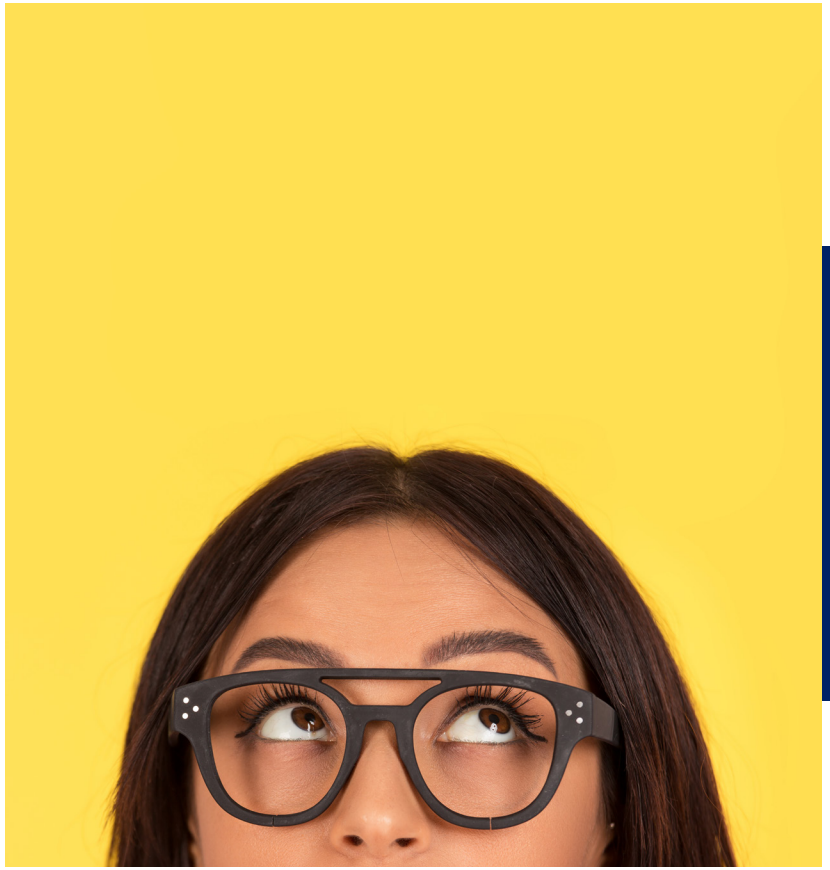

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Machine Learning for Supply Chain Planning 101

What is machine learning and how do you use it in supply chain planning?

