DEMAND FOR TURKISH APPLES: A COMPARISON OF ALMOST IDEAL DEMAND SYSTEM (AIDS) AND ROTTERDAM ESTIMATES

By

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Abstract

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This thesis investigates demand system estimation of five different apple varieties which are Starking Delicious, Golden, Gala, Granny Smith, and Fuji from Isparta in Turkey. Demand estimation is conducted with two well established models: Almost Ideal Demand System (LA/AIDS) and Rotterdam model were used. Results for estimated own-price elasticities, cross-price elasticities and income elasticities are generally consistent with previous literature for both the AIDS and the Rotterdam model. For expenditure elasticities, according to AIDS estimation results, the five apple varieties are all normal goods. However, for the Rotterdam estimation results, two varieties out of the five are inferior goods, those being Golden and Gala.

Keywords: AIDS model, Rotterdam model, Price Elasticity, Apple

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CHAPTER ONE: INTRODUCTION

Apples are widely consumed throughout the world and are mostly a deciduous fruit that grows in trees in temperate regions. They are not too big, easily crushed and most varieties store well. They can be consumed as fruit, cooked, canned, frozen and can be turned into many delicious and healthy meals such as apple shakes, apple cakes, apple pies, and wines. Apple fruit originally came from Central Asia and spread throughout the world over time. Apples have many health benefits and contain vitamins and minerals.

World apple production for 2017/18 decreased by 2.7 million metric tons to 77.3 million tons due to the first spring frosts which severely affected orchards across the European Union. Smaller consumption is expected to reduce consumption to 65.7 million tons and reduce global trade (USDA, 2018). According to USDA, China is the most important producer of apples produced with 44,447,793 million-tons per year followed by the USA (4,649,323), Poland (3,604,271) and Turkey (2,925,828), respectively.

According to the FAO, the number of apple varieties in the world exceeds 6500, but in Turkey, the number of apple varieties reaches 460. However, many fewer varieties are produced commercially. The most important commercial apple varieties are Starking Delicious, Golden, Starkrimson, Grany Smith, Starkspur, Beacon, Jonathan, Black Stoyman Implant and Amasya. The most produced apple varieties in Turkey are Starking (Red Delicious), Golden, Starkrimson, and Amasya apples. Consider is the apple production in Turkey, 34.9% of production belongs to the Mediterranean region, 16.8% of production comes from Central Anatolia Region, 16.7% belongs the Western Anatolia Region, 11% is in the Aegean Region, and 10.3 % of production belongs to east and west of Marmara Region. These regions collectionaly grow about 2,590,978 tons, amounts to 89.7% of Turkey's total apple production. When we consider the production in terms of provinces, 75.5% of the production is realized by the first ten provinces. At the top of these provinces, Isparta, which is in the Mediterranean Region with the most production 634.795 tons. The amount of apples produced in Isparta province is 21.9% of the total country production. This province is followed by Karaman province with 388,404 tons, and the share of this province totals 13.4% of total output. The third largest production province is Nigde. Niğde province produces 317.271 tons, and the share of this province of total production was 11% (Aras,2015).

Although these regions and provinces are at the forefront of production, new apple orchards continue to be established new production areas are being brought into the production. Turkey is among the top three apple producing countries in the world. Roughly two third of production is consumed domestically with the remaining exported. Turkey should consider consumer preferences and demand for apple varieties, since domestic consumption plays an important place role in the apple market.

This study will focus on demand estimation analysis in terms of apple varieties. Following study (Barten, 1968), treats demand as a system of equations, one for each variety. For demand estimation, there are many different models. In this study, we will focus on common two models: Almost Ideal Demand System and Rotterdam Model. Deaton and Muellbauer (1980) proposed the Almost Ideal Demand System Model (AIDS). The AIDS model uses a flexible functional form to estimate demands based on utility maximization subject to a budget constraint. The AIDS model has been utilized by many researchers for empirical analysis of the argued AIDS. Study was selected as one of the top twenty articles published in the American Economic Review over the last 100 years (Arrow, 2011). The Rotterdam Model (RM) was developed by Theil (1965) and

Barten (1966). The most significant difference of the Rotterdam model is that it uses a differential form that can be useful when data are non-stationary.

In this paper, we estimate an apple demand system using apple price and sales for Turkey. For the demand system of apples, we use the linear approximation / Almost Ideal Demand System (LA/ AIDS) and the Rotterdam model. Own-price, cross-price, and expenditure elasticities are calculated for Marshallian demand equations for both the LA/AIDS and the Rotterdam models. After estimation, results for each model, are compared result between the two models and results are interpreted.

CHAPTER TWO: LITERATURE REVIEW

Price and Mittelhammer (1979) estimated cross and income demand elasticities for fourteen fresh fruit using mixed estimation model. In this study, the authors used 25 years of time series data between 1949 and 1973. They concluded that there was no significant difference between their estimates and previous ones. The authors found apples, oranges, and grapefruits demand were all price inelastic.

Seale, Sparks, and Buxton (1992) estimated the Rotterdam model for international trade in fresh apples. The authors used import data for fresh apples from four important import markets to the U.S. They calculated expenditure and price elasticities and found import demand among countries.

Clements and Selvanathan (1988) have focused on how the approach to market demand analysis can be used in marketing. Using the Rotterdam model demonstrate, the authors depicte how the approach can be connected to groups of goods (beer, wine, and spirits) to estimate demand and price elasticities. This investigation additionally furnishes expansions for managing advertising and characterizing the market structure.

Glaser and Thompson (1998) estimated the price and expenditure elasticities for organic and conventional frozen vegetables which have broccoli, green beans, green peas, and sweet corn. For this estimation, authors applied to use Almost Ideal Demand System (AIDS) and analyzed the US monthly supermarket data are highly between September 1990 and December 1996. They find that consumers responsive to price changes.

Richards and Patterson (2000) focused on the impact of consumer learning in terms of experience, variety-specific promotion and generic apple promotion for Fuji apple. The authors used Almost

Ideal Demand System (AIDS) to estimate those effects on the demand for Fuji apples. They find a positive impact for those criteria and find an inelastic price and elastic income.

Anderson and Vilcassim (2001) used a modified AIDS model which includes promotion effects and total category expenditure to assist retail price decisions. They implement their model for three grocery categories; toilet tissue, refrigerated orange juice, and canned tuna. The authors find that a small 0% - 2% change in product line price can help retailers to conduct product categories to a level of optimal performance.

Fonsah and Muhammad (2008) apply to the Rotterdam model to estimate U.S. demand for imported apple juice by country. The authors focus on the impact of China on competing for exporting countries. The authors find that while the U.S. imports that are coming from Argentina, Chile, and the rest of the world are significantly responsive to apple juice prices in China. U.S. imports from China are also significantly responsive to prices in other countries as well.

Sahinli (2010) used the Almost Ideal Demand System to find consumer behavior patterns and price elasticity from urban and rural areas in Turkey. For this study, the author used household income and consumption data between 2002 and 2006. Expenditure and price elasticities for food and non-alcoholic beverages expenditure are estimated.

Anvar, Aziz, and Ali (2012) used the Rotterdam Model to estimate nine major commodities which include apples in Pakistan. For this study, the authors used SUR Method to estimate parameters. They found that all expenditure elasticities were negative as an expectation before starting the study. Substitution and complementary relationships were observed according to the values of the cross-price elasticities. Then, the authors examined the structure and patterns of food consumption in Pakistan in terms of elasticities of these foods.

Li (2013) used Linear Approximate Almost Ideal Demand System (LA/AIDS) model to investigate tree fruit demand. The author focuses on different crops which are apple, peach, strawberry, sweet cherry, and tart cherry and finds.

Wang and Cakir (2018) have studied on Introduction of Honeycrisps apple in terms of welfare effect. The authors estimated consumer demand and retail competition with using structural model. For this study, the authors used store scanner data 61 cities in the United States. According to result consumer welfare of the introduction of Honeycrisp apples has reached 3.14 cents per pound on average, previous was 2.98 cents. In addition, total sales quantity of the Honeycrisp apple was 8.03 %, and total sales revenue of the Honeycrisp apple was 21.25%.

Xie and Myrland (2018) used the Rotterdam model to analyze market participation. For this purpose during this study is to create a method contribution by showing that the metropolis demand model may be extended to incorporate each market participation and consumption intensity as dependent variables instead of exploitation solely amount. The results applying the extended model household data on salmon consumption in France show that prices have a greater impact on attracting new buyers to the product in question to consume more than existing buyers.

The literature for apple demand indicates that price elasticities of demand are often inelastic, that expenditure elasticities can be positive or negative. To date, demand study has been conducted specifically for the Turkish market.

CHAPTER THREE: MODEL OF DEMAND SYSTEMS

3.1. The Linear Approximation / Almost Ideal Demand System (LA/ AIDS)

The AIDS model can be defined as follows in the budget share form (Deaton and Muellbauer, 1980);

Let i be the product index and t index time.

