



Demand Forecasting and Price Optimization

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1 Introduction

Since ever, one of the most important reasons to get a product and not another similar is the price. For that, the product seller has to think deeply to put the right price.

Obviously pricing is a complex practice. Low prices risk negative margin impact, which is not appreciated by sellers while high prices might scare away buyers and could inflict huge losses to sellers due to a wrong estimation.

There are a lot of criteria that have an impact on the product price such as the cost of production, the price of similar products, and the geographical and market variations. So what are the used techniques by companies to avoid client losses due to the price and how data science can enhance companies to make the right decisions ?

The way businesses set prices changes, depending on the nature of the product, the policy that the company elaborates for their margins. It could be even enhanced by the political circumstances sometimes. Factors such as customers and competition are decisive in order to choose your pricing method. Changes in the business field or the development stage of the product may be signs that the company needs to change its pricing strategy. For that data science can make pricing easier, more scientific, and less subjective or even whimsical – taking into consideration all possible factors and historical data. To apply data science for pricing, we have first of all to gather all the necessary data related to the product, its production and distribution cost depending on geographical position if necessary. Once data are gathered and handled in order to be explored, we try to analyse these data through querying and dashboard. The aim of this part is to get a better understanding of features and the impact of each one on the price. After that we can apply several machine learning algorithms such as regression to predict the right price.

2 Adopted strategies by online shops

2.1 Price optimisation

Price optimization is already a factor when developing the pricing strategy of any online retailer. In the digital environment, prices change almost constantly, searching for the point where the best sales ratios are achieved with competitive prices, which continue to bring benefits to retailers. However, online price optimization techniques need competitive price comparison in order to make the best decisions. For this, dynamic pricing software is, without a doubt, your online store's best ally.

4 benefits of price optimisation online Currently, the online sales environment is characterised by three factors:

- A very large number of online sellers, such as marketplaces, eCommerce, resellers and even comparison engines who obtain commissions as intermediaries.
- An endless variety of products that are now accessible to billions of potential customers.
- The constant battle to capture, trap and convert visits to the online store into sales revenue.

In all of these, price always plays a fundamental role. As in traditional, or offline, selling, price remains a decisive factor for the consumer when choosing one product over another, one vendor or their competition. Of course, price was not going to play a lesser role when we move to the digital world, since options are practically infinite. During this battle, being the cheapest option could become the best in order to get the maximum number of sales. However, we must not lose sight of the fact that the price must always meet the minimum requirements of the brand in order for it finally to be able to cover the profits of the eCommerce coffers. Price optimisation strategies are based on precisely this: providing the maximum possible benefit for your online store at all times. With this approach, price optimisation techniques will allow you to always know what the optimal selling price is for your products and that allows you to get both a good sales ratio along with the necessary profits. Every online sales manager knows that this type of action is more than necessary in an environment in which platforms such as Amazon can change the price of their products up to six times in a day (with an average of almost four per product and day). What more concrete benefits can you gain from specialist price optimisation?

Let's look at them schematically:

- Always obtain the highest yield for each sale made.
- Increase sales in those products that, until now, did not seem to stand out in the catalogue due to their prices.
- Improve the profit margin of those products that have very little competition in the market and have good brand positioning.
- Avoid loss of profit due to prices that are out of the market or insufficient sales due to the reduction of certain products.

