Product Price Optimization Using Least Square Method

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***Abstract*— Now-a-days, company's products in market are a multi-billion-dollar industry, largely responsible for giving products to its customers at a reasonable price in business. Optimization makes us to choose a best decision between various decision alternatives. Price, Quantity are the important measures which are fundamental to determine every business in setting up the right price. Price Optimization is the most important decision that a company can make for their products. Being a product Under-priced disappoints the company, getting Over-priced hurts the consumers and can lead to loss if they are less inclined to buy the product at a higher price. we will deal by integrating the company's production operations and the pricing strategies. A company must manage its production properly and set the price to the product ensuring in such a way that a customer is willing to pay price for the product. The main idea is to make prices of products that a company can make best meet with its objectives such as profit, sales, etc. In this Paper, we will try to implement a correct pricing using the data that we have and describe a scalable, online, real-time, updated price optimizer implementation of product price optimization that can be seen for maximizing revenue.**

Keywords—Marketing Industry, Quantity Optimization, Dynamic Pricing, Revenue, Least Square Method, Decision Making Strategy

I. Introduction

From different perspectives of a company, the attentiveness given in the management of revenue and pricing starts with magnificent product research. Pricing is a very important parameter, that renders various challenges to the corporations as well as analyzers[1]. When a product is designed, many big companies, pioneers, analyzers focus mainly on the pricing part only because it improves companies profits, name and fame. Price optimization is one of the most useful techniques that utilizes the data analysis for predicting the behavior of buyers to different prices for services, products. Observing the methodology being implemented, the analysis that we make will be different. Many Companies use price optimization models for determining the structures of prices. By using different Market simulators, we will come to know the choices of people predicting the demand variation at different price points. We will develop a profitable price point for products and services with production costs in mind. The model that we made is also used for price evaluation for different customer segments by targeting customers. Price optimization is used mainly for the sector where the customers are more in numbers[3, 9]. A trader will be estimating the customers reactions in different segments responding to different prices being set in different areas. The prices determined can meet the best business goals by formulating and solving using optimization process. There were many different approaches for increasing the product's profit and increasing the revenue of the company. In big enterprises, the togetherness of decisions related to price making with other details is not just useful, instead it becomes very crucial[4]. The Coordination of standard decisions made by the company makes a technique that enhances the system in improving the capability of production network, which further helps in getting good name, fame, value for company. The Dynamic Pricing strategy of changing the price of products is an important uprise which can be seen in many marketing industries driven all around the world[6].

II. Price Optimization

Each product on the market has its own Demand Curve, which is generated by its pricing. The Demand Curve depicts the estimated number of pieces sold at every price value. It depicts how pricing can be utilized for clear inventories by generating the necessary demand.

Fig-1 Overview of Price Optimization

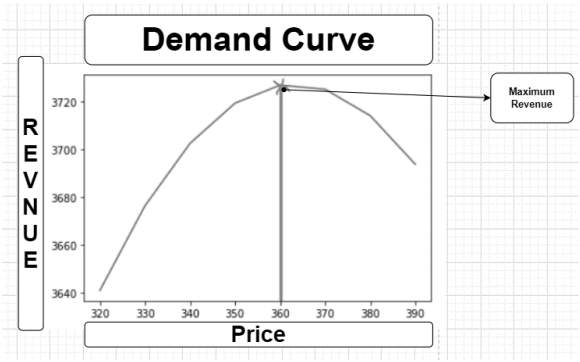

Fig-2 Result of Price Optimization

The Demand Curve anticipates income at each price point in addition to inventories. This might be used to come up with pricing that meets revenue targets.

III. Least Square Regression

If your data demonstrates a direct relationship between the X and Y components, you must choose the optimum line

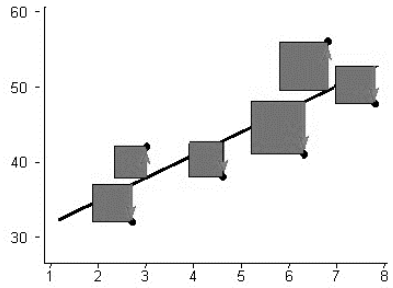

Fig-3 Least square Regression line fitting

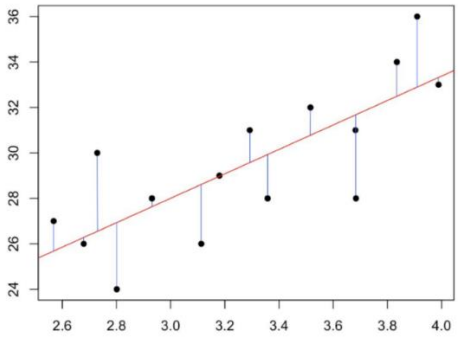

Fig-4 OLS regression example

and then perfectly fit the optimum line which is referred to as regression line. The regression line follows a equation which is y=a+b*x. where a and b are the y-intercept and slope respectively[7–8]. The line focuses on the segregation of the data to the line as least as possible. while calculating the distances in y direction from the line to data point, it is called as least squares. It is called as least square regression because we end with the least sum of squares of the distance from the data points to the line and also called as variance. This is comparatively hard to view but our main objective is to find the conditional equation that finds the optimum line equation which results to fit all the points as close to the line. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

