DSC5101 ANALYTICS IN MANAGERIAL ECONOMICS
Group Project 3
Estimating Price Discrimination in Pumpkin Market

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1. Executive Summary

The world markets for many agricultural products have been undergoing significant reorganization in recent years. Higher productivity in farming, lower transportation cost, and better information availability have introduced new strategies in the pricing determination. Different price discriminations are often observed from transactions as an effective way to increase the market share and profit.

The objective of this project is to investigate the possible price discriminations and rationale behind for the pumpkins sold in 13 US Cities during 2016-2017. Both 2nd degree price discrimination (quantity discount) and 3rd degree price discrimination (different cities as different group) were examined.

The base dataset was retrieved from Specialty Crops Terminal Markets Standard Reports distributed by the United States Department of Agriculture [1], complemented by data from other sources such as per capita income. Linear regression models were run on city and package size against unit net price to examine 3rd degree and 2nd degree price discriminations respectively. As several assumptions were made regarding the use of the variable, a few robustness tests were run to validate the result.

In this report, section 2 will illustrate the methodology for examining price discriminations, including data treatment, variable and model selection; section 3 will present the result and findings, including whether each type of the discriminations existed and what could be the cause; the results will be further validated through robustness tests in section 4; and section 5 will wrap up the conclusions as well as limitations of this study.

2. Research Methodology

2.1 Data Collection and Cleaning

In the preliminary data examination, extensive cleaning was performed and following data were removed: 1) observations (7.6%) with Origin from foreign countries, as they might have very different farming cost and additional importing cost compared to the domestic ones, which could cause bias to the comparison. 2) those (2.5%) with type “Organic”, as they are more expensive than normal pumpkins, but with very few observations. 3) entries from Miami (0.17%), as only 2014 data was available.

Besides trimming, extra data from different sources were also complemented to the dataset: 1) US major cities per capita income in 2015 [2], used to explain rationale behind PD. 2) Driving distance from pumpkin origin (capital city of the state) to destination selling city [3], used to estimate the transportation cost. 3) Other data such as cost of living, groceries index, and local purchasing power were also sourced and tested. However, these data were found to be highly co-linear with the per capita income, thus were not used in the final model.

2.2 Data Preparation

2.2.1 Unified Package Size and Unit Price

As different types of packages were observed in the pumpkin trading data, we need to first calculate their corresponding package size with unified unit, in order to calculate the unit price.

For the packages measured by standard package types, such as 24 inch bins or ½ bushel cartons, we first calculated the package volume in litres (*Refer to Appendix 1 for the calculation for each package type*), and then timed the estimated percentage of pumpkins’ volume in the package, subject to pumpkin size. A ratio ranging from 0.7 to 0.9 were given to pumpkins with size ranging from extra jumbo to small, as generally the smaller the item the less empty space there will be in a fixed-shape package. For the rest packages measured by pounds (e.g. 40 lb cartons), we simply converted them to litres based on data from a food volume weight conversion website [4].

High Price was used to represent the maximum willingness to pay for a package, thus the unit price was calculated as High Price divided by the Unified Package Size, i.e. $/litre.

2.2.2 Transportation Cost and Net Unit Price

A few assumptions were made to estimate the transportation cost: 1) all pumpkins are transported via land by trucks; 2) each truck has capacity of 20 cubic meters (5 x 2 x 2 meters); 3) transportation cost consists of fixed part subject to package size (loading/unloading) and variable part subject to distance (truck wear and fuel). After checking various references, the fixed cost was set at $200/trip and variable cost was set at $0.3/KM [5].

With all these assumptions we were able to calculate Unit Transportation Cost, hence derive pumpkin's Net Unit Price, which is Unit Price – Unit Transportation Cost.

2.3 Variables and Model Selection

The baseline model shown below was used to examine both 3rd degree and 2nd degree discrimination.

$$\begin{aligned}\textit{Net\_Unit\_Price} = \alpha + \beta 1_i * \textit{City\_Name}_i + \beta 2 * \textit{Unified\_Package\_Size} \\ + \beta 3 * \textit{Year} + \beta 4 * \textit{Week} + \beta j * \textit{Variety} * \textit{Item\_Size} * \textit{Origin} + \varepsilon\end{aligned}$$

Besides the variables mentioned above in the data preparation section, there were some other data fields chosen as control variables to eliminate the potential effect of other factors in price difference, including time factor Year and Week (of the year), and properties of pumpkins including Variety, Item Size and Origin.

