U.S. FRESH FRUIT IMPORT MARKET DEMAND ANALYSIS:

IMPORT ELASTICITIES AND SEASONALITY

A Thesis

by

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ABSTRACT

U.S. has consistently been the net importer of fresh fruit over decades. Studies suggest that the demand for fresh fruit will continue to increase because of the globalization of markets and U.S. policies. However, the structure of the import mix has changed dramatically, between 1990-92 and 2010-12. The striking changes of value share are apparently caused mainly by the preference change of consumers, further elasticity estimates, as the indicator of consumers' preference for most fresh fruits, are outdated and or nonexistent. Outdated import elasticities will cause problems in estimating the quantity changes, since the incomes and market fundamentals may have already changed. Seasonality is an import characteristic for the fruit market, the analysis of seasonality could help producers and market managers identify the market competition and opportunities. The seasonality change is analyzed mainly based on five-year monthly average of domestic production and imports amount between1990-94 and 2010-14. Import elasticities are estimated based on a Nonlinear AIDS model. Through the seasonality analysis, we find the domestic production season had no significant change between 1990-94 and 2010-14, whereas, the import window expanded its length. Imports had no significant sign to compete with domestic production during domestic production season, on the contrary, imports have supplemented domestic production during off-season to meet increased U.S. demand. The estimation results show that the imported fruits are also priced inelastic at market level. Imported grapes are the only luxury good (relative to their expenditure elasticities). When expenditures increase,

people prefer more imported grapes and less imported apples. Issues of endogeneity and import versus domestic elasticities are identified but left for future research.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to all my committee members: Prof. David Bessler, Prof. Marco A Palma, Prof Ximing Wu. I learned how to do the research from the methodology class taught by Prof. Bessler. It gives me a new perspective to look at what I am doing and what I am going to do. His guidance will always help me in doing research. Because of the kind help from Prof. Palma, I have a chance to join his weekly research meeting and exhibit my thesis idea to others. Also, I need to thank Prof. Palma to invite me to have dinner at his home. It was an unforgettable night. Prof. Wu taught me econometrics in his class, which helped me a lot in understanding the model.

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CHAPTER I

INTRODUCTION

U.S. consumers have benefited from the year-round availability of fresh fruit, particularly since the 1990s. Fresh fruit imports have risen from $1.68 billion per year in 1990-92 to $6.89 billion per year in 2010-2012 in nominal dollars. These imports contribute to making up the off-season fruit shortage, providing varieties that differ from domestically produced, lowering the fruit price in domestic markets and smooth out price fluctuation(Huang, S. W. 2013). The main suppliers in U.S import market are banana-exporting countries, the Southern Hemisphere, and NAFTA regions, which roughly account for 36 percent, 32 percent, and 27 percent of U.S. fresh fruit import market value, respectively(Huang, S. W. and K. S. Huang 2007). The rapid growth is attributed to the following main factors: (1) increasing consumer income, people could spend more money on fresh fruits (2) government policies; to promote a healthy diet, Dietary Guidelines for Americans was issued every five years to encourage Americans to consumer more fresh fruits. For import policies, the most significant policy is the North American Free Trade Agreement (NAFTA) eliminated the trade barriers and promoted the fresh fruit import dramatically. An additional factor contributing to growth in fruit trade is (3) Industry promotion programs. Fruit industry associations promote the consumption of fruits, such as avocados, blueberries, mangoes, by education of consumers about the nutrition facts and provision of recommendations to add certain fruits into daily diet. Further factor contributing to fruit import growth include: (4) The increasing size and diversity of ethnic population, such as Asians, Africans, Caribbean

islanders, and Hispanics are prefer to consume more tropical produce meals and (5) The improvement of techniques, technological innovation to increase the production, lengthen the production season and enable the fresh fruits to be shipped globally with high quality at affordable prices (Huang and Huang 2007, Nzaku, K., et al. 2010, Knutson, R. D., et al. 2014).

U.S. has consistently been the net importer of fresh fruit over decades Palma, M. A., et al. 2013) and the demand will continue to increase because of the globalization of markets and U.S. policies (Knutson, R. D., et al. 2014). However, the structure of the import mix has changed dramatically, between 1990-92 and 2010-12 (Huang, S. W. 2013). Even though bananas as the most popular fruit still ranks at the top in U.S. fresh fruit import market, their value share shrank from nearly 60 percent to around 28 percent, the value market of apples, as the second most popular fruit also declined significantly, but other tropical fruits, berries, avocados and citrus all increased their value shares dramatically (Huang, S. W. and K. S. Huang 2007, Huang, S. W. 2013). In our study, we focus on five major fresh fruit imports-bananas, grapes, avocados, oranges, strawberries, and apples. We select these fruits because they account for almost two-thirds of the total value of fresh imports and they also represent all the general categories of fresh fruit- tropical , citrus, and non-citrus (Huang, S. W. 2013).

CHAPTER II

LITERATURE REVIEW ABOUT FRESH FRUITS ELASTICITIES

The striking changes of value shares are caused mainly by the preference change of consumers, whereas elasticity as the indicator of consumers' preference for most fresh fruits are outdated and or nonexistent (Seale Jr, J. L., et al. 2013). Outdated elasticities will cause problems in estimating the quantity changes since incomes and markets have already changed (Knutson, R. D., et al. 2014).

Durham, C. and J. Eales (2010) collected fresh fruit elasticities from 16 previous studies, of which 10 of these estimated the elasticities of fresh fruit as an aggregate commodity and nine sources calculated individual fruit elasticities. For fresh fruit as aggregate commodity, the average own price elasticity was -0.66, the minimum was -1.32, the maximum was -0.21. For apples, the elasticities were -0.33, -0.72, -0.16, respectively. For bananas, they were-0.46, -0.74 -0.24. For oranges, they were -0.79, -1.14, -0.27. They found that fresh fruit was price inelastic at the market level, their estimates of elasticities based on the retail level were greater than previous results (previous papers). Hoch, S. J., et al. (1995) found the own price elasticity in a Chicago grocery chain was also elastic. Herrmann, R. (1998) mentioned that price-inelastic demand was not necessary at the retail level because of high price competition between retailers. You, Z., et al. (1996) and Huang, K. S. and B.-H. Lin (2000) showed that fresh grapes and other import fresh fruit were found to be luxury goods, Nzaku, K., et al. (2010), (Nzaku, K., et al. 2011) used the AIDS (Almost Ideal Demand System) model

incorporating seasonality, trend and NAFTA binary variables to analyze the import demand for tropical fresh fruit and vegetable imports, and found that banana, import grapes and other fruit imports were complementary; banana budget share had significant downward trend but other tropical fruits had positive trend; the seasonality for tropical fruit and vegetable was significant. Baldwin, K. L. and K. G. Jones (2013) also analyzed seasonality and substitution of U.S. citrus import demand based on nonlinear AIDS model incorporating seasonal components and trend.