Then budget share for product i at time t is given by:

$$w_{i\,t} = \alpha_{i1}Q_1 + \alpha_{i2}Q_2 + \alpha_{i3}Q_3 + \sum\nolimits_j \gamma_{i\,j} \ln(\, p_{j\,t}) + \beta_i \ln\left(\frac{E_t}{P_t}\right) + V_{i\,t}$$

where:

product share of i is $w_{i\,t} = \left(\frac{q_{i\,t}}{\sum_i p_{i\,t}\, q_{i\,t}}\right)$, where $p_{i\,t}$ is the price of product i at time t, and $q_{i\,t}$ is the quantity of product i at time t.

E_t refers to the total expenditure on the groups of products at time t.

P_t is defined as $\ln(P_t) = \sum_j w_{j\,t} \ln(p_{j\,t})$ and which is a log-linear equivalent of Stone's price index. Parameters of the model are: α_i, γ_i , and β_i.

Q_1, Q_2, and Q_3 represent seasonal effect.

$V_{i\,t}$ is an error term.

Restrictions that provide theoretical consistency of the AIDS model with utility maximization subject to a budget constraint are; the adding up, homogeneity, and symmetry. These are defined as follows (Deaton and Muellbauer, 1980).

- Adding up $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0$, and $\sum_i \beta_i = 0$.
- Symmetry $\gamma_{i\,j} = \gamma_{j\,i}$.
- Homogeneity $\sum_j \gamma_{i\,j} = 0$.

The own-price uncompensated, the cross-price uncompensated and Marshallian demand elasticity formulas are used to calculate the elasticities in this paper, with their definitions being as follows:

The own-price or Marshallian elasticities: $\varepsilon_{ij} = \frac{-1+\gamma_{i\,i}}{w_i-\beta_i}$.

The cross-price or Marshallian elasticities: $\varepsilon_{ij} = \frac{\gamma_{i\,j}}{w_i} - \left(\frac{\beta_i}{w_i}\right) w_j$.

The expenditure elasticity of product i: $\eta_i = 1 + \frac{\beta_i}{w_i}$.

3.2. The Rotterdam Model

The functional form must represent two important features to define consumer demand behavior;

1- It must be adequately flexible to describe variations in the expression of consumers and demand elasticities (Theil, 1980).
2- It must allow the application of restrictions which are arise from the theory of consumer demand (symmetry and homogeneity) (Capps, Church, and Love, 2003).

Since the Rotterdam model, price and quantity variables are expressed by logarithmic differences, and they can easily manage non-stationary data, which is an advantage over other demand systems such as AIDS (Theil, 1980). Even though the Rotterdam model is not derived from an underlying benefit or expenditure function, it fulfills the conditions of integrity when symmetry and homogeneity are applied. (Nayga and Capps, 1994).

As before i indexes products and t indexes time. The demand for product i at time t is:

$$w_{i\,t}\, d\ln q_{i\,t} = a_{i1}Q_1 + a_{i2}Q_2 + a_{i3}Q_3 + b_i \sum_j w_{i\,t}\ d\ln q_{j\,t} + \sum_j c_{i\,j}\ d\ln p_{j\,t} + V_{i\,t}$$

where:

$q_{i\,t}$ is the quantity of product i at time t, $d\ln q_{i\,t} = \ln\left(\frac{q_{i\,t}}{q_{i\,t-1}}\right)$ and $d\ln p_{j\,t} = \ln\left(\frac{p_{j\,t}}{p_{j\,t-1}}\right)$,

$w_{i\,t}$ is product share of i and $w_{i\,t} = \frac{p_{i\,t}\, q_{i\,t}}{\sum_i p_{i\,t}\, q_{i\,t}}$ and $p_{i\,t}$ is the price of product i.

Q_1, Q_2, and Q_3 represent seasonal effect.

$V_{i\,t}$ is an error term.

Parameter restrictions of the Rotterdam demand to ensure utility maximization are;

- Adding up: $\sum_i b_i = 1, \sum_i c_{ij} = 0$. If $c_{ij} > 0$, i and j are substitutes but if $c_{ij} < 0$, i and j are complements, and if $c_{ij} = 0$, i and j are independent.
- Symmetry: $c_{i\,j} = c_{j\,i}$.
- Homogeneity: $\sum_j c_{i\,j} = 0$ (Theil, 1980).

The own-price uncompensated, the cross-price uncompensated Marshallian demand elasticity formulas are used to calculate elasticity in this study.

The own-price, and the cross-price or Marshallian elasticities are :

$$\varepsilon_{ij} = \frac{(c_{i\,j} - w_i b_i)}{w_i}.$$

The expenditure elasticity of product i is:

$$\eta_i = \frac{b_i}{w_i}.$$

CHAPTER FOUR: THE DATA

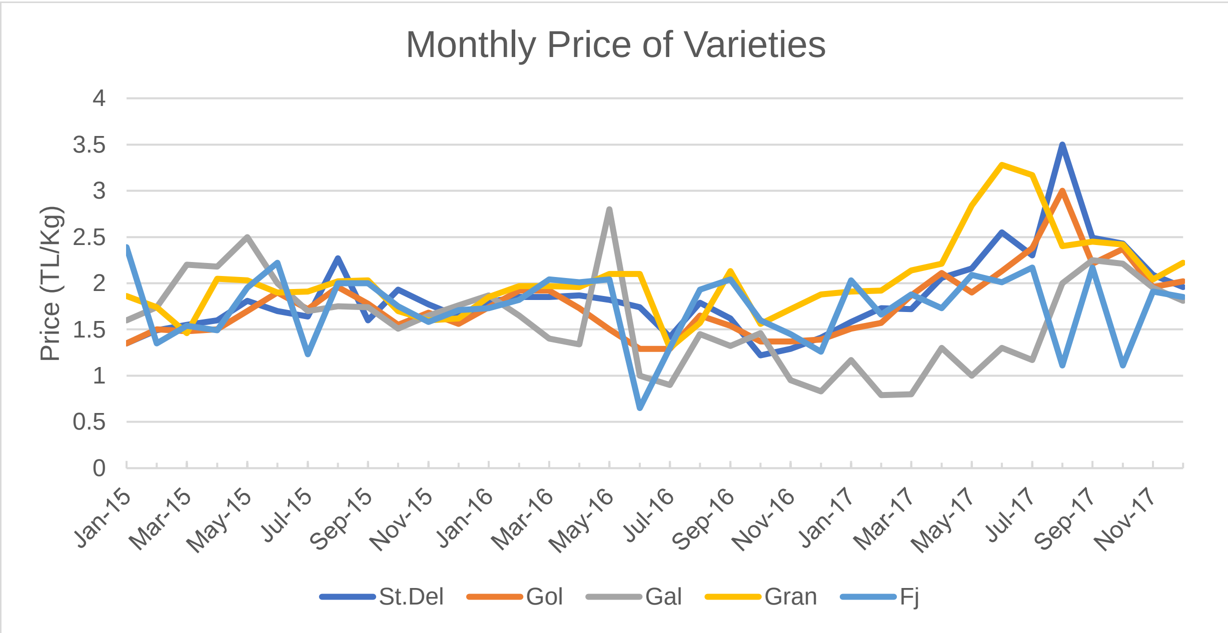
In this study, we use publicly available data from Isparta Commodity Exchange in Isparta, Turkey for estimation of apple demand. The data include monthly apple prices and quantities for three years: 2015, 2016 and 2017. In the data, we have 36 observations to estimate apple demand, and there are five different apple varieties: Starking Delicious, Golden, Gala, Granny Smith, and Fuji from Isparta which is the most important district for production of apple in Turkey. From the data, we calculated expenditure shares and total expenditures of each variable to use for estimation analysis. For both AIDS and the Rotterdam model, we calculated coefficients of estimated parameters, R-squared value, Likelihood Ratio, Expenditure, Marshallian (uncompensated), and Hicksian (compensated) price elasticities for each variety of apples. Estimation results are obtained using R studio software for AIDS. For those results, we use “systemfit”, “micEconAids” packages in R. For the Rotterdam model, and we uses SAS software to obtain estimation results.

Table 1. Descriptive Statistics of the Variables: Monthly Data; 2015-2017

Variables	Mean	Median	Std.Dev	Coef. Var (%)	Max	Min
Price of Starking Delicious (TL/Kg)	1.850	1.780	0.432	23.354	3.50	1.22
Price of Golden (TL/Kg)	1.762	1.710	0.362	20.563	3.00	1.29
Price of Gala (TL/Kg)	1.585	1.625	0.498	31.459	2.80	0.79
Price of Granny Smith (TL/Kg)	2.029	1.970	0.419	20.694	3.28	1.30
Price of Fuji (TL/Kg)	1.744	1.835	0.377	21.638	2.39	0.65
Expenditure Share of Starking Delicious	0.415	0.449	0.157	38.074	0.686	0.003
Expenditure Share of Golden	0.281	0.287	0.098	34.961	0.658	0.003
Expenditure Share of Gala	0.063	0.014	0.086	142.903	0.269	0.002
Expenditure Share of Granny Smith	0.172	0.158	0.089	52.317	0.445	0.034
Expenditure Share of Fuji	0.076	0.047	0.083	110.848	0.388	0.004
Total Expenditure (1000 TL)	4.308	4.011	2.975	69.043	11.173	154.395

Descriptive statistics of apple data used in the study are given in Table 1. Table 1 includes prices for five apple varieties and their expenditure shares by mean, median, standard deviation, the coefficient of variation, maximum and minimum values. In table 1, we also calculated the coefficient of variation because the means of variables are not the same and have high differences. If we evaluate the results in terms of standard deviation, they can mislead us because of that we added a coefficient of variance in that table. The coefficient of variance provides a statistical measure of dispersion of data points in a data series around the mean. In table 1, Gala has the highest variance among apple varieties, the second is Starking Delicious, the third is Fuji, and Golden and Granny Smith have almost same variance.