	Use of Variables In Models				
	Baseline Model		Effect of	Robustness	Robustness
Variables	**3rd Degree PD**	**2nd Degree PD**	**Income in PD**	**Test 1**	**Test 2**
Net_Unit_Price	***DV***	***DV***	***DV***	-	-
Unit_Price	-	-	-	-	**DV**
High_Price (of package)	-	-	-	**DV**	-
City_Name	***IV***	CV	-	***IV***	***IV***
Unified_Package_Size (L)	CV	***IV***	CV	-	CV
Per_Capita_Income	-	-	***IV***	-	-
Distance (Origin to City)	-	-	-	CV	CV
Year, Week, Variety, Item_Size and Origin were the rest control variables for all models.					

Table 1: Summary of Variables

In addition to the baseline model, another model run to further investigate on one of the potential causes for the price discrimination, which was per capita income. Two robustness test models were also run to validate the result and assumptions made in baseline model. Table 1 below summarises the variables used in each model.

3. Result Interpretation

3.1 3rd Degree Price Discrimination

Table 2 shows the result coefficients and significance level of the city dummies in baseline model, ordered by relative Net Unit Price from high to low (*Result for the full list of variables can be found in Appendix 2*).

City Dummies	Coefficients	Reference Country											
		SAN FRANCISCO	LOS ANGELES	DALLAS	NEW YORK	BOSTON	COLUMBIA	CHICAGO	ATLANTA	BALTIMORE	PHILA-DELPHIA	ST.LOUIS	DETROIT
	SAN FRANCISCO												
	LOS ANGELES	-0.0329											
	DALLAS	-0.0483	-0.0154										
	NEW YORK	-0.1389	-0.1061	-0.0907									
	BOSTON	-0.1409	-0.1081	-0.0927	-0.002								
	COLUMBIA	-0.1441	-0.1113	-0.0959	-0.0052	-0.0032							
	CHICAGO	-0.1457	-0.1128	-0.0974	-0.0068	-0.0048	-0.0016						
	ATLANTA	-0.166	-0.1331	-0.1177	-0.0271	-0.0251	-0.0219	-0.0203					
	BALTIMORE	-0.1823	-0.1494	-0.134	-0.0433	-0.0413	-0.0381	-0.0366	-0.0163				
	PHILADELPHIA	-0.2	-0.1672	-0.1518	-0.0611	-0.0591	-0.0559	-0.0543	-0.0341	-0.0178			
	ST.LOUIS	-0.2507	-0.2178	-0.2024	-0.1117	-0.1097	-0.1066	-0.105	-0.0847	-0.0684	-0.0506		
	DETROIT	-0.2571	-0.2242	-0.2088	-0.1182	-0.1162	-0.113	-0.1114	-0.0911	-0.0749	-0.0571	-0.0064	

Table 2: 3rd Degree Price Discrimination Model Result

Significance Level:	.	*	**	***

Based on the relative price differences between each two cities and the significance level, we can observe four tiers of cities where each tier has a significant price difference from the other tiers, and within each tier the difference between individual cities are either very small or insignificant. Tier 1 cities with the highest net price include San Francisco, Los Angeles and Dallas; Tier 2 cities are New York, Boston, Columbia and Chicago; Tier 3 has Atlanta, Baltimore and Philadelphia; the last 2 cities belong to Tier 4. The ranking is generally in line with the cities' per capita income ranking (*See Appendix 3*), except for Dallas, Columbia and Philadelphia.

It can be concluded that 3rd degree price discrimination existed across different tiers of cities, and the price difference between top tier and bottom tier can be as high as $0.25/litre.

3.2 2nd Degree Price Discrimination

Quantity discount was observed as there was a negative and significant correlation (-3.278e-04 ***) between Unified Package Size and Net Unit Price, implying that 2nd degree price discrimination also existed. For every cubic metre increase in package size, the net unit price will be decreased by $0.3278.

