Deep transformation with smart supply chain digitization

By David Simchi-Levi and Kris Timmermans

28%

In just three years, a large global fashion retailer increased its market share by more than 28% and doubled its operating profit. What did the fashion retailer do to achieve, in such a short time, a twofold increase in operating profit while outperforming the growth of the fashion industry? Was it a new marketing and sales strategy? Or perhaps, a more efficient manufacturing technology? Hardly. Did it grow through acquisition? Not even close.

The secret to its success was a significant investment in a supply chain digitization strategy that includes three important components: a unified, single view of demand; supply chain segmentation; and smart planning and execution, all of which are powered by digitization, analytics and automation.

Digitization refers to the establishment of dedicated master data that aggregates information from across the entire supply chain as well as from a variety of sources of external information. Analytics is focused on the integration of three levels of analysis—statistics (diagnostic), machine learning (prediction), and optimization (prescription)—to improve supply chain planning. These levels of analytics focus on understanding customers' or suppliers' behavior (statistics); predicting future behavior (machine learning); and improving decision making (optimization). Finally, automation is about the integration of data and analytics to automate, modify and improve supply chain processes and decision making.

Supply chain digitization has been central to success stories in other industries. In the Consumer-Packaged Goods (CPG) industry, a large manufacturer, whose products are available in supermarkets and food service establishments under various brand names, estimated a two-year payback, and significant improvement to financial and operational performance measures.

10-30%

In the high-tech industry, to give another example, this approach enabled dramatic improvement in service level, by between 10-30% depending on product category. Finally, a large global appliance manufacturer uncovered significant revenue growth and service level improvement while dramatically cutting operating costs.

These stories are worth telling not only because the payoffs are impressive. But, more importantly, because these stories are so rare. One important reason is lack of understanding of what it means and how to make the transformation to a digital supply chain. The perception is that digitization requires an extensive investment in infrastructure, specifically, cloud technology; instrumentation of every supply chain facility and product; automation of every process; and tracking across all supply chain partners. Only if you do all of those, this thinking goes, you can break silos, create an integrated strategy and enable efficiency and new business models.

While we do not dispute that these types of investments allow for supply chain digitization, visibility and transformation, the earlier examples we discussed highlight a different path. These examples are about bringing together available data, advanced analytics and some automation, together with the appropriate processes designed to leverage the technology investment. They illustrate how moderate financial investments lead not only to lower cost and higher revenue, but equally important, better customer experience and retention. Executives who understand this path can take their organization through a successful digital transformation journey. This journey starts by rethinking the firm's demand planning process.

01.

A unified view of demand

Traditional approaches to demand planning apply consensus forecasting techniques. In such an approach, different functional areas—operations, finance, trade, and sales—employ standard statistical techniques to generate their own forecast using historical sales data and some external data. Because each functional area has a different forecast, they must come together in consensus meetings to agree on a compromise.

Such a process has many challenges. First, it takes a long time, typically four to five weeks to generate the various forecasts and reach a consensus that satisfies all business requirements. By the time this is done, the sales data employed is old and new data, readily available, is not used. Second, sitting in these meetings, one realizes that the process is upside-down; rather than agreeing on the data and letting the analytics generate a single forecast, the discussion is typically focused on how to find the right balance between conflicting forecasts. Why are these forecasts conflicting? Because they are generated by different functional areas, each of which has a different responsibility and objective. As a result, it is not clear that the consensus forecast correctly represents market behavior. Finally, executives apply intuition and gut feeling to identify what drives sales, revenue or margin.

To generate a unified view of demand, the starting point is data. Consider the CPG manufacturer discussed earlier. The new approach involved four different sources of data, see Table 1. First, internal data including shipments to retailers (e.g., Carrefour, Waitrose, Walmart, Target), price, discounts, promotion as well as various product characteristics: brand, features, etc. Second, consumer data, which is the demand faced by retailers, can be accessed through POS technology or syndicated data, provided by companies such as IRI and Nielsen that collect, curate and sell market data.