Figure 1. Price of Varieties by month



Where;

St.Del indicates the price of Starking Delicious, Gol indicates the price of Golden, Gal indicates the price of Gala, Gran indicates the price of Granny Smith and Fj indicates the price of Fuji.

Figure 1 shows the price of varieties by month. Generally, all varieties have tidy distribution, but there are a few crucial points. On the 18. Month, the prices of all varieties have a downfall, but the highest loss is for Fuji. Likewise, November 2015 and July 2016, Gala has a wavy price. At the August 2017 and October 2017, price for Starking Delicious, Golden, Gala, Granny Smith increase, while the price for Fuji sharply decreases on price.

Figure 2. Expenditure Share of Varieties by month

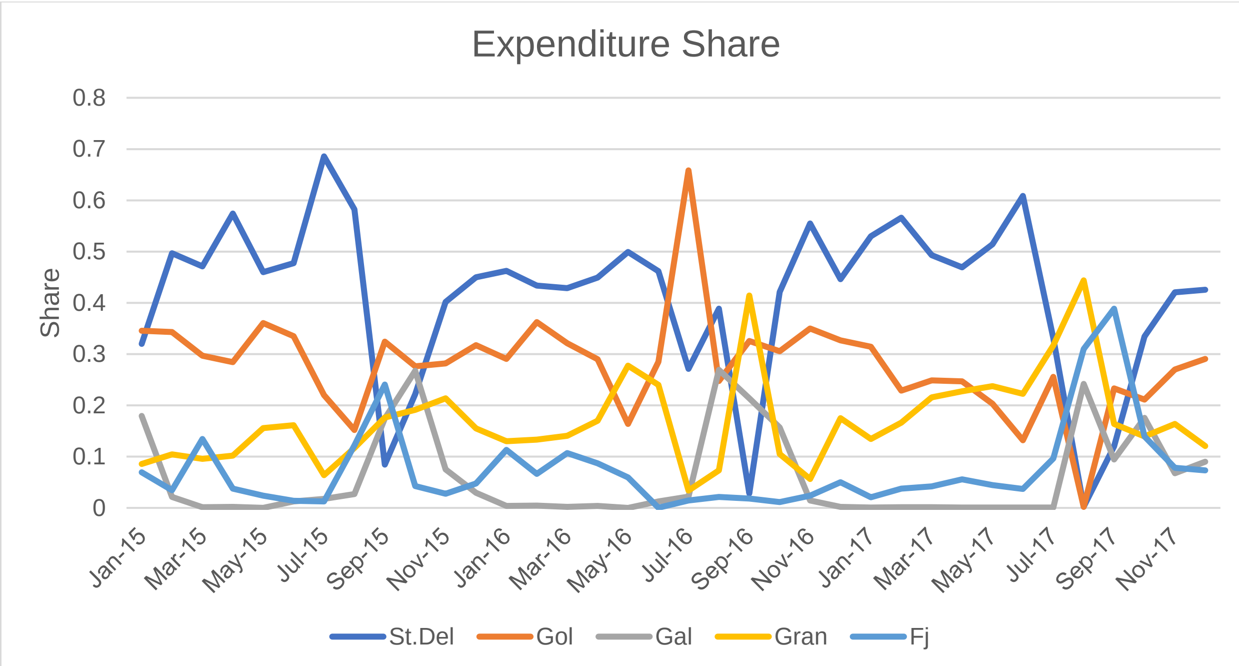


Figure 2 shows the expenditure share of varieties by month. To find expenditure share, we multiplied price and quantity and each variety and divided the total expenditure of all. On the figure, there is an interesting fluctuation among varieties. Most of the years, Gala and Fuji have almost zero expenditure share. Starking Delicious share descents and ascents sharply. Through time September 2015 and July 2016, while Golden, Gala, Granny Smith, and Fuji have increasing expenditure shares, Starking Delicious expenditure share is decreasing.

CHAPTER FIVE: RESULTS

5.1. Demand Estimation for the AIDS model

Table 2. Estimated Coefficients of the AIDS Model

	Estimate	Std. Error	t value	Pr(>|t|)	
α1	-1.292	0.480	-2.686	0.008	**
α2	-0.132	0.388	-0.341	0.734	
α3	1.107	0.240	4.615	<0.001	***
α4	0.762	0.315	2.416	0.018	*
α5	0.553	0.283	1.949	0.054	
β1	0.114	0.032	3.535	<0.001	***
β2	0.030	0.026	1.135	0.259	
β3	-0.068	0.016	-4.180	<0.001	***
β4	-0.043	0.021	-2.019	0.046	*
β5	-0.034	0.019	-1.750	0.083	
γ11	-0.003	0.196	-0.013	0.989	
γ12	-0.164	0.176	-0.929	0.355	
γ13	0.050	0.056	0.888	0.376	
γ14	0.092	0.108	0.845	0.399	
γ15	0.025	0.065	0.381	0.704	
γ21	-0.164	0.176	-0.929	0.355	
γ22	0.004	0.220	0.016	0.988	
γ23	0.029	0.051	0.575	0.566	
γ24	0.006	0.109	0.053	0.958	
γ25	0.125	0.060	2.087	0.039	*
γ31	0.050	0.056	0.888	0.376	
γ32	0.029	0.051	0.575	0.566	
γ33	-0.006	0.034	-0.175	0.862	
γ34	-0.083	0.040	-2.081	0.040	*
γ35	0.009	0.028	0.327	0.744	
γ41	0.092	0.108	0.847	0.399	
γ42	0.006	0.109	0.053	0.958	
γ43	-0.083	0.040	-2.081	0.039	*
γ44	0.061	0.104	0.580	0.563	
γ45	-0.075	0.046	-1.623	0.107	
γ51	0.025	0.065	0.381	0.704	
γ52	0.125	0.060	2.087	0.039	*
γ53	0.009	0.028	0.327	0.744	
γ54	-0.075	0.046	-1.621	0.108	
γ55	-0.084	0.044	-1.896	0.061	
α11	0.064	0.059	1.077	0.283	
α12	0.081	0.061	1.334	0.184	
α13	0.096	0.086	1.117	0.266	
α21	-0.006	0.047	-0.123	0.903	

α22	-0.032	0.050	-0.648	0.518	
α23	0.045	0.068	0.649	0.517	
α31	-0.078	0.029	-2.622	0.009	**
α32	-0.086	0.030	-2.950	0.003	**
α33	-0.113	0.044	-2.593	0.010	*
α41	-0.009	0.039	-0.230	0.819	
α42	0.041	0.041	1.007	0.315	
α43	-0.041	0.056	-0.724	0.470	
α51	0.029	0.036	0.793	0.429	
α52	-0.002	0.036	-0.048	0.962	
α53	0.013	0.051	0.259	0.795	

(A single asterisk indicates significance at a 10% level; A double asterisk indicates significance at a 5% level; A three asterisks indicates significance at a 1% level)

Table 2 shows estimated coefficients of each apple variety using Linear Approximation Almost Ideal Demand System with Stone price index estimation method and α represents coefficients of seasonal effect in the table. On the table, there are 13 statistically significant parameters out of 50 parameters. Seven of them have 10% significance level, three of them have 5% significance level, and three of them have 1% significance level. Coefficient estimates alone are difficult to interpret. To better understand the economic interpretation of the estimated parameters, own-price, cross-price, and expenditure elasticities are presented in the next section.

Table 3. R^2 values and Likelihood Ratio of the Model

Variety	R^2 value
Starking Delicious	0.525
Golden	0.256
Gala	0.608
Granny Smith	0.360
Fuji	0.350

R-squared is a statistical measure indicating how close the data are to the fitted regression line. Table 3 shows the R-squared values of each variety, respectively. In the table, all variables have between 26% and 61% explained variation. Given the widely fluctuations expenditure shares, this seems reasonably good. The lowest variety in terms of R-squared value is Golden with around 26% of the variation explained, and the highest variety is Gala with almost 61%.

	#Df	LogLik	Df	Chisq	Pr(>Chisq)
Model 1	28	181.90			
Model 2	38	197.13	10	30.46	0.0007 ***

The Likelihood-Ratio test (chi-square test) is a hypothesis test that helps to choose the best model between two nested models and the meaning of nested models is that one of the models is a case of the other (Investopedia). There is higher significant chi-squared value and Model 1 includes AIDS, symmetry, and homogeneity imposed but Model 2 includes AIDS, unrestricted. The nested tests could not reject homogeneity and symmetry, so for likelihood ratio, we decided to use the model which imposed symmetry and homogeneity. The likelihood ratio of the model is 181.90 and it is significant. In addition, when we check the logical consistency of the AIDS model, results give us adding-up, homogeneity and symmetry conditions are fulfilled. Also, monotonicity is achieved at 36 out of 36 observations (100%), and the concavity is fulfilled at 0 out of 36 observations (0%).