3.3 Potential Cause of Price Discriminations

The fundamental incentive of price discrimination is to maximize the profit (seller's surplus) through charging customers according to their willingness to pay instead of a uniform price. Therefore, customers' affordability would be one of the key basis behind all price discrimination, which could be linked with their income level. To test this hypothesis, we replaced the City variable in the baseline model by their respective per capita income.

The result showed a positive and highly significant correlation between pumpkins' net price and cities' per capita income, that for every $10K increment in income, price will be raised by **by $0.01**, which on average is around 2.6% increase. It implies that income level has certain influence on the price discrimination, but the effect is limited and could be overturned by other factors (such as particular preference of pumpkin in certain cities). It also explains why the net price ranking of cities from the baseline model do not exactly tally with the income ranking.

2nd degree price discrimination exists universally in non-perfect-competition markets so long as customers have in-equal income or affordability. Among the 13 cities we investigate, Columbia has lowest GINI index 0.452 and New York has highest GINI index 0.505 [6]. Since all cities have relatively high inequality in income, it motivates sellers to adopt 2nd degree price discrimination through different package size offering.

3.4 Demand Elasticity Comparison

Besides price discrimination, the baseline model also reveals the demand elasticity comparison between cities. Assuming marginal cost is the same across sellers and they are all maximizing the profit, according to

MR = MC, MR for all sellers should also be the same. On the other hand, MR = P(1 - $\frac{1}{\eta}$), where η is the demand elasticity. Therefore by comparing the net price of two cities, we can derive the comparison of demand elasticity:

$$\frac{P_1}{P_2} = \frac{1-\frac{1}{\eta_2}}{1-\frac{1}{\eta_1}} \Rightarrow \eta_2 = \frac{P_2\ \eta_1}{P_2\eta_1 + P_1 - P_1\,\eta_1}$$

The P_1 and P_2 in above equation is the net prices of two cities, after removing the influence of other control variables like package size, variety, and etc. In other words, the *P = intercept* for reference city and *P = intercept +* $\beta 1$ for non-reference cities. We used St Louis as reference city, and derived the elasticity comparison between each two cities (See Appendix 4).

4. Robustness Test

4.1 To Test Assumption for Unified Package Size

The unified package size was calculated based on some assumptions regarding package type and item size. To test the validity of the assumptions, we run a test model on two subsets of data of package type “24 inch bin” and “36 inch bin” respectively, using High Price (per package) to replace unit price. It can be observed from the result (*Refer to Appendix 5*) that the country ranking is generally in line with the baseline model and coefficients are still significant, which proves that there is no biasness in our baseline model. The test for other package types are omitted due to insufficient data set.

4.2 To Test Assumption for Transportation Cost

To validate the assumptions on the calculation for transportation cost, which was used in deriving net unit price, we ran another robustness test by replacing the Net Unit Price in the baseline model with Unit High Price, and adding transportation distance as a control variable. The result (*Refer to Appendix 6*) was consistent with the baseline model in terms of the relative coefficients of the city dummies and their respective significance level. Thus, it proved the validity of the net price calculation.

5. Conclusion and Limitation

In this project, we have investigated 12 US cities’ pumpkin market transaction data in 2016-2017, and discovered the existence of 2nd degree and 3rd degree price discrimination. The findings have been tested for robustness and our hypothesis were proved.

The major limitation of this study is on the various assumptions made. A few key assumptions such as transportation cost and pumpkin’s unit price would have fundamental impact to the model accuracy. Though these assumptions had passed their respective robustness tests, the estimated values are still not as good as actual data.

Another limitation is the possible hidden variables. We conducted our study based on variables retrieved from the dataset, however, there are likely to be other factors affecting the price as well, such as particular preference of pumpkin in certain cities, existence of pumpkin reprocessing factories etc. If these hidden variables can be found out, the model accuracy and consistency will be further improved.

