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## Considerations of a retail forecasting practitioner

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### ABSTRACT

Forecasts can be used in an extraordinarily diverse range of ways across many domains in which forecasting practitioners work continuously towards improving their forecasts. Each of these domains may require the analysis of different kinds of inputs and special considerations. Even within a given domain, such as retail, there may be many similar use cases of the same kind of forecast, which can lead to practitioners making different decisions. This paper discusses several of the important decision points that practitioners must work through and uses item-level sales forecasting in the retail domain as leveraged by pricing and inventory management as examples of the different paths that may be taken. It considers how each use can lead to a different forecasting objective, and a corresponding focus on different error metrics. In addition, there are several tradeoffs in the forecasting methods that are used to meet each of the objectives best, including the kinds of models used, the running time speed, and forecast accuracy requirements.

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### 1. Introduction

The responsibilities of a forecasting practitioner are far-reaching and diverse. Practitioners combine the positions of a business consultant who understands the needs of the business, a data engineer who pipes data into the system, a data analyst who interprets and modifies the input data, a scientist who builds and tests models, and an account manager who partners with the business team to integrate the forecasts into their processes. While it is important to develop skills in each of these areas in order to become a well-rounded forecaster, it could be argued that the first is the most important: the ability to understand and interpret both the needs of the business and the impact of these needs on the later forecast modeling process. This paper will cover several of these connections between business requirements and forecasting models and methodologies, using the retail industry as an example of why different decisions will be made.

The retail industry has been undergoing a gigantic shift from purely brick and mortar stores to both unified physical and digital businesses and purely digital e-commerce

retailers. E-commerce has enabled companies to have easier and faster access to much more information about customer preferences and actions, as well as to react to this information far more quickly than was possible traditionally. The ability to serve the customer in more diverse ways has led to a need to reexamine many of the traditional core retail processes and the ways in which data science supports them.

Sales forecasts are an integral component of many core retail processes, including the general areas of pricing and inventory management. The areas may be thought of as a set of sequential processes in which the price of an item is set so as to maintain a reasonable margin and then inventory is purchased to support the expected sales at that price, but in actual fact they often interact closely with each other and with other business processes. A simplistic view of each area is as follows. The retailer must determine the best price for meeting or exceeding customer expectations, as well as for achieving the business' goals around revenue and profit. Inventory management must plan the proper amount of inventory and warehouse capacity to support the projected sales, minimizing excess inventory but remaining in stock. This continues until the item reach the end of its lifecycle and is discontinued. These process can

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also interact with other areas of the business; for instance, marketing may impact both inventory and pricing decisions (Hanssens, 1998). Different processes make use of forecasts in related but distinct ways.

Since many of the uses of forecasts revolve around granular actions such as pricing or inventory management, it is worth noting the overall scale of the problem in the retail domain. Physical stores can hold over 200,000 distinct items, while online retailers may offer over 100 million items. Walmart has roughly 5000 stores throughout the United States, meaning that approximately 1 billion unique forecasts must be generated in order for the business to run. When sales of items online are forecasted by geographical location, the number of forecasts can exceed 1 trillion. In order for the business to run smoothly, systems must be developed for generating these forecasts quickly and efficiently.

This paper discusses the similarities and differences between the domains of pricing and inventory management as they relate to e-commerce retailers and the impact of each on the decisions made while forecasting. The layout of the remainder of this paper is as follows. We start by giving a brief introduction to e-commerce pricing and inventory, then examine the impacts on the forecasting objectives, forecast horizons and error metrics used. This is followed by a discussion of the impact of the maximum computation time on modeling choices, and we close with some concluding comments as to how a forecasting practitioner should view these findings.

## 2. Retail domains

Before a forecast practitioner can make a thorough examination of the many different forecasting methods available and an accurate assessment of their performances, the practitioner must have a deep understanding of the intended use of the forecast, since the forecasts are generated in order to improve a specific outcome, not just for the sake of existing. The first step in improving a forecast is to determine why the forecast is needed and how it will be used. Here, we describe the domains of pricing and inventory management and their main uses of forecasts.

### 2.1. Pricing

Pricing items correctly is critical to the success of any retailer, since prices that are too high will deliver a poor customer experience and drive customers to the competition, but prices that are too low can quickly harm a business' finances. There are many different considerations involved when a business is deciding on a pricing strategy, including price perception, revenue, and profit. The optimal price of an item may vary over time as customer preferences and business conditions change. For a general review of this field of dynamic pricing, see den Boer (2015); the current paper will restrict its discussion to the retail domain. Intuitively, price perception is the key to establishing a long-term relationship with the customer and can be influenced by both the price relative to the competitors' prices and the stability of the price. The short-term impact of pricing relative to the competitors can be measured easily, while

the long-term impact on customer retention can require a considerable time investment to determine. Pricing above the competition has a clear negative impact on price perception, but an unstable price that fluctuates wildly can also have a negative impact, as it can degrade trust in the fairness of the price. When a retailer sells commodity goods that are available easily from other competitors, a direct price comparison online becomes easy. Even for many exclusive and private label items that may not have exact comparisons at a competitor, customers can often find comparable items and judge the price fairness based on similar characteristics of the items. Prices have a direct impact on both revenue and profitability, as lower prices can drive more sales but possibly at lower profit levels; thus, the price elasticity of demand is a key input when making pricing decisions. There is a clear tradeoff that must be made between sales and profitability, and companies may make different decisions as to the best area to focus on. Small start-up companies will often invest money in driving top line revenue growth in order to build their market share, with the hope of taking advantage of this larger market share in the long term. Large publicly-traded companies in mature markets have more of a tendency to focus on increasing the shareholder value by maintaining a consistent profitability. Overall, though, every company is different, with their leadership deciding on the best path forward.

There are two primary retail pricing strategies that are adopted widely. The first is the everyday low price strategy, in which a company maintains consistently low prices with minimal price changes, and sales will often last for months. The reduced fixed costs as a result of avoiding changing prices, including no longer needing the marketing to support them, can then be reinvested in lower prices. A low price strategy depends directly on the price relative to competitors. In this strategy, the company does not need to always beat the competition on every item, but should offer a relative saving to the customer in aggregate. Walmart is an adherent of this strategy, and is even known for its "Everyday Low Prices" slogan. This is in contrast to the high-low pricing strategy, where a company will price an item higher than average but with the occasional deep discount. These discounts are often short-lived, and sales are driven more by the size of the discount than by the actual price. The hope is that such high discount items will draw more customers to the store and that these will then purchase more items at the regular price. In both of these strategies, the prices for most items still remain relatively constant, with only a small percentage changing on any given day.

With the advent of the Internet, the ease with which customers can comparison-shop and the reduced costs of changing prices have led to a far more dynamic pricing ecosystem. If any retailer lowers the price of a given item, other retailers will quickly become aware, and must then decide how to react. Several e-commerce retailers, such as Walmart, Amazon, and Ebay, also have large marketplaces where third-party sellers can sell their goods for a commission. Since multiple marketplace sellers may be selling the same item, these sites treat the price as a key input into which offers to highlight when a customer looks for the

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