5.1.1. Demand Elasticities of the AIDS model

Table 4. Expenditure Elasticities

Variety	Expenditure Elasticity
Starking Delicious	1.237 (0.043)
Golden	1.046 (0.053)
Gala	0.207 (0.253)
Granny Smith	0.839 (0.083)
Fuji	0.532 (0.192)

Table 4 shows expenditure (income) elasticities of each apple variety. All are positive and values in parenthesis represent standard errors of varieties. The positive sign of the expenditure elasticities explains that all five apple varieties are normal goods. Expenditure elasticities are statistically different from each other. It implies that consumer preferences are not consistent when expenditure changes. As income rises consumers prefer a higher proportion to Starking Delicious and Golden, with a lower increase in demand for Gala, Granny Smith, and Fuji. The tree fruit demand analysis using limited dependent variable models (Li, 2013) has similar expenditure elasticities, with all varieties exhibit positive expenditure elasticities. However, the paper of Lin, Yen, Huang and Smith, 2009, estimates negative expenditure elasticities for apple.

As a result of our model, Marshallian elasticities showed in Table 5, Hicksian elasticities are presented in Table 6. The elasticities of the main corner show its price elasticity, while others show cross-price elasticities and values in parenthesis represent standard errors of varieties. The smaller the price elasticity of a variety tells us there is higher competitiveness of that variety with the other varieties. It can be thought that the highest competitive power has the advantage of directing the market and price setting. When interpreting Marshallian elasticities, it should be remembered that consumers prioritize the benefits of varieties. In other words, consumers don't care about their budgets, and they care about their benefits from the product. However, in Hicksian elasticity, consumers pay attention to the smallest amount of spending they make while making their preferences.

Table 5. Marshallian (uncompensated) Price Elasticities

	Starking Delicious	Golden	Gala	Granny Smith	Fuji
Starking Delicious	-0.743 (0.438)	-0.466 (0.374)	-0.082 (0.130)	0.133 (0.267)	-0.079 (0.164)
Golden	-0.608 (0.582)	-0.625 (0.664)	0.027 (0.167)	-0.288 (0.358)	0.448 (0.209)
Gala	-0.129 (1.315)	0.363 (1.083)	-0.164 (0.921)	-0.764 (0.978)	0.488 (0.817)
Granny Smith	0.487 (0.751)	-0.416 (0.649)	-0.311 (0.275)	-0.184 (0.753)	-0.415 (0.329)
Fuji	-0.142 (1.196)	1.818 (0.972)	0.376 (0.582)	-0.889 (0.839)	-1.695 (0.672)

Table 5 demonstrates Marshallian price elasticities, and the most of results are negative, so they are inelastic which means that when the price goes up, consumers' buying habits stay about the same, and when the price goes down, consumers' buying habits also remain unchanged, and they are complementary goods that means when the price increases for one good, the demand for the complement will decrease with other variables. Granny Smith-Starking Delicious, Gala-Golden, Fuji-Golden and Fuji-Gala are substitute goods that means when the price increases for one good, the demand for the substitute will increase with each other. Also, Marshallian demand elasticity is -0.743 for Starking Delicious, - 0.625 for Golden, -0.164 for Gala, - 0. 184 for Granny Smith and – 1.695 for Fuji. These elasticities represent that when the prices go 1% up, the demand is inevitable to decrease by 0.743 % for Starking Delicious, 0.625 % for Golden, 0.164 % for Gala, 0.184 % for Granny Smith and 1.695 % for Fuji. In table 5, when looking at the Marshallian own-price elasticities, all apple varieties have negative elasticities, and the lowest one is Gala with – 0.164. That means the highest benefit is Gala for costumers. That is why Gala has competitiveness among other varieties. Granny Smith has the second highest benefit, and the last one is Fuji. In addition, Table 5 also shows the coefficients of cross-price elasticities outside of main diagonal. Positive cross-elasticity indicates competition between two varieties; the elasticity with a negative sign indicates complementarity. If those two varieties have positive elasticity, it tells if the price of a variety increases, the amount of the other's sale will increase. However, if there is a negative cross-elasticity, it says if the price of a variety increases, the amount of the other's sale will decrease. For cross-elasticities, when Granny Smith-Starking Delicious, Gala-Golden, Fuji-Golden and Fuji-Gala have positive elasticity, others have negative elasticities among them.

Table 6. Hicksian (compensated) Price Elasticities

	Starking Delicious	Golden	Gala	Granny Smith	Fuji
Starking Delicious	-0.232 (0.441)	-0.119 (0.373)	-0.007 (0.130)	0.344 (0.265)	0.014 (0.164)
Golden	-0.175 (0.585)	-0.332 (0.665)	0.091 (0.167)	-0.110 (0.356)	0.526 (0.209)
Gala	-0.044 (1.312)	0.421 (1.081)	-0.151 (0.922)	-0.729 (0.476)	0.503 (0.815)
Granny Smith	0.834 (0.757)	-0.181 (0.649)	-0.259 (0.275)	-0.041 (0.749)	-0.356 (0.329)
Fuji	0.077 (1.190)	1.968 (0.969)	0.408 (0.583)	-0.798 (0.037)	-1.655 (0.671)

Table 6 indicates Hicksian price elasticities and most of results are negative as well and it tells us that they are complementary goods and inelastic. However, Granny Smith-Starking Delicious, Fuji-Starking Delicious, Gala-Golden, Fuji-Golden and Fuji-Gala are substitute goods in table 6. When interpreting the results in terms of Hicksian own-elasticities, Granny Smith has the lowest elasticity with -0.041. In terms of the Hicksian approach, Granny Smith has the highest competitiveness, while Gala is in second place, Starking Delicious is in third place, Golden is in fourth place, and Fuji is in the last place. In addition, Table 6 also shows the coefficients of cross-price elasticities outside of main diagonal. For cross-elasticities, when Granny Smith-Starking Delicious, Fuji-Starking Delicious, Gala-Golden, Fuji-Golden and Fuji-Gala have positive elasticity, others have negative elasticities among them. These results are consistent with literature investigating tree fruit market using limited dependent variable models (Li, 2013). In that paper, she reached that own-price Marshallian and Hicksian demand elasticities are all negative that are -1.394 for Red delicious, -1.357 for Golden delicious, -1.436 for Gala, -1.259 for other varieties and -3.717 for Organic apples at the 5% the significance level for the five apple categories.

Looking at the results of Richards, T. J., & Patterson, P. M. (2000) paper, our results are also consistent with them because their own-price elasticities of all varieties are negative. They found – 0.683 for Red Delicious, - 0.201 for Golden, - 0.406 for Granny Smith, - 0.323 for Gala and – 1.137 for Fuji. Also, another paper (Lin, Yen, Huang and Smith, 2009) has consistent results with our study that all varieties of that study have negative demand elasticities.

Table 7. Demand Elasticities of the Estimated AIDS Model

			Estimate	Std. Error	t value	Pr (>|t|)	
Ex	Starking		1.218	0.043	27.977	< 0.001	***
Ex	Golden		1.050	0.053	19.816	< 0.001	***
Ex	Gala		-0.079	0.253	-0.310	0.757	
Ex	Granny		0.818	0.083	9.816	< 0.001	***
Ex	Fuji		0.422	0.192	2.193	0.030	*
Eh	Starking →	Starking	-0.504	0.441	-1.142	0.255	
Eh	Starking →	Golden	-0.105	0.373	-0.281	0.779	
Eh	Starking →	Gala	0.129	0.130	0.995	0.325	
Eh	Starking →	Granny	0.380	0.265	1.436	0.157	
Eh	Starking →	Fuji	0.099	0.164	0.605	0.546	
Eh	Golden →	Starking	-0.164	0.585	-0.281	0.779	
Eh	Golden →	Golden	-0.350	0.665	-0.526	0.599	
Eh	Golden →	Gala	0.099	0.167	0.596	0.553	
Eh	Golden →	Granny	-0.107	0.356	-0.301	0.765	
Eh	Golden →	Fuji	0.522	0.209	2.492	0.014	*
Eh	Gala →	Starking	1.305	1.312	0.994	0.322	
Eh	Gala →	Golden	0.643	1.081	0.595	0.553	
Eh	Gala →	Gala	-0.650	0.922	-0.704	0.482	
Eh	Gala →	Granny	-1.445	0.976	-1.480	0.141	
Eh	Gala →	Fuji	0.146	0.815	0.179	0.858	
Eh	Granny →	Starking	1.086	0.757	1.435	0.153	
Eh	Granny →	Golden	-0.196	0.649	-0.302	0.763	
Eh	Granny →	Gala	-0.408	0.275	-1.482	0.141	
Eh	Granny →	Granny	-0.016	0.749	-0.022	0.983	
Eh	Granny →	Fuji	-0.466	0.329	-1.415	0.159	
Eh	Fuji →	Starking	0.721	1.190	0.605	0.546	
Eh	Fuji →	Golden	2.414	0.969	2.498	0.014	*
Eh	Fuji →	Gala	0.105	0.583	0.180	0.858	
Eh	Fuji →	Granny	-1.184	0.837	-1.415	0.159	
Eh	Fuji →	Fuji	-2.055	0.671	-3.063	0.003	**
Em	Starking →	Starking	-1.052	0.438	-2.402	0.018	*
Em	Starking →	Golden	-0.453	0.374	-1.213	0.227	
Em	Starking →	Gala	0.075	0.130	0.578	0.564	