2.2 Retailer Dynamic Pricing

Dynamic pricing strategies are governed by the modification of prices at times when market conditions change. These readjustments are made according to changes made by your competitors, in particular, and always aims to achieve the most competitive price possible for each product in your store. Analysing any pricing strategy, it can be perfectly affirmed that dynamic pricing is one of the techniques involved in price optimisation. For the strategy to be effective, it is necessary for product prices to adapt and change as many times as necessary in order to adjust to the market conditions. In general, when we talk about dynamic pricing, we end up referring to price optimisation because we do not understand the implementation of one technique without the other. After all, both are necessary to make your online store maintain the sales opportunities ahead of your competition and get the maximum possible benefit from them at all times. In this sense, the circle would be closed by Competitor Price Monitoring, which provides the necessary data to conduct all these price modification actions. What to consider during price optimisation? Dynamic pricing actions must be carried out gingerly when it comes to making decisions. Once the competitor's price changes have been identified, it is necessary to study the data and recognise the elements that will form the actions to be taken. Among them it will be necessary to detect the dates and times of the changes to know if they correspond to specific events, the percentage of the price change, the order in which competitors have made the change to detect the leader and verify the achievement of sales caused by this alteration in price. With all this data, each online store can begin to parameterise the changes they want to occur in their product catalogue. With dynamic pricing tools this action can be carried out easily and automatically as it will only be necessary to indicate the rules to be followed and the order in which these are executed. Within the framework of a dynamic pricing strategy, it is also necessary to recognise the need to which the price change responds. This means indicating whether it is a special discount day, whether it is a time of high demand for a specific product or if, on the other hand, it can respond to specific competitor promotions. For example, due to an excess of stock you make an aggressive, low price, strategy to get the stock to move. On the other hand, it is also important to consider when the dynamic pricing strategy is going to respond only to the needs of your own catalogue. It may be the case that your eCommerce is the only one with a specific product for sale. In these cases, you will have to cross-reference the stock data in your catalogue with the supply and demand records in order to adjust prices accordingly and boost sales at higher profits. If, however, what you need is to adjust the price of your products to meet a beneficial promotion per brand, it must fit your dynamic pricing strategy to keep your store's accounts positive. Specifically, your eCommerce can find itself in these three situations when it comes to price optimisation:

- Your store has the cheapest prices for high-demand products.
- There are competitors with better prices for the same products found in your eCommerce.

- Your prices are equal to those of your competitors but your ratio to sale is lower than the rest.

In the latter case, a price optimisation tool will be your best support, as it will help you see how far you can lower the price of your products in order to gain sales. In addition, specialised software, such as Minderest's, will tell you at all times what type of costs your competition covers with the selling price of your products, giving you another dimension to study in your competitors' strategy and allowing you to see for yourself in which items you can save in your business. Choosing the best dynamic pricing tool Dynamic pricing software implements the necessary technology to automate all the processes necessary to carry out the price optimisation of an online store. These are responsible for monitoring competitor prices and executing the actions defined by the eCommerce once they have reached certain milestones or have met the parameters defined in the strategy.

A good dynamic pricing tool is characterised by allowing its user (the eCommerce) to process as much data as possible, as well as tracking as many personalised variables as necessary. Minderest's dynamic pricing tool is capable of recording and processing large volumes of prices from multiple competitors as well as automatically making all relevant changes in the prices of your online store. Today, it is a renowned leader in the market and is trusted by large eCommerce such as Leroy Merlin, Decathlon or L'Oréal.

Thanks to Minderest's technology, with its dynamic pricing tool it is possible to monitor the competition as well as update the prices of your catalogue while taking into account:

- Prioritisation of variables in case more than one criterion converges.
- Product stock situation in your catalogue or warehouse.
- Time slots, in relation to the demand for the product at that time.

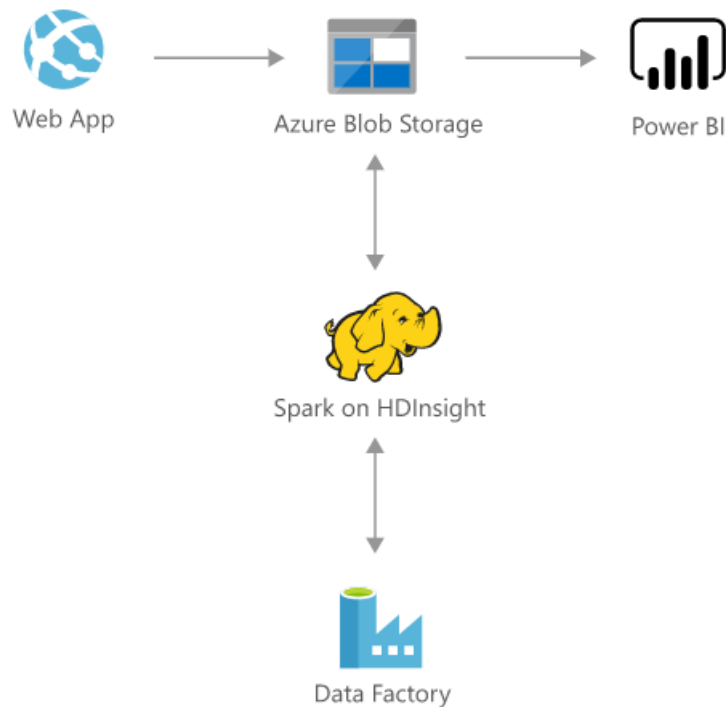
Plus, with Minderest's dynamic pricing solution you'll have the reports you need as often as you need. This way, you will always have the precise data to make the best decisions for your pricing strategy and, of course, always keep the profit margins applicable to your business. Without a doubt, a dynamic pricing software is completely necessary to carry out a dynamic pricing strategy. Only with the help of this technology will it be possible to undertake the task of changing prices as many times as necessary and continue to maintain the competitiveness of eCommerce in the market.