Table 1: Four sources of data

Category	Execution
Internal Data	Historical Data: Sales (or Shipments); Prices; Discounts, Promotion Product Characteristics: SKU, Product Family, Brand, features
Consumer Data	POS information or syndicated data, provided by companies such as IRI and Nielsen
Socioeconomic Information	Quarterly GDP, Purchasing Managers' index, Consumer Purchasing Index, unemployment and Inflation rates
External Data	Google trends, social media mention of products, average temperature, precipitation, holidays and competitor prices, Pandemic Info

The third source of data is socioeconomic information including Quarterly GDP, Purchasing Managers' index (PMI), Consumer Purchasing Index (CPI) unemployment and Inflation rates. This data helps better understand consumer behavior, seasonality and trends, and hence predicts future patterns.

Finally, external data includes google trend, social media mention of products, average temperature, precipitation, holidays (national and/or regional) and competitor prices. Evidently, competitor behavior has an impact on the CPG product demand. The problem of course, is that the CPG company has information on the competitor price at a specific time, but when generating a forecast for the next fifty weeks, one needs to predict the competition's behavior well into the future. That requires developing an engine within the demand planning process whose focus is on understanding and predicting competitor pricing strategies.

The data collected allows the firm to follow a **five-step circular process** for demand planning, see Figure 1, to generate a supply plan, financial plan and sales plan for the next fifty or so weeks. We refer to this time horizon as **the planning horizon**.

In the first step, trade planning information—plans for future promotion, discounts and marketing investments—together with the data described earlier is applied to generate market demand forecast, by SKU, retailer and week combination for the entire planning horizon. This forecast represents the CPG's best understanding of market demand for each brand and each SKU faced by individual retailers. Remarkably, in our experience, most CPG companies have never tried to predict market demand at this level.

The second step is about applying the demand forecast generated in the first step, together with past CPG-to-Retailer historical shipment data to generate a forecast of the retailer's future orders, at the SKU and week level for the entire planning horizon. This is the best understanding the CPG has of future orders from the retailer to the manufacturer. Of course, these shipment forecasts do not consider any business constraint, such as available inventory or limited manufacturing capacity, since they simulate the retailer orders, but the retailer has no insight about this information. This is done in the next step.

The third step is converting the shipment forecast into a feasible supply plan, a plan that considers available resources—raw-material and finished goods inventories, manufacturing capacity constraints and limitations—and maximize certain performance measures.

The fourth step is about aggregating the retail SKU, weekly forecasts and generating a financial forecast at the brand level, for every month of the planning horizon. This financial forecast is then compared with the firm's business objectives as well as trade plan—this is the fifth and last step of the circular process.

Figure 1: A five step circular process for demand planning

Compared with consensus forecast—where each functional area generates its own forecast and executives need to agree on a compromise—the circular process is all about a single forecast generated throughout the process. It starts with the data described in Table 1 and applies advanced analytics in every step. Thus, the process is mostly automated and the role of executives is to agree on the data while letting the machine generate the prediction.

The reader may wonder what type of forecast accuracy can one achieve when applying the circular process? Is there a way to interpret the forecast and understand, or explain, what drives certain behavior? Finally, how can one ensure that this process sticks and the various functional areas follow this single, unified view of demand? We answer these questions below.

Forecast Accuracy

Recall that the Bullwhip Effect suggests that variability in customer demand is significantly lower than variability in retail orders. This implies that predicting consumption, i.e., market demand, should be an easier task than predicting retail orders. This explains why forecast accuracy at the end of step 1 is so high. Indeed, a recent implementation at the CPG company indicates forecast accuracy of 85% at the SKU, week, retail level when measuring accuracy of a consumption forecast generated today for five to eight weeks from now. This is an impressive accuracy level that is explained by the power of data and advanced analytics.

Step 2 is the critical step. Here, we apply the forecast generated in step 1 together with historical shipment information to generate shipment forecast. In this case, this approach led to a 15-20 percentage point improvement in forecast accuracy relative to the standard, consensus-based forecast, applied by the CPG. The implications are clear: higher shipment forecast accuracy translates to a more effective supply plan which reduces lost sales, and therefore boosts revenue; and at the same time, increases service levels and hence customer experience.

Finally, since the financial plan is based on aggregate forecast at the brand and month level, forecast accuracy is significantly higher. Indeed, in multiple implementations of this approach at several CPG companies, forecast accuracy clicked at 95-97% for the so-called one-month leg. That is, this is the forecast accuracy when generating a forecast at the beginning of this month for next month.

Interpretability

Compared with other technical challenges associated with generating a single unified view of demand, this one is probably the most critical and difficult. Indeed, in our experience, no executive is going to follow a strategy just because a black box, developed by data scientists, says so. What is needed is the ability to interpret and explain the process output.