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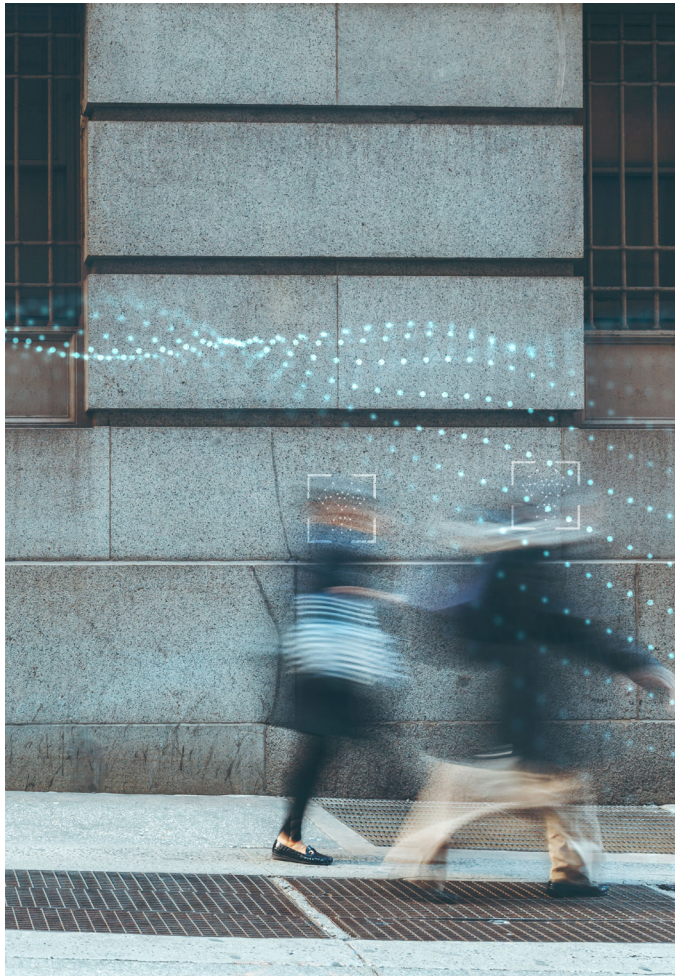
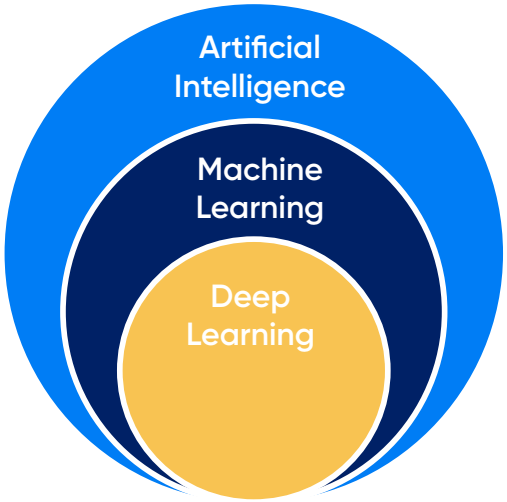
Machine Learning: Ubiquitous but Still Mysterious

Machine learning seems to be everywhere you look, from television commercials and supply chain conferences to university degrees. But despite its buzzword status and adolescent-age maturity, this technology is still shrouded in mystery for many supply chain practitioners. In this hyped-up stage in technology maturity, it's crucial to be well informed so you can see beyond the headlines and apply the technology correctly to solve business problems and deliver real value.

If you have no background in machine learning, this ebook will teach you the basics. Do you already have some machine learning experience under your belt? We've got you covered with some specifics on machine learning in supply chain planning, a few of the top business use cases, and tips for how to get started.



+ What Is Machine Learning?



Does all the machine learning and AI speak have you confused? You're not alone. Here's a simple primer on the most commonly used terms.

Machine Learning vs. Artificial Intelligence

/ Artificial Intelligence (AI)

The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, language translation, and decision support systems.

IDC predicts spending on AI systems will reach $97.9 billion in 2023, more than two and a half times the $37.5 billion spent in 2019.[1]

/ Machine Learning

A branch of AI that is concerned with the question of how to construct computer programs that automatically improve with experience. So instead of being explicitly programmed or told what to do, you feed the program the data and it learns what to do.

/ Deep Learning

Family of machine learning methods based on neural networks architecture, that, due to recent advances in the ability to successfully train multiple layers of networks ("deep" networks), have become the top performing algorithms in specific fields (computer vision, speech recognition, etc.)

The Three Primary Flavors of Machine Learning

/ Supervised learning

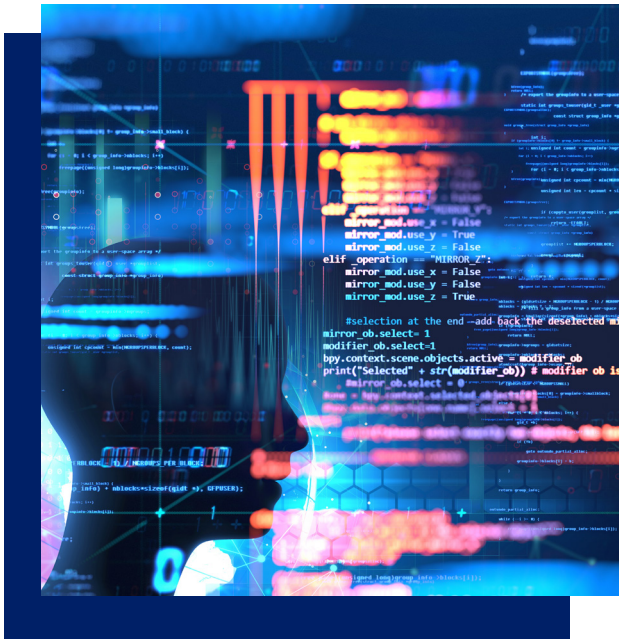
Supervised learning is the most-used type of machine learning in business because of its ability to solve real-world computational problems. It learns by identifying patterns and relationships from a labeled training dataset which already contains a known value for the target variable for each record. Since the algorithm is equipped with the correct answers during training, it is then able to "learn" how the rest of the features relate to the target. Supervised learning is best used to classify or predict outcomes. For example, predicting the failure of mechanical parts in engines, or predicting customer churn.[2]