3 Proposed Solution for the Demand Forecasting and Price Optimization using Microsoft Azure Tools

Pricing is recognized as a pivotal determinant of success in many industries and can be one of the most challenging tasks. Companies often struggle with several aspects of the pricing process, including accurately forecasting the financial impact of potential tactics, taking reasonable consideration of core business con-

straints, and fairly validating the executed pricing decisions. Expanding product offerings add further computational requirements to make real-time pricing decisions, compounding the difficulty of this already overwhelming task. This solution addresses the challenges raised above by utilizing historical transaction data to train a demand forecasting model. Pricing of products in a competing group is also incorporated to predict cross-product impacts such as cannibalization. A price optimization algorithm then employs the model to forecast demand at various candidate price points and takes into account business constraints to maximize profit. The solution can be customized to analyze various pricing scenarios as long as the general data science approach remains similar. The process described above is operationalized and deployed in the Cortana Intelligence Suite. This solution will enable companies to ingest historical transaction data, predict future demand, and obtain optimal pricing recommendations on a regular basis. As a result, the solution drives opportunities for improved profitability and reductions in time and effort allocated to pricing tasks.

4 Architecture



Save time and let one of these trained SI partners help you with a proof of concept, deployment integration of this solution. The Cortana Intelligence Suite provides advanced analytics tools through Microsoft Azure - data ingestion, data storage, data processing and advanced analytics components - all of the essen-

tial elements for building a demand forecasting and price optimization solution. This solution combines several Azure services to create powerful advantages. Azure Blob Storage stores the weekly raw sales data. Apache Spark for Azure HDInsight ingests the data and executes data preprocessing, forecasting modeling and price optimization algorithms. Finally, Data Factory orchestrates and schedules the entire data flow. The 'Deploy' button will launch a workflow that will deploy an instance of the solution within a Resource Group in the Azure subscription you specify. The solution includes multiple Azure services (described below) along with a web job that simulates data so that immediately after deployment you can see data flowing through the end-to-end pipeline.

5 Technical details and workflow

5.1 Azure Data Factory

Azure Data Factory is used to orchestrate and schedule the entire data flow. In this solution, it is mainly used to schedule the data aggregation, demand forecasting and price optimization. Here is an overview of the ADF pipelines. You can monitor the data pipelines by clicking the link on your deployment page.

Here is an overview of the generated ADF pipelines.

RetailDFModel Price Optimization Pipeline:

In each cycle, Spark activities will ingest the raw data from Azure Blob Storage, aggregate the raw unstructured transaction data to weekly sales data, train demand forecasting model, solve price optimization problems and prepare the data for Power BI visualization.

Model Retrain Pipeline:

Demand forecasting model is retrained on up-to-date sales data to keep improving the predictive performance. The Model Retrain Pipeline can be deployed in a different cycle time from the two pipelines above, since there are no dependencies between Model Retrain Pipeline and Retail DFModel Price Optimization Pipeline. In this solution demo, the Retail DFModel Price Optimization Pipeline are scheduled to run hourly, which represents weekly in the reality. While Model Retrain Pipeline is scheduled to run every four hours, which represents four weeks (approximately one month) in the reality.