CHAPTER III

THEORETICAL MODEL

The almost ideal demand system is one of the most popular model in demand analysis proposed by Deaton, A. and J. Muellbauer (1980), in which the expenditure shares as the dependent variables is a function of price and the related food expenditures as:

$$W_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{P}\right)$$

Where W_i is the expenditure share associated with banana, orange, apple, strawberry, avocado, and table grape; $\propto_i$ is subsistence consumption share for ith good; p_i is the price for imported fruit i; X is the total expenditure on all imported fresh fruits we study; and P is the translog price index, which we defined as:

$$\ln(P) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln(p_i) + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij}^{*} \ln(p_i) \ln(p_j).$$

$\alpha_i, \beta_i,$ and γ_{ij} are coefficients to be estimated and $\gamma_{ij} = (\gamma_{ij}^{*} + \gamma_{ji}^{*})/2$.

Each γ_{ij} represents 10^2 times the effect on the ith budget share of a 1 percent change of p_j with (x/p) held constant. β_i represents the change of the ith budget share with respect to real expenditure with prices remain constant. If $\beta_i > 0$, the commodity is considered to be a luxury good, if $\beta_i < 0$, the commodity is considered to be a necessity. If $\gamma_{ij} > 0$, goods i and j are substitutes, if $\gamma_{ij} < 0$, they are complements (Deaton, A. and J. Muellbauer 1980).

The following constrains should be applied to guarantee the model is consistent with consumer demand theory:

$\sum \propto_i = 1,\ \sum_{i=1}^{n} \gamma_{ij} = 0, \text{and } \sum \beta_i = 0$ (adding-up property);

$\sum_{j=1}^{n} \gamma_{ij} = 0$ (Homogeneity)

$\gamma_{ij} = \gamma_{ji}$ (Symmetry)

One of the main reason for its popularity is that a linear price index could be applied to the model to replace the nonlinear form index. The Stone price index was introduced suggested by Deaton, A. and J. Muellbauer (1980), which is defined as:

$$\ln(p) = \sum_{i=1}^{n} W_i \ln p_i$$

The linear AIDS model has been used extensively and it was more frequently used than nonlinear form in many previous works. The linear AIDS model is actually an approximation to the nonlinear model but not derived from a well specified representation of preferences. The problem using linear AIDS is that Stone index is not the real index which should satisfy a fundamental property of index numbers. So approximation properties may be seriously affected by the fact that the Stone price is not invariant to the changes in the units of measurement of prices (Moschini, G. 1995). Therefore, to avoid this problem, the nonlinear AIDS model will be applied in our work.

Arnade, C. and D. Pick (1998) extend their model to incorporate seasonality. The seasonality could be represented by a variable that consists of interaction term between a trend variable and a trigonometric variable. The interaction terms could be created for every frequency and can be used as an exogenous variable in economic model. Arnade, C., et al. (2005) incorporate seasonality components above in AIDS model. So the final model is defined as:

$$W_i = \propto_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{P}\right) + \sum_{u=1}^{4} a_{1iu} f_u + \sum_{v=1}^{4} a_{2iv} g_v + a_{3i} t$$

f_u and g_v are seasonal functions defined as $f_u = \cos(\left(\frac{u}{z}\right)\pi t)$ and

$g_v = \sin(\left(\frac{v}{z}\right)\pi t)$, t coincides with the observation number, z=s/2 where s is the frequency of the data, since we are using monthly data, s=12, u and v represent different seasonal frequencies of the data, for example if u and v equal 3, then there is three seasonal cycles in a year.

Since the sum of expenditure is 1, the coefficients of seasonality and trend also have to satisfy the following condition:

$\sum_{i=1}^{n} a_{1i} = 0, \sum_{i=1}^{n} a_{2i} = 0, \sum_{i=1}^{n} a_{3i} = 0.$

The AIDS model implies that Marshallian price elasticity for good i with respect to good j is

$$\epsilon_{ij}^{M} = \frac{\gamma_{ij} - \beta_i(w_i - \beta_j \ln\left(\frac{X}{P}\right))}{w_i} - \delta_{ij}$$

Where $\delta_{ij} = 1$ if i=j, $\delta_{ij} = 0$ otherwise.

Expenditure elasticity is given by

$$e_i = \frac{\beta_i}{w_i} + 1$$

Marshallian elasticities could be transformed into Hicksian elasticities through the Slutsky equation.

$$\epsilon_{ij}^{H} = \epsilon_{ij}^{M} + w_i * e_i$$

Below we estimate Import Elasticities. This is somewhat at variance with standard elasticity estimation, where one looks at both imports and domestic production. So our study provides import elasticities. Our reason for taking this (admittedly non-standard approach) is that we wanted to focus just on imports and not add the complication of domestic production. Further research might well look at both imports and domestic production as separate goods, similar to the approach taken by Armington-like demand systems (Armington, P. S. 1969). This would have given us a 12 commodity study, which, while certainly doable, was deemed beyond the scope of the MS Thesis.

CHAPTER IV

DATA AND METHOD

We will use the monthly import price, import quantities and domestic quantities for banana, apple, orange, strawberry, avocado, and grapes between 1990 and 2014 from U.S. Department of Commerce, U.S. census Bureau, Foreign Trade and ERS calculations using census trade statistic. The expenditure share for each good will be calculated by the import price and quantity, the price for each good will be divided by its price mean to get mean scaled price data (Goodwin, B. 2008). Since the sum of the expenditure share is 1, one of the share equations is deleted to avoid the singularity, we will drop the banana share equation (Actually it does not matter which one will be eliminated, we can recover the parameters by adding up property). The nonlinear AIDs model will be estimated by applying the MODEL procedure and the econometric method of ITSUR (iterated seemingly unrelated regression) in SAS computer program (Goodwin, B. 2008). Then the import elasticities will be calculated at the mean value of the observation based on the formulas above. Since we only focus on the import market, all the import elasticities we calculate are import elasticities. The seasonality change will be analyzed mainly based on five-year monthly average of domestic production and imports between1990-94 and 2010-14, simple graphs will apply in my analysis. Since the production of banana in U.S is very trivial, we do not report the graph analysis for banana.

