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**THE NATIONAL UNIVERSITY OF SINGAPORE**

**Master of Science Business Analytics**

**DSC5101 Analytics in Managerial Economics**

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**Project 3**

**Estimating the Price Discrimination of**

**US Pumpkin Price**

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# 1 Executive Summary

The objective of this project is to evaluate the level of price discrimination in the US pumpkin markets. We first establish linear regression models to study the relationship between the net price of pumpkins and their physical properties including pumpkin variety and size, which directly determines the pumpkin prices. The residual net prices are derived and regressed against US cities and pumpkin origins, to examine the potential third-degree price discrimination. Robustness tests are further performed to address the time effect and the variation of transportation cost. Second-degree price discrimination with respect to pumpkin variety and third-degree price discrimination with respect to US cities are identified. We conclude that consumers in higher-paying cities tend to be charged higher prices for same types of pumpkins. The corresponding price elasticities are derived in the remaining part of the study

Key Findings

* Third price discrimination is found between different cities. The net price difference has significant relationship with the city's’ personal income and consumer price index(CPI).
* Second price discrimination is identified between different packages, the possible reason is that the seller use quantity-discounting menu price to increase the profit.
* The Demand Elasticity matches closely with the personal income. Higher income generally implies relatively lesser elasticity of demand.

Implication

* To maximize the product profit, seller could utilize third degree price discrimination of the net price based on the city's’ economic factor such as personal income and consumer price index(CPI).
* For fresh perishable product, transportation method is important. Seller should select the most efficient and worthy transportation method to balance the transportation cost and the transportation duration.
* Based on the customer demand, the seller can package the pumpkin and offer a quantity-discounting menu price to convert some consumers surplus into profit.

# 2 Introduction

Price discrimination refers to the exercise of offering a same product to different consumers at different prices. It is a common pricing strategy that is frequently adopted by most businesses to achieve the purpose of profit maximization. In general, price discrimination can be classified into three categories, including personalized pricing (first-degree), menu-pricing (second-degree), and group-pricing (third-degree). Second-degree and third-degree price discriminations are common in agricultural markets.

In order to study the price discrimination in the US pumpkin market, we constructed the dataset of pumpkin prices with the recent one year’s Specialty Crops Terminal Markets Standard Reports distributed by the United States Department of Agriculture. We estimate the net prices of pumpkins by subtracting the approximate transportation cost from the average pumpkin prices. Linear regression models are built to evaluate the significance of correlation between pumpkin price and city as well as pumpkin variety. Furthermore, we examined the robustness of our analysis with respect to the time effect and the variation of unit shipping cost. In the last part of our study, the demand elasticity of different cities are evaluated and correlated with the city income.

# 3 Baseline Model and Tests

## 3.1 Third Degree Price Discrimination

The baseline model of pumpkin prices is derived based on the following assumptions.

* The change of pumpkin price over time is negligible.
* The transportation of pumpkins between US cities is via truck with a uniform rate of 0.37.
* Supply of pumpkins is constant over the time period under study.
* The cost incurred from growing pumpkins is considered at the same level over different origins.

The baseline model is formulated with two steps of linear regression. Firstly, we calculate the net price of pumpkins by subtracting the estimated shipping cost from the average pumpkin prices. We make a hypothesis that the pumpkin price has no correlation with the cities. The net price of pumpkins is regressed against the pumpkin variety and size. From the results shown in the following table, it can be observed that the net price of pumpkins has close relationship with the variety of pumpkins. After counteracting the effect of variety, we regress the net price residual against city and origin separately. Half of the cities under study have significant coefficients. Additionally, cities with larger coefficients correspond to higher average annual salary, which indicates the existence of third-degree discrimination with respect to cities. It is easy to understand that people with better standard of living tend to have higher willingness to pay for their food and commodities.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |  |
| (Intercept) | 161.099 | 26.038 | 6.187 | 8.18E-10 | \*\*\* |
| VarietyBLUE TYPE | 49.692 | 16.591 | 2.995 | 0.0028 | \*\* |
| VarietyCINDERELLA | 23.15 | 11.91 | 1.944 | 0.05214 | . |
| VarietyFAIRYTALE | 27.004 | 11.13 | 2.426 | 0.0154 | \* |
| VarietyHOWDEN TYPE | -30.945 | 9.609 | -3.22 | 0.00131 | \*\* |
| VarietyHOWDEN WHITE TYPE | -9.746 | 12.571 | -0.775 | 0.43833 |  |
| VarietyKNUCKLE HEAD | 30.855 | 16.298 | 1.893 | 0.05855 | . |
| VarietyMINIATURE | -115.744 | 11.348 | -10.199 | < 2e-16 | \*\*\* |
| VarietyMIXED HEIRLOOM VARIETIES | 10.526 | 14.632 | 0.719 | 0.47205 |  |
| VarietyPIE TYPE | -29.056 | 10.183 | -2.853 | 0.00439 | \*\* |
| Item.Sizejbo | -20.847 | 24.92 | -0.837 | 0.40299 |  |
| Item.Sizelge | -21.87 | 24.551 | -0.891 | 0.37319 |  |
| Item.Sizemed | -34.714 | 24.585 | -1.412 | 0.15818 |  |
| Item.Sizemed-lge | 18.052 | 25.013 | 0.722 | 0.4706 |  |
| Item.Sizesml | -25.974 | 24.79 | -1.048 | 0.29495 |  |
| Item.Sizexlge | 14.204 | 24.699 | 0.575 | 0.56534 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |  |
| City.NameATLANTA | -23.969 | 7.555 | -3.173 | 0.00155 | \*\* |
| City.NameBALTIMORE | 9.937 | 9.185 | 1.082 | 0.27949 |  |
| City.NameBOSTON | 51.84 | 8.259 | 6.277 | 4.68E-10 | \*\*\* |
| City.NameCHICAGO | 9.002 | 8.535 | 1.055 | 0.29177 |  |
| City.NameCOLUMBIA | 22.903 | 8.382 | 2.732 | 0.00637 | \*\* |
| City.NameDALLAS | 20.133 | 9.16 | 2.198 | 0.02813 | \* |
| City.NameDETROIT | -4.611 | 11.818 | -0.39 | 0.69649 |  |
| City.NameLOS ANGELES | 43.065 | 13.912 | 3.095 | 0.00201 | \*\* |
| City.NameNEW YORK | 25.323 | 9.373 | 2.702 | 0.00698 | \*\* |
| City.NamePHILADELPHIA | 21.391 | 11.262 | 1.899 | 0.05773 | . |
| City.NameSAN FRANCISCO | 59.902 | 11.56 | 5.182 | 2.54E-07 | \*\*\* |
| City.NameST. LOUIS | -6.844 | 10.16 | -0.674 | 0.5007 |  |

