

# **Product Demand Prediction with**

## **Machine Learnings**

To Create a machine learning model that forecasts product demand based on historical sales and external factors, helping businesses optimize inventory management and production planning to meet customer needs efficiently.

### **Problem faced:**

The problem of predicting demand for a new product based on its characteristics and description is critical for various industrial enterprises, wholesale and retail trade and, especially, for modern highly competitive sector of air transportation, since solving this problem will optimize production, management and logistics in order to maximize profits and minimize costs. Classic demand forecasting methods assume the availability of sales data for a certain historical period, which is obviously not the case when concerning a new product. Most research papers are limited either to a specific category of goods or use sophisticated marketing methods. This paper proposes the use of machine learning methods. We used data about new product demand from the Ozon online store. The input data of the algorithm are characteristics such as the price, name, category and text description of the product. To solve the regression problem, various implementations of the gradient boosting algorithm were used, such as XGBoost, Light GBM, Cat Boost. The forecast accuracy is now about 4.00. The proposed system can be used both independently and as part of another more complex system.

### **Product Demand Prediction (Case Study)**

A product company plans to offer discounts on its product during the upcoming holiday season. The company wants to find the price at which its product can be a better deal compared to its competitors. For this task, the company provided a dataset of past changes in sales based on price changes. You need to train a model that can predict the demand for the product in the market with different price segments.

The [dataset](#) that we have for this task contains data about:

- the product id;
- store id;
- total price at which product was sold;
- base price at which product was sold;
- Units sold (quantity demanded);

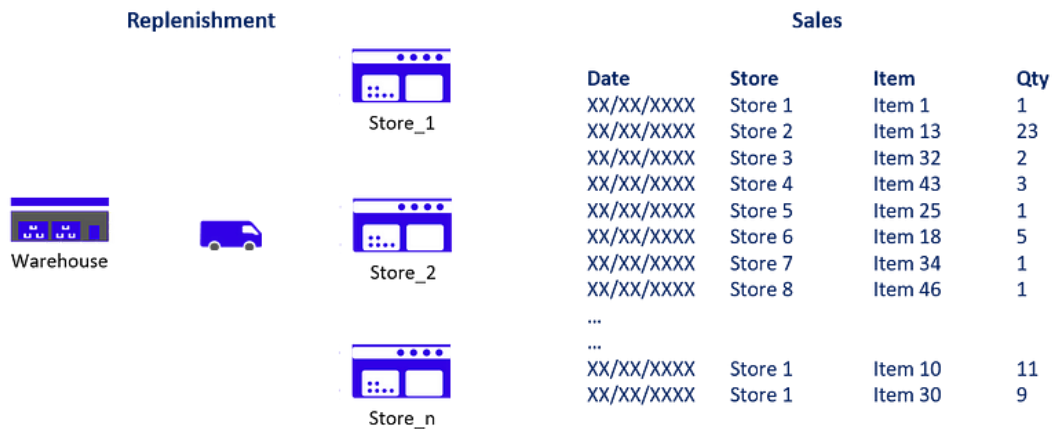
I hope you now understand what kind of problem statements you will get for the product demand prediction task. In the section below, I will walk you through predicting product demand with machine learning using Python.

## **Product Demand Prediction using Python**

We can see that most of the data points show the sales of the product is increasing as the price is decreasing with some exceptions

### **Problem statement and objective:**

For most retailers, demand planning systems take a fixed, rule-based approach to forecast and replenishment order management.



Such an approach works well enough for stable and predictable product categories but can show its limits regarding Inventory and Replenishment Optimization.

This potential optimization can reduce operational costs by:

- **Inventory Optimization:** matching [store inventory](#) with actual needs to reduce storage space needed (**Rental Costs**)
- **Replenishment Optimization:** optimizing replenishment quantity per order to minimize the number of replenishments between warehouse and stores (**Warehousing & Transportation Costs**)

## MACHINE LEARNING MODELS DEVELOPMENT

There are no “one-size-fits-all” forecasting algorithms. Often, demand forecasting features consist of several machine learning approaches. The choice of [machine learning models](#) depends on several factors, such as business goal, data type, data amount and quality, forecasting period, etc.

Here you’ll find those machine learning approaches when applied to our retail clients. These approaches can also be used for most demand forecasting cases:

- ARIMA/SARIMA
- Regression models
- XGBoost
- K-Nearest Neighbors Regression
- Random Forest
- Long Short-Term Memory (LSTM)

Below we would like to describe in more detail 3 ML approaches for working with time series data for real demand forecasting projects.