CHAPTER V

SEASONALITY ANALYSIS AND RESULTS

Banana

Banana has always been the top import fresh in U.S import market for decades, the amount of consumption increased from 7 pounds per person in 1970 to 10.4 pounds in 2010. However, US banana production is very limited, which is mainly from Hawaii and Florida, only accounting for 0.01% of the total world production. Even though banana remains the top position in import market value over decades, its import market share declined dramatically from nearly 60% in 1990-92 to 28.3% in 2010-12, which is caused by consumers shifting their fruit expenditure from bananas to other fresh fruits (Evans, E. and F. Ballen 2010, Huang, S. W. 2013).

Figure 1. Seasonal shipment relationships for domestic and import apple between 1990-94 and 2010-14

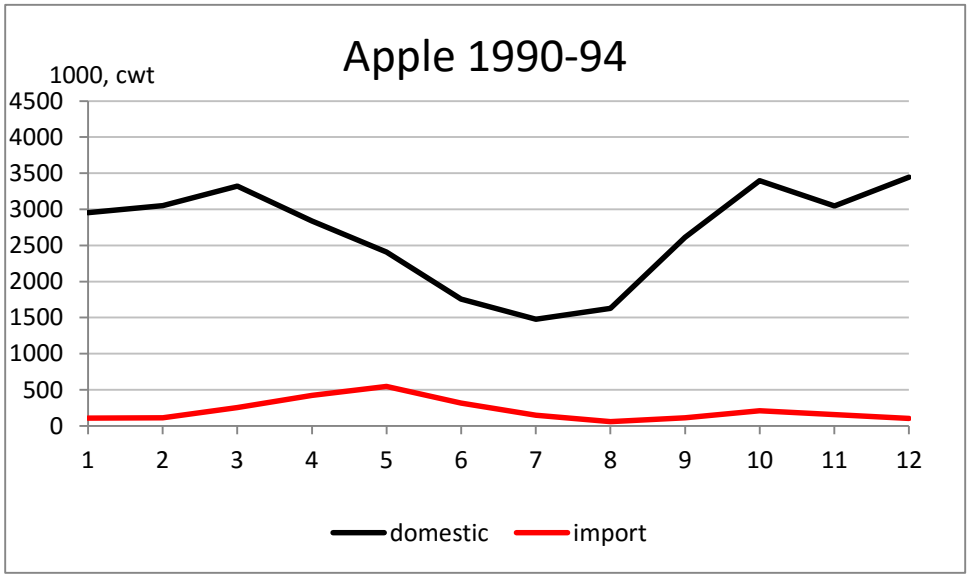
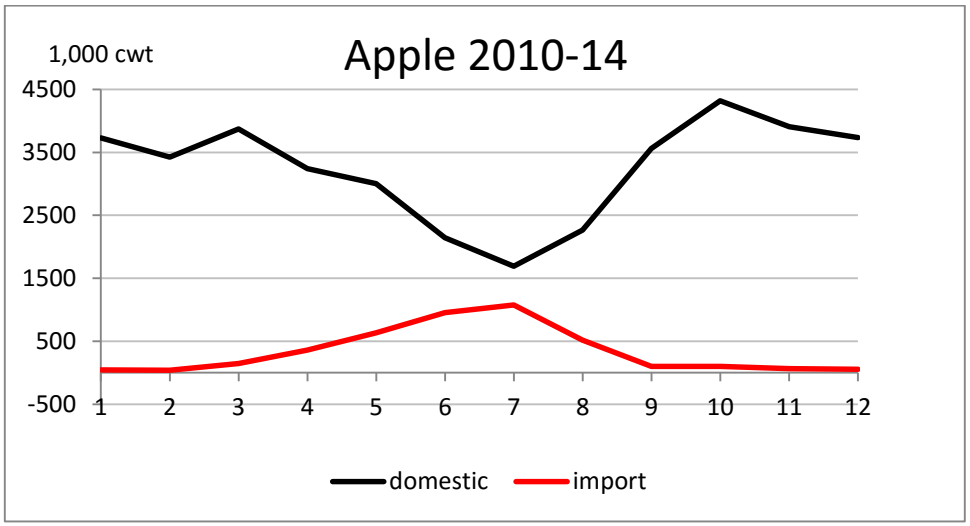


Figure 1 Continued

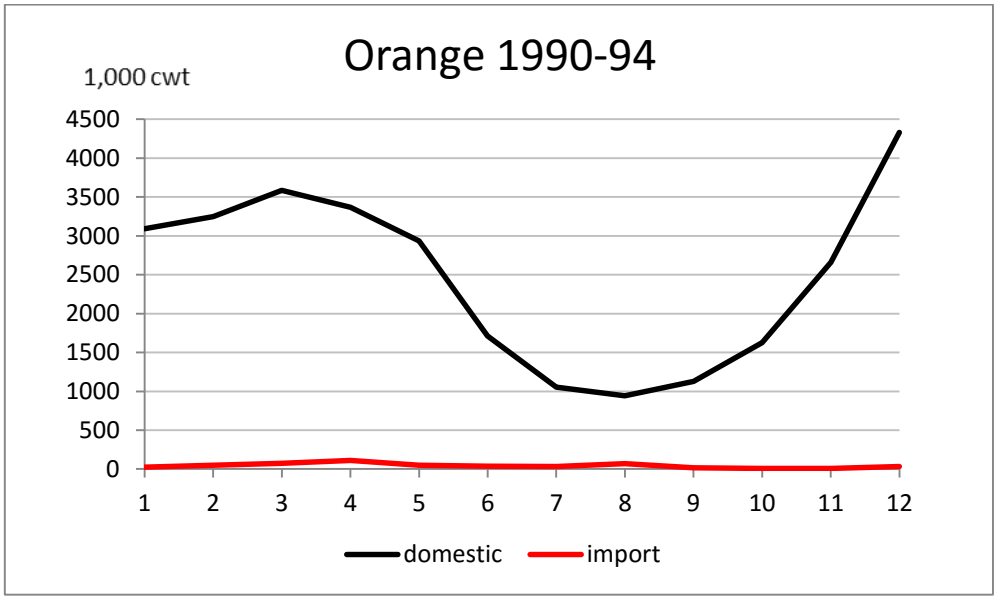


Apple

United States is the world second largest apple producing and exporting country following China. It also one of the world's largest importing countries, which is primarily caused by the demand of off-season and specific varieties. Apple could produce commercially in 36 states, however, Washington alone accounts for almost 60 percent of total production in United States. In U.S.15 most popular varieties take up around 90% percent of domestic production, among which Red Delicious as the traditional variety keep occupying the top position over decades. However, the market value of Red Delicious was decreasing gradually since 1990s. Consumers' preference continued to shift away from Red Delicious to other varieties, especially for Fuji and Gala. The main production season for United States is fall and winter. As we can see from the Figure 1, the total annual domestic fresh production increased between 1990-94 and 2010-14, and the maximum domestic shipment increased almost 1000 (1000 cwt).