In order to gain more evidence on the third-degree discrimination over cities, we select a few origins with more data points such as Michigan. The same conclusion can be reached with the aforementioned regressions.

## 3.2 Second Degree Price Discrimination

When the firm lack of detailed information of each customer, firm utilizes second degree discrimination with different menu price designed to sort consumers. The result shows that the pumpkin price has second price discrimination where unit net price is different from each package. At first, we made hypothesis that there is no price difference between packages. The pumpkin weight is estimated based on different package and Item size. The unit package net price can be calculated by divided the estimated weight from the net price. However, it is found that the hypothesis fails because the price difference has significant differences between different packages. As a result, the pumpkin price model has second price discrimination on different package.

One possible reason for the second price discrimination is because the different customers prefer different packages. Retailer shop will order large quantity of pumpkin and enjoy cheaper unit price. On the other hand, personal customers prefer to pay more unit price for small packages.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Package | Estimate | Std. Error | t value | Pr(>|t|) |  |
| Package 1 1/9 bushel cartons | 0.019792 | 0.008354 | 2.369 | 0.01797 | \* |
| Package1 1/9 bushel crates | -0.163707 | 0.022653 | -7.227 | 8.36E-13 | \*\*\* |
| Package1/2 bushel cartons | 0.029899 | 0.011035 | 2.71 | 0.006826 | \*\* |
| Package20 lb cartons | 0.585355 | 0.036414 | 16.075 | < 2e-16 | \*\*\* |
| Package24 inch bins | 0.008039 | 0.009275 | 0.867 | 0.386267 |  |
| Package36 inch bins | -0.060739 | 0.009146 | -6.641 | 4.54E-11 | \*\*\* |
| Package50 lb cartons | 0.01001 | 0.03386 | 0.296 | 0.767553 |  |
| Package50 lb sacks | -0.074594 | 0.044205 | -1.687 | 0.09175 | . |
| Packagebushel cartons | -0.061047 | 0.018411 | -3.316 | 0.000939 | \*\*\* |

# Robustness Tests

## 4.1 Time effect

The first robustness test is carried out to study the time effect on price discrimination. Fixed effect regression is performed over the same sets of control variables, as used in the baseline model. The results of regression indicate that the aforementioned second degree and thrid degree price discrimination generally exist over the time period under study.

## 4.2 Varying transportation cost

In the Baseline model, assumption is made that the pumpkin transportation is only made by truck. From the research, fresh vegetables are transported through trucks and trains between the states. Ship transport is most common transport ways between countries. As a result, to improve the robustness of the transportation fee calculation. Following assumption is made.

* Distance < 1500 KM, truck is used, the transportation uniform rate is 0.37
* 1500KM<= Distance< 3000 KM, train is used, the transportation uniform rate is 0.03
* Distance >= 3000 KM, ship is used, the transportation uniform rate is 0.10

Introduced the nonlinear transportation cost, the result indicates that the price discrimination is more related to CPI with p value 0.0378.

# 5 Demand Elasticity Analysis

To find the pumpkin demand elasticity for each city. Following assumptions are made:

* For every date, the demanded quantity represents unit quantity for each package.
* Pumpkin supply is is inelastic to price change since pumpkins is seasonal product so that the price is mainly controlled by the harvest season.

In the month of October, the quantity of pumpkin is highest mainly related to the Halloween festival. We have data for 4 months (Sep, Oct, Nov, Dec) for years 2016 and 2017. Due to paucity of data across Oct months in 2016 and 2017, we compare change in aggregate quantity demanded with respect to change in price across Cities.

From Year 2016 to 2017, the Price Elasticity of Demand for San Francisco is 0.88 which is inelastic price elasticity of demand.

At the same time, the Price Elasticity of Demand for San Francisco is 4.856638 which is high elasticity of demand.

The results match closely with the incomes of each city. The San Francisco which has the highest per capita income have the smallest demand elasticity. On the contrast, the lowest income city - Columbia, has the highest price elasticity. The results meet our expectation that higher income generally implies relatively lesser elasticity of demand.

# 6 Conclusion

On our analysis on pumpkin price differentiation across U.S cities’ terminal market, we observe second-degree and third-degree price discrimination. We observe menu pricing based on unit net price difference across packages. We observe group pricing where prices are different across cities based on the average income in the city. We also performed robustness tests to verify the price discrimination model and to validate our assumptions. We also performed demand-elasticity analysis and concluded that San-Francisco (with highest net income) is relatively inelastic to changing pumpkin prices compared to Columbia (with lowest net income).

# Reference

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