Em	Starking	→	Granny	0.189	0.267	0.707	0.481	
Em	Starking	→	Fuji	0.024	0.164	0.145	0.885	
Em	Golden	→	Starking	-0.636	0.582	-1.093	0.276	
Em	Golden	→	Golden	-0.651	0.665	-0.978	0.330	
Em	Golden	→	Gala	0.053	0.167	0.317	0.752	
Em	Golden	→	Granny	-0.273	0.358	-0.761	0.448	
Em	Golden	→	Fuji	0.457	0.209	2.188	0.031	*
Em	Gala	→	Starking	1.341	1.315	1.019	0.310	
Em	Gala	→	Golden	0.666	1.083	0.615	0.539	
Em	Gala	→	Gala	-0.646	0.921	-0.702	0.484	
Em	Gala	→	Granny	-1.432	0.978	-1.463	0.146	
Em	Gala	→	Fuji	0.151	0.817	0.184	0.854	
Em	Granny	→	Starking	0.718	0.751	0.957	0.340	
Em	Granny	→	Golden	-0.430	0.649	-0.663	0.508	
Em	Granny	→	Gala	-0.445	0.275	-1.615	0.109	
Em	Granny	→	Granny	-0.145	0.753	-0.193	0.847	
Em	Granny	→	Fuji	-0.517	0.329	-1.570	0.119	
Em	Fuji	→	Starking	0.531	1.196	0.444	0.658	
Em	Fuji	→	Golden	2.293	0.972	2.363	0.020	*
Em	Fuji	→	Gala	0.086	0.582	0.148	0.883	
Em	Fuji	→	Granny	-1.251	0.839	-1.489	0.139	
Em	Fuji	→	Fuji	-2.082	0.672	-3.097	0.002	**

(A single asterisk indicates significance at a 10% level; A double asterisk indicates significance at a 5% level; A three asterisks indicates significance at a 1% level)

In table 7, "Ex" indicates expenditure (income) elasticities, "Eh" represents Hicksian (compensated) price elasticities and "Em" implies Marshallian (uncompensated) price elasticities. Table 10 shows demand elasticities for the AIDS model by the covariance matrix of the coefficients. In the table, there are eleven significant p-value results, but they have different significant levels. Expenditure elasticities of Starking Delicious, Golden, and Granny Smith have a very high significance level with 1%. Hicksian price elasticity of Fuji (0.003) and Marshallian price elasticity of Fuji (0.003) have 5% significance level. Expenditure elasticity of Fuji (0.030), Hicksian price elasticity of Golden-Fuji (0.014), Hicksian price elasticity of Fuji-Golden (0.014), Marshallian price elasticity of Starking Delicious (0.018), Marshallian price elasticity of Golden-

Fuji (0.031), and Marshallian price elasticity of Fuji-Golden (0.020) have 10% significance level or 90 % corresponding confidence level.

5.2. Demand Estimation for Rotterdam model

Table 8. Estimated Coefficients of the Rotterdam Model

Parameters	Estimate	StdErr	t Value	Pr > |t|	
a11	2.268	0.869	2.610	0.014	**
a12	0.196	0.006	2.960	0.006	**
a13	-0.013	0.004	-3.311	0.029	**
b1	-0.017	0.147	-0.121	0.909	
c11	-0.713	0.508	-1.403	0.171	
c12	-1.086	0.777	-1.401	0.173	
c13	0.212	0.732	0.290	0.774	
c14	0.375	0.698	0.544	0.595	
c15	0.508	0.557	0.913	0.370	
a21	-0.196	0.581	-0.344	0.738	
a22	0.169	0.276	0.610	0.545	
a23	-0.233	0.212	-1.110	0.282	
b2	0.036	0.098	0.366	0.720	
c21	0.388	0.339	1.146	0.262	
c22	1.325	0.519	2.553	0.016	**
c23	-0.008	0.490	-0.024	0.987	
c24	-0.155	0.466	-0.333	0.743	
c25	-0.149	0.372	-0.400	0.691	
a31	-0.102	0.049	-2.101	0.045	**
a32	0.019	0.006	2.960	0.006	**
a33	0.463	0.366	1.275	0.217	
b3	0.011	0.008	1.273	0.216	
c31	-0.037	0.028	-1.301	0.205	
c32	-0.102	0.044	-2.333	0.027	**
c33	-0.092	0.041	-2.224	0.034	**
c34	-0.039	0.039	-1.012	0.323	
c35	-0.020	0.031	-0.643	0.526	
a41	-1.928	0.816	-2.368	0.025	**
a42	-0.036	0.018	-1.940	0.063	**
a43	0.644	0.198	3.230	0.003	**
b4	0.972	0.138	7.045	<.0001	***
c41	0.347	0.477	0.739	0.473	

c42	-0.138	0.730	-0.195	0.851	
c43	-0.086	0.688	-0.127	0.901	
c44	-0.155	0.655	-0.243	0.814	
c45	-0.324	0.523	-0.623	0.540	
a51	-0.042	0.015	-2.847	0.008	**
a52	0.031	0.024	1.523	0.141	
a53	-0.012	0.014	-0.833	0.416	
b5	-0.002	0.002	-0.649	0.526	
c51	0.014	0.009	1.650	0.110	
c52	0.001	0.013	0.110	0.915	
c53	-0.026	0.012	-2.143	0.041	**
c54	-0.026	0.012	-2.187	0.038	**
c55	-0.014	0.009	-1.496	0.148	

(A single asterisk indicates significance at a 10% level; A double asterisk indicates significance at a 5% level)

The t-values associated with the parameters of the Rotterdam model are calculated under the equations system and shown in table 8. In the table, a, b and c are parameters of the Rotterdam model and a represents seasonal effect. The results show that ten parameters are statistically significant out of thirty-five parameters. Each coefficient indicates that if the price of a variety (out of five apple varieties) increases the share of that variety also increases and leads to a decrease in the share of other varieties. For instance, the c11 which is corresponding to Starking Delicious - Starking Delicious shows that as the price of Starking Delicious increases (-0.713) people allocate a lower share of their budget to Starking Delicious. However, increase in the prices of Gala (c13 = 0.212), Granny Smith (c14 = 0.375) and Fuji (c15 = 0.509) increase their share and consumer will not prefer to spend for Starking Delicious anymore. In addition, the coefficient of c22 which is corresponding Golden - Golden shows that increase in the price of Golden (1.325) increase also its share in consumer budget but it leads to decrease the share of Gala (c23 =-0.008), Granny Smith (c24 = -0.155) and Fuji (c23 = -0.149).

Table 9. R^2 values and the Likelihood Ratio of the model

Variety	R^2 value
Starking Delicious	0.231
Golden	0.387
Gala	0.314
Granny Smith	0.713
Fuji	0.433

Table 9 shows R-squared values, respectively. In the AIDS result, the lowest R^2 variety was Golden, and the highest was Gala but, in the Rotterdam results, the smallest R^2 variety is Starking Delicious, at 23%. The highest R^2 is Granny Smith, at 71%.

	#Df	LogLik	Df	Chisq	Pr(>Chisq)
Model 1	34	108.60			
Model 2	38	182.31	4	27.642	<.0001***

For the likelihood ratio, the Rotterdam model which imposed symmetry and homogeneity has a value of 108.60, and it is significant. Model 1 includes symmetry and homogeneity imposed but Model 2 includes unrestricted. The nested tests could not reject homogeneity and symmetry, so for likelihood ratio, we decided to use the model which imposed symmetry and homogeneity.

5.2.1. Demand Elasticities of the Rotterdam Model

Table 10. Expenditure Elasticities

Variety	Expenditure Elasticities
Starking Delicious	0.510 (0.086)
Golden	-0.619 (0.032)
Gala	-0.732 (0.076)
Granny Smith	2.946 (0.320)
Fuji	1.055 (0.244)

The expenditure (income) elasticities of the all varieties which we calculated using Rotterdam Model are shown in Table 10. The results show that Starking delicious (0.51), Granny Smith (2.946) and Fuji (1.055) are normal goods, but Golden (-0.619) and Gala (-0.732) are inferior goods which a good whose demand drops when people's incomes rise . Also, we can classify these variables as necessity or luxury good. For this purpose, we can say that Granny Smith and Fuji are luxury goods because they have more than one expenditure elasticity, which has the most effect on income, that means that a small change in income will cause a more substantial share change in its demand and Starking Delicious is necessity good according to the Rotterdam expenditure elasticity results. Results show that change in the income of consumer how the effect of spending their money on different varieties of apples. The study about the Rotterdam model for fresh apples to trade by countries (Seale and friends, 1992) has expenditure elasticities which countries have positive elasticity to trade fresh apples. However, the paper of Xie and Myrland, 2018, has negative expenditure for the household budget for salmon consumption by the Rotterdam model.