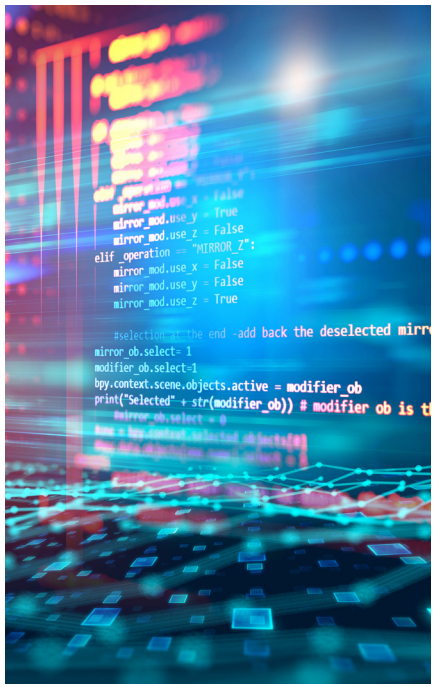
In this supervised learning image classification example, numerous varying product images and corresponding labels (e.g. coat, ankle boot, etc.) are fed into the machine learning algorithm. This process is repeated over many training examples until the "learner" is fully trained.

+ Label: "Sandal" → **Machine Learning Algorithm**

After the algorithm has completed the training phase, a new image not yet seen by the learning algorithm is presented. Hopefully, the system is able to correctly classify the image as a "sandal" based on what it has learned.

→ **Machine Learning Algorithm** → **Output: "Sandal"**





/ Unsupervised learning

With unsupervised learning, the system is learning from unlabeled training data. You feed it a set of attributes or features and it finds the commonality and patterns in the data. Clustering and association are the most common use cases for this branch of machine learning. For example, the algorithm is given numerous examples of objects (some round, some pointy and others that are not so easily categorized). Then, unsupervised learning algorithms can be used to create clusters in a more accurate and granular way than traditional techniques—and with these additional insights, unknown unknowns become apparent.[2]

