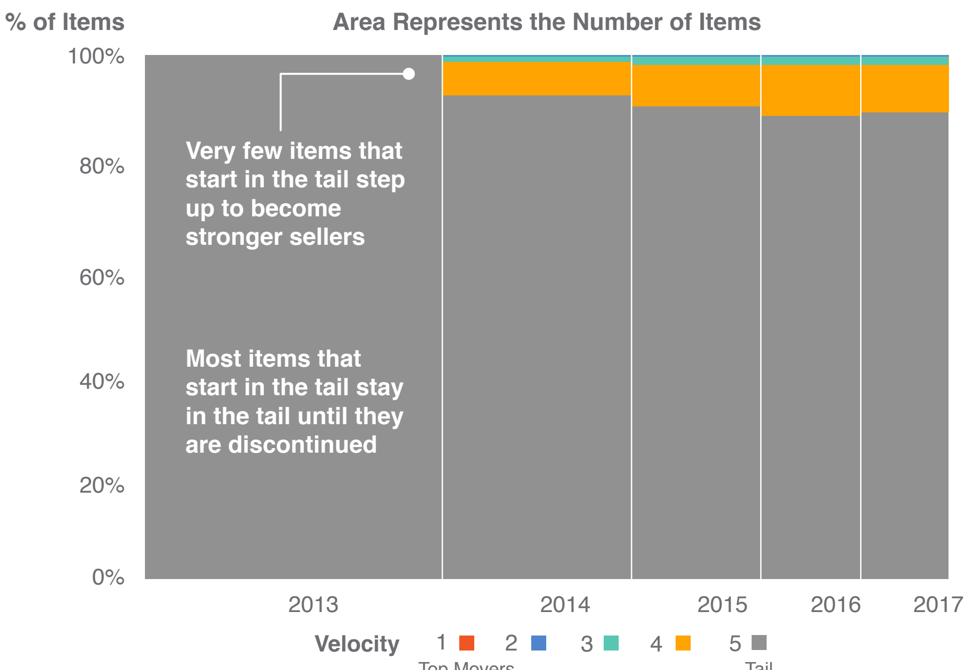
Percent of New Items by Sales Volume Quintile



The chance that an item will start off in the tail and move out of the tail is slim. While there are some isolated instances of a new item rising from the tail to become a top mover, they are few and far between. The reality is that most items that start in the tail remain there. An analysis of all data points since 2010 reveals that no item that was in the tail for its first two years has ever become a top mover.

In light of these findings, while management teams may understandably be reluctant to hold back innovation, they now have firm data on how better to control the costs of proliferation. Given the poor success rate of new items and their disproportionate contribution to supply chain complexity, there is a strong argument for aggressively culling new products if volume does not take off within the first year.

Evolution of New Items in the Tail: Very Few Become Fast Movers



State of Demand Prediction

This section of the study looks at trends in forecastability (ease of forecasting), forecast value-added, error, bias and volume exposed to extreme error. The analysis includes both the performance of demand sensing as well as traditional demand planning. Special attention is given to items in the tail and new product introductions.

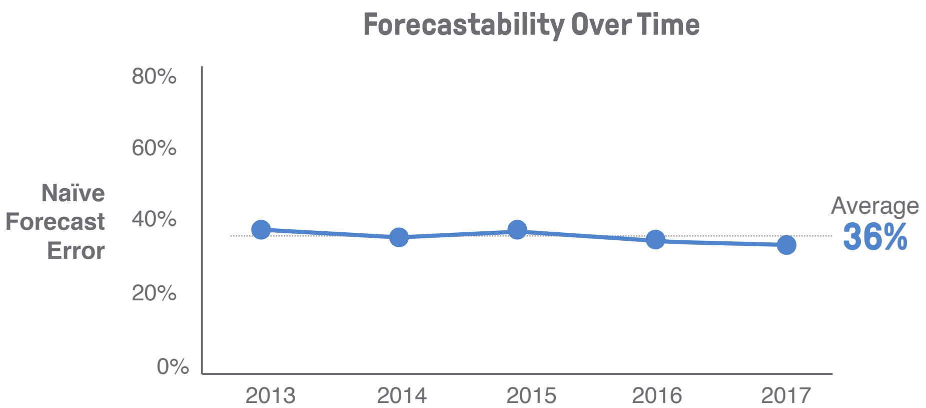
Forecastability

Naïve forecasts are critical to understanding how forecastable a business is

To benchmark a company's forecasting performance, management must recognize that some businesses are easier to forecast than others. Forecast error is affected by many things beyond the control of the demand planner, such as the way companies go to market, their distribution strategies and whether products are perishable. When evaluating forecasting capabilities independent of such factors, a naïve forecast is used to establish a baseline.

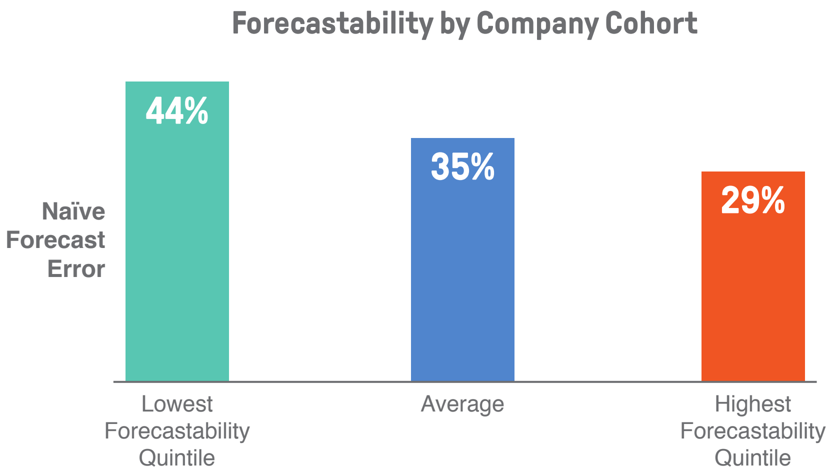
A naïve forecast is a simplistic forecast based on a seasonally adjusted moving average, and the accuracy of this forecast is a measure of forecastability. A business with a lower naïve forecast error is more forecastable than one with a higher naïve error. In this study, error is measured at the base code and month level for all discussions of naïve forecast and forecast value-added.

Naïve forecast error has gradually declined over the last five years, from 38% to 35%, meaning that forecasting has become slightly easier over time.



Forecastability varies considerably by company. While the average naïve forecast error for all companies is 35%, companies in the cohort with the lowest forecastability have a naïve error of 44%, and those with the most forecastable businesses have an error of 29%.

The groupings for highest or lowest quintile are unrelated to each company's skill at forecasting. Rather, they reflect different go-to-market strategies, distribution models and product types. The analysis demonstrates the significant differences in forecastability among businesses, which should be considered when benchmarking demand planning performance and productivity.



Ways to Improve Forecastability

One way to make a business more forecastable is to manage more aspects of the supply chain. Direct store delivery supply chains typically have 10% lower weekly error than warehouse-delivered businesses. The two key reasons for this are direct visibility into consumer demand and control over retailer execution. Visibility into consumer demand improves forecastability by reducing the bullwhip effect and removing structural uncertainty. Direct participation in retail execution gives manufacturers more control over shelf stocking and in-store promotional merchandising, increasing the chance that actual sales will match forecasts.

Companies for which direct store delivery is not a feasible option should consider expanding vendor-managed inventory programs and leveraging store data to sense demand at retailer distribution centers. The volatility between retailer distribution centers and stores can be half the volatility that occurs between the manufacturer and retailer distribution centers. This presents an opportunity to reduce days of inventory by up to a week.

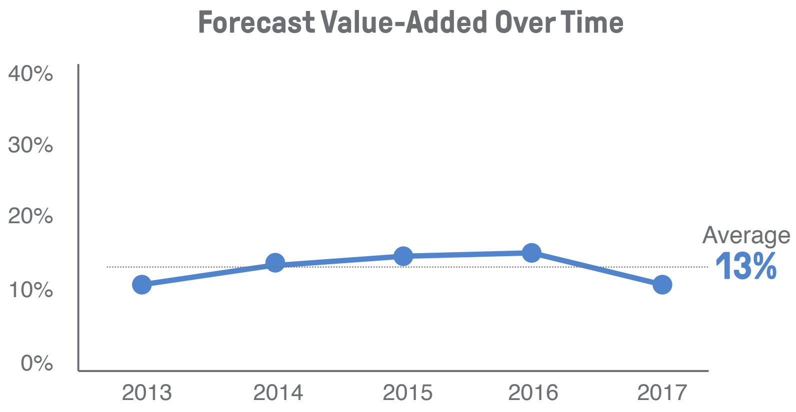
Companies that can't adopt a direct store delivery model should consider expanding vendor-managed inventory and leveraging store data to sense demand at retailer distribution centers. This can remove up to a week of inventory.

