PRICE OPTIMIZATION TO MAXIMIZE SALES PROFIT

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EE-608 Applied Modeling and Optimization

Problem Description

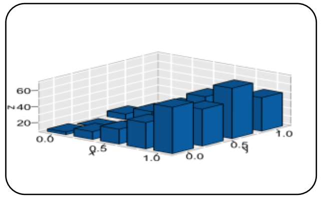
Setting the appropriate price is one of the most important decisions a business can make. Price and quantity are two essential factors that influence every company's bottom line. If customers are prepared to pay more, underpricing will result in a decline in the company's revenue; on the other hand, overpricing might result in the same problem if customers are less likely to purchase the product at a higher price.

- Data Analysis for the purchase history of product
- Find optimum price for the product
- Maximize revenue for the e-commerce business
- Predict Profit based on the Unit Price of the product
- Predicting based on observation, visualization and finally planning based on the results
- Increasing number of customers

Solution Approach

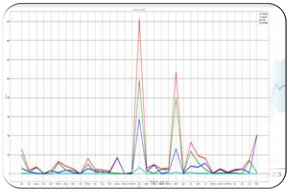
01

Collect Purchase History for Products



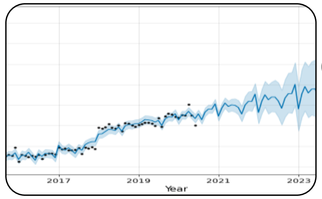
02

Data Preparation & Data Analysis



03

OLS Model – Relation between price & profit



04

Optimization – Steepest Descent Algorithm

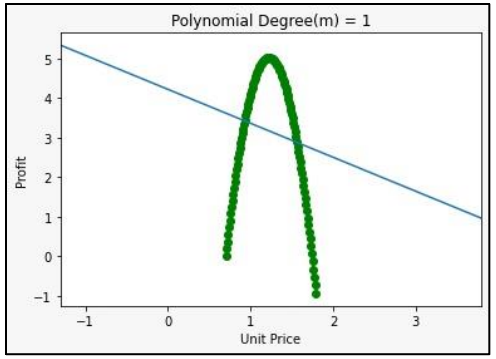
05

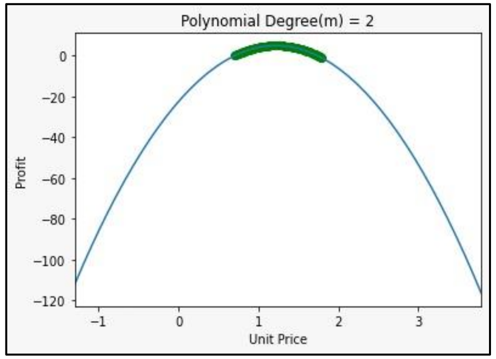
Optimal price having a maximum profit

Technology Stack

Optimization Models & Proposed Solution

Polynomial Fit





Objective Function

f(x) = −18.43(x2) + 45.05x − 22.50

f”(x) = -36.86(Negative)

Collected purchase history for a single product

Ordinary Least Squares model – To find the relation between Price and Quantity

Plot the curve showing relation between Price and Profit based on data generated from ols model

Objective Function - −18.43(x2)+45.05x−22.50

Objective Function fitting the curve (Price vs Profit)

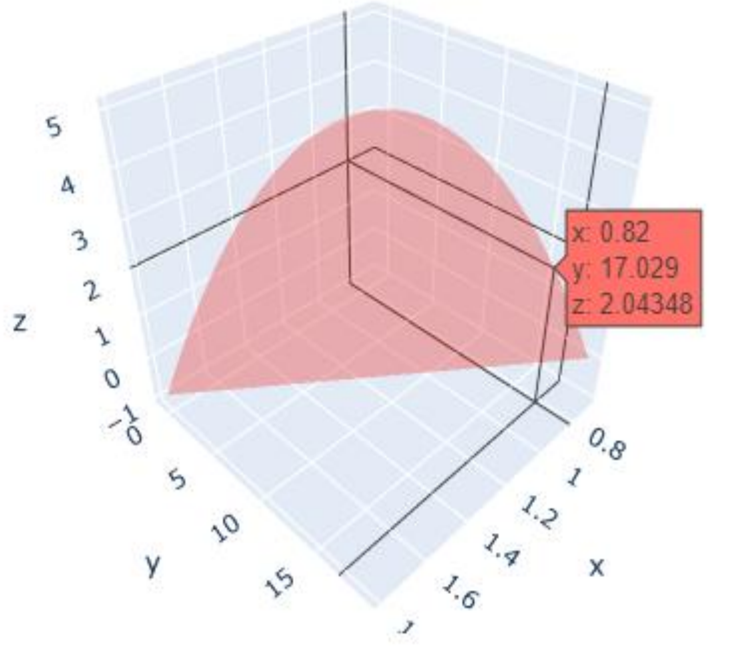
Polynomial Fitting to get the objective function equation

