



MAXIMIZING SUPPLY CHAIN PROFITABILITY USING MACHINE LEARNING AND ADVANCED ANALYTICS

HOW VIEWING INVENTORY AS AN INVESTMENT
IS CHANGING THE GAME FOR RETAILERS

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Maximizing Supply Chain Profitability

Retailers are in the business of predicting the future, then buying and positioning their inventory accordingly. But until now, legacy approaches and inadequate computing power have resulted in seat-of-the-pants inventory management. The resulting inventory distortion (out-of-stocks and overstocks) costs retailers more than \$1 trillion annually, including more than \$252 billion in North America alone, according to IHL's [Retail's \\$1.1 Trillion Inventory Distortion Problem](#).

Every retailer would like to predict the future far more accurately. When it comes to inventory profitability, that now may be possible. Using machine learning to support predictive and prescriptive analytics, retailers can yield greater profits and fewer losses from inventory management. Recent tech advancements — lowered computing costs and artificial intelligence (AI) — put game-changing tools in retailers' hands.

According to BRP's *Digital Commerce Benchmark Survey*, more than half (56%) of retailers surveyed utilize or plan to utilize AI, including machine learning, within the next five years.

Retailers adopting a best practice approach in applying these advanced technologies to inventory management report significant net profit improvement, between 10% and 40%.



Leveraging Fintech To Drive Inventory Profit: **3 Steps**

Maximizing the impact of machine learning, predictive and prescriptive analytics requires adopting a new mindset about how to approach inventory management. These three steps enable retailers to approach inventory as a profit center using a prescriptive approach.

Define Inventory for Profit, or Profit Optimized Inventory (POI)

Identify the Limitations of Traditional Inventory Management

Implement a POI Approach

Define Inventory for Profit, or Profit Optimized Inventory (POI)

Retailers are in business to earn a profit. Inventory is retailers' largest investment. But very few retailers use profit as a key performance indicator (KPI) for inventory management. That is largely because retailers have historically lacked the data, models and technology to make such a calculation. Siloed legacy retail systems have been incapable of calculating profitability — which requires a cross-department view — as part of day-to-day retail decisions. So, they have used department-specific KPIs as stand-ins.

One common inventory KPI is target service level. A retailer setting a target service level of 97% wants 97 of 100 customers to find what they want in stock. So, they set inventory levels designed to meet that level of demand across product lines.

But not all items are equally profitable. Retailers expend similar effort being in-stock on an item that delivers just pennies in margin, say bars of soap, versus a \$500 cook set with a 50% margin. The cook set may sell much more slowly, say one set a month per store, so the retailer sets the target inventory level at one, while the soap target is four cases a week per store. But the risk of understocking the soap is just pennies, while being understocked on the cook set is \$250 per set. Being overstocked on cook sets is worth the investment, considering the margin an unforecasted purchase will deliver, but not for the soap.

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By infusing retail inventory decisions with technology adapted from financial technology (fintech), retailers can now leverage their data to make profit-driven decisions about inventory — as well as many other aspects of their businesses.

CASE IN POINT: PEP BOYS

Automotive retailer **Pep Boys** carries a large SKU count with many slow-turn items that customers value, but don't buy often. Because the retailer relies on 4R to tune its inventory investments toward profit opportunity rather than risk mitigation, it can afford to carry these items. 4R's solution allows for spending more on inventory when the cost of carrying additional product is outweighed by the lost margin to be recovered.

"Simply put, we have better answers to our inventory challenges," said Camille A. Fratanduono, former Vice President, Merchandising Operations for Pep Boys. "Our store operations team and our customers have already responded favorably to the positive changes we've made."

By leveraging fintech-inspired technology to manage inventory, a retailer's inventory becomes its "stock portfolio."

That's right on target, because **inventory productivity as it relates to profit turns out to be an important leading indicator to stock performance and retail performance in the general market**, according to a 2014 *Harvard Business Review* article, *Retail Inventory: Managing the Canary in the Coal Mine*, co-written by 4R co-founder Dr. Ananth Raman.

You can't improve what you can't measure. To achieve inventory profitability, retailers need to use profitability as an inventory KPI.





Identify the Limitations of Traditional Inventory Management

Another issue with commonly used KPIs such as turn, in-stock rates and service levels is that they can fight against one another. There are a variety of ways to improve turn, for example, including cutting inventory. But if you decrease inventory while demand remains the same, eventually customers see out of stocks and walk away. Similarly, aiming for high in-stock rates can result in excessive inventory carrying costs and margin loss from discounting to dispose of unsold merchandise.

Retailers are forced to use a trial-and-error approach to try to balance all of these KPIs, because traditional inventory management solutions are not designed for this task. Every individual SKU a retailer sells will have an optimal point on each KPI that is different even from other items in the same product category. An individual item might be distinguished not just by margin but by the size of the case pack, fixture minimums, review periods and so on. But traditional retail systems treat entire categories, even entire lines, as if their requirements were the same.