6. Reference

[1] Specialty Crops Terminal Markets Standard Reports from United States Department of Agriculture
https://www.marketnews.usda.gov/mnp/fv-report-configstep1?type=termPrice

[2] State of New Jersey Department of Labor and Workforce Development
http://lwd.state.nj.us/labor/lpa/industry/incpov/msa_pci.xls

[3] Distance Calculator
https://www.distancecalculator.net/country/united-states

[4] Pumpkin Weight to Volume Conversion
https://www.aqua-calc.com/calculate/food-volume-to-weight/substance/pumpkin-blank-pie-blank-mix-coma-and-blank-canned

[5] Victoria Transport Policy Institute
http://www.vtpi.org/tca/tca0501.pdf

[6] The Business Journals
https://www.bizjournals.com/bizjournals/news/2014/01/31/gini-indexes-of-income-inequality-in.html

[7] Dimensions of Pumpkin Bins
http://bulkbin.com/produce-bins/bottom-flap-bins/pumpkin-bins/

7. Appendix

Appendix 1: Calculation of Unified Package Size

Package Type	Conversion Rule	Package Size (Litres)
24 inch bins	Pumpkin bins are usually designed to fit on GMA 48″ x 40″ standard pallet for compatibility with shipping and storage systems [7], thus an k inch bin is normally referring to packages with dimension: k″ x 48″ x 40″	755.12
36 inch bins		1132.68
1 1/9 Bushel Cartons	1 US bushel = 35.2391 litres	39.15
1/2 Bushel Cartons		17.6195
k lb cartons	1 lb of raw pumpkin ≈ 0.94 litres [4]	0.94k

Appendix 2: Baseline Model Result Interaction Terms Omitted)

```
(Intercept)                                -3.413e+01  1.116e+01  -3.058 0.002279 **
`City Name`DETROIT                         -6.431e-03  1.624e-02  -0.396 0.692280
`City Name`ATLANTA                          8.469e-02  1.626e-02   5.209 2.26e-07 ***
`City Name`BALTIMORE                        6.842e-02  1.565e-02   4.371 1.35e-05 ***
`City Name`BOSTON                           1.097e-01  1.346e-02   8.154 9.52e-16 ***
`City Name`CHICAGO                          1.050e-01  1.090e-02   9.633  < 2e-16 ***
`City Name`COLUMBIA                         1.066e-01  1.334e-02   7.990 3.37e-15 ***
`City Name`DALLAS                           2.024e-01  2.248e-02   9.002  < 2e-16 ***
`City Name`LOS ANGELES                      2.178e-01  6.250e-02   3.485 0.000512 ***
`City Name`NEW YORK                         1.117e-01  1.291e-02   8.657  < 2e-16 ***
`City Name`PHILADELPHIA                     5.063e-02  1.495e-02   3.387 0.000732 ***
`City Name`SAN FRANCISCO                    2.507e-01  6.088e-02   4.118 4.12e-05 ***
Unified_Package_Size                       -3.278e-04  9.446e-06 -34.702  < 2e-16 ***
Year                                        1.709e-02  5.524e-03   3.095 0.002019 **
Week                                       -4.033e-03  6.473e-04  -6.231 6.58e-10 ***
VarietyBLUE TYPE                            5.558e-02  2.256e-02   2.463 0.013916 *
VarietyCINDERELLA                           1.003e-01  7.312e-02   1.371 0.170626
VarietyFAIRYTALE                            6.689e-01  8.148e-02   8.210 6.14e-16 ***
VarietyHOWDEN TYPE                          1.357e-01  7.544e-02   1.799 0.072256 .