While, the consumer demand in spring and summer are satisfied primarily by importing from southern Hemisphere. Chile as the top and counter season supplier in U.S. apple import market accounts for almost 60 percent of market value, and Canada, while as the year around supplier, accounts for nearly 20 percent of import market share. The import maximum shipment point shifted from May to July and the maximum shipment amount doubled between 1990-94 and 2010-14. (Lynch, B. 2010, Huang, S. W. 2013).

Figure 2. Seasonal shipment relationships for domestic and import orange between 1990-94 and 2010-14.



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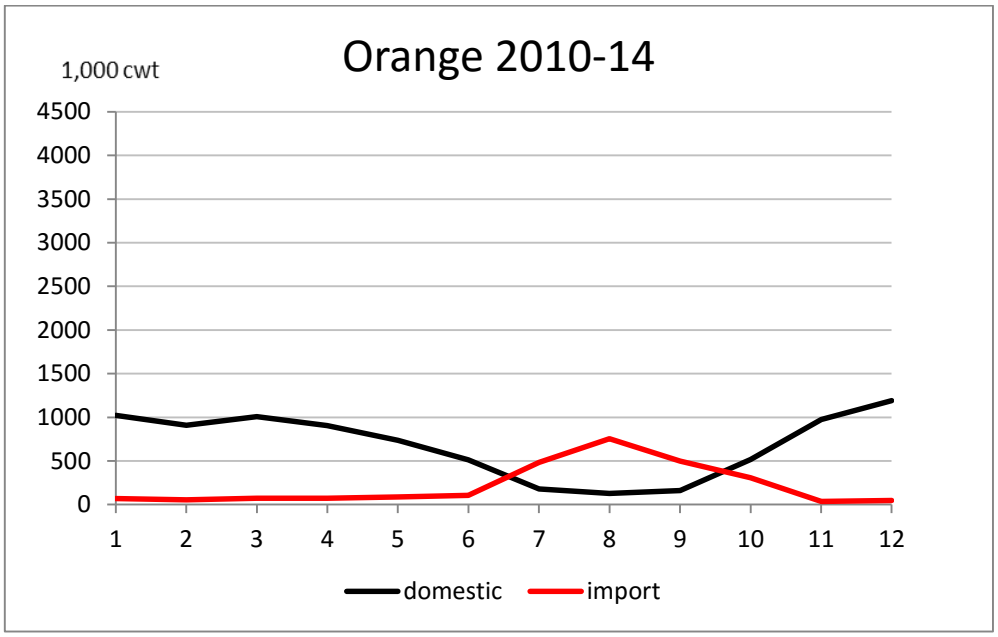


Orange

U.S is the second-largest orange producer in the world, but the majority of oranges production are processed into juice, not for fresh use. Consumer prefer orange juice because of its convenience and year-round availability over fresh orange (Pollack, S. L., et al. 2003). Florida has more than 70 percent of domestic production but few of them go to the fresh market. California's orange dominates the fresh used orange market with around 85 percent of domestic produced fresh orange. Despite the domestic production has been static since 1980, per capital consumption of fresh orange has dropped almost 24 percent over decades, which is caused largely by consumer preference shifts to more convenient and easy- to-consume fruits and also the greater availability of different fresh fruits in the marketplace(Huang, S. W. 2013). In Figure 2, we can see the fresh used

orange shipment decreased dramatically between1990-94 and 2010-14, since most of orange were processed to juice. The domestic production seasonality does not change much over decades, which is from November through May and the main fresh orange imports starts from Jun, peak on August, and end on November. The main suppliers for U.S. orange market are South Africa, Chile, Mexico, and Australia. In 1990-94, fresh orange imports amount was almost zero, but in 2010-14, the orange import amount became significant. The imports is increasing largely because of seasonal shortage, even though the import oranges only accounts relatively small portion of domestic production. The import peaks on July following by California navel season and ends when Florida early-season varieties begins.

Figure 3. Seasonal shipment relationships for domestic and import grape between 1990-94 and 2010-14.

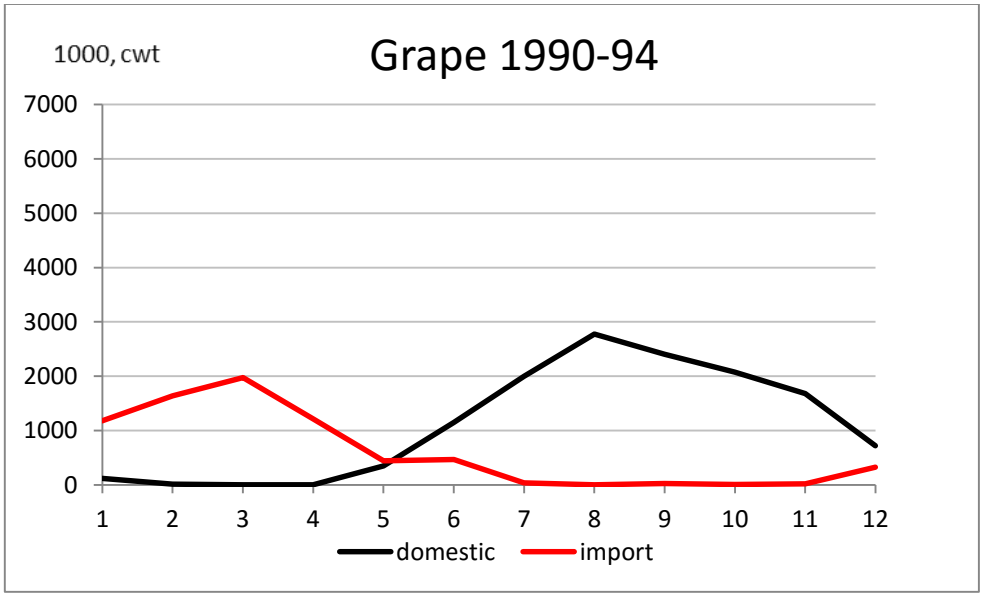
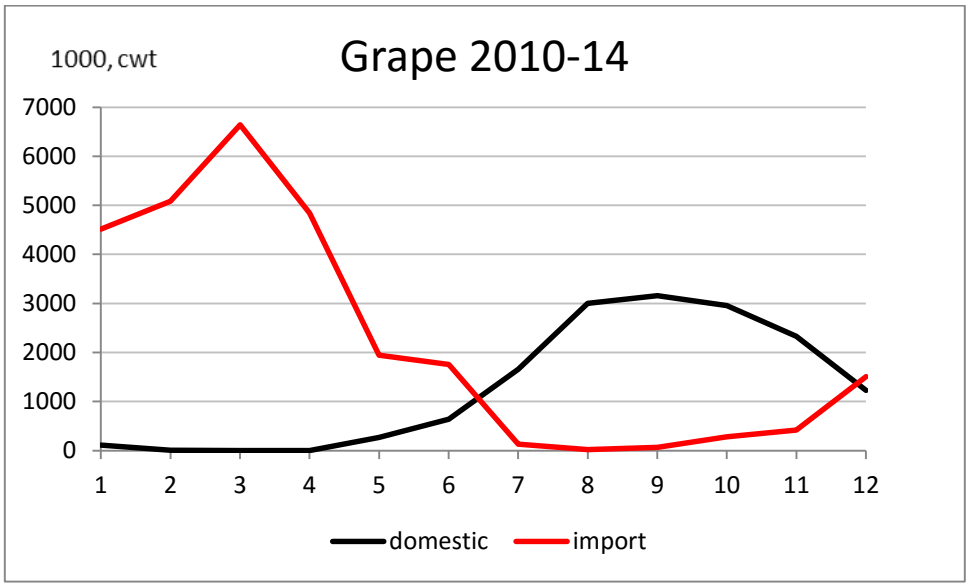