5.2 Azure Blob Storage

Both raw data and analytical results are saved in Azure Blob Storage in this solution. You can monitor the generated datasets by clicking the link on your deployment page. There are mainly two final result datasets: Aggregated Sales Data and Optimization Result Data. Each record of Aggregated Sales Data contain weekly sales, product features and store features for one product sold at one store in a specific week. Each record of Optimization Result Data contain predicted weekly sales on this record's features, recommended optimal price, product features and store features for one product sold at one store in a specific

week. Aggregated Sales Data only contain historical data, whereas Optimization Result Data contain historical recommendations as well as the future price recommendation for the coming week. Aggregated Sales Data contain records for all stores, whereas Optimization Result Data only contain records for stores in treatment group, because only stores in treatment group accepts/needs the recommended price from optimization algorithm.

5.3 Apache Spark for Azure HDInsight

In this solution, Spark on HDInsight is used to ingest and preprocess the raw data, build and retrain the demand forecasting models, and execute price optimization algorithms. You can monitor the Spark jobs submitted via Azure Data Factory by clicking the link on your deployment page.

5.4 Workflow

- 1.The simulation data is generated hourly by newly deployed Azure Web Jobs.
- 2.This synthetic data is stored at Azure Blob Storage, that will be used in the rest of the solution flow.
- 3.Spark on HDInsight is used to ingest and preprocess the raw data, build and retrain the demand forecasting models, and execute price optimization algorithms.
- 4.Azure Data Factory orchestrates and schedules the entire data flow.
- 5.Finally, Power BI is used for results visualization, so that users can monitor the results of the sales, predicted future demand as well as recommended optimal prices for a variety of products sold in different stores.

5.5 IBM Omnichannel Intelligent Pricing

Omnichannel price optimization software from IBM allows you to coordinate pricing across channels, ensure compliance with pricing strategies and optimize prices for products – from new offerings to markdowns – by automating time-consuming pricing tasks using advanced merchandising science. The pricing software improves responsiveness to competitor pricing and drives efficiency, accuracy and consistency by automating pricing tasks. Plus, our cognitive capabilities automatically assimilate new data and improve their pricing recommendations without requiring any human intervention. IBM Dynamic Pricing combines performance data, such as cart abandonment rates and browsing history, with sales, inventory, and the latest competitive pricing information, and in real time applies these insights to recommend the most appropriate pricing action. While pricing is always critical to driving sales, reacting to competitor price changes is not always the best course of action. With IBM Dynamic Pricing, retailers can intelligently determine which changes they should respond to (and how) and which should be ignored, all based on potential impact on the business. When taking action is appropriate, the solution automatically

makes real-time pricing recommendations. For example, a retailer might find that a competitor rolled out a promotion on a key product, reducing the price by 15 percent. IBM Dynamic Pricing evaluates and decides based on product availability, price sensitivity and customer demand that an 8 percent pricing change will still enable the retailer to compete and to achieve sales and margin objectives. This price would then be automatically updated online.

5.5.1 Omnichannel demand modeling framework:

We develop a framework to model sales channels as substitutable purchase choices for consumers, while also capturing the heterogeneity of channel preferences across locations. With this framework, we can quantify own- and cross-channel demand interactions, especially, the impact of the innumerable number of store prices on online demand. This method overcomes the limitations of the legacy approach that treated the online channel as simply another store location. We use this framework to predict channelspecific demand by location.

5.5.2 Omnichannel price optimization:

We study the omnichannel pricing (OCP) of nonperishable (basic) products in the context of developing a regular pricing solution (also referred to as base pricing). We formulate and solve an integrated price optimization problem across multiple channels and locations subject to certain practically important channel, volume, and price image goals.

(a) Single product pricing:

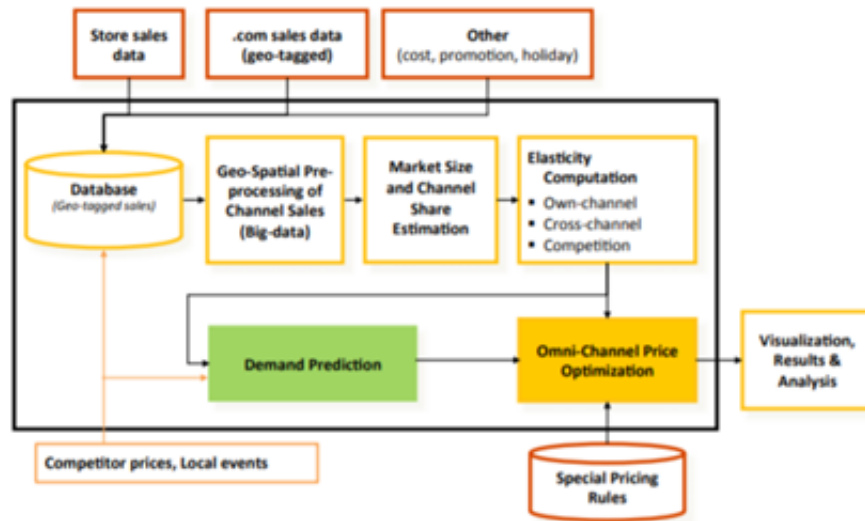
We use attraction demand models to represent consumer preference across sales channels and observe that the resulting optimization model is a non-linear, non-convex NP-Hard problem due to certain complicating pricing constraints and the multilocation aspect of the problem. We employ specialized mathematical transformations to recover a computationally tractable and exact mixed-integer programming (MIP) reformulation that can be solved to (near) optimality using commercial off-the-shelf MIP solvers such as CPLEX. In certain special cases of two channel operations such the brick-and-mortar and online channels, we propose a pseudo polynomial decomposition method to OCP and derive an insightful price coordination result.

(b) Assortment pricing:

Using nested attraction demand models, we additionally manage crossproduct demand interactions within channel assortments. We exploit the concave structure of the nest attraction function and obtain a tractable MIP formulation that admits a variety of additional cross-product constraints. We show that this MIP yields an effective upper bound and can achieve (near) global optimal solutions.

6 Implementation and business value assessment

We performed a business value assessment as a part of our OCP implementation for one of the major omnichannel retailers in the United States. For 100 products in the two product categories that we analyzed, we found that the degree of cross-channel price sensitivity to demand can be up to 50% of the own channel price elasticity. We solved the resulting OCP formulation and obtained a projected profit lift of 7% using omnichannel pricing over their legacy pricing system, while also satisfying several other critical business and pricing goals. These results were presented at the retailer's site to a senior team that included their Vice-President for revenue management. Their response was overwhelmingly positive, and we had a similar experience with the other retailers. IBM Harsha, Subramanian and Ettl: Omnichannel demand modeling and price optimization 4 Commerce followed it up with an internal evaluation and deployed a proprietary version into production in 2014 as a cloud solution. This solution was showcased as one of the retail analytics success stories in the smarter-commerce global summit in 2014, and included a presentation on its capabilities by the retailer.

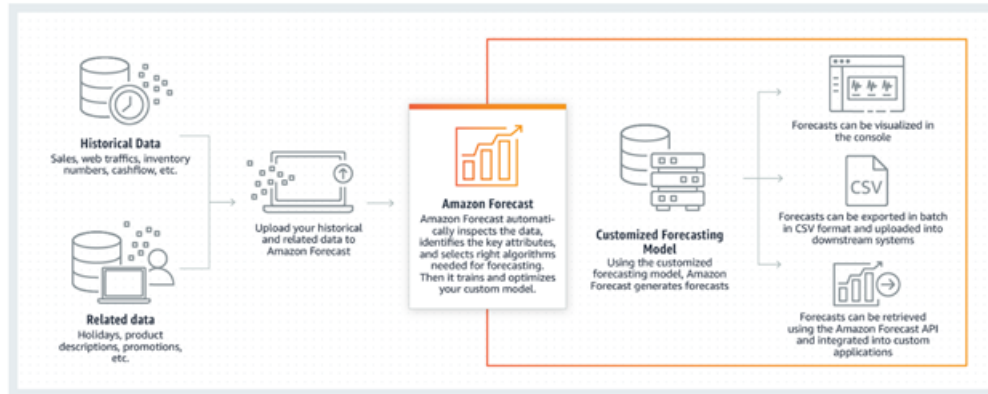


Amazon Forecast is a fully managed service that uses machine learning to deliver highly accurate forecasts. Companies today use everything from simple spreadsheets to complex financial planning software to attempt to accurately forecast future business outcomes such as product demand, resource needs, or financial performance. These tools build forecasts by looking at a historical series of data, which is called time series data. For example, such tools may try to predict the future sales of a raincoat by looking only at its previous sales data with the underlying assumption that the future is determined by the past. This approach can struggle to produce accurate forecasts for large sets of data that have irregular trends. Also, it fails to easily combine data series that change