VarietyHOWDEN WHITE TYPE                    1.911e-01  7.563e-02   2.527 0.011645 *
VarietyKNUCKLE HEAD                        -3.370e-02  5.389e-02  -0.625 0.531865
VarietyMINIATURE                            8.930e-01  7.464e-02  11.964  < 2e-16 ***
VarietyMIXED HEIRLOOM VARIETIES             8.547e-02  7.393e-02   1.156 0.247890
VarietyPIE TYPE                             1.968e-01  5.357e-02   3.673 0.000251 ***
`Item Size`exjbo                            5.335e-02  2.773e-02   1.924 0.054656 .
`Item Size`jbo                              1.737e-01  6.801e-02   2.554 0.010794 *
`Item Size`lge                              3.053e-02  5.352e-02   0.570 0.568500
`Item Size`med                              3.969e-02  5.481e-02   0.724 0.469116
`Item Size`med-lge                         -4.863e-02  4.991e-02  -0.974 0.330022
`Item Size`xlge                             1.443e-01  5.341e-02   2.701 0.007016 **
```

```
OriginCOLORADO                                      9.331e-02  6.230e-02   1.498 0.134506
OriginDELAWARE                                      2.112e-02  5.947e-02   0.355 0.722578
OriginFLORIDA                                       2.299e-01  5.585e-02   4.116 4.14e-05 ***
OriginILLINOIS                                      1.964e-01  9.219e-02   2.130 0.033407 *
OriginINDIANA                                       7.143e-02  7.894e-02   0.905 0.365684
OriginMARYLAND                                      4.200e-02  6.454e-02   0.651 0.515334
OriginMASSACHUSETTS                                 2.073e-01  7.239e-02   2.863 0.004274 **
OriginMICHIGAN                                      7.220e-02  5.609e-02   1.287 0.198255
OriginMISSOURI                                      6.047e-01  7.505e-02   8.057 2.02e-15 ***
OriginNEW JERSEY                                   -1.399e-02  8.860e-02  -0.158 0.874527
OriginNEW MEXICO                                   -2.411e-01  4.811e-02  -5.012 6.28e-07 ***
OriginNEW YORK                                      1.492e-01  8.840e-02   1.688 0.091748 .
OriginNORTH CAROLINA                               -4.045e-02  5.679e-02  -0.712 0.476472
OriginOHIO                                          1.645e-01  6.217e-02   2.646 0.008256 **
OriginPENNSYLVANIA                                  3.576e-02  5.739e-02   0.623 0.533311
OriginTENNESSEE                                     3.832e-03  5.620e-02   0.068 0.945656
OriginTEXAS                                         4.401e-02  6.393e-02   0.689 0.491264
OriginVERMONT                                       3.042e-02  5.938e-02   0.512 0.608561
OriginVIRGINIA                                     -6.828e-04  3.188e-02  -0.021 0.982916
 [ Result for interaction terms omitted]
---
Signif. codes:  0 ?**?0.001 ?*?0.01 ??0.05 ??0.1 ??1

Residual standard error: 0.04566 on 1103 degrees of freedom
  (237 observations deleted due to missingness)
Multiple R-squared:   0.98, Adjusted R-squared:  0.9768
F-statistic: 304.1 on 178 and 1103 DF,  p-value: < 2.2e-16
```