Interpretability has three different levels of requirements. The first level is to understand what drives the forecast. Is the increase/decrease in volume forecast at a specific time period due to competitor behavior, cannibalization across products, promotion and discounts, or a mere special event and holiday? The good news is that the technology today is mature enough to allow for decomposition of a single SKU-week forecast to its basic components.

This is however not enough. The second level is to understand changes in the forecast of a specific week generated at different time periods. That is, executives would like to understand why the forecast generated last week is quite different from the forecast generated this week. This is a bit more complex, but still within today's technical capability.

Importantly, a forecast is a single number (so-called, point estimator) representing demand for a specific SKU, week, retail combination. Notice that different input data, representing the same environment, may generate a slightly different forecast, i.e., a different point estimator, and the two forecasts are consistent because they fall within the same margin of error (the so-called confidence interval). This is very much like polling used by various newspapers to generate presidential forecasts which might be slightly different, but still consistent, since they all fall within the same margin of error.

When the two forecasts fall outside the margin of error, that's where explain-ability is important. For this purpose, one needs to make sure that each time the circular process is followed, inputs and outputs of the process are stored and are readily available for such an analysis.

The third and most challenging level to explain are deviations between forecasts and realized (actual) sales since there are gaps between operational planning and execution. Indeed, realized sales is affected by the way decisions—pricing, promotion, discounts or inventory—are executed. Unfortunately, the forecasting process includes only planning information; retailer execution—retail actual price, inventory on the shelf—in most cases is not transparent to the manufacturer.

Put in a different way, the forecast might be different than realized sales, not because of any forecasting problem, but rather due to retailer's operational and execution challenges, challenges that are not transparent to the manufacturer's planning team. What can help is information about the retailer's on-hand inventory and prices paid by consumers at the retail cashier. But, our experience is that most retailers do not provide CPG trade partners with downstream visibility to this information. Thus, a gap between the forecast and actual sales should trigger an investigation of the difference between planning and execution.

Make-it-Stick

At its heart, the process we described above for demand planning is interdisciplinary; it brings together people from the various silos to agree on the data and let the analytics generate the forecast. For this purpose, executives need to establish a Forecast Center of Excellence that brings together people from the various silos—finance, operations, trade and sales together with information technologists and data scientists—whose responsibility is to agree on the data and follow the circular process described in Figure 1.

One question that comes up often is how frequently one should run this process. The answer depends on the clock speed of the various businesses and brands. For most businesses, steps 1-3 are executed on a weekly or biweekly schedule while steps 4-5, those focusing on financial plan and trade, are executed on a monthly schedule. But there are clear exceptions. For short lifecycle products—such as CPG products sold only over a six or seven-week horizon, around a Holiday or special event—this process could be executed twice a week. The same is true for fashion products, whose selling season lasts no more than ten or eleven weeks.

02.

Supply chain segmentation

Traditional operations strategies have often focused on either efficiency, responsiveness or a combination of the two. In operational efficiency, the firm focuses on low-cost strategies across all functional areas. This includes supplier selection, manufacturing strategies, product design and distribution and logistics. Typically, in such a strategy, production and distribution decisions are based on long term forecasts, inventory of finished goods is positioned close to customer demand and supplier selection is mostly based on components costs; hence sourcing from low-cost countries is often the mantra.

By contrast, a responsive strategy focuses on speed, order fulfillment, service level and customer satisfaction. Here, the objective is clearly not to squeeze as much cost out of the supply chain as is humanly possible; rather the objective is to eliminate stock outs and satisfy demand by competing on response time and speed to market. Typically, in such a strategy, product variety is high and product lifecycle is short, manufacturing or product assembly is based on realized demand rather than forecast, products may be customized, buffer inventory of components is emphasized, and sourcing, supplier selection and the transportation strategies all rely on speed rather than only on low-cost.

Although seasoned operations and supply chain executives understand the difference between efficiency and responsiveness, many are confused about when to apply each strategy. Worse still, senior managers typically spend a considerable amount of time and energy on customer value but may be ignorant about the connection between the consumer value proposition and operations strategies.