Table 11. Marshallian (Uncompensated) Price Elasticities of Demand

	Starking Delicious	Golden	Gala	Granny Smith	Fuji
Starking Delicious	-1.813 (0.516)	-0.146 (0.398)	0.175 (0.222)	0.708 (0.316)	1.365 (0.130)
Golden	-0.110 (0.595)	-0.105 (0.729)	0.231 (0.305)	0.307 (0.444)	-0.396 (0.184)
Gala	2.117 (1.610)	1.543 (1.478)	-1.631 (1.406)	1.279 (1.312)	1.436 (0.548)
Granny Smith	-0.584 (0.756)	-2.066 (0.712)	1.666 (0.435)	-1.142 (0.808)	-0.455 (0.238)
Fuji	1.266 (0.720)	-1.539 (0.699)	1.403 (0.419)	-2.430 (0.549)	-1.822 (0.311)

The Marshallian (uncompensated) price elasticities are demonstrated in Table 11. As we expected, own-price elasticities are satisfied that all variables have a negative relationship between the price of one variety and its quantity demanded. The absolute calculation of the own-price elasticities of all varieties shows that a commodity does not have too much price sensitivity. The Marshallian price elasticity of Golden (-0.105) indicates that it is the least price responsive. Other varieties have more than 1 uncompensated price elasticities which are Granny Smith (-1.142), Gala

(-1.631), Starking Delicious (-1.813) and Fuji (-1.822), respectively. When we look at the cross-price elasticities of Marshallian, while Starking Delicious has a strong substitute with Fuji (1.365), Granny Smith (0.708) and Gala (0.175), it has a complement relation with Golden (-0.146). Following the same way, Golden can be substituted with Granny Smith (0.307) and Golden (0.231), but Starking Delicious (-0.112) which is weak among all varieties and Fuji (-0.396) are complements of Golden. For Gala, all varieties are a substitute of it. For Granny Smith, however, all varieties are complemented with it. While Fuji has a strong substitute with Gala (1.403) and Starking Delicious (1.266), it has complemented with Granny Smith (-2.432) and Golden (-1.539) respectively. These elasticities show that the consumers of Turkey consume all type of apples and they can easily replace one variety with the others but probably, because of the price they are elastic not for the contains which they have. These results are consistent with a study about the Rotterdam demand model for important foods in Pakistan (Anwar and Friends, 2012). They found own-price elasticity -0.904 for Apples and Apples has substituted with Mango (0.602). Another study (Brown and Lee, 2002) calculated uncompensated elasticities by Rotterdam model and got -0.524 for Apples, and it was complemented with other fruits which are Orange, Grapes, Banana, and Grapefruits.

Table 12. Hicksian (Compensated) Price Elasticities of Demand

	Starking Delicious	Golden	Gala	Granny Smith	Fuji
Starking Delicious	-1.462	-0.107	0.177	0.726	1.366
Golden	-0.139	-0.127	0.231	0.021	-0.397
Gala	1.768	1.482	-1.143	0.865	1.427
Granny Smith	1.064	0.049	1.757	-0.981	-0.383
Fuji	1.602	-1.642	1.480	-2.316	-1.261

Table 12 shows the Hicksian (Compensated) price elasticities by the Rotterdam model. The main diagonal, which is highlighted on the table, is showing own-price elasticities of each variety. The results of compensated elasticities also have fulfilled negatively for all varieties for own-price elasticities. The compensated elasticities have fewer absolute terms comparing the uncompensated elasticities in terms of offsetting effect of changes in real income in compensated approach (Anwar and Friends, 2012). For Hicksian own- price elasticities, Golden (-0.127) and Granny Smith (-0.981) are calculated as least price responsive. Also, Starking Delicious, Gala and Fuji have higher own-price elasticity with -1.462, -1.261, -1.143, respectively. For cross-price elasticities, Starking Delicious has a strong substitute with Fuji (1.366), Granny Smith (0.726) and it has weak substitute with Gala (0.177), but Starking has complemented with only Golden (-0.107). Following the same purpose, while Golden has substituted with Gala (0.231) and Granny Smith (0.021) which is very weak, it has complemented with Starking Delicious (-0.139). Then, Gala has a relationship with other varieties as a substitution. Likewise, except Fuji (-0.383), Granny Smith also has substituted with others. Lastly, Fuji has two substitutions which are Starking Delicious (1.602) and

Gala (1.480) and two complements with Granny Smith (-2.316) and Golden (-1.642). These results have similar elasticities with the study of Anwar and Friends, 2012. They found own-price elasticity for Hicksian elasticity -0.858 for Apples and Apples has substituted with Mango (0.572) as Marshallian elasticity. Also, research of Brown and Lee, 2002 is consistent compensated elasticities with our results.

CHAPTER SIX: CONCLUSION

This study compares demand estimation systems for apple varieties which are Starking Delicious, Golden, Gala, Granny Smith, and Fuji in Turkey by prices and expenditures on consumer demand in terms of almost ideal demand system (AIDS) and the Rotterdam Model. For this purpose, publicly available data was used from the Isparta Commodity Exchange in Turkey in 2015, 2016 and 2017 as monthly observation and focused on the Isparta region, which is the most important apple producer city in Turkey. It is hoped that the results which have obtained may assist people who have interest to this topic are such as producers, retailers, and policymakers to plan future strategies. We reached different results for AIDS and the Rotterdam model. The elasticity results show that excepting Golden, the uncompensated own-price elasticities of the Rotterdam model are much larger than the uncompensated own-price elasticities of AIDS. While the Rotterdam model uncompensated own-price elasticities are Starking Delicious (-1.813), Golden (-0.105), Gala (-1.631), Granny Smith (-1.142), and Fuji (-1.822), the uncompensated own-price elasticities of AIDS model are Starking Delicious (-0.74295), Golden (-0.62557), Gala (-0.16433), Granny Smith (-0.18415), and Fuji (-1.69536). Most of the uncompensated own-price elasticities are also larger than uncompensated cross-price elasticities both AIDS and the Rotterdam model. It indicates that consumers who prefer to buy apples more sensitive to the uncompensated own-price changes of apple varieties.

For compensated own-price elasticities, AIDS and the Rotterdam model have a little different from uncompensated own-price elasticities. Excepting Golden and Fuji, compensated own-price elasticities of the AIDS model are lower than the Rotterdam model. While the AIDS compensated own-price elasticities are Starking Delicious (-0.23161), Golden (-0.33224), Gala (-0.15173), Granny Smith (-0.04138), and Fuji (-1.65543), the compensated own-price elasticities of the Rotterdam model are Starking Delicious (-1.462), Golden (-0.127), Gala (-1.143), Granny Smith (-0.981), and Fuji (-1.261). Also, although the all own-price elasticities of the Rotterdam model are lower than 1, the all own-price elasticities of the AIDS model are between -1 and 0 except Fuji. It explains that for the Rotterdam, the demand for each variable is relatively elastic which mean small change in price will lead to a relatively large change in quantity. However, for AIDS, the demand for each variable is relatively inelastic which mean that large change in price will cause a relatively small change in quantity. For compensated and uncompensated elasticities, our paper is consistent with Lin et al., (2009), Richards and Patterson (2000), and Li (2013) for the AIDS model. For the Rotterdam model, our results are also consistent with Brown and Lee (2002) and Anwar et al., (2012).

Looking at the expenditure elasticities for apples there is a significant impact on the demand of five apple varieties. According to AIDS estimation results, the five apple varieties are all normal goods, Starking Delicious (1.2367298), Golden (1.0456662), Gala (0.2073784), Granny Smith (0.8391190), and Fuji (0.5320023). However, for the Rotterdam estimation results, two varieties out of five are inferior goods, Starking Delicious (0.51), Golden (-0.619), Gala (-0.732), Granny Smith (2.946), and Fuji (1.055). The paper of Li (2013) focused on the U.S apple varieties by AIDS model and it had also similar expenditure elasticity with our paper because all varieties were normal goods as well. However, Anwar et al., (2012) used the Rotterdam model to get demand estimation of major foods in Pakistan and they found that all major foods were also normal good that is not similar with our results because we found that two varieties of apple are inferior good by the Rotterdam model.

According to the obtained results, it is observed that this is an interesting distribution structure on Turkey's apple. For this purpose, the causes of this difference should be investigated, and the main apple varieties demanded by the consumers should be determined. Again, in this context, consumers should be informed about apple varieties, the characteristics of apples and what kinds of purpose they are.

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APPENDIX

FIT DIAGNOSTICS FOR THE ROTTERDAM MODEL

For the Rotterdam Model, SAS give us excellent graphs to see residual and distribution of observations of each equation for estimation. For each equation, we separated one page to avoid confusion which is relating to figures.