Forecast Value-Added

The value of demand planning investments varies dramatically by company

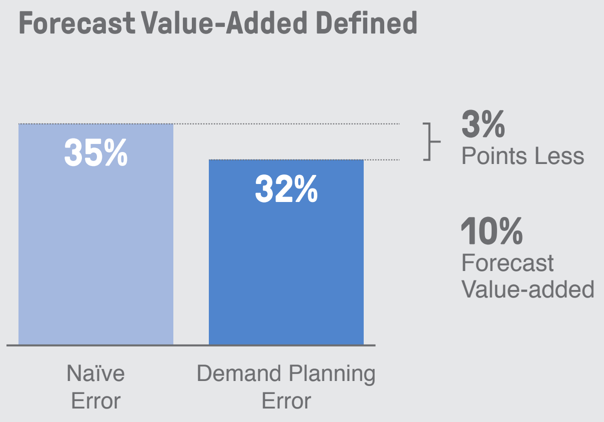
The value achieved from a company's investments in demand planning processes, people and technology is measured by forecast value-added, which is the difference between the forecast error and the naïve forecast error. While forecast error is frequently used to track demand planning performance, the forecast value-added metric allows for apples-to-apples comparisons across companies, divisions, categories and/or products because it accounts for differences in forecastability.

Forecast value-added has been steady at 13%, plus or minus a few percentage points each year. After improving for several years, the value-added provided by demand planning decreased last year, dropping to 10%. A deeper dive reveals that this drop was the result of a slight decrease in naïve forecast error at the same time as a slight increase in demand planning forecast error. In other words, demand planning accuracy got worse, even though the businesses were slightly easier to forecast.



What is Forecast Value-Added?

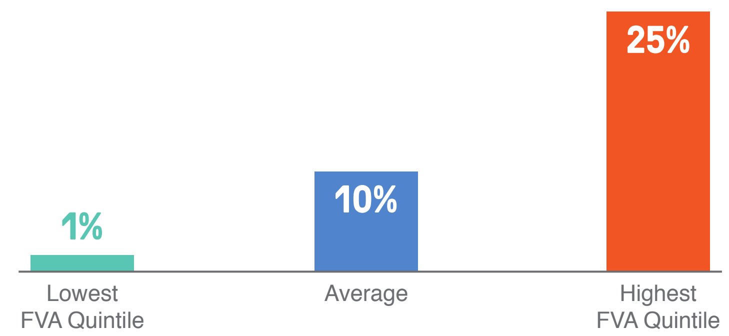
Demand planning represents a large expense for most companies, and every organization needs a way to measure its performance. Forecast value-added provides a standard measure of the value realized by investments in planning systems, processes and people. It compares the relative difference between the forecast error of a forecasting system and that of a seasonally-adjusted naïve forecast, which is basic and rudimentary. As a relative metric, forecast value-added is effective for measuring value regardless of company size, go-to-market strategy, distribution model or product mix.



Some companies do better than others in generating value from demand planning investments. Best-in-class demand planning organizations reduced forecast error by 25%, lowering the cohort's average naïve forecast error from 36% to 27%. This is *2.5 times higher* than the average for all companies. For companies in the lowest quintile, the value of demand planning was dramatically less at only 1%, *10 times less* than the average and *25 times less* than best-in-class. This wide discrepancy highlights the real impact of planning choices by companies, independent of the specific characteristics of their businesses.

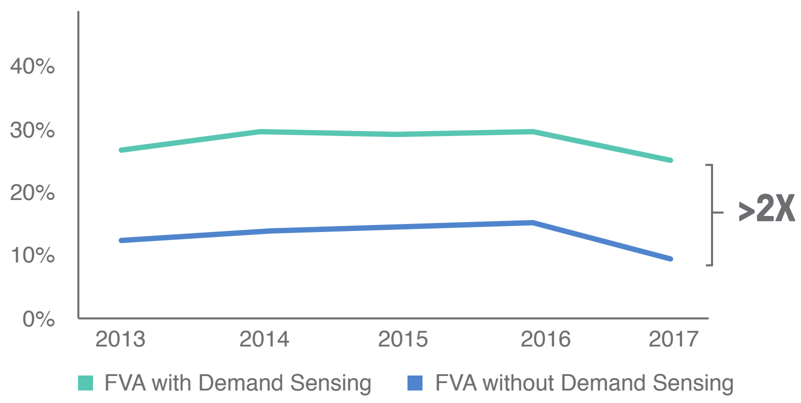
Best-in-class demand planning groups and processes reduced forecast error by 25%, 2.5X more than the average for all companies.

Forecast Value-Added by Company Performance Cohort



More and more, companies looking to increase forecast accuracy beyond what is possible with traditional demand planning are investing in demand sensing technology. The data confirms that demand sensing applications consistently provide a dramatic boost in forecast value-added. Over the last five years, value-added with demand sensing was 27% — more than double traditional demand planning on its own.

Demand Sensing Forecast Value-Added Advantage



Demand sensing consistently provides a forecast value-added of 27%, more than twice that of traditional demand planning.

In addition to pursuing a step change in performance from demand sensing, companies should consider programs to incrementally increase forecast value-added. These include structural initiatives to deal with incentive conflicts in sales and operations planning (S&OP), automating promotional inputs to the forecast, controlling item proliferation and network rationalization. These activities can both increase forecastability and lower error.

What is Demand Sensing?

As with many trendy terms, “demand sensing” is often used loosely without a common understanding of its meaning. Demand sensing is not simply augmenting demand planning with more current demand data but rather a fundamentally different way of forecasting with a focus on the near term. Here is a simple but instructive analogy: To answer the question of how much milk to buy at the grocery store on the next visit, a traditional demand planning approach would be to buy the average of what was purchased during the same week the last two years. In contrast, the demand sensing approach — which is more accurate — looks at how much milk is already in the refrigerator and takes into account the fact that milk consumption has recently increased in the household because college-aged children are home for a long holiday.

More formally, demand sensing is a technique for forecasting near-term daily demand across a horizon of several weeks, taking into account all available current information on inventory levels, recent shipments, open orders, customer ordering behavior and any causal factors that could affect demand. Demand sensing is distinguished from traditional demand planning as shown in the following table:

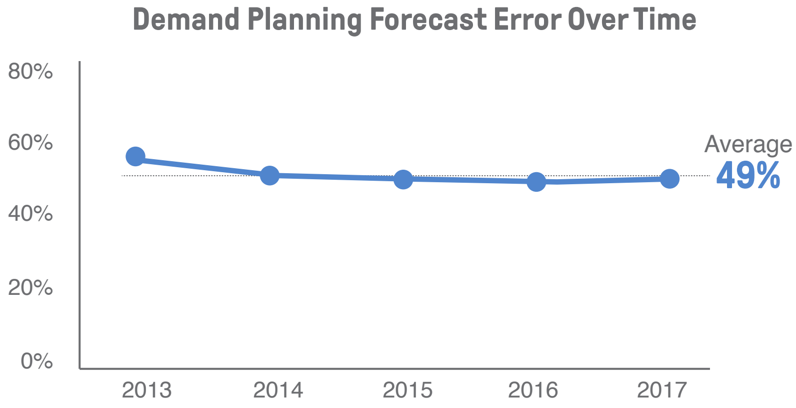
Demand Planning	Demand Sensing
Uses seasonal patterns to predict sales, using average sales at the same time in past years as the primary driver of the forecast	Uses multiple current demand signals and order patterns to predict daily sales, optimizing a blend of signals for each product and location
Does not understand the relationship between demand in different periods	Understands the relationship between demand in different periods
Focuses on managing the demand plan	Focuses on enabling product supply to make better decisions by improving accuracy of projected inventory
Provides weekly or monthly forecasts	Provides forecasts in daily buckets that are updated each day
Requires manual review and model tuning	Operates with full automation and self-tuning algorithms

Forecast Error

Demand planning error is essentially stuck

While forecast value-added is important for comparing performance across companies, accuracy is still a key metric to measure the quality of the forecast. This in turn is essential to the quality of inventory projections and supply chain performance. Accuracy is most often reflected in terms of forecast error, specifically mean absolute percentage error (MAPE). Error can be measured at different aggregation levels. In this study, demand planning error and bias figures are reported at the weekly item-location level because this is typically most meaningful for supply chain operations decisions that impact service and cost.

Demand planning forecast error has remained essentially flat over the last five years, averaging 49% plus or minus 1%, with the exception of a slight drop in 2014. Traditional demand planning performance is stuck, and efforts to improve it have yielded only small gains.

