Price Elasticity of Demand Report

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1 An Introduction to Price Elasticity of Demand

1.1 What is Price Elasticity?

The fundamental assumption in economics is that people will buy the product or service if it's cheaper, and fewer will buy it if it's more expensive. But the phenomenon is more quantifiable than that, and price elasticity shows exactly how responsive customer demand is for a product based on its price.

1.2 How is it calculated?

Assuming that Q is the quantity of demand for a certain commodity, and P is the commodity's price. Then the formula for price elasticity of demand:

$$E_d = \frac{\Delta Q/Q}{\Delta P/P} \tag{1}$$

Let's look at an example. Say that a company raised the price of one of its items from \$100 to \$120. The price increase is $\frac{\$120-\$100}{\$100}$ or 20%. Now let's say that the increase caused a decrease in the quantity sold from 1,000 items to 900 items. The percentage decrease in demand is -10%. Plugging those numbers into the formula, you'd get a price elasticity of demand of:

$$E_d = \frac{\Delta Q/Q}{\Delta P/P} = \frac{-100/1000}{20/100} = -0.5 \tag{2}$$

1.3 How to interpret price elasticity?

There are four zones of elasticity. Products and services can be:

1. **Perfectly Inelastic:** $E_d = 0$
   Where the quantity demanded does not change when the price changes. Products in this category are things consumers absolutely need, and there are no other options from which to obtain them.

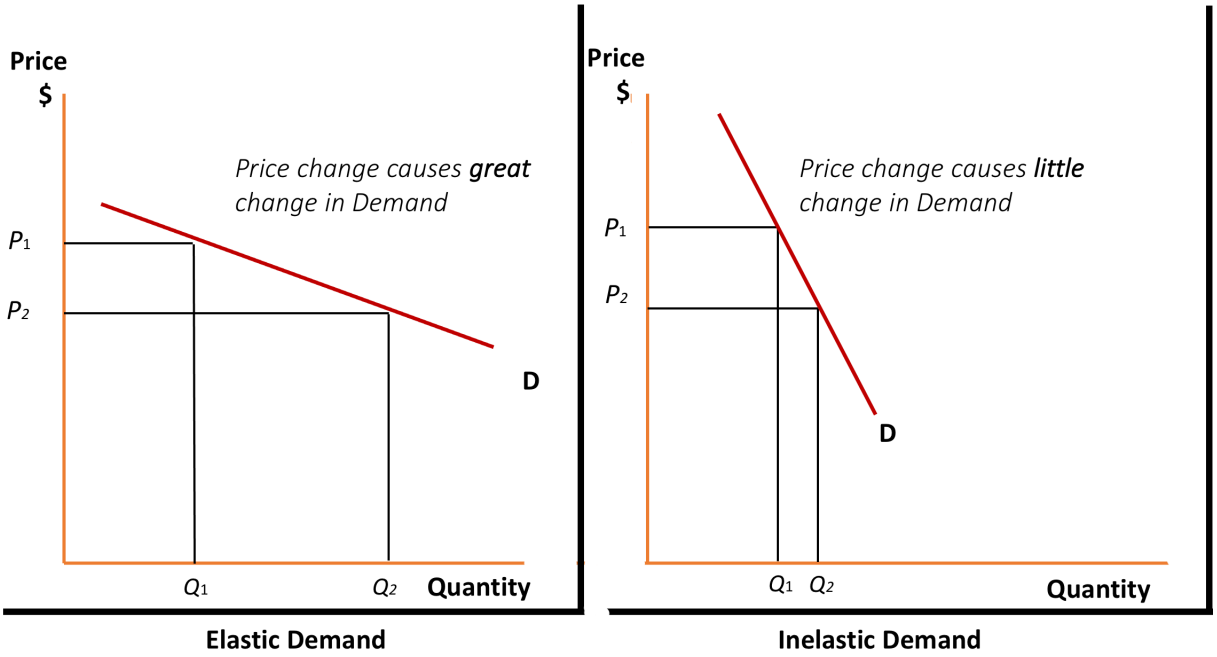


Figure 1: Caption

2. **Inelastic:** $-1 < |E_d| < 1$
   Where 1% of changes in price cause slight changes in demand (less than 1%). Gasoline is a good example here because most people need it, so even when prices go up, demand doesn't change significantly. Products with stronger brands tend to be more inelastic.

3. **Positively Elastic:** $E_d < -1$
   Where 1% changes in price cause, a significant increase in quantity demanded. This scenario is highly unlikely.

4. **Negatively Elastic:** $E_d < -1$
   Where any very small change in price results in a very large decline in the quantity demanded.