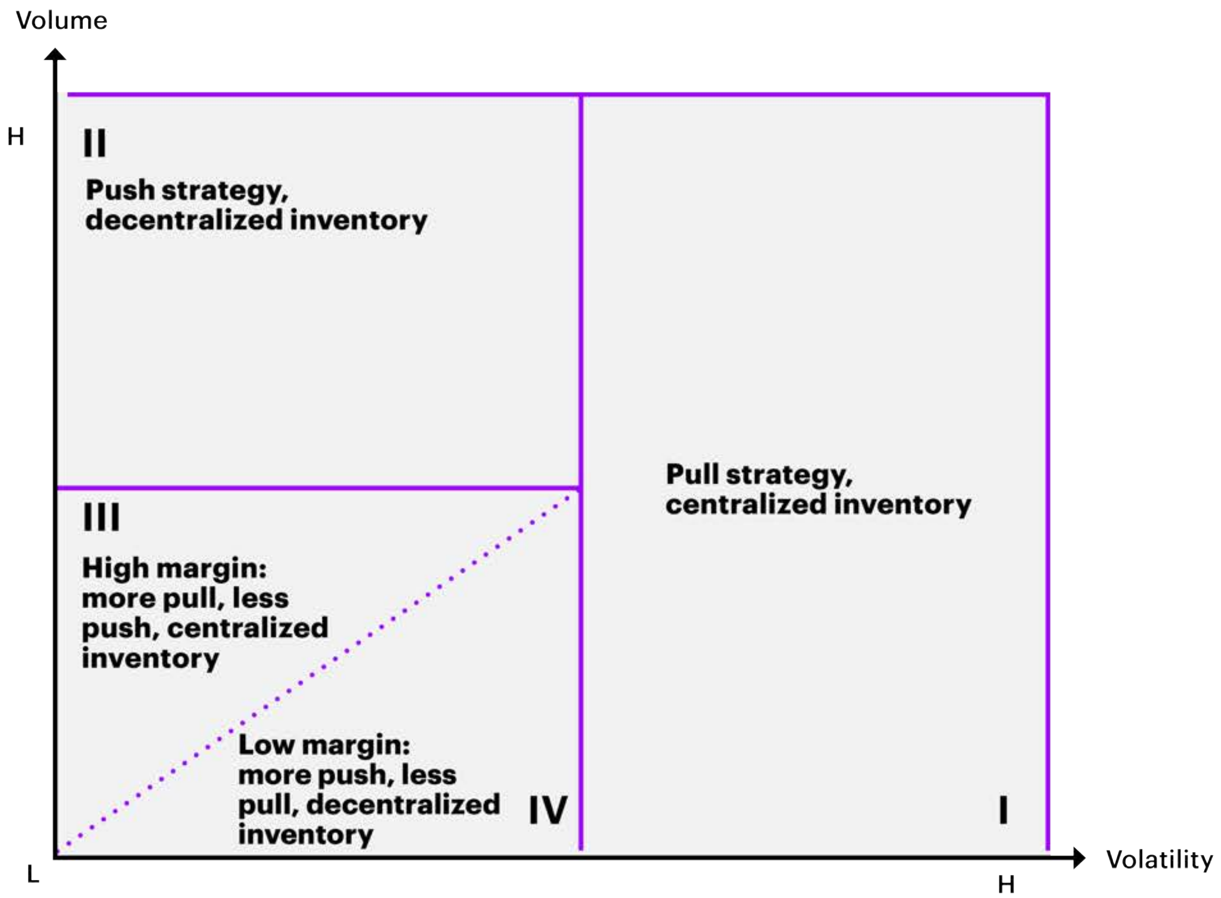
At the heart of the problem is the question "what drives operations and supply chain strategies?" Customer value proposition, channels to market and product characteristics are the key drivers of the appropriate operations strategy. Implementing a strategy that does not match these drivers leads to inefficiencies, unnecessary expenses and poor customer service at best, or to an eventual business failure at worst.

Consider again the CPG manufacturer discussed in the previous section. To identify the appropriate supply chain strategy, the firm considered a large number of drivers to find out those that best explains variations in sales data.

This is again where data and analytics played an important role. Sniffing through the data, the analytics identified three drivers that explain sales data the best: sales volatility, volume and margin. Why? Because they are directly related to risk—stockouts, service levels, inventory, transportation—faced by the CPG. The higher the volatility, the riskier the product. Similarly, the higher the product margin, the higher the risk. By contrast, volume is inversely proportional to risk, that is, the higher the volume, the lower the risk. These drivers are consistent with our findings in other CPG and Retail companies, except that sometimes, margins are replaced by price or product cost.