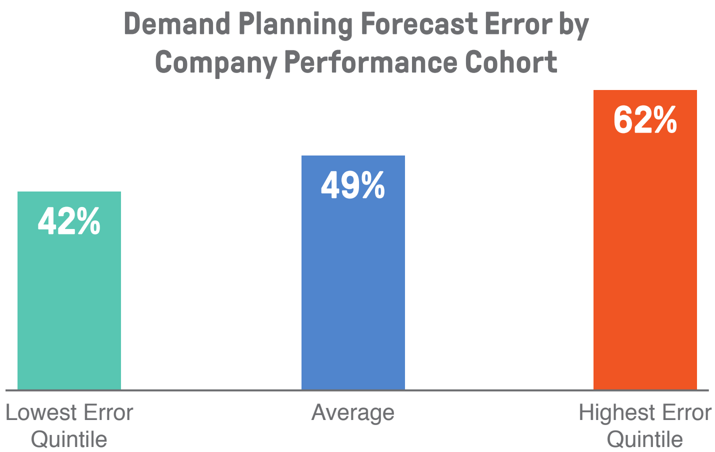


More About MAPE

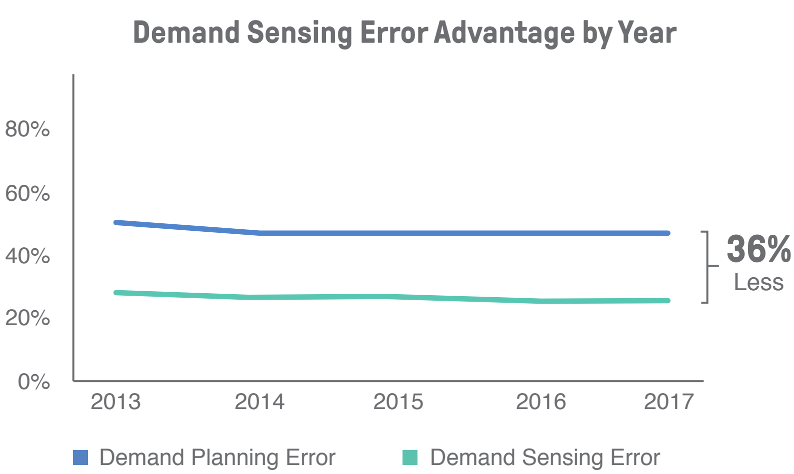
Mean absolute percentage error (MAPE) is a common way of measuring forecast accuracy. It is calculated as total absolute error (the difference between forecast and shipments) summed and divided by total shipments. While some companies use forecasts in the denominator, this study standardizes on the use of shipments, which is the preferred method. Being a measure of absolute error, MAPE is always positive. The higher the MAPE, the lower the quality of the forecast. Some planners refer to this type of MAPE as “weighted MAPE” (WAPE or WMAPE), because when aggregating MAPE measurements across items or time, the metric is weighted by product volume.

MAPE can be measured at different levels of aggregation. In this study, discussions of naïve forecast and forecast value-added measured error at the monthly base code-location level. Forecast error and bias are measured at the weekly item-location level, since that is typically the level relevant to supply chain operations.

The study revealed a considerable difference in accuracy among companies. The cohort with the highest forecast error experienced 62% error compared to 42% for the cohort with the lowest error. Not surprisingly, there is a significant overlap between the companies with highest/lowest demand planning error and naïve forecast error. All things being equal, products with low forecastability have higher forecast error and products with high forecastabilty have lower error.



Just as demand sensing dramatically improves forecast value-added, it does the same for accuracy, consistently reducing forecast error by an average of 36% over the last five years. With demand planning performance essentially flat, demand sensing offers an attractive opportunity for a step change in forecast improvement. This demonstrates the value of augmenting traditional demand planning techniques with current data, machine learning and automation.

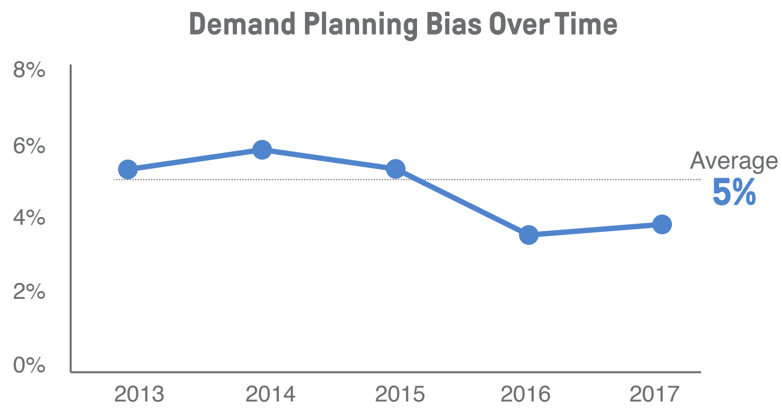


Forecast Bias

Bias is slowly improving, but most companies can still do better

Whereas error is an indication of forecast quality (how far wrong it was), bias measures the quality of the S&OP process (how effectively the organization worked together on creating a consensus forecast). Bias reveals the tendency of an organization to consistently over- or under-forecast sales. Ideally bias should be zero — meaning a forecast is just as likely to be too high as too low — but it is typically positive, reflecting a false sense of optimism or an affinity to pad forecasts to ensure service and avoid stock-outs. Positive bias also may be an indication of incentive conflicts in the S&OP process, especially for organizations where the sales organization holds a disproportionate influence.

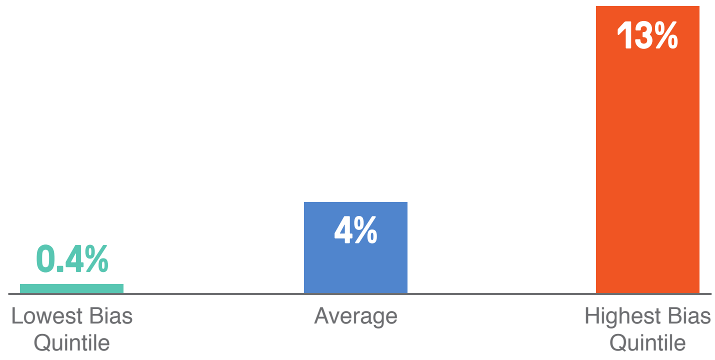
Since this study started in 2010, bias has come down gradually, perhaps because companies have developed more realistic expectations of growth and/or they have improved their S&OP processes. Over the last five years, bias has averaged 5%, plus or minus 1%.



Last year, the average bias dipped to 4% but varied considerably among companies. For the first time since 2010, multiple companies essentially eliminated bias — a job well done! The cohort of companies with the best performance has a bias 0.4%, compared to 13% for the cohort with the highest bias.

While bias limits the degree of forecast accuracy, the two are not always correlated. In this study, some companies with the highest error have the lowest bias. While these companies have accuracy challenges, they seem to have effective S&OP processes to minimize — and in some cases even eliminate — systematic bias.

Demand Planning Bias by Company Performance Cohort



Extreme Error

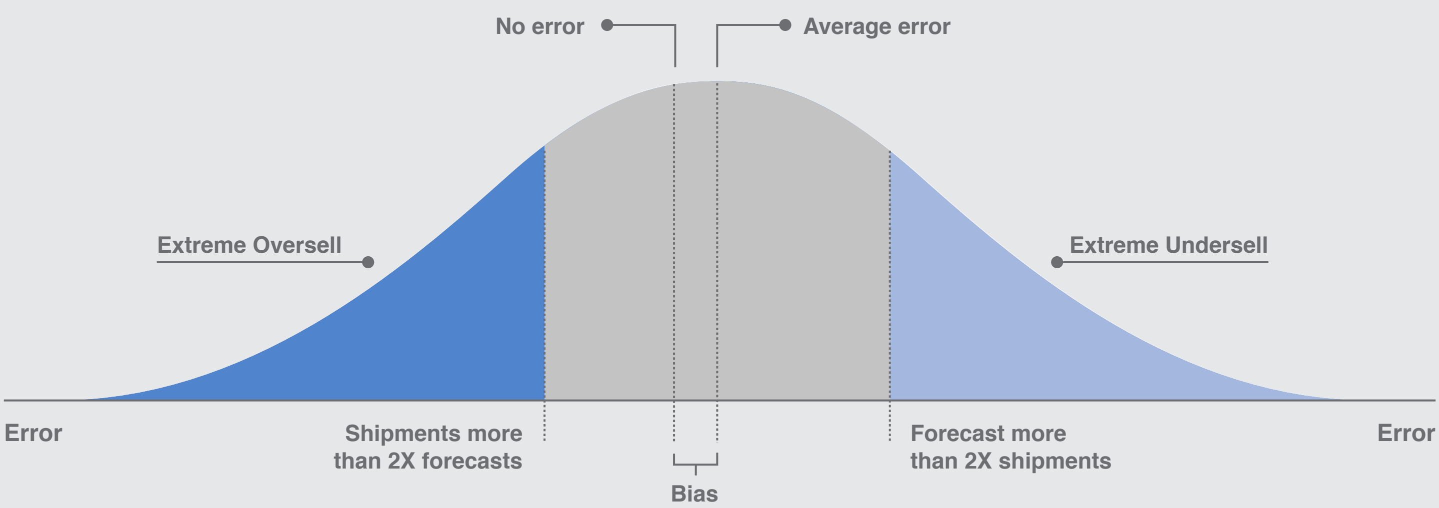
Volume exposed to extreme error drives the most costly service and inventory issues

Extreme error is a metric E2open created to measure the most disruptive issues in the supply chain. It represents the percentage of sales volume that differs from what is expected by more than 100%. Well-designed supply chains are able to deal with a reasonable amount of volatility without too much disruption and cost. Yet when error is extreme, the disruption and costs become very high.