As a result, what these systems report as optimal service levels will actually be detrimental to the business for many of those items. They may over- or underreact to market changes, driving a seesaw effect with inventory levels. That's because the technology to look across KPIs to determine a lowest risk/highest profit recommendation at the individual item level has not been available until now.

Finding Hidden Pricing Patterns

One retailer operated two stores less than five miles apart, with nearly identical demo- and psychographics. So, the retailer allocated the same assortments in the same quantities for both stores. But their performance was markedly different. Then 4R applied a price filtering algorithm that looked at purchase patterns for high-, medium- and low-priced product assortments. It turns out that **one of the locations had a strong propensity toward high price points, while the location less than five miles away demonstrated a preference for medium- and low-price points.**

The retailer modified the stores' assortments accordingly. The low-price-preferring store didn't make as much margin with more low-cost items, but substantially increased revenue and therefore overall profitability. The high-end store's sales didn't increase volume by much, but profitability rose nicely.

Because there were no obvious indicators to suggest this pattern, **the retailer would likely never have discovered it without machine learning and advanced analytics.**



Machine learning is the key to opening up this capability, replacing trial and error with goal-based science and precision. One ideal application for machine learning is to make a large volume of small decisions — such as setting an optimal inventory level down to the individual item level. Machine learning is all about finding underlying patterns and hidden factors in the data, supporting predictive analytics. For example, if the forecast is wrong, what is the economic impact of being over or under for that individual item?

These results are built into models that predict future behavior that retailers can use to forecast or create demand with far better accuracy. With the right guidelines and supervision in place, machine learning and advanced analytics are techniques that help retailers find answers to previously unanswerable questions, such as, “What is the optimal inventory level for an individual item in terms of maximizing profit?” Because it has a bigger picture to work with, this technology brings consistency rather than bullwhip effects to inventory levels.

The science used to reach that particular result is called the Markowitz Efficient Frontier Model. Other machine learning models apply in different situations, such as whether the customer is a VIP, or recognizing an item as a “loss leader” because of the high margin built into the service component of the sale, such as low-priced pool chemicals driving high-margin pool cleaning services.

Machine learning supports the process of *predictive analytics* — forecasting what is likely to happen. Predictive analytics findings underlie the process of *prescriptive analytics*, which tells a retailer which levers to pull to achieve the objective of profit generation or enhancement. The two are complementary, so that the better the machine learning, the models it is used to create, and the cleanliness and quality of the data, the better the output of the next level: *prescriptive analytics*, also called *optimization*.

The results of this process drive prescriptive analytics and true optimization, telling the retailer precisely what it can do to achieve desired results (see sidebar). This can be fed back into traditional inventory management systems to drive better profitability.

CASE IN POINT: THE VITAMIN SHOPPE

Despite creating and scaling a successful store model, **The Vitamin Shoppe** faced challenges in precisely managing its inventory across channels, which include wholesale, retail and direct to consumer. 4R evaluated its data and developed and proved out a model based on machine learning and advanced analytics. Now, The Vitamin Shoppe sends 4R sales and inventory data on a weekly basis, and 4R applies its model to generate profit-optimized inventory levels to support demand across channels. These results are merged into The Vitamin Shoppe's existing systems to drive store shipments, DC fulfillment levels and vendor orders.

"4R's Store and DC solutions have helped us drive significant improvements in our inventory efficiency and in-stocks," said Jason Scheffer, former VP, Inventory, Transportation and Supply Chain Solutions for The Vitamin Shoppe. "When we implemented 4R, we quickly saw 4R's models set inventory levels that made more sense and performed better. **4R helped us drive in-stocks from 90% to 96% while simultaneously upping inventory turns 30%.** The service-based solution gave us an unprecedented level of connection between our inventory management decisions and their impact on our business."





STEP THREE

Implement a POI Approach

Machine learning and advanced analytics are the underlying engines of a profit-optimized inventory approach. Retailers switching to 4R's subscription-based POI model are seeing increases in profitability of 1% to 2% of sales. Retailers not yet using any type of optimization prior to implementation of 4R are seeing even more dramatic impacts following deployment, as much as double or triple that number. Put another way, that means a net profit improvement of between 10% and 40%. That has as a staggeringly positive impact on the bottom line.

Retailers can achieve this level of result even starting from relatively immature analytics capability, without significant capital investment.

Here are the five steps to attain these benefits:

STEP ONE

Benchmark your inventory efficiency and financial productivity.

Retailers already have everything they need to find out how a POI approach would benefit them: historical data. This data can be run through multiple machine learning and advanced analytics models at a high level to identify potential opportunities. That helps identify those areas that would deliver the fastest return. Then a deep-dive, granular-level benchmarking determines the profit potential.

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High-level inventory productivity analysis typically determines improvement potential within a 10% rate of error, while the deep dive results in identifying profitability opportunity within 2%. This approach sets a clear benefit that retailers can expect when applying the model to live data.