Figure 3 Continued

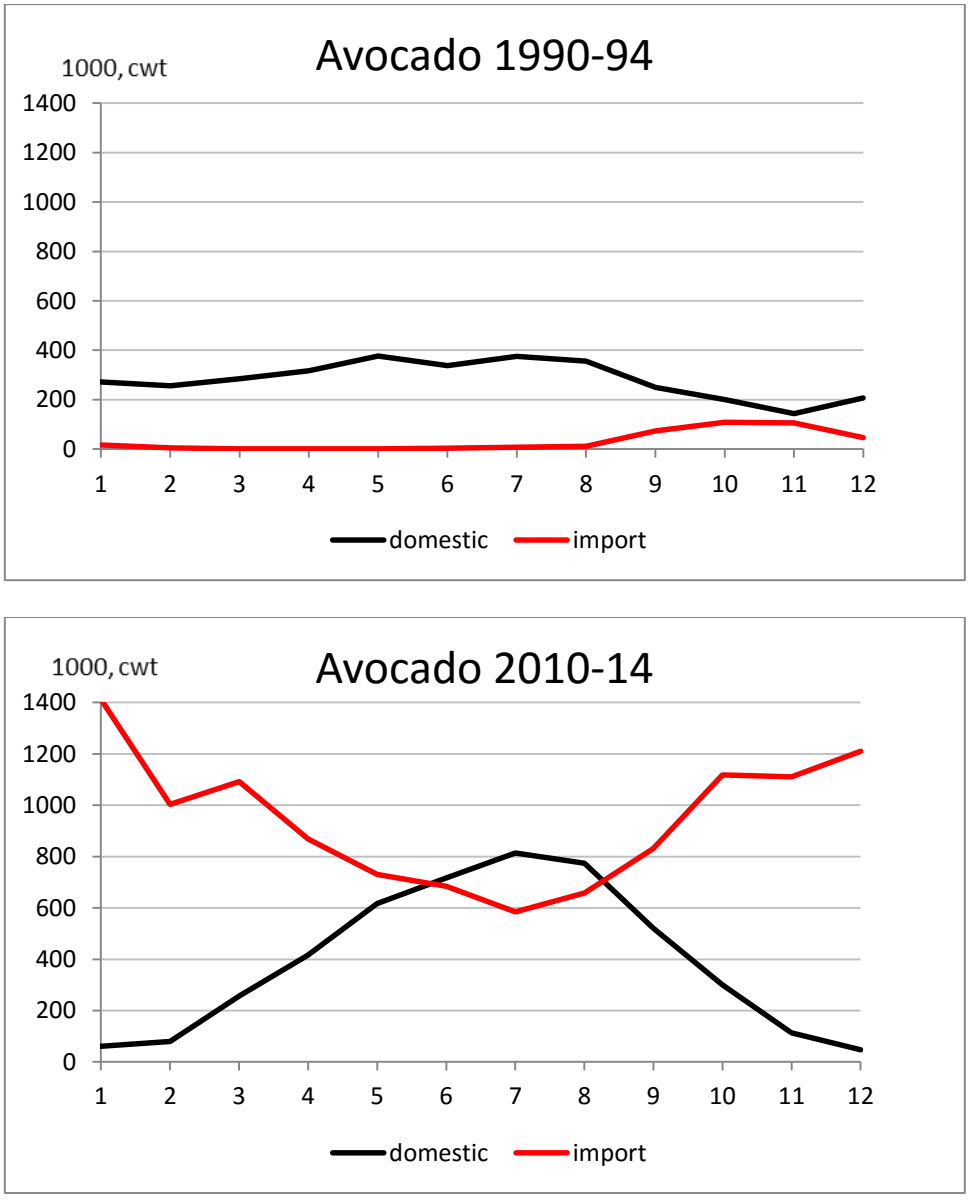


Grape

U.S. is also the biggest importer in the world because of the off-season demand. Between 1990-94 and 2010-14, domestic grapes production almost remain the same level, but import grapes increased significantly with roughly 70 percent, as we can see from the Figure 3, the maximum import shipment on March almost tripled. Domestic season for grapes is from May through December, so more than 90% of import fresh grapes enter U.S market in the winter and spring. However, the winter import window expanded to September from November in 2010-14. Chile and Mexico almost dominate import market totally accounting for 98 percent of imported table grapes(Huang, S. W. 2013), Chile dominates U.S. fresh grape market from January through April, peaking in March and effectively ending by July. Southeastern California starts to provide a limited

amount of fresh grapes in May and June, at this time, Mexico shipments enter the market and end before the largest volume of domestic grapes from central California.