over time (such as price, discounts, web traffic, and number of employees) with relevant independent variables like product features and store locations. Based on the same technology used at Amazon.com, Amazon Forecast uses machine learning to combine time series data with additional variables to build forecasts. Amazon Forecast requires no machine learning experience to get started. You only need to provide historical data, plus any additional data that you believe may impact your forecasts. For example, the demand for a particular color of a shirt may change with the seasons and store location. This complex relationship is hard to determine on its own, but machine learning is ideally suited to recognize it. Once you provide your data, Amazon Forecast will automatically examine it, identify what is meaningful, and produce a forecasting model capable of making predictions that are up to 50% more accurate than looking at time series data alone. Amazon Forecast is a fully managed service, so there are no servers to provision, and no machine learning models to build, train, or deploy. You pay only for what you use, and there are no minimum fees and no upfront commitments.

50% more accurate forecasts with machine learning Amazon Forecast provides forecasts that are up to 50% more accurate by using machine learning to automatically discover how time series data and other variables like product features and store locations affect each other. You are better able to understand how these complex relationships ultimately affect demand than what looking at time series data alone can deliver. The models that Amazon Forecast builds are unique to your data, which means the predictions are custom fit to your business. Reduce forecasting time from months to hours With Amazon Forecast, you can achieve forecasting accuracy levels that used to take months of engineering in as little as a few hours. You can import time series data and associated data into Amazon Forecast from your Amazon S3 database. From there, Amazon Forecast automatically loads your data, inspects it, and identifies the key attributes needed for forecasting. Amazon Forecast then trains and optimizes your custom model, and hosts them in a highly available environment where it can be used to generate your business forecasts. By automatically handling the complex machine learning required to build, train, tune, and deploy a forecasting model, Amazon Forecast enables you to create accurate forecasts quickly. Create virtually any time series forecast Multiple types of time series forecasts are required to run your business, from cash flow to product demand to resource planning. Amazon Forecast allows you to build forecasts for virtually every industry and use case, including retail, logistics, finance, advertising performance, and many more. Using machine learning, Amazon Forecast can work with any historical time series data and use a large library of built-in algorithms to determine the best fit for your particular forecast type automatically. Secure your business data and peace of mind Every interaction you have with Amazon Forecast is protected by encryption. Any content processed by Amazon Forecast is encrypted with customer keys through Amazon Key Management Service, and encrypted at rest in the AWS Region where you are using the service. Administrators can also control access to Amazon Forecast through an AWS Identity and Access Management (IAM) permissions policy – ensuring

that sensitive information is kept secure and confidential.



7 Use cases

7.1 Product Demand Planning

You can use Amazon Forecast to forecast the appropriate inventory levels for your various store locations. You provide Forecast information like historical sales, pricing, store promotions, store locations, and catalog data from your retail management systems in a CSV (comma-separated values) format into Amazon S3 storage. You can then combine that with associated data like website traffic logs, weather, and shipping schedules. Amazon Forecast will use that information to produce a model that can accurately forecast customer demand for products at the individual store level. Export your forecasts in batch in CSV format and import them back into your retail management systems so that you can determine how much inventory to purchase and allocate per store.

7.2 Financial planning

Accurate financial forecasting like sales revenue predictions is fundamental to every business' success. Amazon Forecast can forecast key financial metrics such as revenue, expenses, and cash flow across multiple time periods and monetary units. You first upload your historical financial time series data to Amazon S3 storage and then import it to Amazon Forecast. After producing a model, Amazon Forecast will provide you with the expected accuracy of the forecast so that you can determine if more data is required before using the model in production. The service can also visualize forecasts with graphs in the Amazon Forecast Console to help you make informed decisions.

7.3 Resource planning

Planning for the right level of available resources, such as staffing levels, advertising inventory, and raw material for manufacturing is important to maximize revenue and control costs. For example, a broadcasting company may want to optimize ad inventory regionally. It can import historical viewership data across different program categories and geographic regions, content metadata, and regional demographics into Amazon Forecast. The service will learn from this data and provide accurate local forecasts.

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