Extreme Error: Most Problematic for the Supply Chain

Extreme oversell error: Sales exceed *two times* the forecast. This imposes hardships on human resources, erodes margins through transshipments, expediting and/or unplanned production changes, and risks service levels.

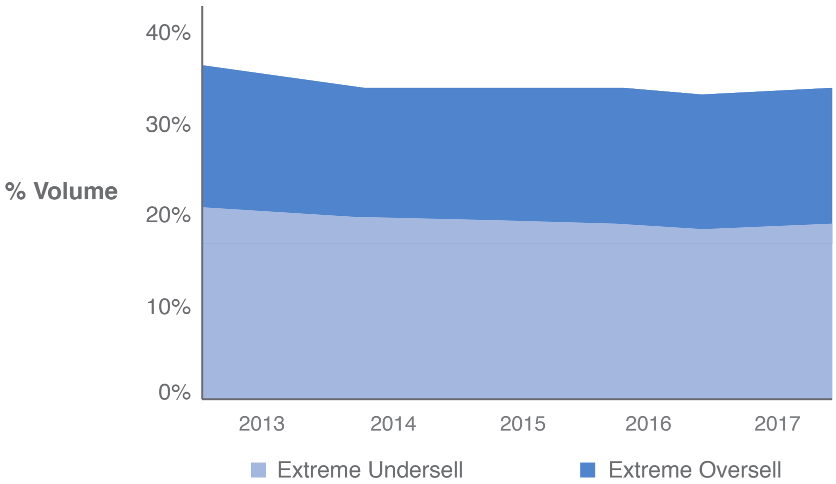
Extreme undersell error: The forecast exceeds *two times* the sales. This has less of an impact on staff than extreme oversell error, but there are significant financial consequences stemming from high levels of excess inventory, poor use of working capital, and ongoing finance and carrying costs.



A shocking 35% of volume is subject to extreme error. This figure is consistent year over year, varying by only 1-2%. The high levels of extreme error shed light on the otherwise hidden costs of traditional planning systems. More than 15% of sales volume exceeds the forecast by at least *two times*, risking service levels, eroding margins through costly expedites and reducing productivity as staff scrambles to fill orders. Likewise, 20% of volume was less than half the forecast, resulting in excess inventory, poor return on invested capital and losses from spoiled or obsolete stock.

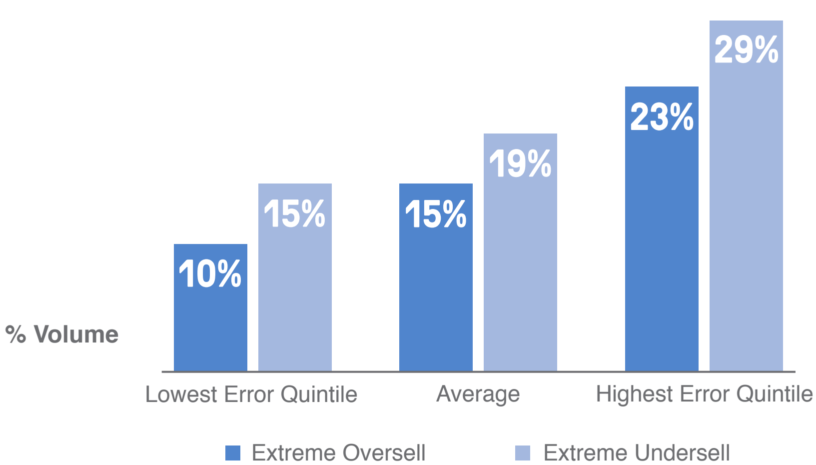
The asymmetry between under- and over-forecasting reflects the positive bias observed in the study. Excess inventory highlights one of many financial implications of bias.

Extreme Error Over Time



The degree of extreme error varies considerably across companies. The volume that is subject to extreme oversell ranges from 10% to 23% for the cohort of companies in the lowest and highest quintiles. Similarly, extreme undersell ranges from 15% to 29%. For companies in the highest quintile for both extreme oversell and undersell, more than 50% of their volume is in the extreme error category. Companies that experience high degrees of extreme undersell error also tend to suffer from extreme oversell error.

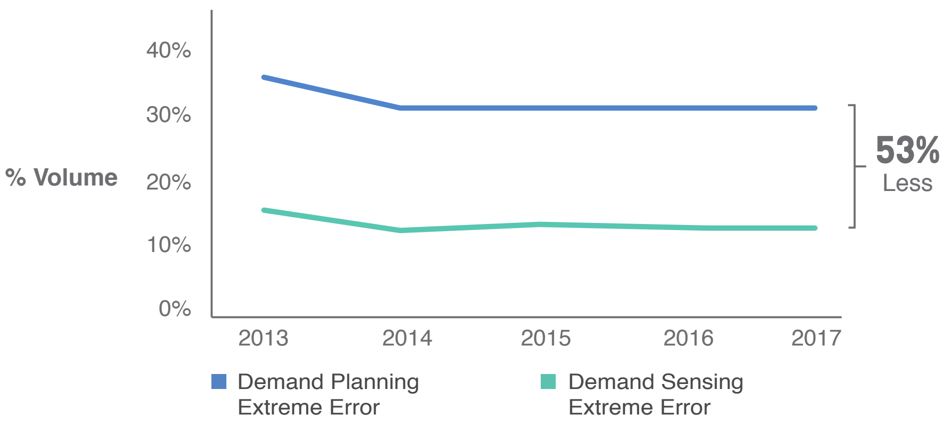
Extreme Error by Company Performance Cohort



Many companies struggling with the costly disruptions caused by extreme error have turned to demand sensing technology. The study revealed that, in addition to significantly improving overall accuracy, demand sensing also dramatically cuts instances of extreme error. Over the last five years, companies running demand sensing consistently enjoyed a 53% reduction in extreme error. This sharp reduction is a huge financial driver, improving service, productivity and capital investment performance.

Demand sensing does a great job of lowering forecast error but an even better job of reducing extreme error.

Demand Sensing Extreme Error Advantage Over Time



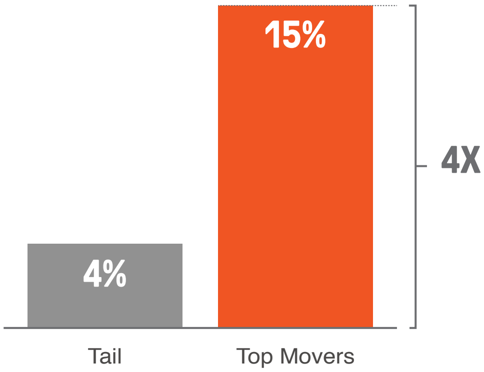
Forecasts for Items in the Tail

Demand sensing increases forecast accuracy by the same amount for both top movers and tail items

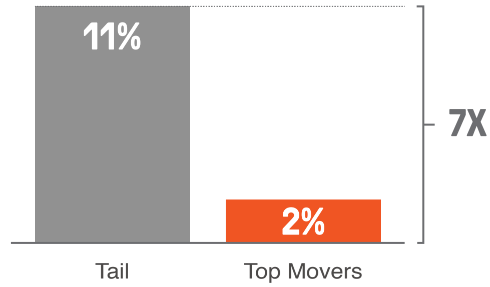
Higher-velocity items are generally easier to forecast than slower-moving goods for several reasons. One is that top movers have nearly half the naïve forecast error than items in the tail — 27% compared to 50% — making them twice as forecastable. Top movers also benefit from the extra attention that planners spend on these important products. As a result, they outperform items in the tail in every metric. Forecast value-added for top movers is *four times greater* than for items in the tail. Error and bias are *two times* and *seven times higher* respectively for items in the tail. Such metrics are driven by low sales volumes and the huge number of slow-moving items.

Not only are tail items harder to forecast than top movers, but they also lack the same level of attention because planners simply do not have enough time to focus on them. Not surprisingly, the volume of items in the tail subjected to extreme error is *three times greater* than for top movers. This constitutes a disproportionate burden caused by tail items in terms of both operational costs and capital invested in inventory.