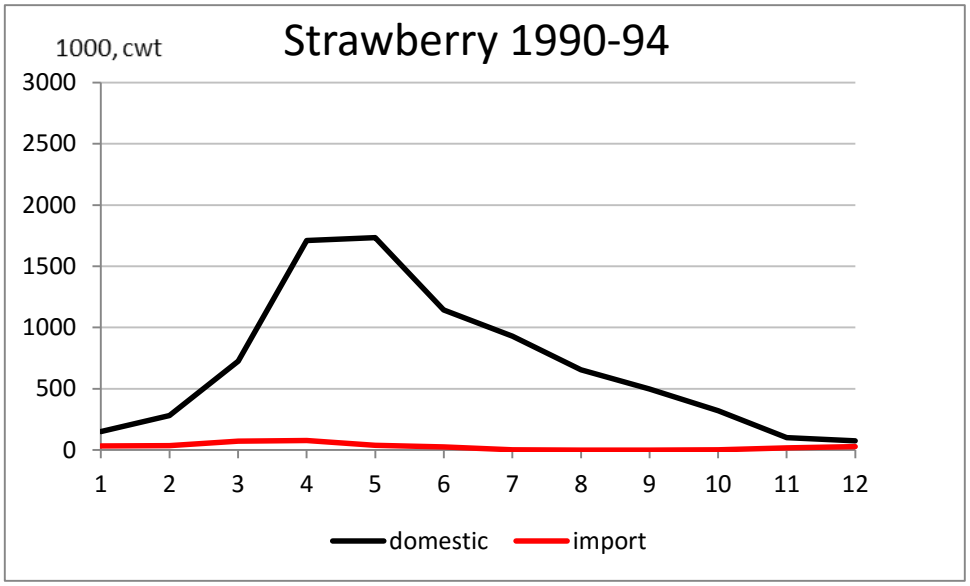
Figure 4. Seasonal shipment relationships for domestic and import avocado between 1990-94 and 2010-14.

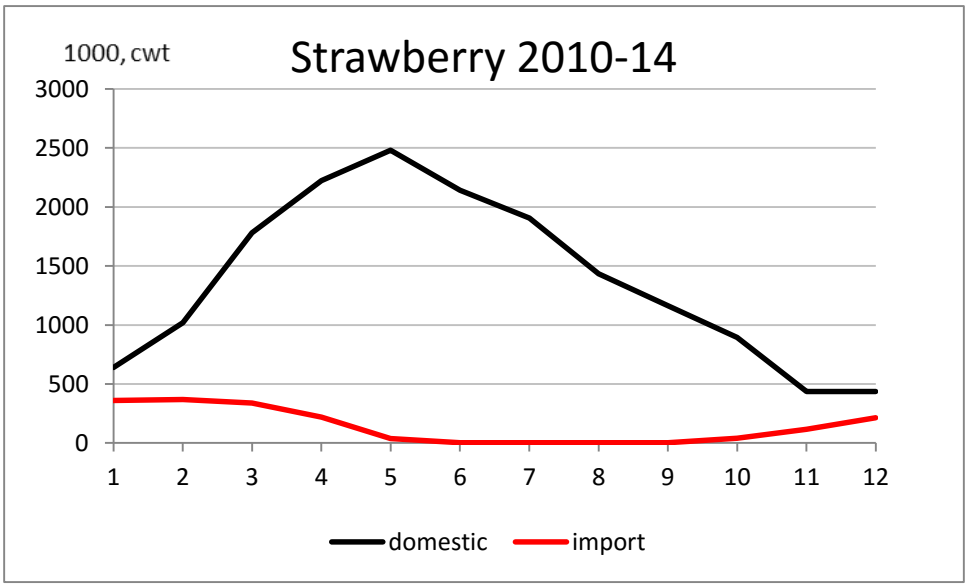


Avocado

Since all the import barriers of avocado were eliminated in 2007, U.S then became the world largest importer. U.S domestic production is mainly from California and Florida because of avocado growing climate. Avocados from California account for almost 90 percent of total domestic production. Avocados could produce year-round in U.S, but the main season is from April to September. Chile once used to be the largest supplier in U.S avocado market before 2005, but after Mexico entered U.S market, the market share of Chile shrank to almost 14 percent. While, Mexico as the world's leading avocados producer and exporter can supply U.S market year-round, which accounts for almost 80 percent market value recently. The main import season centers in October through March, to avoid the domestic production season. In 1990-94, the import period was from September to October, however, the import period became year-round in 2010-14. U.S imported avocado even in domestic production season. As we can see from the Figure 4, both import and domestic shipments increased dramatically between 1990-94 and 2010-14. The Average annual avocado import amount for U.S. increased almost 2,214 percent since 1990, reaching about 420,954 metric tons in 2010-12 (Huang, S. W. 2013). The demand of avocado in U.S increased dramatically over years, but the domestic production even could not satisfy the increased demand. The increased demand mainly attributed to avocado industry-funded program, these program significantly promoted the consumption of avocado.

Figure 5. Seasonal shipment relationships for domestic and import strawberry between 1990-94 and 2010-14.





Strawberry

U.S. is the leading strawberry production country, while it is also the fourth largest importer of fresh strawberry in the world. The average annual imports tripled, reaching 119,915 metric tons, between 1990-92 and 2010-12(Huang, S. W. 2013). California as the main domestic producer occupies nearly 90 percent U.S. production. Strawberries growing season from California can be all the year, but the main shipment time for California's strawberries is in spring and summer. While Florida strawberries primarily enter the market in winter, from December to March. The whole domestic shipment for U.S. fresh strawberry peaks between April and June. From Figure 5 we can see, the import amount is limited in 1990-94, however, import strawberries grow significant in 2010-14. Import strawberries mainly enter U.S. market in winter and spring. Since strawberries are delicate and relatively hard to ship, Mexico is nearly the only supplier of fresh strawberries in U.S market. But U.S fresh strawberry market is dominated by domestic production, either in total production or in any season, import strawberries play a trivial role in U.S. fruit market (Boriss, H., et al. 2006, Huang, S. W. 2013).

CHAPTER VI

RESULTS ABOUT IMPORT FRESH FRUIT ELASTICITIES

Figure 6. Monthly expenditure shares from 1990 through 2014.