Second Derivative -> -36.86(negative) -> Concave Function

Optimization Model – Steepest Descent Algorithm – maximize profit

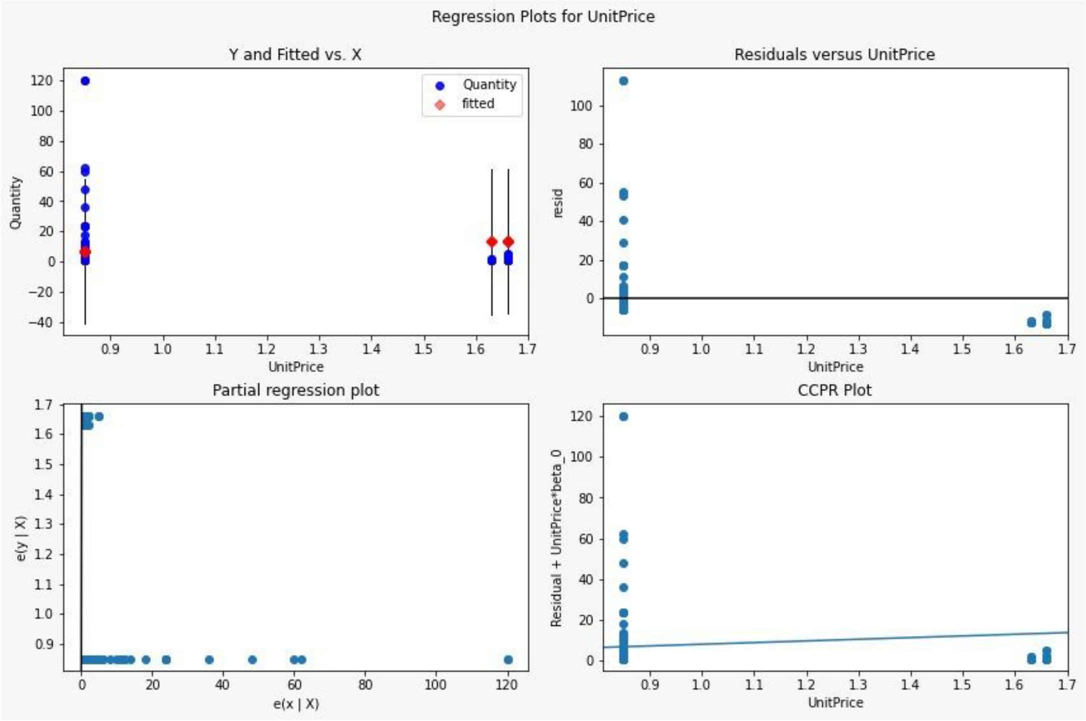
Optimal Price (having maximum price)

Concave Function(Price vs Quantity vs Profit)



Optimization Models & Proposed Solution

Regression plots



Model Summary - Snippet

```
Price elasticity of the product: -18.439451422002907
                            OLS Regression Results
==============================================================================
Dep. Variable:               Quantity   R-squared:                       0.093
Model:                            OLS   Adj. R-squared:                  0.079
Method:                 Least Squares   F-statistic:                     7.040
Date:                Thu, 15 Dec 2022   Prob (F-statistic):            0.00988
Time:                        21:11:38   Log-Likelihood:                -317.18
No. Observations:                  71   AIC:                             638.4
Df Residuals:                      69   BIC:                             642.9
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept     32.1493      7.966      4.036      0.000      16.257      48.042
UnitPrice    -18.4395      6.949     -2.653      0.010     -32.303      -4.576
==============================================================================
Omnibus:                       81.903   Durbin-Watson:                   1.242
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              737.954
Skew:                           3.573   Prob(JB):                    5.69e-161
Kurtosis:                      17.085   Cond. No.                         6.17
==============================================================================
```

- ✓ Ordinary Least Squares regression (OLS) is a common technique for estimating coefficients of linear regression equations which describe the relationship between one or more independent quantitative variables and a dependent variable (simple or multiple linear regression). The least squares stand for the minimum squares error (SSE). Maximum likelihood and Generalized method of moments estimator are alternative approaches to OLS.
- ✓ By training the ols model we try to find the relation between the UnitPrice and Quantity and make predictions for Quantity based on any given UnitPrice.
- ✓ Steepest Descent Algorithm is used to minimize or maximize your function and find the optimal solution or saddle point for your function. We have used this model to maximize profit

Validating Solution

- ✓ To validate the solution, we have used the below code to get maximum profit from the dataset and this is similar to what we got using the Steepest Descent algorithm.
- ✓ Also, we calculated the second derivative of the objective function and it is negative which shows that our function is a strictly concave function. And hence, we will only have one maximum.

Code Snippet – Maximum profit from Dataset

```
ind = np.where(test['Profit'] == test['Profit'].max())[0][0]
test.loc[[ind]]
```

	UnitPrice	Quantity	Profit
52	1.22	9.653217	5.019673

Code Snippet – Maximum profit from Steepest Descent Algorithm

```
df.to_csv('Output - Steepest Descent Algorithm.csv', sep='\t')
df
```

	Iteration	alpha	Price	Profit	Second order
0	1.0	-0.02713	1.2222	5.0299	-74807.4621500000

KEY INSIGHTS

- After performing an optimization algorithm on a single product from our dataset, we were able to find that the price will be 1.22 in order to achieve maximum profit.
- We have shown a single product for optimization. The same steps can be performed on the remaining products. We can get similar insights on the optimal prices for all the products
- Additionally, the steepest descent algorithm is only one of many possible approaches to price optimization. Other algorithms, such as linear programming and interior point methods, may also be used to solve these types of problems. Additionally, real-world price optimization problems may involve complex factors and constraints that require more sophisticated algorithms and modeling techniques.

CONCLUSION

- Price optimization is necessary for all types of industries in society. Using optimization algorithms for price optimization can be a viable strategy for businesses that want to maximize their profits.

- By analyzing historical sales data and other market factors, optimization algorithms can identify patterns and trends that can be used to predict customer behavior and determine the optimal price for a product or service.

SUGGESTIONS FOR IMPROVEMENT

- We have shown a single product for optimization. We can have a family of products that have some relation. In this scenario, a price change in one product can affect profit gain for another product, and so on. To handle such scenarios, we need to work on our data and find some good relations between the products.
- We did not consider all the factors like seasonal products, climate change, etc. If we consider all these factors, we can have a better solution.

THANK YOU