Appendix 3: US Cities Per Capita Income Ranking (2015)

City_Name	Average Annual Income (USD)
SAN FRANCISCO	$ 79,206
BOSTON	$ 68,292
NEW YORK	$ 64,588
PHILADELPHIA	$ 57,173
BALTIMORE	$ 55,275
LOS ANGELES	$ 54,526
CHICAGO	$ 53,886
DALLAS	$ 51,099
ST. LOUIS	$ 48,977
DETROIT	$ 46,894
ATLANTA	$ 45,092
COLUMBIA	$ 40,420

Appendix 4: Relative Demand Elasticity

	Reference Elasticity η											
Compared Elasticity η_2	SAN FRANCISCO	LOS ANGELES	DALLAS	NEW YORK	BOSTON	COLUMBIA	CHICAGO	ATLANTA	BALTIMORE	PHILADELPHIA	ST.LOUIS	DETROIT
SAN FRANCISCO												
LOS ANGELES	$\eta_2 = \frac{30.8914\eta}{30.9244 - 0.033\eta}$											
DALLAS	$\eta_2 = \frac{30.8754\eta}{30.9244 - 0.049\eta}$	$\eta_2 = \frac{30.8754\eta}{30.8914 - 0.016\eta}$										
NEW YORK	$\eta_2 = \frac{30.7914\eta}{30.9244 - 0.133\eta}$	$\eta_2 = \frac{30.7914\eta}{30.8914 - 0.100\eta}$	$\eta_2 = \frac{30.7914\eta}{30.8754 - 0.084\eta}$									
BOSTON	$\eta_2 = \frac{30.7834\eta}{30.9244 - 0.141\eta}$	$\eta_2 = \frac{30.7834\eta}{30.8914 - 0.108\eta}$	$\eta_2 = \frac{30.7834\eta}{30.8754 - 0.092\eta}$	$\eta_2 = \frac{30.7834\eta}{30.7914 - 0.008\eta}$								
COLUMBIA	$\eta_2 = \frac{30.7804\eta}{30.9244 - 0.144\eta}$	$\eta_2 = \frac{30.7804\eta}{30.8914 - 0.111\eta}$	$\eta_2 = \frac{30.7804\eta}{30.8754 - 0.095\eta}$	$\eta_2 = \frac{30.7804\eta}{30.7914 - 0.011\eta}$	$\eta_2 = \frac{30.7804\eta}{30.7834 - 0.003\eta}$							
CHICAGO	$\eta_2 = \frac{30.7784\eta}{30.9244 - 0.146\eta}$	$\eta_2 = \frac{30.7784\eta}{30.8914 - 0.113\eta}$	$\eta_2 = \frac{30.7784\eta}{30.8754 - 0.097\eta}$	$\eta_2 = \frac{30.7784\eta}{30.7914 - 0.013\eta}$	$\eta_2 = \frac{30.7784\eta}{30.7834 - 0.005\eta}$	$\eta_2 = \frac{30.7784\eta}{30.7804 - 0.002\eta}$						
ATLANTA	$\eta_2 = \frac{30.7581\eta}{30.9244 - 0.166\eta}$	$\eta_2 = \frac{30.7581\eta}{30.8914 - 0.133\eta}$	$\eta_2 = \frac{30.7581\eta}{30.8754 - 0.117\eta}$	$\eta_2 = \frac{30.7581\eta}{30.7914 - 0.033\eta}$	$\eta_2 = \frac{30.7581\eta}{30.7834 - 0.025\eta}$	$\eta_2 = \frac{30.7581\eta}{30.7804 - 0.022\eta}$	$\eta_2 = \frac{30.7581\eta}{30.7784 - 0.020\eta}$					
BALTIMORE	$\eta_2 = \frac{30.7418\eta}{30.9244 - 0.183\eta}$	$\eta_2 = \frac{30.7418\eta}{30.8914 - 0.150\eta}$	$\eta_2 = \frac{30.7418\eta}{30.8754 - 0.134\eta}$	$\eta_2 = \frac{30.7418\eta}{30.7914 - 0.050\eta}$	$\eta_2 = \frac{30.7418\eta}{30.7834 - 0.042\eta}$	$\eta_2 = \frac{30.7418\eta}{30.7804 - 0.039\eta}$	$\eta_2 = \frac{30.7418\eta}{30.7784 - 0.036\eta}$	$\eta_2 = \frac{30.7418\eta}{30.7581 - 0.016\eta}$				
PHILADELPHIA	$\eta_2 = \frac{30.7240\eta}{30.9244 - 0.200\eta}$	$\eta_2 = \frac{30.7240\eta}{30.8914 - 0.167\eta}$	$\eta_2 = \frac{30.7240\eta}{30.8754 - 0.151\eta}$	$\eta_2 = \frac{30.7240\eta}{30.7914 - 0.067\eta}$	$\eta_2 = \frac{30.7240\eta}{30.7834 - 0.059\eta}$	$\eta_2 = \frac{30.7240\eta}{30.7804 - 0.056\eta}$	$\eta_2 = \frac{30.7240\eta}{30.7784 - 0.054\eta}$	$\eta_2 = \frac{30.7240\eta}{30.7581 - 0.034\eta}$	$\eta_2 = \frac{30.7240\eta}{30.7418 - 0.018\eta}$			
ST.LOUIS	$\eta_2 = \frac{30.6734\eta}{30.9244 - 0.251\eta}$	$\eta_2 = \frac{30.6734\eta}{30.8914 - 0.218\eta}$	$\eta_2 = \frac{30.6734\eta}{30.8754 - 0.202\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7914 - 0.118\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7834 - 0.110\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7804 - 0.107\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7784 - 0.105\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7581 - 0.085\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7418 - 0.068\eta}$	$\eta_2 = \frac{30.6734\eta}{30.7240 - 0.051\eta}$		
DETROIT	$\eta_2 = \frac{30.6670\eta}{30.9244 - 0.257\eta}$	$\eta_2 = \frac{30.6670\eta}{30.8914 - 0.224\eta}$	$\eta_2 = \frac{30.6670\eta}{30.8754 - 0.208\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7914 - 0.124\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7834 - 0.116\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7804 - 0.113\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7784 - 0.111\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7581 - 0.091\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7418 - 0.075\eta}$	$\eta_2 = \frac{30.6670\eta}{30.7240 - 0.057\eta}$	$\eta_2 = \frac{30.6670\eta}{30.6734 - 0.006\eta}$	