Figure 3: Fit Diagnostics for Equation 1 of the Rotterdam Model

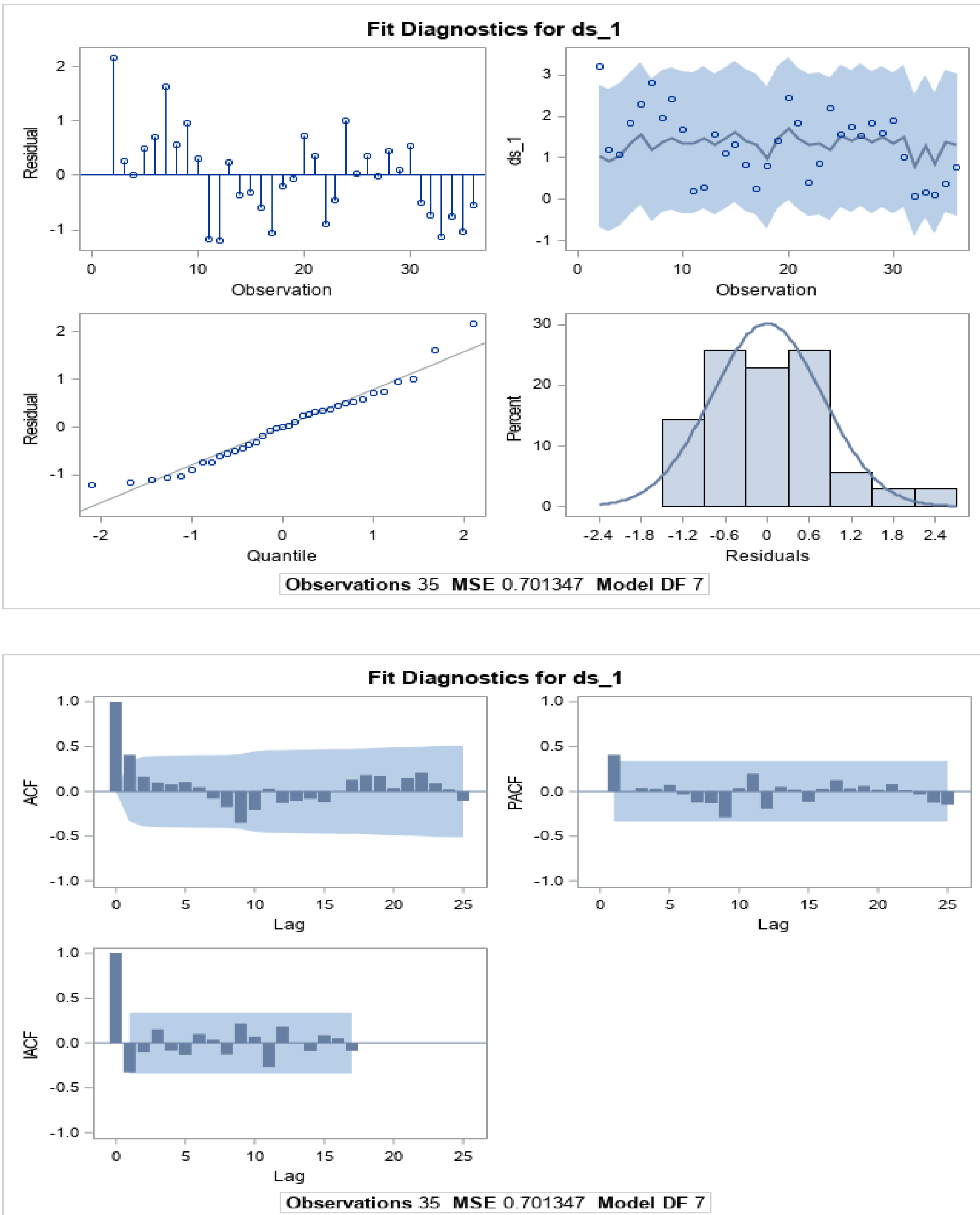
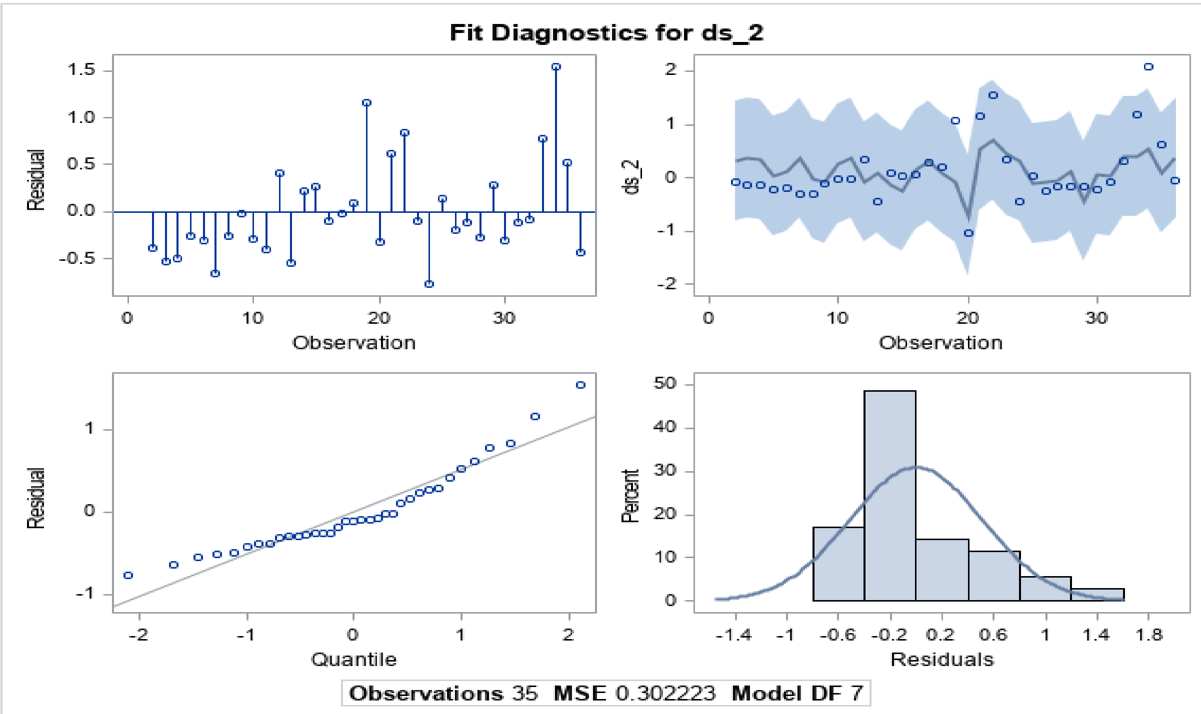