### Product Demand Prediction Model

Now let’s move to the task of training a machine learning model to predict the demand for the product at different prices. I will choose the **Total Price** and the **Base Price** column as the features to train the model, and the **Units Sold** column as labels for the model:

```
x = data[["Total Price", "Base Price"]]
```

```
y = data["Units Sold"]
```

Now let’s split the data into training and test sets and use the decision tree regression algorithm to train our model:

```
xtrain, xtest, ytrain, ytest = train_test_split(x, y,  
  
test_size=0.2,  
  
random_state=42)
```

```
from sklearn.tree import DecisionTreeRegressor
```

```
model = DecisionTreeRegressor()
```

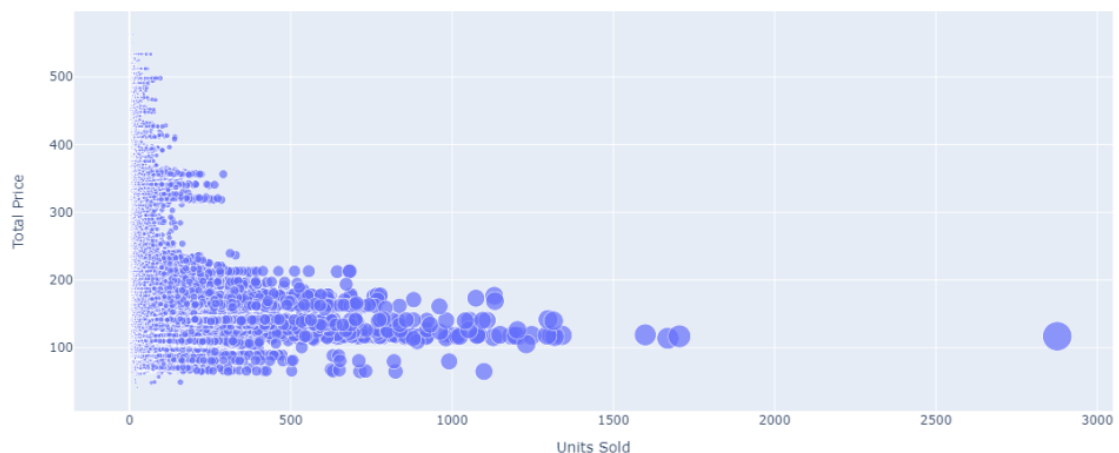
```
model.fit(xtrain, ytrain)
```

Now let's input the features (**Total Price**, **Base Price**) into the model and predict how much quantity can be demanded based on those values:

```
#features = [["Total Price", "Base Price"]]
```

```
features = np.array([[133.00, 140.00]])
```

```
model.predict(features)
```



# Key Factors Affecting Demand Forecasting

Demand forecast tasks depend on a lot of obvious and non-obvious factors. Here are the ones with the most impact.

## PRODUCT TYPES AND MODELING ERRORS

The product type is an important factor to consider for the demand model. For example, for a perishable item that has an actual demand of 100 cases, the prediction of selling 90 cases is preferred over the prediction of 110 cases. Missing the sales of 10 cases is a better result than wasting 10 cases, even though the actual error is the same percentage.

## REGIONAL IMPACTS ON MODEL PERFORMANCE

Predictive models are strongly influenced by regional factors that include customer behavior and cultural determinants. They also include the following:

- Marketing campaigns may be regionally specific and have a different impact that depends on where a customer is located.

- Holidays may vary between regions, which might be a consideration for adjusting the model.

- Legal issues/laws may limit the use of certain data in different regions.

## NEW COMPETITORS ON THE MARKET

Demand forecasting is a dynamic concept. The more competitors and product alternatives are present in the market, the harder demand forecasting becomes. The competition level contains sub-factors, such as the number of alternative products and competitors.

So, it is a very good idea to add this information dynamically to your demand forecasting model.

## ECONOMIC SITUATION

The state of the economy influences businesses and demand forecasting models. To put it more bluntly: periods of economic decline are likely to cause lower demand for expensive products, though sales of low-priced goods may go up. Therefore, an

economic situation as well as trends aren't external factors and should be considered when building AI models.

## Benefits of ML Demand Forecasting for Business

Looming uncertainty and changes in the market lead to highly volatile data. Unlike traditional methods, demand forecasting using machine learning is more flexible and allows the quick infusion of new information into models. That's why ML models are adaptive and accurate enough to bring obvious benefits to the business:

Increase in sales. All needed products will be available in the store, so customers can purchase them without waiting for long delivery times.

Customer satisfaction maintenance. Warehouses will plan purchases in advance, so customers won't face the problem of their favorite product's absence.

Higher inventory turnover. Thanks to proper planning of goods in warehouses, poorly selling goods will not be stale.

Reduction in the number of spoilage products. Demand forecasting will help to competently plan the delivery of products, considering expiration dates.

Reduced personnel costs. By analyzing and predicting future demand, we can plan an optimal number of employees for proper shift support.

ML demand forecasting methods, like other use cases of machine learning forecasting, can rely on a tremendous amount of data to make accurate predictions. However, the question of how to develop such models remains open, and we will consider it in the following section.



## Summary

So this is how we plan to train a machine learning model for the task of product demand prediction using Python. Price is one of the major factors that affect the demand for the product. If a product is not a necessity, only a few people buy the product even if the price increases.