Appendix 5: Robustness Test 1 (Unified Package Size) Result

Robustness Test for Package Type

	36 inch bin		24 inch bin	
	High Price		High Price	
SAN FRANCISCO	7.90E+01	***	1.64E+02	***
LOS ANGELES	1.58E+02	***	1.76E+02	**
DALLAS	6.03E+01	.	1.75E+02	***
NEW YORK	6.32E+01	***	1.08E+02	***
BOSTON	6.09E+01	***	1.29E+02	***
COLUMBIA	2.97E+01	.	2.43E+02	***
CHICAGO	2.67E+01	**	6.55E+01	***
ATLANTA	1.74E+01		1.73E+02	***
BALTIMORE	5.87E+01	***	1.79E+02	.
PHILADELPHIA	3.41E+01	***	5.08E+01	***
DETROIT			-3.63E+01	

Appendix 6: Robustness Test 2 (Transportation Cost) Result

	Reference											
	SAN FRANCISCO	LOS ANGELES	DALLAS	NEW YORK	BOSTON	COLUMBIA	CHICAGO	ATLANTA	BALTIMORE	PHILADELPHIA	ST.LOUIS	DETROIT
SAN FRANCISCO		2.22E-02	-4.48E-02	1.20E-01	1.19E-01	1.20E-01	1.30E-01	1.48E-01	1.62E-01	1.76E-01	2.18E-01	2.34E-01
LOS ANGELES	-2.22E-02		-6.70E-02	9.78E-02	9.63E-02	9.75E-02	1.08E-01	1.26E-01	1.39E-01	1.54E-01	1.96E-01	2.12E-01
DALLAS	4.48E-02	6.70E-02		1.65E-01	1.63E-01	1.65E-01	1.75E-01	1.93E-01	2.06E-01	2.21E-01	2.63E-01	2.79E-01
NEW YORK	-1.20E-01	-9.78E-02	-1.65E-01		-1.43E-03	-2.45E-04	9.80E-03	2.79E-02	4.15E-02	5.60E-02	9.80E-02	1.14E-01
BOSTON	-1.19E-01	-9.63E-02	-1.63E-01	1.43E-03		1.18E-03	1.12E-02	2.93E-02	4.30E-02	5.74E-02	9.94E-02	1.16E-01
COLUMBIA	-1.20E-01	-9.75E-02	-1.65E-01	2.45E-04	-1.18E-03		1.01E-02	2.81E-02	4.18E-02	5.62E-02	9.82E-02	1.15E-01
CHICAGO	-1.30E-01	-1.08E-01	-1.75E-01	-9.80E-03	-1.12E-02	-1.01E-02		1.81E-02	3.17E-02	4.62E-02	8.82E-02	1.05E-01
ATLANTA	-1.48E-01	-1.26E-01	-1.93E-01	-2.79E-02	-2.93E-02	-2.81E-02	-1.81E-02		1.37E-02	2.81E-02	7.01E-02	8.64E-02
BALTIMORE	-1.62E-01	-1.39E-01	-2.06E-01	-4.15E-02	-4.30E-02	-4.18E-02	-3.17E-02	-1.37E-02		1.44E-02	5.65E-02	7.27E-02
PHILADELPHIA	-1.76E-01	-1.54E-01	-2.21E-01	-5.60E-02	-5.74E-02	-5.62E-02	-4.62E-02	-2.81E-02	-1.44E-02		4.20E-02	5.83E-02
ST.LOUIS	-2.18E-01	-1.96E-01	-2.63E-01	-9.80E-02	-9.94E-02	-9.82E-02	-8.82E-02	-7.01E-02	-5.65E-02	-4.20E-02		1.63E-02
DETROIT	-2.34E-01	-2.12E-01	-2.79E-01	-1.14E-01	-1.16E-01	-1.15E-01	-1.05E-01	-8.64E-02	-7.27E-02	-5.83E-02	-1.63E-02	