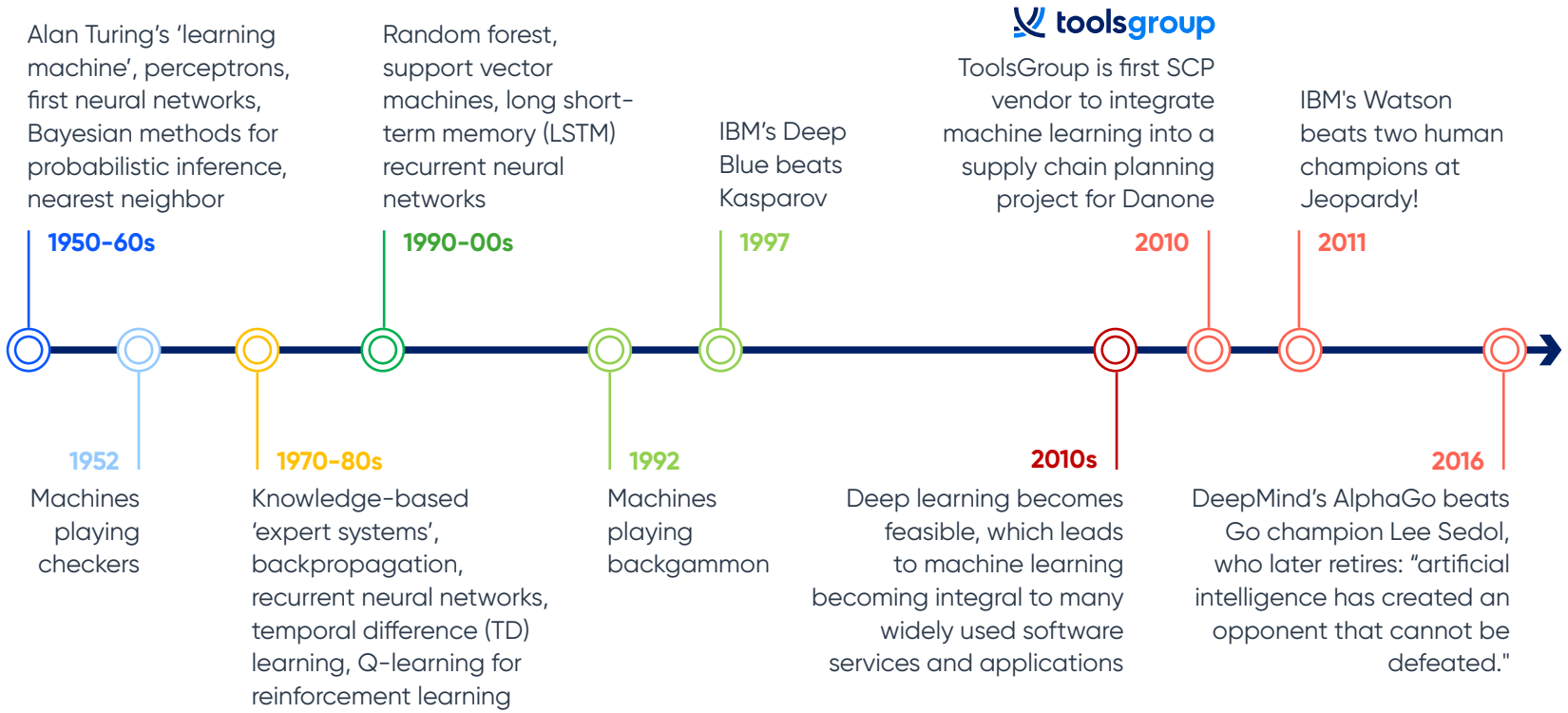
In this example of unsupervised learning, there are no input labels. The algorithm is attempting to learn the labels and thus the clusters or classes.

/ Reinforcement learning

In reinforcement learning, an agent is learning to take actions in environments from episodes of experience, to maximize long-term reward. The agent discovers which actions from a given state yield the most reward by trial and error, trading off exploration and exploitation in responding (deciding on next step to take) to feedback (rewards) for each step taken.

+ A [Very] Short History of Machine Learning

Though machine learning is all over the headlines today, it's not a new discipline. The original field of machine learning was formalized back in the 1950s with mathematician Alan Turing's prediction of a "learning machine". Turing delivered a lecture in 1947 where he declared that "what we want is a machine that can learn from experience."[3] Seventy years ago, we already had machines learning how to play checkers, and in the 1970s and 1980s technology progressed significantly. A big focus in this stage was knowledge-based expert systems, which were equipped with a preprogrammed set of rules (i.e. "if this, then do that"). Of course, these programs evolved to the machines of today which learn the rules based on experience. IBM's Deep Blue beating world champion Garry Kasparov in chess in 1997 was a pivotal event in AI/machine learning history.[4]



/ AI Milestone: Computer Learns to Play Atari Breakout

If you grew up in the 1980s, you're probably familiar with Atari video games. Atari Breakout is a game where the player uses a joystick to control a pedal at the bottom of the screen and moves it left or right, trying to hit a moving ball. The goal is to clear the bricks on top; as you're clearing the bricks, your score increases. A company called DeepMind developed a machine learning algorithm (deep reinforcement learning, DQN) that learns how to play this game and generalizes the learning across multiple games. The algorithm was given sensory input (what you see on the screen) and was told to "learn" to maximize its score. Without knowing the concept of the ball or what the controls do, the algorithm, over 600 training episodes, learns that digging a tunnel through the wall is the most effective way to beat the game.[5]