A. Advantages of least squares fitting

Least squares permit the residuals to be treated as a persistent amount where subordinates (proportions of how much a capacity's yield changes when an info changes) can be found. This is significant, as the purpose of discovering a condition in any case is to have the option to anticipate where different focuses on the line (even focuses that are far past the first focuses) may lie.

B. Disadvantages of Least Squares Fitting

Anomalies can have an unbalanced impact on the off chance that you utilize the least squares fitting technique for discovering a condition for a bend. This is on the grounds that the squares of the balances are utilized rather than the supreme worth of the counterbalances; anomalies normally have bigger balances and will influence the line more than directs nearer toward the line. These lopsided qualities might be valuable now and again.

C. Ordinary Least Squares

Ordinary least squares regression is an approach to discover the line of best fit for a bunch of information[5]. It does this by making a model that limits the amount of the squared vertical distances (residuals).

The distances are squared to stay away from the issue of distances with a negative sign. At that point the issue simply becomes sorting out where you should put the line so the good ways from the focuses to the line are limited. In accompanying picture, the best fitted line has more modest good ways from the focuses to the line than the arbitrarily positioned line[10].

IV. IMPLEMENTATION

- Firstly, we imported all the packages and loaded the data which is in the form of a csv file
- Initialize the variables those are dependent and target variable in our case they are price and quantity respectively
- We implemented least square algorithm alias linear regression
- The steps we followed for linear regression are:
  - First, we have to find the best fitting line. To find that line we require the mean of both our variables they are quantities, prices and the length of the data.
  - Next step includes finding slope and intercept of the line. We have

$$m = \frac{\sum_{i=1}^{n}(x_i - \bar{X})(y_i - \bar{Y})}{\sum_{i=1}^{n}(x_i - \bar{X})^2} \quad (1)$$

$$b = \bar{Y} - m\bar{X} \quad (2)$$

  - formulas to find the slope(m) and the intercept(b) they are
  - Now solving these formulas in python requires some logic and it's just a for loop and some values updating and combining them
  - Start a for loop which runs n times that is length of the data. Now to find the slope we use two variables to update slope they are numerator and denominator of the slope we use the above formula to update them they are
  - numer =$\sum(x[i] - mean_x) * (y[i] - mean_y)$ (3)
  - denom=$\sum(x[i] - mean_x)^2$ (4)
  - after the end of the for loop we find the slope as m=numer/denom
  - next we find intercept of the best fit line i.e., c=mean_y-(m*mean_x)

- Now we got the required values i.e., our model is trained
- The required line is plotted as shown in Fig-6
- The results of the trained model is as shown in Fig-7

- Now if we are given prices and the cost of the material with the help of the revenue formulae, we are going to predict the best profit giving price
- Formula for revenue in sales = (Price – cost) *quantity_demanded
- We will get quantity_demanded from our trained model = slope*price + y_intercept

Maximum revenue gives the best price so we find the maximum revenue so at the end we will be left with best price. As shown in Fig-7 maximum point gives the best price

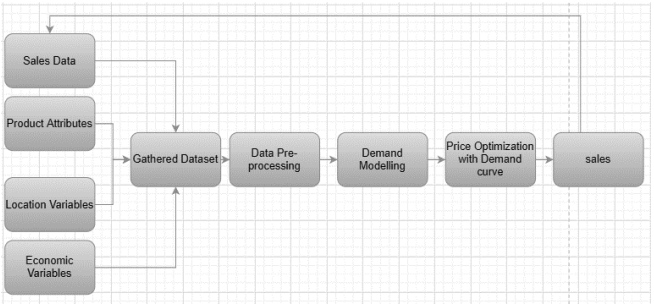

Fig-5 System Design

V. Result & Analysis

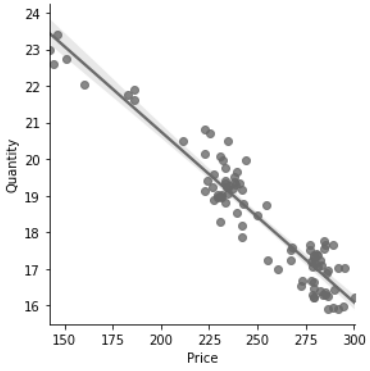

Fig-6 OLS regression best fit line for the data

OLS Regression Results

Dep. Variable:	Quantity	R-squared:	0.901
Model:	OLS	Adj. R-squared:	0.900
Method:	Least Squares	F-statistic:	811.2
Date:	Sun, 30 May 2021	Prob (F-statistic):	1.69e-46
Time:	11:13:12	Log-Likelihood:	-77.493
No. Observations:	91	AIC:	159.0
Df Residuals:	89	BIC:	164.0
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	30.0515	0.413	72.701	0.000	29.230	30.873
Price	-0.0465	0.002	-28.482	0.000	-0.050	-0.043