STEP TWO

Implement financial investment modeling: optimal financial return vs. chasing service levels. With opportunities identified, the next

step is to determine the business strategy. Retailers approach profit optimization with a variety of goals. Some want to minimize up-front cash outlay and gradually implement optimization over time. Others want to maximize the benefit as quickly as possible, or continue current performance while lowering risk.



These goals shape how profit optimization models are tuned, with implementation and refinement determined by the outcome the retailer is seeking.

STEP THREE

Determine the customer behavior that drives the right mix of inventory for every item at every location. Retailers know customer behavior patterns shape inventory demand. So, they employ tools to help them discover and understand those patterns, looking for things like seasonality, price variables and response to promotion.

But there is another layer underlying those patterns: systems. To use customer behavior patterns to optimize profitability, it's key to identify the systems that cause that behavior. For example, an automotive retailer may be in stock with 4, 3, 2 or 1 of a particular tire model. The customer behavior is buying those tires 1, 2 or 4 at a time — but almost never 3. That's because there is an underlying system: a four-wheeled car. There is a correlation between being in stock with four and customer behavior: If the auto retailer is not in stock with four of those tires, it loses a certain amount of business.

Such correlations exist with many items, but only become evident when the underlying system is identified via machine learning and advanced analytics.

Gartner's *Using Algorithmic Retailing to Drive Competitive Advantage* reports that application of algorithms in retailing “supports the evolution of unified retail through smart data discovery that paves the way toward analytically driving every decision and leveraging smart machines for productivity and detailed understanding. Algorithms are required for execution of opportunities identified from big data.”

STEP FOUR

Clearly demonstrate the return on inventory in a live pre/post, test/control environment. To be certain that a change resulting from profit optimization can be fully attributable to that process, it's essential to test and control the output in a live environment. This entails matching two store groups through a rigorous, scientific clustering process, then implementing the recommendations of the POI process in one store group while the matched store group does not see the change.



This process ensures that the models and patterns are accurate and predictive of the results the retailer will achieve with the recommended profit optimization model.

Family Dollar used the process of evaluating, proving and implementing to ensure 4R Systems' Profit Optimized Store Inventory Service would optimize for profit across all of the chain's replenishment items. As a result, 4R accurately projected the improvement to inventory efficiency and allowed Family Dollar to optimize key decisions for store and DC inventories, replenishment items and more.

"4R's inventory service has improved our ability to maintain inventory levels that satisfy customer needs better and more profitably," said Bryan Causey, Senior Vice President – Planning, Allocation and Replenishment, Family Dollar Stores.

STEP FIVE

Deploy highly measurable, flexible and scalable solutions that utilize the latest advances in machine learning and advanced analytics. Machine learning and advanced analytics can produce powerful results. But they do so when skilled people can target their power toward an objective. Without those sorts of guardrails tuning the algorithms and models in the right direction, machine learning can produce ill-advised outcomes.

Because of this, the best approach to leveraging machine learning and advanced analytics to achieve profit optimized inventory is via an actively managed service. Once the model is tested and proven, the retailer regularly shares data with the provider to run through optimization engines; that data is then fed back into the retailer's merchandising systems. According to BRP's *Digital Commerce Benchmark Survey*, one-third of respondents are outsourcing their technology domain for predictive analytics to a third party, often as a way to overcome outdated infrastructure.

Retail is constantly changing, now faster than ever, so it's essential that this process be continuously improved through close collaboration between the provider and retailer staff, with the provider augmenting the retailer's in-house analytics capability. Machine learning and advanced analytics must be actively maintained to constantly seek new patterns in the data that suggest the need for change while keeping models closely aligned with retailer business objectives. Continuous monitoring, human insights and updating the models are all critical to enable retailers to react quickly enough to the rapidly changing marketplace.

Conclusion: Boost Inventory Profitability With POI

The application of fintech technologies including machine learning, predictive analytics and prescriptive analytics to retail decision-making could not come at a better time. Retailers are challenged by a market that is changing at a breakneck pace just as digital transformation makes go-to-market strategies more complex.

By adopting Profit Optimized Inventory as a KPI, identifying the limitations of their traditional inventory management solutions and implementing a POI approach, retailers can unlock tremendous value currently trapped in their data. They can uncover the hidden patterns and identify the correct levers to pull to make optimized inventory decisions that maximize the profitability of their largest investment, while staying on top of rapidly shifting trends and customer expectations.



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4R Systems is a leading provider of advanced inventory and supply chain services, which help retailers gain significantly increased profits by optimizing their omnichannel inventory and related supply chain decisions. Founded by supply chain experts from The Wharton School and Harvard Business School, 4R provides capabilities that profit optimize the matching of supply and demand. From initial launch through replenishment to end-of-life for products—ranging from shortlived fashion items to long term staples—4R provides retailers with services that fit their business. Clients using 4R have seen increases in profitability of 1-2% of sales as a result of higher sales levels on lowered inventory.

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