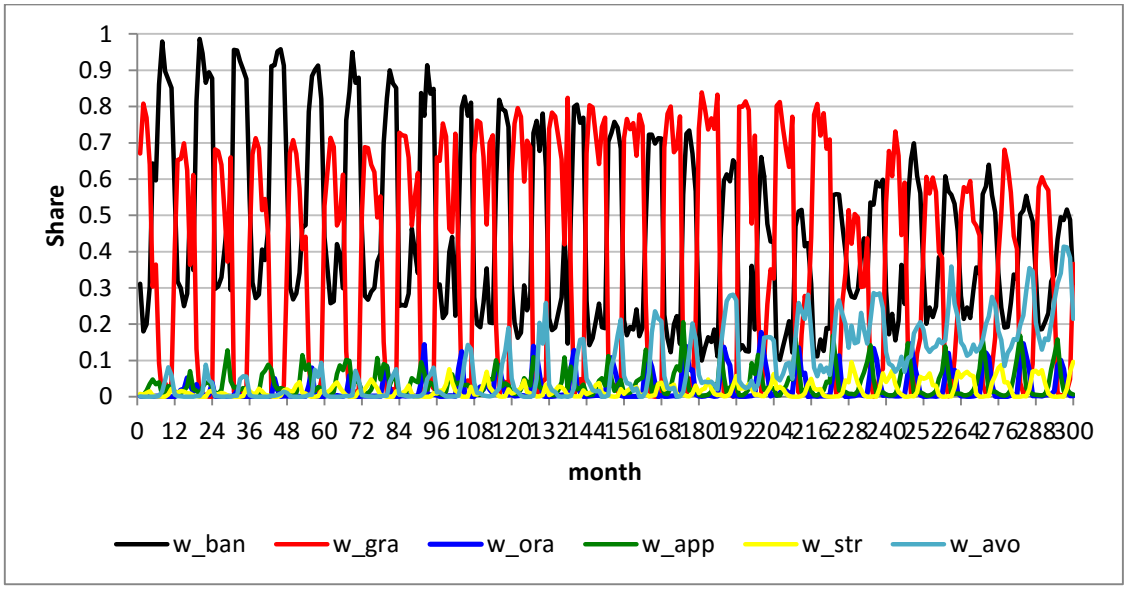


Figure 6 shows the monthly expenditure share change for each import fruit from 1990 to 2014. The monthly expenditure shares show strong seasonality and trend for import bananas, grapes, oranges, apples, strawberries, and avocados between 1990 and 2014. Import banana expenditure share is the only one that experienced a downward trend, while all the other expenditure shares have increasing trend. So in our model, the seasonality components and trends are incorporated.

Table 1. Estimates of Nonlinear AIDS Model of U.S. Demand for Import Fresh Fruits. (Notes: The values are coefficient, standard error, p value.*, **, *** denote statistical significance at 5%, 1%, 0.1%)

Description	Fresh bananas	Fresh apples	Fresh oranges	Fresh Strawberries	Fresh grapes	Fresh avocados
Intercept	2.141611***	0.26451***	0.101683***	0.060409**	-1.79789***	0.22968***
	0.0880	0.0320	0.0302	0.0192	0.0704	0.0648
	(<0.0001)	(<0.0001)	(0.0009)	(0.0019)	(<.0001)	(0.0005)
Fresh bananas	-0.17606***					
	0.0353					
	(<.0001)					
Fresh apples	-0.05823***	-0.00196				
	0.00810	0.00534				
	(<.0001)	(0.7136)				
Fresh oranges	-0.03614***	-0.0023	0.019648***			
	0.00682	0.00282	0.00300			
	(<.0001)	(0.4161)	(<.0001)			
Fresh Strawberries	-0.01547**	0.008483***	-0.00289	0.009523***		
	0.00491	0.00240	0.00164	0.00209		
	(0.0018)	(0.0005)	(0.0795)	(<.0001)		
Fresh grapes	0.332682***	0.054441***	0.025123**	0.00591	-0.46407***	
	0.0319	0.00928	0.00821	0.00520	0.0364	
	(<.0001)	(<.0001)	(0.0024)	(0.2564)	(<.0001)	
Fresh avocados	-0.04678***	-0.00043	-0.00344	-0.00555**	0.045911*	0.01029
	0.0136	0.00367	0.00300	0.00198	0.0179	0.00733
	(0.0006)	(0.9070)	(0.2523)	(0.0055)	(0.0108)	(0.1615)
Real expenditure	-0.20583	-0.03019***	-0.01212**	-0.00679**	0.288253***	-0.03332***
		0.00428	0.00404	0.00256	0.00925	0.00862
		(<.0001)	(0.0029)	(0.0086)	(<.0001)	(0.0001)
Sin1		0.011042**	-0.01591***	0.017391***	0.180423***	-0.03652***
	/	0.00342	0.00321	0.00210	0.00773	0.00661
		(0.0014)	(<.0001)	(<.0001)	(<.0001)	(<.0001)
cos1		-0.03896***	-0.01432***	0.007379***	0.023994***	0.031507***
	/	0.00223	0.00192	0.00156	0.00592	0.00388
		(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)
sin2		0.004892***	0.017935***	-0.00354**	0.012157*	-0.01975***
	/	0.00189	0.00178	0.00111	0.00588	0.00377
		(0.0100)	(<.0001)	(0.0016)	(0.0395)	(<.0001)
cos2		0.017418***	-0.01207***	0.005545***	0.026705***	-0.00811*
	/	0.00213	0.00196	0.00137	0.00651	0.00406
		(<.0001)	(<.0001)	(<.0001)	(<.0001)	(0.0466)
sin3		-0.00615***	0.000256	-0.00512***	0.029662***	-0.00069
	/	0.00185	0.00175	0.00110	0.00603	0.00384
		(0.0010)	(0.8834)	(<.0001)	(<.0001)	(0.8575)
cos3		-0.00149	0.011706***	0.00078	-0.02007***	-0.00606
	/	0.00178	0.00167	0.00106	0.00580	0.00368
		(0.4048)	(<.0001)	(0.4631)	(0.0006)	(0.1007)
sin4		0.006412***	-0.00087	0.000074	0.008105	-0.00355
	/	0.00174	0.00164	0.00103	0.00579	0.00361
		(0.0003)	(0.5950)	(0.9431)	(0.1630)	(0.3258)
cos4		0.004865**	0.003434*	-0.00054	-0.00982	-0.00089
	/	0.00172	0.00162	0.00102	0.00578	0.00359
		(0.0050)	(0.0351)	(0.5928)	(0.0903)	(0.8037)
trend		0.00011***	0.000139***	0.000076***	-0.0008***	0.000824***
	/	0.000027	0.000023	0.000015	0.000069	0.000046
		(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)
R square		0.6887	0.7545	0.6405	0.9477	0.8013