Omnibus:	3.453	Durbin-Watson:	1.533
Prob(Omnibus):	0.178	Jarque-Bera (JB):	2.460
Skew:	0.237	Prob(JB):	0.292
Kurtosis:	2.349	Cond. No.	1.74e+03

Fig-7 OLS regression results of the model

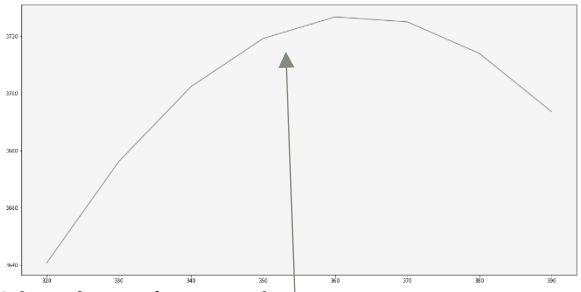

Fig-8 demand curve of revenue and price

VI. Challenges

The most important challenges in price optimization which emerge in data's acquisition, integration is:

A. *TheCrawlingProcedure*

Procuring the data appropriate for price optimization happens using a crawling procedure. We use crawling mainly for comparing offers. We search from different Internet sources, marketing places and various online portals which are designed to compare prices and give us the best offer[2].

B. *Complexness*

One of the most difficult issues in pricing optimization techniques is overcoming complexity. It emerges as a result of massive data quantities and deployment of multilayered marketing tactics. Difficulty facing may be handled with the assistance of comprehensive arrangement options, which the merchants online employ to adjust their desired price schemes. Independently configurable and flexible rules will enable price optimization based on specific criteria and the pricing strategy of the individual store.

C. *Usability*

The convenient and adaptable settings, which need to be straightforward and obvious for implementation, is another significant one in terms of usability. A problem is also presented by the possibility of several users to make modifications to the software at the same time. The gap between complexity needs and user simplicity is a significant issue in creating the complete software solutions for price optimization.

D. *TimeRisk*

Time based factors of pricing optimization are also important. Prices vary significantly more often in internet retail than in brick-and-mortar stores. A weekly upgrade of product's data and pricing is fundamental necessity for responding quickly to price changes among competitors.

E. Security

The security component is also quite important. The accuracy of the computations, as well as the retailer's protection from price spirals, should always take precedence. Individual price controlling must be in the hands of store. In an ultimate world, a price optimization which is automated must never make random price changes, but rather present the price ideas that subsequently can be implemented swiftly, simply, securely into commodities administrative systems.

VII. Applications

- Targeting Exact Place Many businesses classify their markets based on consumer size, product families, and geography, but none of these classifications take into account real we mainly must notice the segment that consumers make a lot of focus. Businesses will remain with an inadequate picture to price their goods more properly if they do not bother about the matters which consumers care a lot. This care for customers surely affects the pricing behavior and helps in increase in revenue.
- There are software's which are available for price optimization that uses fundamental controlling criteria to help provide better pricing. Essentially, price managers use well-known rules of thumb throughout the firm. However, a lack of effective instruments frequently hinders them from being implemented equally. Pricing tools simply automate existing manual procedures. They do not completely stand on the promise of price optimization, which extends beyond the self-regulation of elementary processes. Based on all available data, these algorithms provide consumer-specific pricing suggestions.
- Data for Price-Optimization Various analysts feel that without having any approach to customers loss data, correct market pricing cannot be made but instead the correct market pricing can be made with the help of only win data. By getting familiar to a price point where all the conditions are met allows us to manage prices to increase profit amounts by evaluating win data to calculate win rate.

VIII. Conclusion

In this paper we found the price at which the profit will be maximized by combining economic theory and statistical modelling. In various studies, we can see that the top performers across industries are those who change their price often accordingly to the situations. Price optimization assists merchants in determining how customers will react to various pricing methods for products and services and in setting the ideal prices. To determine the optimum prices for lists of items and services, machine learning models may consider critical pricing aspects such as purchase histories, season, inventories, rival pricing, etc. In the starting phase, we created the demand and profit functions, then performed a regression to identify the parameter values required to enter the profit function, and last, we verified revenues at various price levels to get the price for the highest revenue. we used algorithms and improved some of the strategies for the improvement of a product's price.

In further research, we can be improving the prediction of prices by experimenting with various other models with the help of different machine learning models that may be updated in real time by using appropriate decision making for the selection of solutions.

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