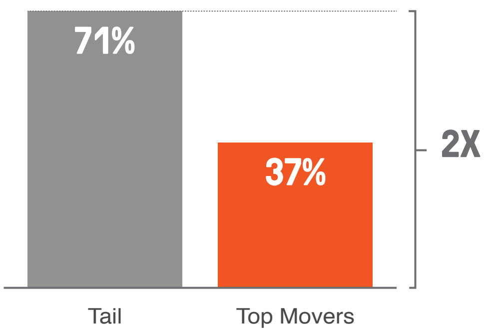
Forecast Value-Added
for Fast-and Slow-Moving Items



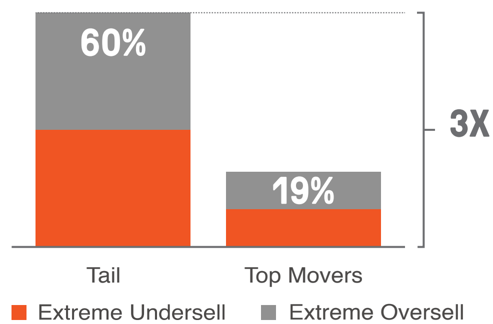
Forecast Bias
for Fast-and Slow-Moving Items



Forecast Error
for Fast-and Slow-Moving Items

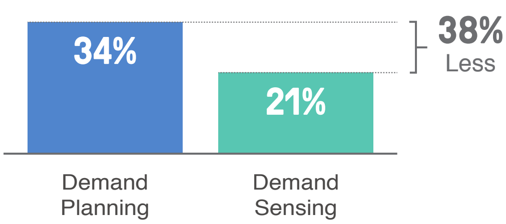


Extreme Error
for Top Movers and Items in the Tail

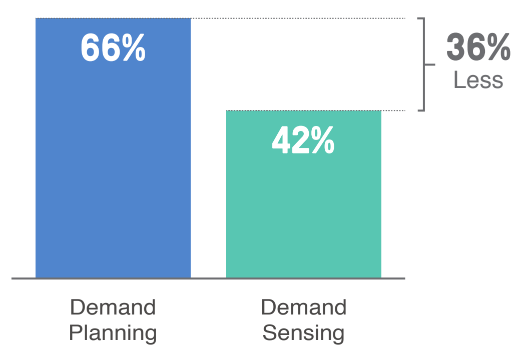


Demand sensing consistently improves forecast performance for all items regardless of velocity, cutting error for both top movers and items in the tail by 38% and 36% respectively. This underscores the benefit of using current signals to better predict demand. The improvements also highlight the scalability that comes with automated algorithms — and there are never too many items for an algorithm. Unlike a planner, demand sensing algorithms can give the same care and attention to the slowest-moving item in the tail as the company's number one seller. The result is a step change in performance for error metrics.

Demand Sensing Advantage:
Forecast Error for Top Movers



Demand Sensing Advantage:
Forecast Error for the Tail



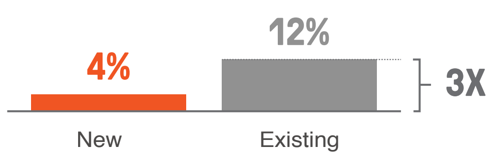
New Item Predictions

New items present forecasting difficulties and have more error and bias

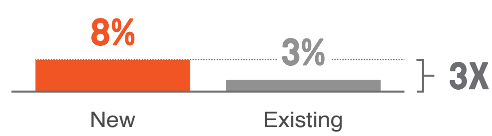
New items are particularly challenging to forecast due to the lack of sales history required by traditional forecasting techniques. Naïve forecast error is 45% for new items compared to 32% for existing items (not shown in graphs), meaning that new items are *1.4 times harder* to forecast. Not surprisingly, despite the extra attention given to new items, forecast value-added is one-third that for existing items, and demand planning forecast error is *1.3 times higher*. Of particular interest is the fact that bias for new items is *three times higher*, reflecting the habitual over-optimism for product introductions. Over-optimism is probably made worse by the high hurdle rates and fierce competition for development funds that create an expectation that every new item has to be a winner. Finally, as a result of the higher forecast error for new items, volume exposed to extreme error is *1.4 times higher* than for existing items.

A closer look reveals that forecast value-added for new items in the tail is actually negative. This is almost certainly due to the 20% demand planning bias on these items. Given that 94% of new items end up in the tail, the impact is significant. With forecast error at 80% on these items, the risk of obsolete materials and stock-outs is high.

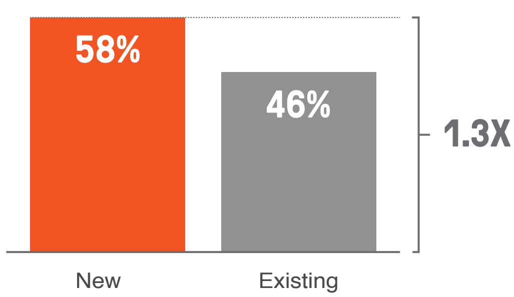
Forecast Value-Added for New and Existing Items



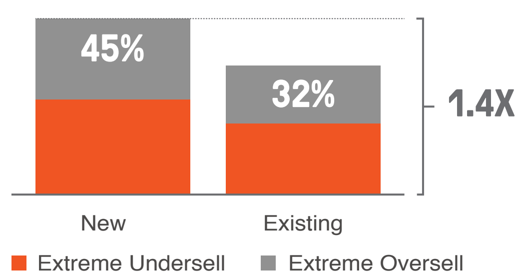
Forecast Bias for New and Existing Items



Forecast Error for New and Existing Items

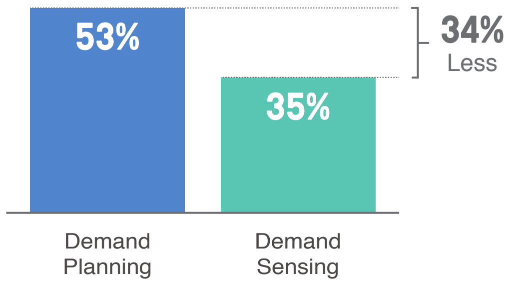


Extreme Error for New and Existing Items

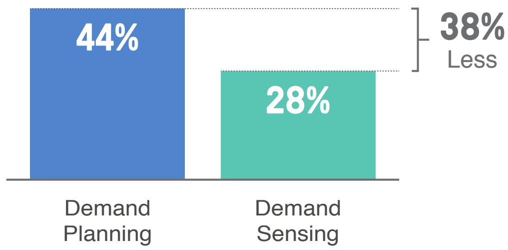


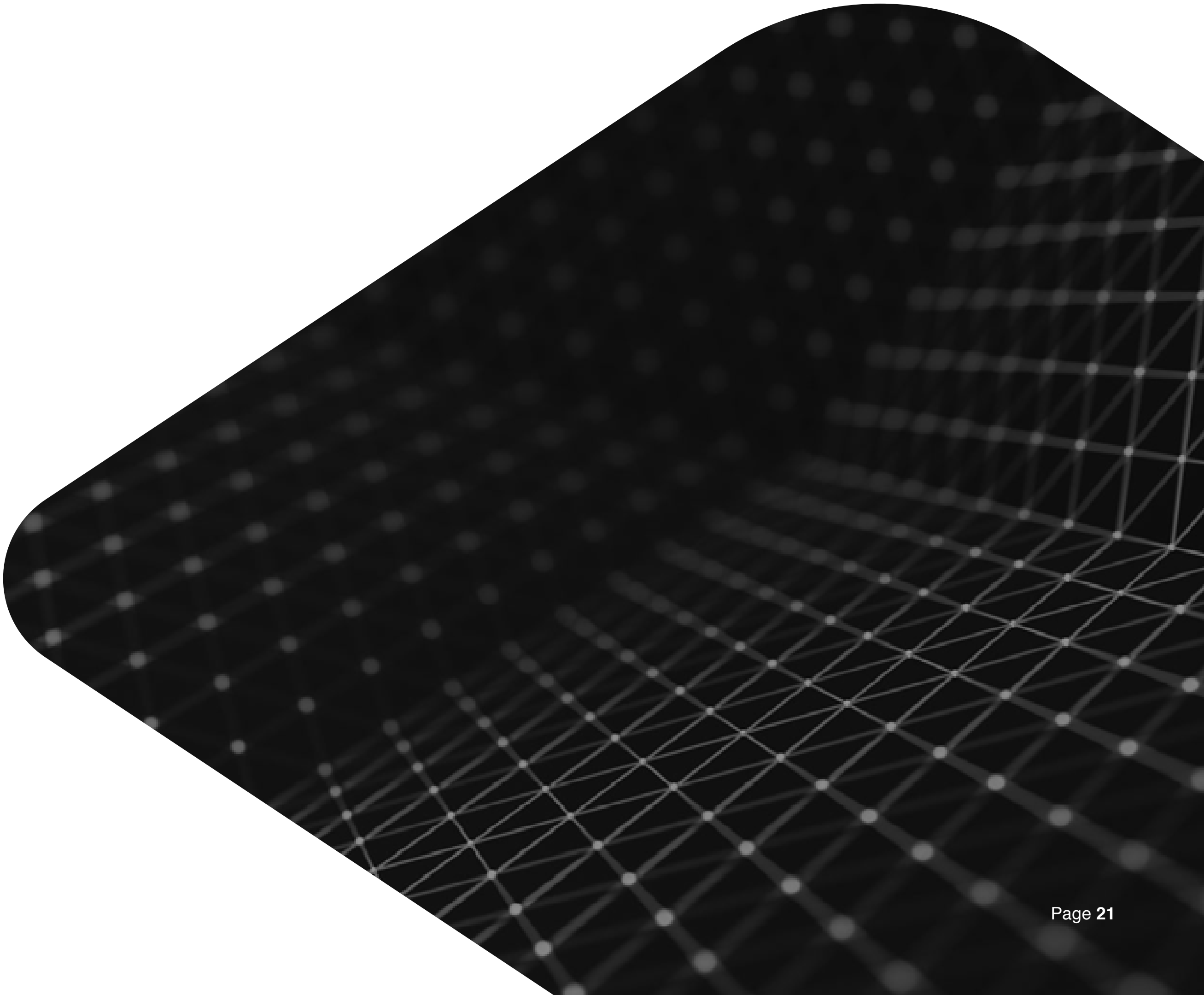
Demand sensing consistently improves performance, cutting forecast error for new and existing items by 34% and 38% respectively. Demand sensing's focus on current demand signals is particularly useful for new products because of their lack of sales history. This significantly improves new item forecasting while reducing the large amount of time planners typically spend on new items using traditional demand planning methods. Demand sensing offers similar step changes in performance for other metrics such as forecast value-added and extreme error.