Image courtesy of DeepMind.com

+ Machine Learning in Supply Chain Planning

In a recent survey of North American supply chain professionals conducted by ToolsGroup and Spinnaker, 30 percent of respondents said they had a machine learning project underway or had a project slated to begin within 12 months.[6] Forecast accuracy is a primary driver of the use of machine learning in supply chain planning. As Tim Payne of Gartner explains, end users "want to get better, more accurate demand plans that do not involve absorbing masses of demand planner time to accomplish."[7]

Deloitte found that 82% of enterprises adopting machine learning and AI have gained a financial return from their investments.[8]

Forecasting is also a logical place for the high level of automation which machine learning brings. In the same survey, 41 percent of respondents expect more productive planners as a result of machine learning-augmented supply chain projects, and they won't likely be disappointed. For businesses that have applied machine learning, increased productivity is a significant benefit. The planner's role is being enhanced by AI and machine learning, which automates certain tasks and self-learns over time for better results. As a result, planners can increase productivity.

- ToolsGroup customer Lennox Residential achieved 99.7 percent no-touch, computer-controlled planning and replenishment—planners have to intervene in only three out of every 1,000 planning decisions.
- Just one full-time planner now handles all planning for the Absolut Vodka global brand. This allows more time for value-added work and exception management.

Machine learning also supports the development of more resilient supply chain planning practices. "The large scale use of ML in SCP (supported by hyperscale cloud platforms) helps to quantify the uncertainty of the supply chain environment. This progressively changes the balance between unknown uncertainty and known variability. This enables the supply chain to be set up with the optimal level of resiliency to buffer this new level of uncertainty, while work can be undertaken to reduce known variability."[9] Businesses that use machine learning-augmented supply chain platforms can harness real-time data for immediate action. This is the foundation businesses need to predict and sense demand changes and make smart pivots—which are essential capabilities for resiliency and survival amid disruptions.

"What machine learning really helps with is its ability to convert unknown uncertainty to known variability."
- Gartner9

+ When Should You Use Machine Learning in Supply Chain Planning?

Business problems that leverage demand planning, including those related to demand forecasting, sensing and shaping are prime candidates for using artificial intelligence to help automate supply chain processes. And for good reason: increasing forecasting complexity and rapidly shifting consumer demand are often exacerbated by seasonality, new product introductions, promotions, and myriad causal factors (e.g. weather, social media), making demand planning extremely complex. More businesses are using machine learning to address these processes than any other area of supply chain planning.[4]

80% to 90%

Digital tools can automate 80% to 90% of supply chain planning[10]

Here are some of the top supply chain planning machine learning use cases. Machine learning models various demand effects as layers on top of your baseline probabilistic forecasts.

Seasonality
Clustering and classification of multiple seasonality patterns (day-in-week, week-in-month, month-in-year)

Promotion Management
Clustering of past promotions, classification of new promotions based on attributes and uplift calculation

New Product Introduction
Clustering of past launch profiles, classification of new items based on their attributes and regression for baseline forecast generation

POS Demand Sensing
Advanced techniques to improve sell-in forecast using sell-out demand data