The CPG's supply chain segmentation strategy is summarized in Figure 2. As you can see, the CPG now has four different segments. Box I represents products characterized by high volatility. The framework described earlier suggests that in this case, stockout, service levels and inventory risks are high. To mitigate these risks, inventory is positioned upstream in central distribution centers so that demand from many retail outlets can be aggregated, allowing reduced inventory levels while maintaining high levels of service—a Pull strategy. Such a strategy generates significant inventory savings but requires fast delivery, typically through cross-dock facilities to maximize truck utilization.

Figure 2: The CPG supply chain segmentation strategy



Box II characterizes products with high volume and low volatility. In this case, forecasts are reliable while managing transportation cost is an important objective. For this purpose, products are positioned in local warehouses close to market demand, and inventory replenishment is done based on a fixed schedule—a Push strategy. This strategy allows shipping fully loaded tracks as close as possible to consumers, thus reducing transportation costs.

Boxes III and IV are characterized by conflicting drivers. Assuming everything else being equal, low volatility suggests a Push-based strategy while low product volume motivates a Pull-based strategy. For this reason, we distinguish between high and low margins. High margin products are riskier, and hence, many of these items are positioned at centralized locations and replenished based on consumption. In this case, the supply chain strategy is much closer to a Pull strategy. By contrast, low margin products, Box IV will follow a supply chain strategy much closer to a Push strategy.

Once the segmentation is done, detailed sourcing, manufacturing and logistics strategies are developed. Of course, in this case, the objective is to consider synergies across the various segments, so as to benefit from economies-of-scale. This is achieved by leveraging cross-segment volume in sourcing; sharing infrastructure and capacity in manufacturing and logistics; and consolidating demand and supply information for better planning and execution. This is the focus of the next section.

03.

Smart planning and execution

Business planning processes, such as sales and operations planning (S&OP), are not new, but powered by data, analytics and automation, they allow executives to shift focus from consensus planning to input data review and agreement. Once the input data is finalized, the process is automated, so the analytics generate the plan.

Specifically, S&OP is a business process that continuously balances supply and demand. Today, S&OP is simply an extension of the consensus forecast described earlier, and hence suffers from similar limitations: it starts with a consensus forecast, not a unified view of demand; it does not include cross-functional engagements; it does not distinguish between different supply chain segments; and, it is mostly driven by common sense, experience and intuition, not data and analytics. Because this is a manual process, it is typically a month-long process used to guide supply and demand balancing.

Smart planning entails a departure from the month-long, manual, S&OP process and requires major changes in the way departments operate. Since the objective of S&OP is to ensure the entire firm is marching toward the same business outcomes, it should bring together engineering, finance, operations, sales and supply to agree on the plan.

Smart planning starts at the beginning of step 3 of the circular process described earlier and generates a plan by letting an optimization engine determine the right trade-offs to achieve the various business outcomes. So smart planning brings together digitization (the data used in the circular process); analytics (prediction technology) to generate the uncontained forecast; and automation (optimization technology) to convert the unconstrained forecast into a supply plan. This plan drives the entire firm, from master production schedules to material planning, all the way to supply plan.

Because the process is automated, the role of executives is not to find a compromise between different forecasts or different supply plans; rather, their role is to agree on the data and input parameters, such as investments in promotion and marketing in a specific region, or sales targets for a specific brand and market, so the supply plan for the next forty or fifty weeks can be finalized. Given the automation and the change in the role of executives involved in S&OP, this month-long process can now be executed on a weekly basis.

While not every company or business unit needs to follow a weekly S&OP process, this is especially critical for products in segments I of Figure 2 where demand volatility is high and trade and promotion may change quite frequently depending on inventory and market consumption. Independent of frequency, the S&OP process is supported by supply chain monitoring—collecting information throughout the supply chain, and monitoring the state of the business—so that executives can apply the process to navigate the business in the right direction.

But monitoring the current state of the supply chain, using the so-called Key Performance Indicators (KPIs), is not enough. What is also needed is an ability to predict what is likely to happen in the near future so that corrective actions can be taken. For example, monitoring KPIs such as inventory and service levels may suggest that no action needs to be taken; however, reviewing shipment tracking data may indicate that lead times are likely to increase, and as a result, service levels will go down in the next few weeks, triggering either more inventories or suggesting the need to expedite shipments.