Demand Sensing Advantage: Forecast Error for New Items



Demand Sensing Advantage: Forecast Error for Existing Items





Inventory

For the first time, this year's study looks at inventory performance. The participants in this part of the study include companies running both E2open Demand Sensing and E2open Multi-Echelon Inventory Optimization. In addition to analyzing days of stock on hand for different functions of inventory, the study also measured the financial benefit achieved from the deployment of multi-echelon inventory optimization software and the impact of combining demand sensing with inventory optimization.

Finished goods inventory across all major types of stock were examined:

- **Safety stock:** Minimum inventory required as a safety margin or buffer to prevent stock-outs while meeting target service levels
- **Cycle stock:** Inventory above and beyond safety and excess stock required to fulfill normal demand over a specific period
- **Transit stock:** Stock in transit from one location to another
- **Ground stock:** Stock on hold for quality assurance, order picking and similar reasons
- **Excess stock:** Excess inventory resulting from overly optimistic forecasts (positive forecast bias)

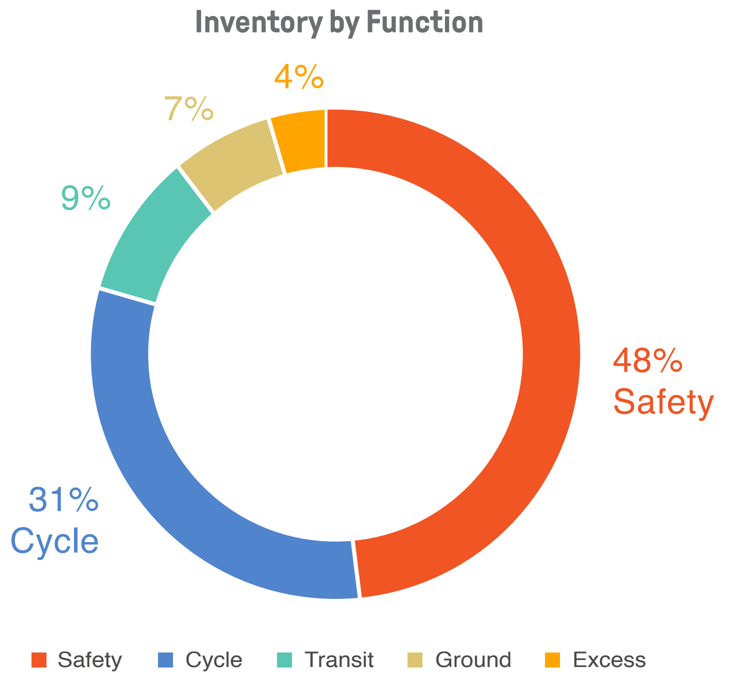
It is particularly enlightening to see how much more inventory is carried for slow-moving items and to understand the size of the various inventory components.

Volume of Safety Stock

Safety stock dwarfs other components of inventory

Not surprisingly, safety stock is by far the largest component of inventory, comprising of 48% of all finished goods on hand and followed by cycle stock at 31%. Typically, about 80% of safety stock is driven by forecast error, with the remainder stemming from poor schedule compliance and unreliable transportation. As such, the strategy to improve accuracy by sensing demand — which lowers forecast error by close to 40% — is a natural first step for companies seeking to significantly cut unproductive inventory and free up working capital.

Typically, about 80% of safety stock is driven by forecast error. Improving accuracy by sensing demand is a natural first step toward cutting unproductive inventory and freeing up working capital.



True Cost of the Tail

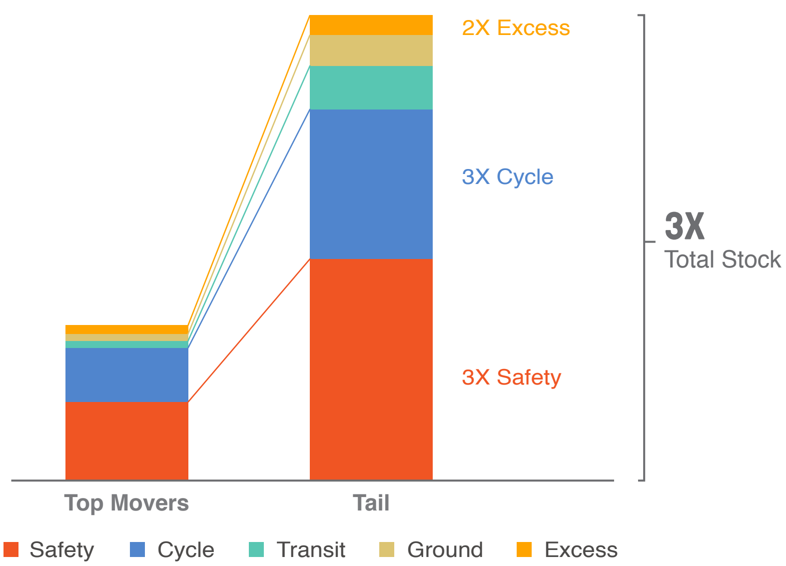
The tail requires three times more inventory of all types

The disproportionate share of inventory expenses incurred by the long tail is a primary cost of item proliferation. The data reveals that companies invest and carry *three times more* stock to support items in the tail compared to top movers. A deeper analysis finds that safety stock is *three times higher* because of the increased forecast error in the tail. Cycle stock is *three times higher* because of the need to trade off inventory investments and carrying costs against optimal production lot size and transportation load size. Excess stock is twice as high because of the increased bias and over-optimism for items in the tail. All these generate real yet often hidden costs that erode profitability, increase working capital requirements and decrease both return on capital and shareholder value.

The disproportionate inventory burden required to support items in the tail creates real yet often hidden costs that erode profitability, return on capital and shareholder value.

Rationalizing product portfolios and improving forecast accuracy are essential for containing these costs. One approach to targeting items for discontinuation is for supply chain and finance to work together to identify products that destroy value. This can be achieved by comparing gross margin with inventory carrying costs and identifying items where extra costs exceed gross profits. The most effective way to get a step change in forecast accuracy — especially for items in the tail — is to sense demand.

Stock Invested in Top Movers and the Tail (Days Inventory)



Value of Inventory Optimization

Inventory optimization is especially effective when combined with demand sensing, cutting safety stock by 31%

The conventional way to set target safety stock levels is to use a simple rule of thumb that is often based on a days-of-supply target. Unfortunately, such rules of thumb are by nature blunt instruments, frequently resulting in excessive inventory or service issues.

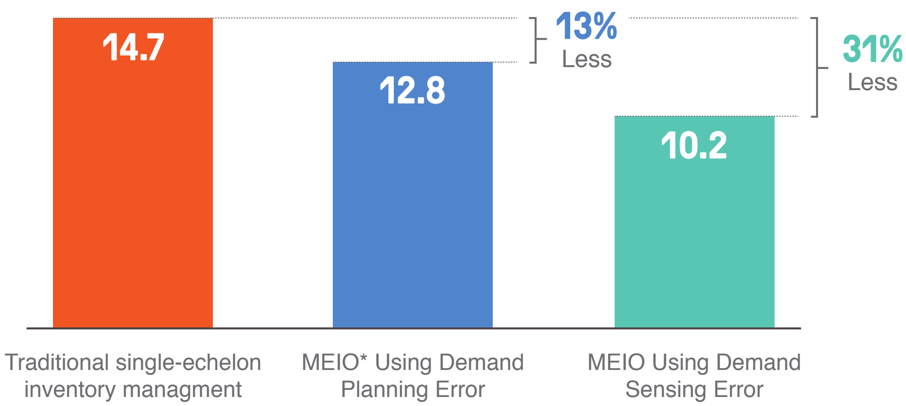
To minimize inventory levels and take advantage of the increased forecast accuracy from demand sensing, companies in the study use E2open Multi-Echelon Inventory Optimization to precisely set stock targets. As a multi-echelon solution, the application looks at the entire supply chain and considers the impact on stock held at each node to determine the lowest possible system-wide inventory.