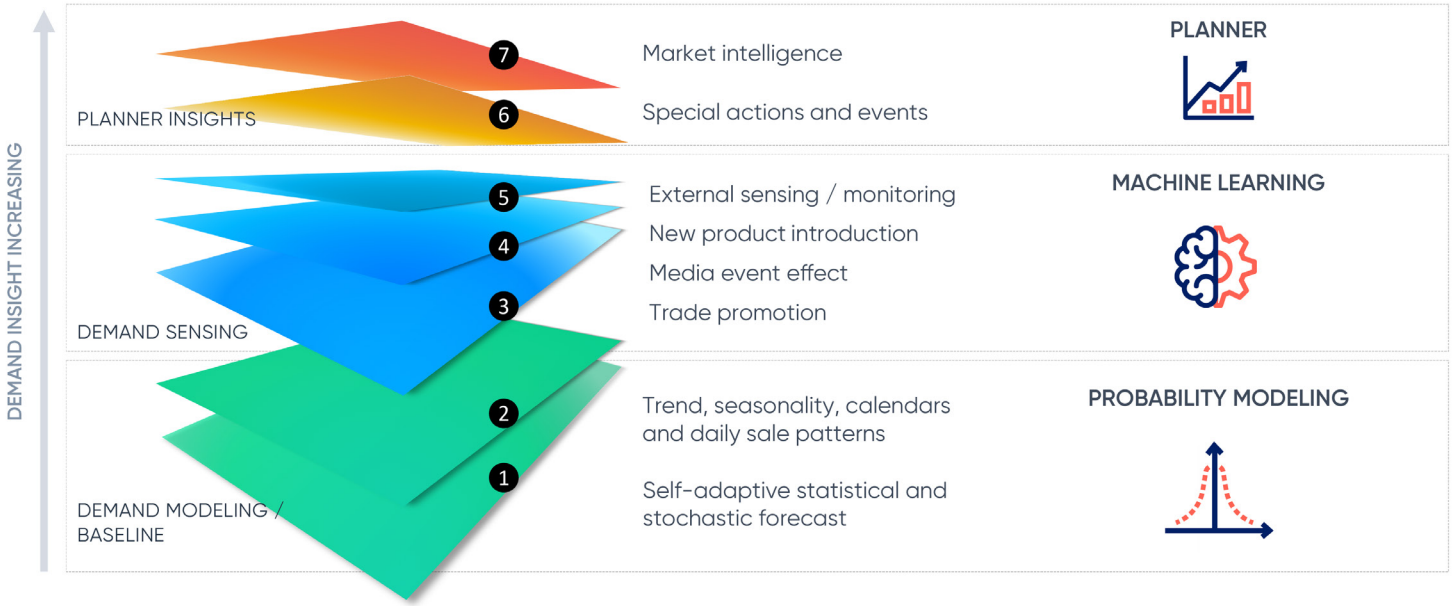
External Demand Causals
Weather, social media, IoT, market trends, indicators and other external data

Product Lifecycle Management
Algorithms weigh up attributes and sales of similar items to estimate the shape and duration of the product life cycle

+ The Secret to Success: Combine Machine Learning with Baseline Forecasting

Our experience at ToolsGroup suggests that forecasting can't be completely based on machine learning techniques. Instead, it requires a solid statistical backbone to deal with the stochastic nature of demand. We recommend using a hybrid approach that uses probability forecasting and machine learning technologies, which work together seamlessly and automatically.

Begin with a self-adaptive model for probabilistic forecasting using granular historical demand. This is critical to success with advanced machine learning and yields significant benefits on its own. Then, further improve your probability forecast by applying machine learning technology on the existing historical data to get a more robust, reliable baseline that accurately models the phenomena shaping the demand. Then layer on more sophisticated machine learning using external data sources.



ASTON MARTIN

+ Luxury Car Maker Accelerates Growth with Machine Learning Under the Hood

Luxury sports car manufacturer Aston Martin has been in business for more than 100 years. It's built a brand that's synonymous with style, performance, and status. And it has a growing clientele outside the UK including the Middle East and Asia.

But new demands from its international client base prompted Aston Martin's board to raise targets for first time availability (FTA) for its parts across all car categories by 2 percent without increasing inventory. They're already a ToolsGroup customer, but now need to take their 95 percent service level to 97 percent. No small feat.

So Aston Martin turned to ToolsGroup again to leverage some new innovations in machine learning using seasonality clustering to better segment demand patterns. This new approach enabled them to not only meet the new goal for availability, but do it while carrying less inventory.

Within two months, they improved service levels to 97.1 percent and reduced inventory by 18 percent, freeing up more working capital.