Similarly, a shutdown of a supplier's manufacturing facility due to man-made or natural disasters could affect available supply down the road, but traditional KPIs might not capture that impact. What is needed is to complement KPIs with Key Performance Predictors (KPPs), that is, performance measures that predict what the state of the supply chain will be in the next three to six weeks if no corrective actions are taken.

To illustrate the need and the impact of KPPs, consider the earlier days of COVID-19. On February 23, 2020, Professor Simchi-Levi and a high-tech executive, Pierre Haren, submitted a paper to Harvard Business Review entitled "**How Coronavirus Could Impact the Global Supply Chain by Mid-March (hbr.org).**" It appeared online on February 28, where the authors used data and a single KPP—Time-to-Survive which measures the number of weeks demand can be satisfied during a disruption—to predict that "the impact of Covid-19 on global supply chains will occur in mid-March, forcing thousands of companies to throttle down or temporarily shut assembly and manufacturing plants in the US and Europe." This prediction was highly accurate. Indeed, newspapers all over the world reported during the week of March 16, 2020, on supply chain shutdowns in the US and Europe. See, for example, this **Fortune article** on the automotive industry in Europe from March 17, 2020.

These performance measures (KPPs) are central to smart execution, a new business process that compliments smart S&OP. Specifically, while S&OP balances supply and demand for the next forty to fifty weeks, and commits resources for the first four to six weeks (the so-called frozen horizon,) smart execution is focused on the short term (no more than six weeks) and tries to identify and quickly respond to disruption and deviation from the plan.

Smart execution brings together three capabilities that define supply chain digitization: first, real-time internal and external data to identify potential deviations from the plan, supply disruption or new demand information; second, intelligence, specifically Artificial Intelligence, to identify the potential impact of the new signal on supply chain performance; third, optimization, to decide on the best way to respond, considering various supply chain trade-offs and objectives.

04.
The payoffs

For most of its history, the CPG manufacturing company has focused on a one-size-fits-all strategy, where forecast is achieved by consensus, S&OP is a month-long process, the supply chain strategy does not distinguish between different products and channels, and deviations from the plan and supply disruptions are managed ad-hoc.

The company excelled in operational efficiencies by embracing continuous improvements of production, packaging, distribution and order fulfillment processes, but without fundamentally changing them.

Their executives, however, recognized that operational efficiency can accomplish only so much. They observed that for certain product categories, they need to emphasize speed (responsiveness,) but their supply chain strategy is focused on reducing cost (efficiency). And, they concluded that their month-long planning process was way too long, with executives arguing about which forecast is appropriate, while new data that should have been applied to improve the forecast is ignored. In short, work was done as it should, but executives recognized that data, analytics and automation could offer new ways to compete, but it was not clear exactly how.

The introduction of the circular process, see Figure 1, enables a week-long smart planning process. In this process, decision makers spend time agreeing on data, letting the analytics generate retailer order forecast and from there a supply plan. When generating the supply plan, planners collaborate and agree on the various business targets and constraints while the plan itself is generated by an optimization model. Because the process is automated, executives are free to think carefully about strategy—business targets by retailer, region and product categories—and identify the most appropriate one and the corresponding supply plan.

Table 2: Supply chain processes: planning vs. execution

	Planning	Execution
Primary Purpose	Develop a supply plan and commit resources for the frozen horizon	Quick response to deviation from plan, or supply/demand disruption
Time-Horizon	Medium: Forty to fifty weeks	Short-Term: Up to six weeks
Process	Discrete: Weekly or Biweekly depending on supply chain segment	Continuous: Monitor and recommend actions on daily or hourly basis
Primary Data	Historical	Real-Time
Prediction Objective	Demand	KPPs

As important as the planning process is, it mostly relies on historical data. Smart execution complements smart planning by incorporating vital real-time information to estimate KPPs—the future state of the supply chain—and respond accordingly. Table 2 on the prior page compares and contrasts the two processes. As you can see, the two processes complement each other on every dimension.

Companies that took the digitization path described in this article reported some important benefits.

5-10%

These include service level improvement of 5-10%, implying better customer experience

10%

reduction in lost sales by up to 10%, leading to higher revenue

10-20%

inventory and waste reduction by 10-20%, translating into cost savings.

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