Table 1 is the estimated results of nonlinear model. The intercept represents the subsistence consumption share, the intercepts of fresh bananas, apples, oranges, strawberries, grapes, and avocado are all statistically significant with value 2.141611,0.26451, 0.101683, 0.060409, -1.79789 and 0.22968, respectively. Bananas as the top popular fresh fruit in American diet has the biggest subsistence consumption, which is reasonable. As for grapes, the sign of intercept is negative, it is probably because of the dramatic expenditure share change. During the fresh grape import window, its expenditure share could reach around 70 percent, but in the domestic season, import fresh grape drops to almost zero. As we can see from the real expenditure coefficients, all the values are statistically significant for fresh banana, apples, oranges, strawberries, and avocados and the coefficients of real expenditure except for grapes are all negative, which means that bananas, strawberries, oranges, and apples are necessities, but for grape, the coefficient of real expenditure is positive, which means it is the only luxury good. All the budget share equations have significant trend at 0.1% significance level except for bananas and grapes. Since we dropped the fresh banana budget share equation, we do not have coefficient of trend for import fresh banana, but we can see from the previous graph, import bananas have obviously downward trend. All the commodities have at least four statistically significant seasonality variables, where the seasonal frequencies of the data equal to 1 and 2. Fresh apples and grapes have more statistically significant seasonal variables. The significance of seasonal components show that seasonality is an important character in fresh fruit market, which is consistent with the earlier results from Nzaku, K., et al. (2010)

Table 2. Uncompensated Elasticities for Import Fresh Fruits.

	GRAPE	ORANGE	APPLE	STRAWBERRY	AVOCADO	BANANA
GRAPE	-0.745737	-0.02604	-0.069721	-0.039138	-0.148575	-0.726994
ORANGE	0.0648916	-0.11112	0.0466457	-0.084767	0.0364998	-0.442247
APPLE	-0.115678	0.0368264	-0.825175	0.2858635	0.2763959	0.1510646
STRAWBERRY	-0.418493	-0.118316	0.595528	-0.426102	-0.17978	-0.063754
AVOCADO	-0.218393	0.0070169	0.1030526	-0.036258	-0.744627	0.2734795
BANANA	-0.149713	-0.024501	-0.000838	-0.001323	0.0583096	-0.428141

Table 2 contains all uncompensated import elasticities. All the own-price import elasticities of demand for all the fresh fruits we study are negative, conforming to economic theory. All the own price import elasticities are all less than 1 and the range is from -0.11112 for orange to -0.825175 for apple, which is consistent with previous studies that fresh fruit is priced inelastic in market level(Durham, C. and J. Eales 2010). So if the price increases 10%, the demand of apple will decrease the most among these fruits we study for about 8.2%. In previous studies (Durham, C. and J. Eales 2010), the own price import elasticities for bananas are from -0.74to -0.24, our own price elasticity of import fresh bananas is -0.428141, which is in the range. Nzaku, K., et al. (2010) also estimated the import elasticities of U.S fresh fruit and vegetable imports using quarterly data from 1989-2008. Our magnitude of the banana elasticity is comparable to -0.5416 reported by them. For apples, the own price import elasticities range from -0.72

to -0.16 concluded by Durham, C. and J. Eales (2010), but the own price elasticity of import apples in our study is -0.825175, which is smaller than the minimum value of previous study. For oranges, the own price import elasticities are from -1.14 to -0.27 in previous studies, but our own price elasticity of bananas is -0.11112, which is out of the range and greater than the maximum value. For grapes, the elasticity is -0.7457, the magnitude is greater than 0.3823 reported by Durham, C. and J. Eales (2010). For avocados, the own price elasticity is -0.744627, which is comparable to -0.8823 reported by Nzaku, K., et al. (2010). We should notice that, in our comparison of import elasticities, most of the import elasticities in previous study are estimated by domestic consumption data rather than import data. The difference of import elasticities might also come from the different types and time period of the data. However, the resources about import elasticities from previous studies are very limited.

From table 2, we also can see that grape and apple, strawberry, avocado, and banana are complements, Strawberry and all the other fruits are complements except for apple, since their cross-price import elasticities are negative. Strawberry and apple are substitutes. Avocado and orange, apple, and banana are substitutes. Nzaku, Houston et al. (2011) had some same results with us, they found import avocados are substitutes for bananas, import grapes; bananas and grape imports are complements.

Table 3. Import Expenditure Elasticities for Import Fresh Fruits

GRAPE	1.7562047
ORANGE	0.4900962
APPLE	0.1907023
STRAWBERRY	0.6109165
AVOCADO	0.6157286
BANANA	0.546207

The expenditure import elasticities are reported in Table 3. As we can see from the table, all the expenditure import elasticities have positive sign, which is consistent with economic theory. The expenditure import elasticities range from 0.1907023 for apples to 1.7562047 for grapes, So, when income increase, the demand of import grapes will increase the most and the demand of import apple will increase the least, which means people prefer more import grapes and less import apples for a fresh fruit budget constructed by all the fruits we study. The magnitude of expenditure import elasticities for oranges, strawberries, avocados and bananas are closely at the same level. Import fresh grapes is the only luxury good because its expenditure elasticity is greater than 1. You, Z., et al. (1996) also found that fresh grapes was luxury commodity.

CHAPTER VII

CONCLUSIONS

As the consumer demand increased rapidly since 1990s, both domestic production and imports increased dramatically. Domestic production season had no significant change between 1990-94 and 2010-14, whereas, the length of import window has expanded. Imports have no significant sign to compete with domestic production, on the contrary, imports have supplemented domestic production during off-season to meet increased U.S demand (Huang, S. W. and K. S. Huang 2007).

Most of estimation results from nonlinear AIDS model are statistically significant, especially for trend and seasonality components. Trend and seasonality are very import characteristics for the import fresh fruit market. The own-price import elasticities for all import fruits we study are all negative and less than 1, which means import fresh fruits are also price inelastic in the market level. Import grapes are the only luxury good, and it is the complement for all the other import fruits we study. However import apples have the minimum magnitude of expenditure elasticity, and it is the substitute for most of other import fruits. As the expenditure increases, consumers shift their preference from import apple to other import fruits, especially import grapes. We did not address possible endogeneity issue with respect to expenditures. In consumer theory, income is exogenous. Not having income we use expenditures in this thesis, as have others in the literature. This is a problem left for future research (Wang, Z. and D. A. Bessler, 2006).

For the further study, we will find statistical methods to estimate significance of seasonality movements and how they shift over years. And it is better to estimate total consumer demand if we get consumption for both domestic and import market.

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