+ Machine Learning Helps Tackle Company Expansion and Demand Complexity

Lennox Residential Heating and Cooling faced the challenge of managing an ambitious North American distribution network enlargement while simultaneously transitioning to a hub-and-spoke model with 55 shipping and 161 selling locations. The company wanted to improve service levels and optimize inventories to reallocate working capital and balance inventory in the changing network. But the supply chain environment was daunting, with a multi-echelon distribution network about to grow by 250 percent, 450,000 SKU-Locations, and many slow movers and new product introductions.

Lennox implemented a transformational supply chain planning solution to dynamically rationalize the inventory mix and create an operational plan that sets inventory stocking targets and balances service levels with inventory cost. Lennox uses machine learning to reliably model highly variable seasonal demand patterns. It sifts through hundreds of thousands of SKU-Locations to identify "clusters" of those with similar seasonality profiles. These enhanced seasonality clusters substantially increase peak period forecast accuracy.

Results:

- Improved service levels by 16 percent
- Increased inventory turns by 25 percent
- Supported significant increases in sales and market share growth

GRANAROLO

+ Using Machine Learning to Improve Promotional Forecasting

The dairy market is characterized by short shelf-life products and strong promotional pressures. Dairy producer Granarolo runs thousands of promotions annually, producing 34,000 item-promotion forecasting combinations and causing demand peaks of up to 30 times baseline sales. This environment requires optimized inventory management and the ability to provide immediate response times.

To manage promotions and correctly estimate peak demand, Granarolo adopted ToolsGroup supply chain planning software, which uses machine learning technology to translate historical data into reliable estimates of future promotions. Using past promotional data, the system automatically generates proposals consistent with promotional peaks. The system proposes dynamic safety stock levels that consider each product class' forecast accuracy and store replenishment frequency so Granarolo can maintain high service levels in the face of changing demand.

Results:

- Forecast reliability increased by 5pp
- Inventory levels reduced by more than 50 percent
- Reduced delivery time by 50 percent, minimizing obsolescence

+ How Can You Get Started with Machine Learning?

When you've been delivering machine learning solutions as long as ToolsGroup has, you learn a thing or two. Here is a quick list of tips for success in using machine learning in supply chain planning.

/ Start with a specific business objective

Having a solid charter of what you want to accomplish and why is essential before charging down the machine learning path.

/ Start simple and layer in complexity

1. Apply the right technology to "small data" to create a baseline adaptive model for probability forecasting using historical demand history

2. Further improve baseline probability forecast by applying machine learning technology on existing historical data for:

- Trade Promotion
- Media Event Effect
- New Product Introduction

3. Look for additional correlations using external data such as weather, indicators, POS, social media, search, IoT, etc.

/ Understand the four dimensions of data

To get real results from machine learning you'll need to have the right data—be sure to consider all four dimensions:

- Data Volume
- Data Granularity
- Data Quality
- Data Variety

/ Plan to operationalize your machine learning solution

Instead of building a machine learning solution to tackle a one-off business challenge, consider long-term sustainability and plan to operationalize your results for continued success.

/ Choose self-adapting models

To achieve the stability and adaptability required for operational use, it's important to use models that are self-adaptive and do not require continuous tuning by experts.

/ A connected solution is crucial

Incorporate your self-adaptive models into an integrated business solution, with models updated automatically on a frequent basis to react to changes in the business.

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A Pioneer in Applying Machine Learning to Supply Chain Challenges

Whether you're new to AI technologies or have some experience under your belt, the right machine learning technology partner can help you reap the rewards without requiring a team of data scientists. For 10 years, ToolsGroup has been on the forefront of developing machine learning techniques to solve supply chain planning problems. We can help you identify the resources you need, and even provide managed services experts in machine learning and data science to ensure your project is executed properly, and with sustainability and business objectives in mind.

To learn more, visit **toolsgroup.com**

Resources

(1) Worldwide Spending on Artificial Intelligence Systems Will Be Nearly $98 Billion in 2023, According to New IDC Spending Guide
(2) 3 Types of Machine Learning for the Enterprise. Published 29 January 2020 - ID G00465941
(3) https://www.forbes.com/sites/gilpress/2017/02/19/alan-turing-predicts-machine-learning-and-the-impact-of-artificial-intelligence-on-jobs/
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