In addition to service levels, inputs for inventory optimization calculations include variability in demand and supply. Forecast error is a particularly important input for determining optimal safety stock targets. With this in mind, the study examined the inventory investment required for three different scenarios:

- **Traditional approach:** Traditional single-echelon inventory management
- **Multi-echelon inventory optimization with demand planning:** Multi-echelon inventory optimization using demand planning forecasts as inputs
- **Multi-echelon inventory optimization with demand sensing:** Multi-echelon inventory optimization using the more accurate forecasts provided by demand sensing

Multi-echelon inventory optimization with demand planning forecasts yielded a 1.9-day decrease in inventory — a 13% reduction — compared with traditional single-echelon inventory management. The combination of multi-echelon inventory optimization and demand sensing yielded an additional 2.6-day decrease in inventory for a total reduction of 4.5 days or 31%.

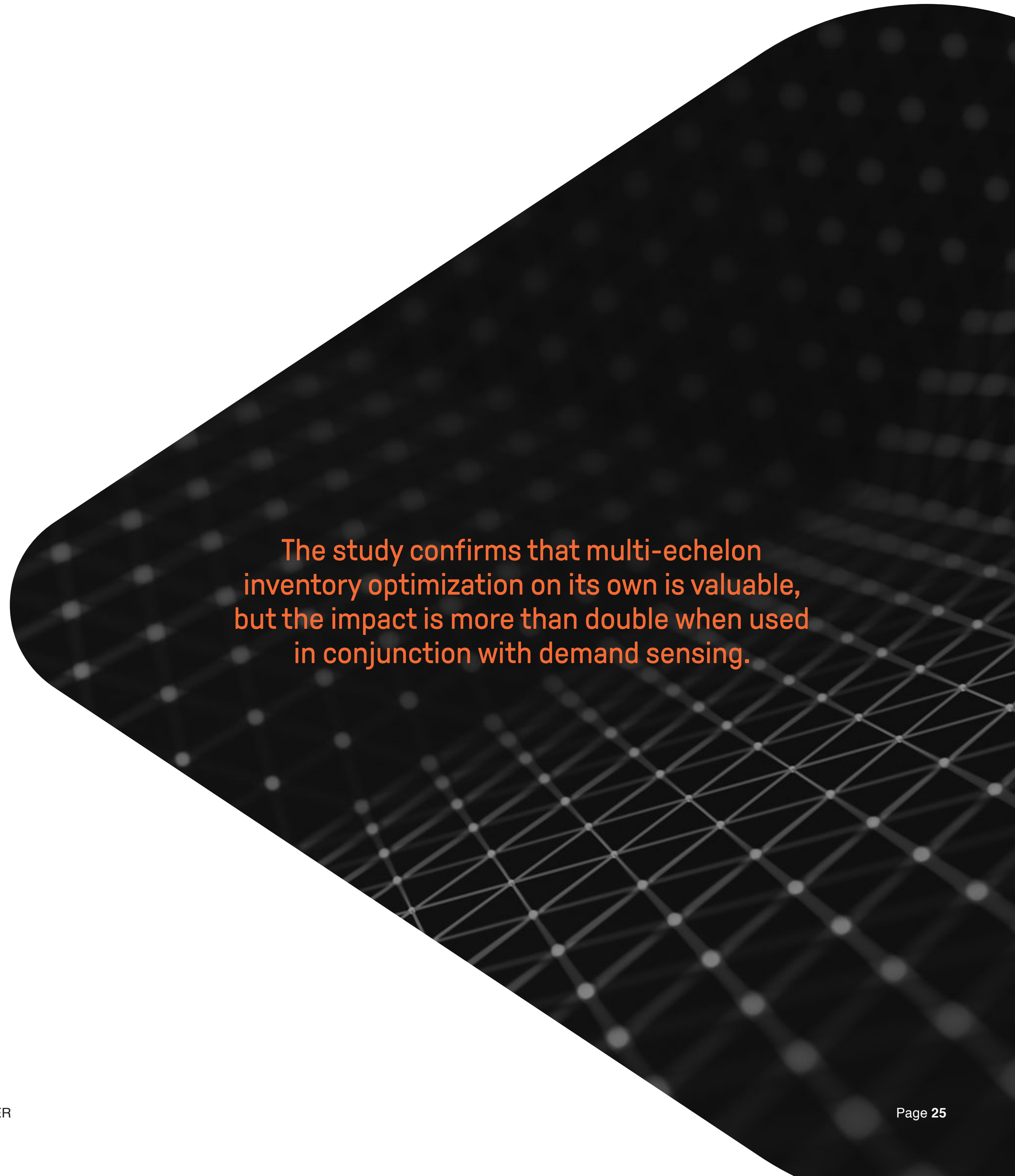
Days Safety Stock by Inventory Management Method



*Multi-echelon inventory optimization is often called MEIO.

With the cost of a day of inventory ranging between hundreds of millions to billions of U.S. dollars for global packaged goods companies, these reductions represent large savings with direct bottom line impact. The study confirms that while multi-echelon inventory optimization on its own is valuable, the impact is more than double when used in conjunction with demand sensing.

Leaders have been successfully running demand sensing and inventory optimization software for more than a decade. Companies not doing so should consider it.

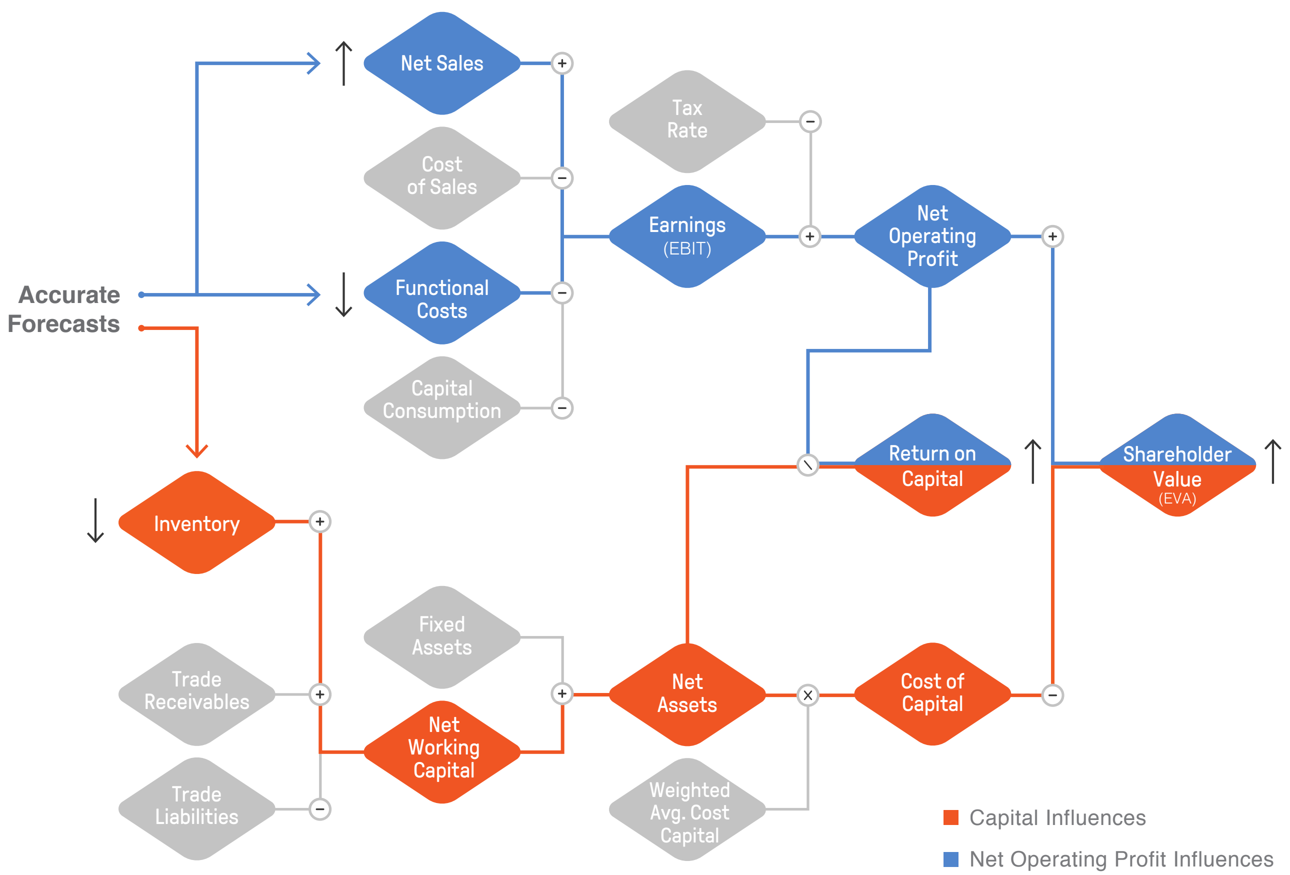


The Takeaway: Accuracy Matters

Accurate forecasting is strategic. Every decision by management is ultimately based on a forecast, so getting it right is important. Unfortunately, the statistical jargon that surrounds forecasting often falls on deaf ears for anyone outside of the supply chain planning domain. While this study contains an abundance of fascinating and helpful statistics, it can be difficult for business leaders in other departments to connect the dots between investments in accuracy and achieving corporate objectives or increasing shareholder value.