2 The Model

2.1 Th Libraries used:

1. Pandas
2. Numpy
3. Matlotlib
4. Seaborn
5. Statmodels

2.2 Data Preparation:

1. **Column Names Change:** The column names are not convenient to work with. So we will change them as follows:

   - date_week → Week
   - sku_cde → ItemID
   - cost_price → CostPrice
   - regular_price → RegularPrice
   - regular_volume → RegularVolume
   - promo_price → PromoPrice
   - promo_volume → PromoVolume

2. **Change "sku_cde":** The "sku_cde"s are not convenient to work with. we will replace the "sku_cde"'s as follows:

   - 111708109 → Id1
   - 11990782 → Id2
   - 12062063 → Id3
   - 130680236 → Id4
   - 137353695 → Id5
   - 62875832 → Id6
   - 73267284 → Id7
   - 84630314 → Id8
   - 95208654 → Id9

   further, I'll refer to the item names as the ItemID mentioned above.

I did a few more changes in the data frame, and they are very well mentioned in the ".ipynb" file

2.3 Statistical Model:

I tested the following three statistical models from "Statsmodels" library for accuracy:

1. OLS (Ordinary Least Squares) link
2. WLS (Weighted Least Squares) link
3. GLS (Generalized Least Squares) link

I used Linear regression models because "Price" and "Volume" are both continuous variables. Also, given the data size, this was the most suited model. After testing accuracy, I decided to use the OLS model for price elasticity calculation.

The price elasticity for the linear regression model is calculated as follows:

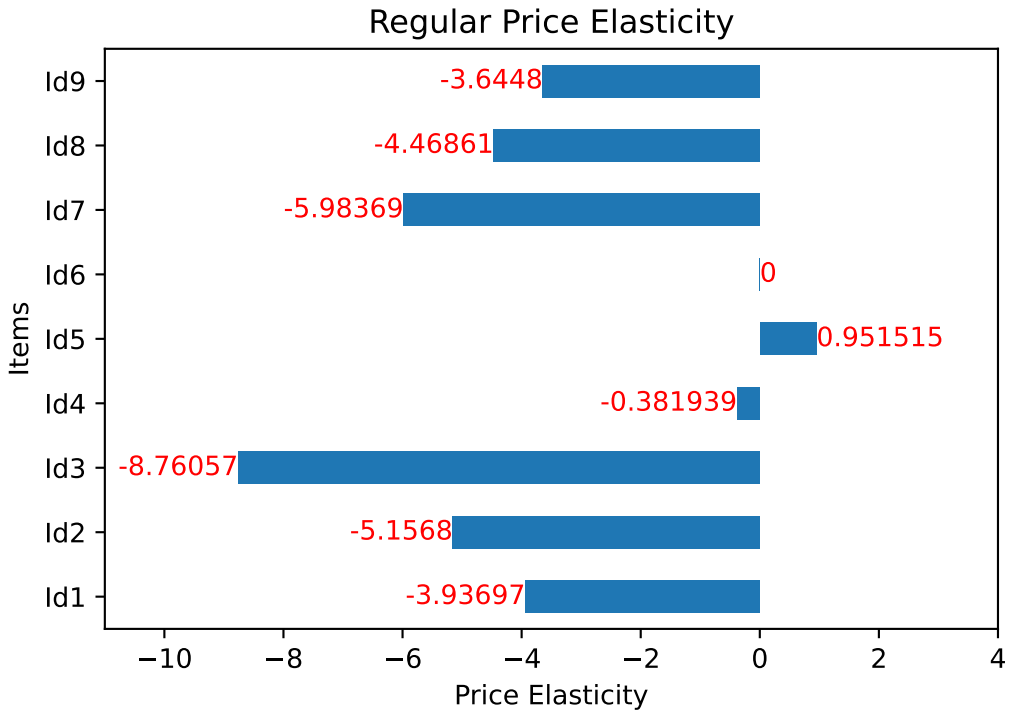
$$E_d = slope(Coeficientofregressionmodel) \times \frac{PriceMean}{VolumeMean} \tag{3}$$

3 The Results:

To obtain these results, we used "OLS Model" from "Statsmodels" library.

3.1 Price Elasticity For Regular Price Data:

Item ID	E_d	**Elasticity Zone**
Id1	-3.936970	Elastic (Negatively Elastic)
Id2	-5.156805	Elastic (Negatively Elastic)
Id3	-8.760572	Elastic (Negatively Elastic)
Id4	-0.381939	Elastic (Negatively Elastic)
Id5	0.951515	Inelastic
Id6	NA	NA
Id7	-5.983689	Elastic (Negatively Elastic)
Id8	-4.468611	Elastic (Negatively Elastic)
Id9	-3.644798	Elastic (Negatively Elastic)



from the above table and figure, I inferred the following:

1. For ItemID with Id1, Id2, Id3, Id7, Id8, and Id9, demand is Elastic (Negatively Elastic) to price.

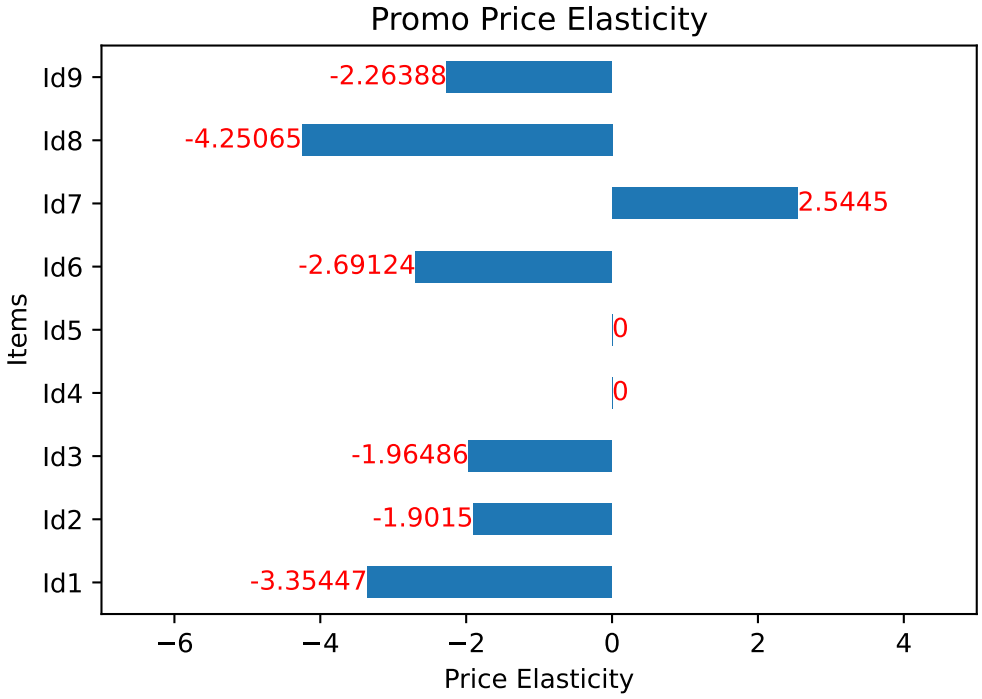
2. For ItemID with Id4, and Id5, demand is Inelastic to price.

3. For ItemID with Id1, I could not calculate the price elasticity as the data was available for only one price point, and we can not fit a regression model for one data point.

My Suggestion on Regular Price: As Id1, Id2, Id3, Id7, Id8, and Id9, demand is Elastic (Negatively Elastic) to price, we can not increase the price for these items. Also, for Id2, Id3, and Id7, elasticity is too high by decreasing the prices of these items, we can increase the demand very quickly. For example, the Price elasticity for Id3 is **-8.77** which means with **10%** decrease in price will increase the demand by **87.7%**.

3.2 Price Elasticity For Promo Price Data:

Item ID	E_d	**Elasticity Zone**
Id1	-3.354475	Elastic (Negatively Elastic)
Id2	-1.901496	Elastic (Negatively Elastic)
Id3	-1.964864	Elastic (Negatively Elastic)
Id4	NA	NA
Id5	NA	NA
Id6	-2.691237	Elastic (Negatively Elastic)
Id7	2.544505	Elastic (Positively Elastic)
Id8	-4.250652	Elastic (Negatively Elastic)
Id9	-2.263876	Elastic (Negatively Elastic)



from the above table and figure, I inferred the following:

1. For ItemID with Id1, Id2, Id3, Id6, Id8, and Id9, demand is Elastic (Negatively Elastic).
2. For ItemID with Id7, demand is Elastic (Positively Elastic) to price. Id7 is a highly unlikely scenario; In this case, demand is increasing with an increase in price.
3. For ItemID with Id4, and Id5, I could not calculate the price elasticity as the data was available for only one price point, and we can not fit a regression model for one data point.

My Suggestion on Promo Price: As Id1, Id2, Id3, Id6, Id8, and Id9, demand is Elastic (Negatively Elastic) to price, we can not increase the price for these items. Also, for Id8, elasticity is too high; by decreasing the prices of these items, we can increase the demand very quickly. For example, the Price elasticity for Id8 is **-4.25** which means with **10%** decrease in price will increase the demand by **42.5%**.

4 My Motivation:

Firstly, I would like to say that this was a really interesting and intriguing problem. To solve It, I used a linear regression model. However, there is more We can do in this problem and other such business problems "Argility" addresses as follows:

1. We can build a more robust machine learning and deep learning model which will maximize the profit by adjusting prices to ensure the highest demand.
2. We can build, a data model to adjust prices in real-time to keep the demand high provided real-time data.
3. We can build a dashboard that will show the real-time prices and demand for the business and, at the same time, will show the suggested price for items to maintain the demand in the market.

Looking to work with Argility's extraordinary team to work on many such interesting problems.