Figure 4: Fit Diagnostics for Equation 2 of the Rotterdam Model



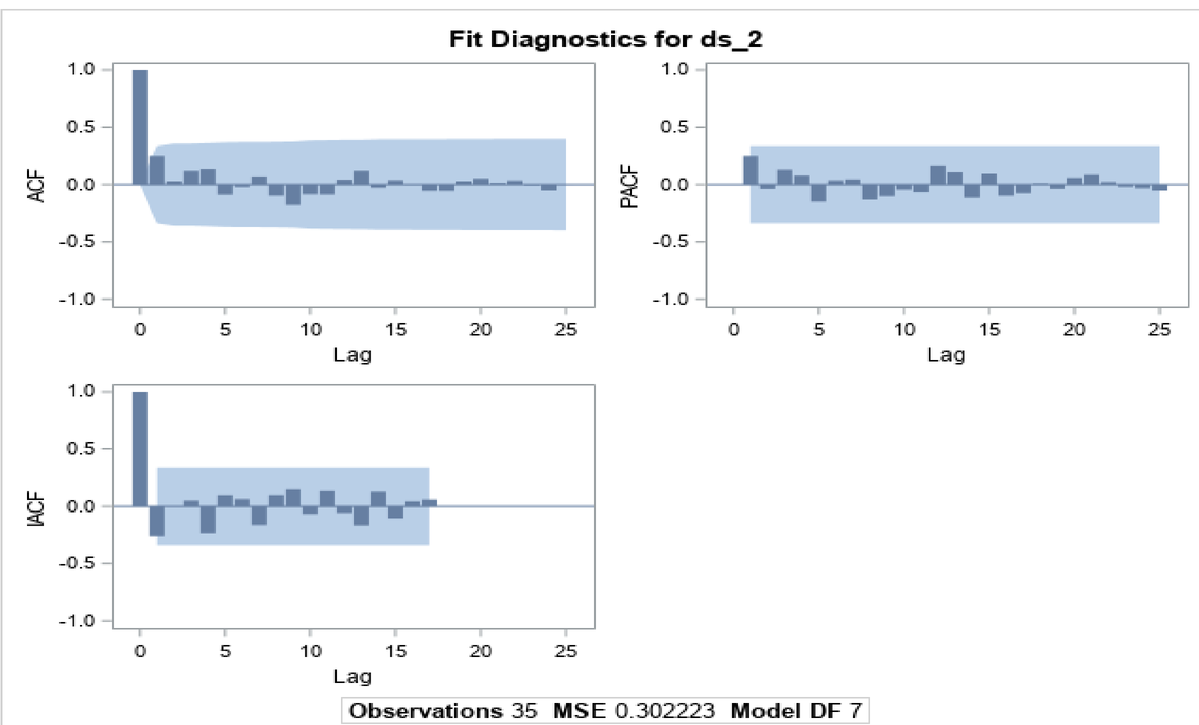


Figure 5: Fit Diagnostics for Equation 3 of the Rotterdam Model

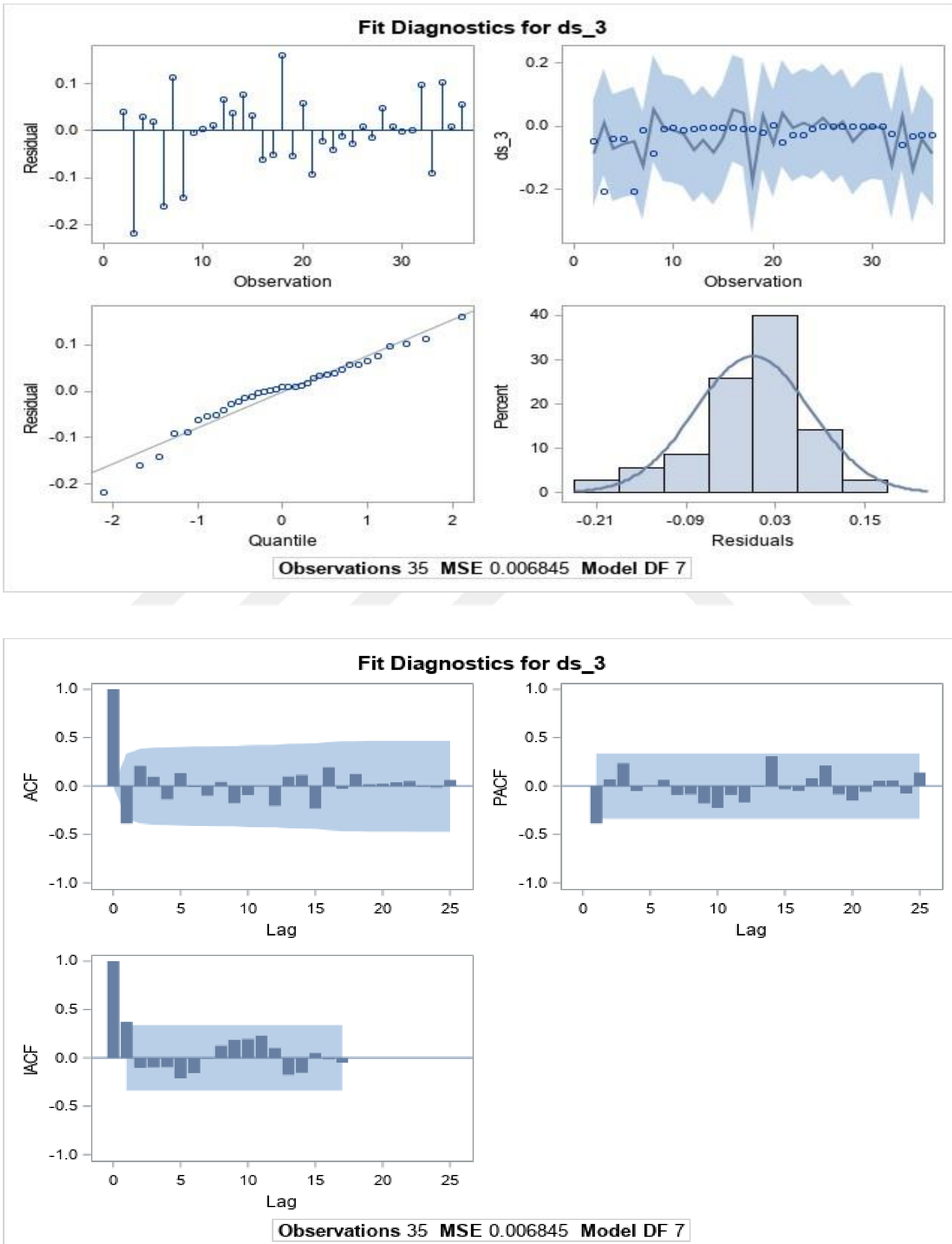
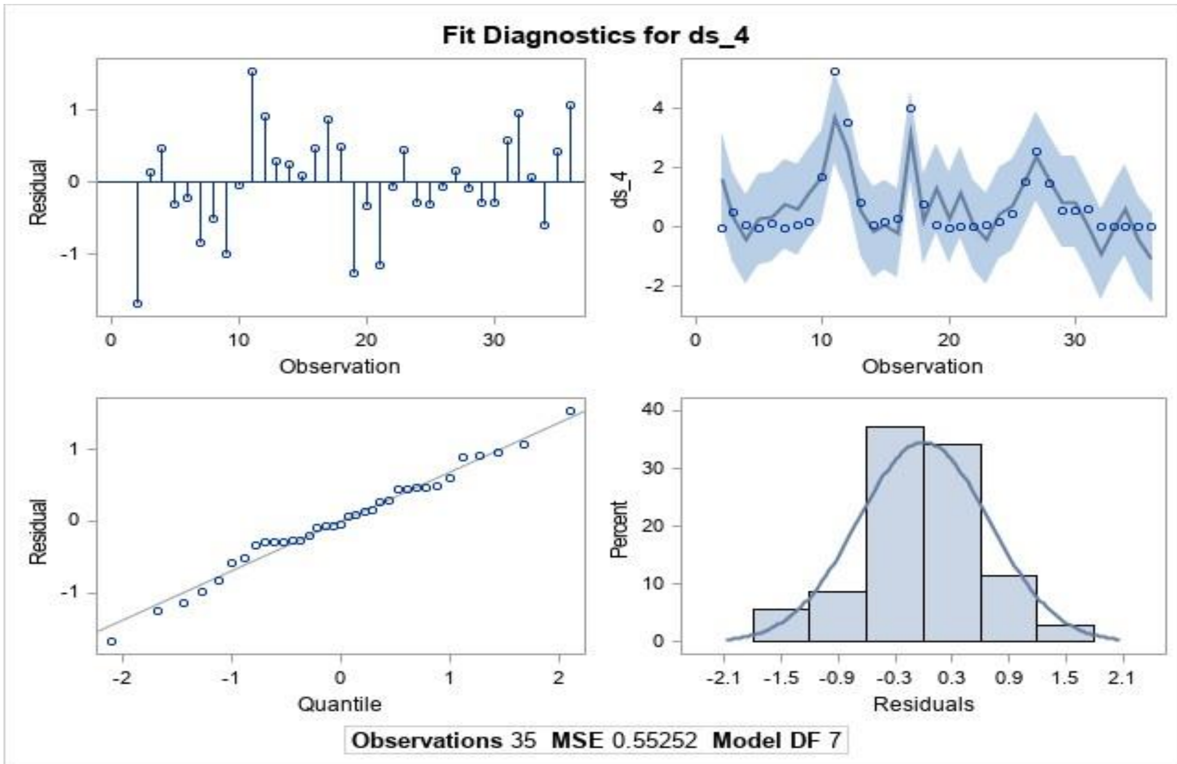


Figure 6: Fit Diagnostics for Equation 4 of the Rotterdam Model



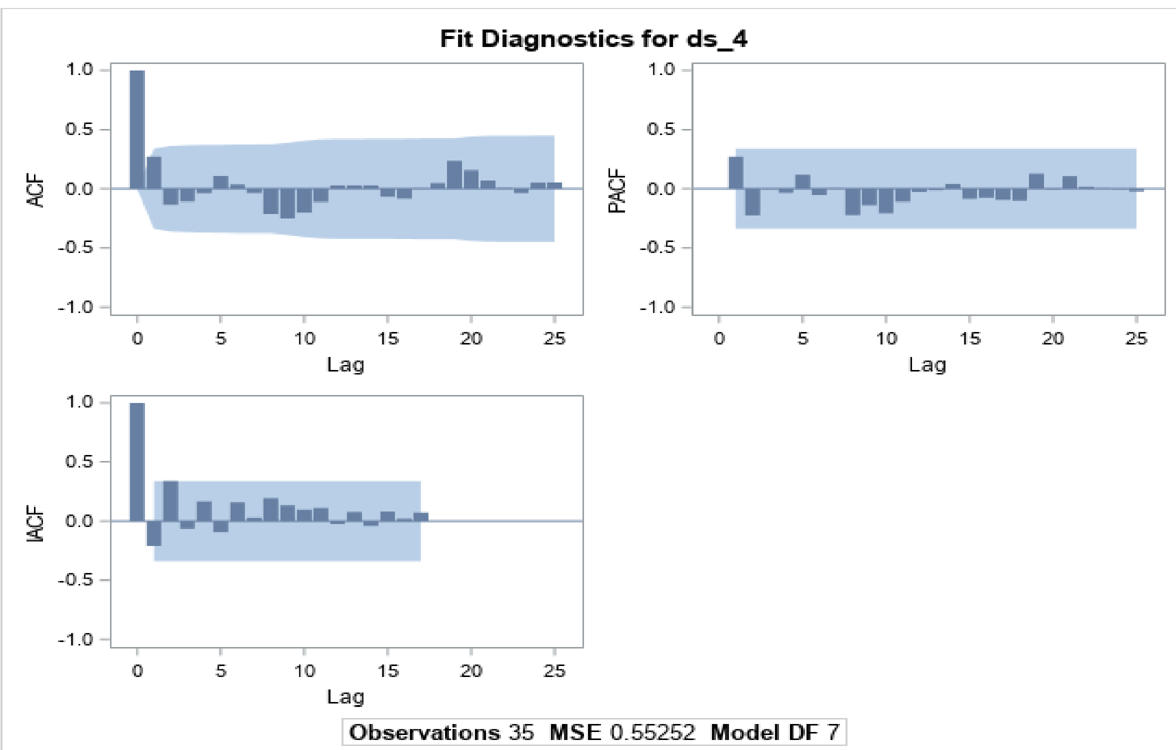


Figure 7: Fit Diagnostics for Equation 5 of the Rotterdam Model