The inventory findings reported this year will no doubt help to bridge this gap by translating technical terms like mean absolute percentage error, bias and forecast value-added into a metric every department head understands: cash invested in inventory. However, this is just one side of the story. In board-level language, improvements in forecast accuracy drive bottom-line financial results through a combination of capital and net operating profit influences. The capital influences path starts by reducing inventory. The net operating profit influences path begins by driving costs down and increasing sales through improved service. The two paths combine to generate increased return on capital and increased shareholder value.

Relationship Between Forecast Excellence and Financial Performance



Trends to Watch

A number of trends have gained momentum since the last study. These will undoubtedly affect forecasting and inventory practices in the future. The following trends are among the most significant:

- **Digital transformation:** Just about every company has a digital transformation initiative, but there's little consensus about what digital transformation means. Some supply chain organizations are redefining digital transformation as their replacement strategy for SAP APO rather than orchestrating a true transformation. These companies are looking for incremental improvements with a reliable return on investment (ROI), which is unlikely to give them the transformation senior management expects. Real transformation will require fundamentally rethinking how to manage the supply chain by, for instance, extending it to include the upstream multi-tier supplier network and the downstream channel network.

- **Machine learning and artificial intelligence (AI):** There is new interest in smarter software, but other than demand sensing, there are not many proven, scalable applications on the market yet. In pursuing demand sensing, many companies are finally getting around to using downstream data in a structured way, not just for individual customer teams but also to drive enterprise-wide supply chain decisions. Companies just starting this now are 10 years behind the leaders.

- **Outsourced supply chains:** At last, companies in many industries are following the high-tech example and seeing the importance of orchestrating their multi-enterprise supply chains. More manufacturing is outsourced than ever before, and with much of their inventory in non-finished goods — about one-third for consumer goods companies, for example — manufacturers should seize the opportunity to manage their suppliers more effectively.

- **Reinvention of S&OP and integrated business planning (IBP):** For many companies, S&OP and IBP bring to mind a room full of people arguing about an aggregate sales forecast. Leading companies separate responsibilities to minimize incentive conflict. For example, the sales group owns promotions but not the total forecast, marketing owns drivers and activities but not the total forecast and supply chain owns the total forecast. The separation of responsibilities and automating the related processes greatly enhances results. This is already happening, evidenced by the decreasing forecast bias observed over the last few years.

Methodology

Due to their reliance on self-reporting and company-specific metrics, traditional forecasting studies lack consistency and comparability across participants. This study is based on a common data standard at each participating company, so all the information is gathered in the same format, rolled up and aggregated for meaningful comparisons. Study participants receive private reports so they can view performance improvements over time as well as their performance compared with their peers.

The public version of this study reports the forecasting and inventory performance of the warehouse-delivered businesses of the companies participating in the study. To ensure comparability across participants, a consistent set of metrics and standards was applied to the dataset. Error metrics are reported at these aggregation levels:

Metric	Aggregation Level
Forecast error and bias	Item/location/week
Forecast value-added and naïve forecast error	Base code/location/month
Extreme error	Base code/location/month

When displaying many of the metrics derived from this study, it was necessary to round percentage calculations for ease of viewing and interpretation. If some percentage totals do not add to 100%, this was due to such rounding.

Each year, there are minor deviations from prior results stemming from restatements after a company divests a division, reallocation of items within base codes and the number of companies participating in the study.

Glossary

Active items	Items with sales in a particular calendar year are considered active items in that year.
Base code	Base code refers to a set of items that share a Universal Product Code (UPC) or Global Trade Item Number (GTIN), for example, all types of a manufacturer's six-roll-per-pack, 100-sheet regular paper towels regardless of the pattern.
Bias	Bias is calculated by dividing the difference between total forecasts and shipments by total shipments. Positive and negative bias represent over- and under-forecasting respectively.
Cumulative items	This is the number of items that was for sale at any time in the current and prior years. It includes both active and discontinued items.
Cycle stock	The portion of inventory that is replenished in a warehouse periodically for fulfilling downstream orders is considered cycle stock.
Demand planning	This refers to traditional demand planning solutions employed by participating companies to create forecasts using a time-series analysis of historical data and augmented to reflect promotions as well as planner insights.
Demand sensing	This advanced forecasting technique uses machine learning to predict near-term daily demand based on current demand signals. Demand sensing is automated and self-tuning. All companies participating in this study use E2open's Demand Sensing application.
Direct store delivery	This is the practice of manufacturers that deliver products directly to retailer stores, as opposed to the more common approach of delivering to retailer distribution centers and allowing retailers to replenish their stores.
Discontinued items	Items that were last shipped in the prior calendar year are considered discontinued.
Excess stock	This is extra inventory carried due to over-forecasting actual demand. Excess stock is calculated based on historical forecast bias measured over total lead time.
Extreme oversell error	This is calculated as the percentage of volume for which shipments exceed forecasts by more than two times.
Extreme undersell error	This is calculated as the percentage of volume for which forecasts exceed shipments by more than two times.
Forecast value-added (FVA)	Forecast value-added, also known as FVA, is the difference in mean absolute percentage error (MAPE) between a planning system forecast and a naïve forecast, divided by the naïve forecast. Forecast value-added represents the percentage forecast improvement attained from investments in people, processes and technology.
Forecastability	Forecastability is the degree to which demand can be accurately predicted. A rise in the naïve forecast error indicates a drop in forecastability.

Ground stock	Inventory on hold due to quality assurance, order picking time, aging time and similar reasons is considered ground stock.
Item	The lowest level of the product hierarchy, an item constitutes a unique product. For example, a brand of six-roll-per-pack, 100-sheet paper towels might come in different design patterns all sharing the same UPC or GTIN. Each specific design pattern would constitute a separate item.
Mean absolute percentage error (MAPE)	A common way to measure forecast accuracy, MAPE is the sum of absolute errors (absolute differences between forecasts and shipments for each time period and appropriate granularity) divided by the sum of shipments. MAPE is always positive. Some companies call E2open's MAPE measurement "weighted MAPE" (WAPE or WMAPE), because when aggregating MAPE measurements across items or time, the metric is weighted by the volume.
Multi-echelon inventory optimization (MEIO)	Also known as MEIO, multi-echelon inventory optimization is an advanced technique that reduces inventory by mathematically determining the minimum amount of safety stock required at all stocking echelons in the extended supply chain to achieve customer service targets. All companies participating in the inventory portion of this study use E2open's Multi-Echelon Inventory Optimization application.
Naïve forecast	This simple forecast is based on a seasonally-adjusted moving average. The naïve forecast provides a means to measure forecast value-added.
New item	Any item with less than 12 months of history is considered a new item. This includes items with changes in product size, short-lived items such as displays, line extensions and entirely new products.
Safety stock	Inventory maintained to mitigate the risk of stock-outs due to uncertainties in demand and supply is considered safety stock.
Shipments	This is the quantity of items shipped in physical cases.
Transit stock	Inventory in transit from one location to another is considered transit stock.
Velocity	An item's rate of sale is its velocity. Sales velocity separates top movers from the tail. In the study, base codes are parsed into five quintiles by velocity. Velocity 1 refers to the fastest-moving products (also called top sellers or top movers), and velocity 5 items make up the tail.

About E2open

At E2open, we're creating a more connected, intelligent supply chain. It starts with sensing and responding to real-time demand, supply and delivery constraints. Bringing together data from customers, distribution channels, suppliers, contract manufacturers and logistics partners, our collaborative and agile supply chain platform enables companies to use data in real time, with artificial intelligence and machine learning to drive smarter decisions. All this complex information is delivered in a single view that encompasses your demand, supply and logistics ecosystems. E2open is changing everything. *Demand. Supply. Delivered.* Visit www.e2open.com.

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