A STRUCTURAL SHIFT IN THE DEMAND FOR FLORIDA CITRUS

Anne Metz

With the advent of the severe freezes in January of the 1976-77 season there was a severe decrease in the supply of Florida Citrus. In order to maintain inventories throughout the year processors increased the F.O.B. price incrementally throughout 1977 (Niles). Processors acted on the assumption that as the price of citrus products increased, consumers would decrease consumption. Thus price would perform its natural rationing function, and allocate the available supply. This pricing policy assumes that the demand for citrus products is relatively elastic. Despite the higher prices however, consumers did not decrease their consumption as was expected (Tilley). This phenomenon has created a stir among the Florida Citrus industry. Question: Has the structure of the market demand-supply relationship for the Florida Citrus product changed over the years? If so, what implications does this change have for the citrus industry?

A more traditional approach to analysis of this type of problem is the estimation of demand curves. Although, to test for a structural shift using this method would entail the estimation of demand curves for each of the various product forms (fresh, canned, FCOJ, COJ, etc.), largely because of the changes over time in market shares related to the different product forms. This would be a cumbersome task, to simplify the process, the estimation of revenue functions was chosen as an alternative approach.

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The objectives of this paper are 1) to estimate the relationship among annual crop size, aggregate disposable income and total revenue received by the Florida Citrus industry, 2) to test for a structural shift that may have occurred in the supply-demand relationship for citrus, over the years 1958-75, and 3) to examine factors contributing to the change in structure of the demand.

DEVELOPMENT OF THE THEORETICAL MODEL

Much of the discussion that follows comes from Tomek and Robinson's Agricultural Product Prices. An aggregate demand curve is defined as the sum of each individual's demand curve for a commodity, and an aggregate supply curve is the sum of each individual producer's supply curve for that commodity. This aggregate demand curve measures how much consumers are willing to buy at various prices, while the aggregate supply curve measures how much producers are willing to supply at various prices. The interaction of these supply and demand curves comprise a market. The intersection of the supply curve and demand curve yields an equilibrium price, P_e, and an equilibrium quantity, Q_e. At this equilibrium point the market clears, which says quantity demanded equals quantity supplied, i.e., $Q_D = Q_S$. If P_e is multiplied by Q_e we obtain total revenue (TR) received by the industry at equilibrium (see Figure 1).

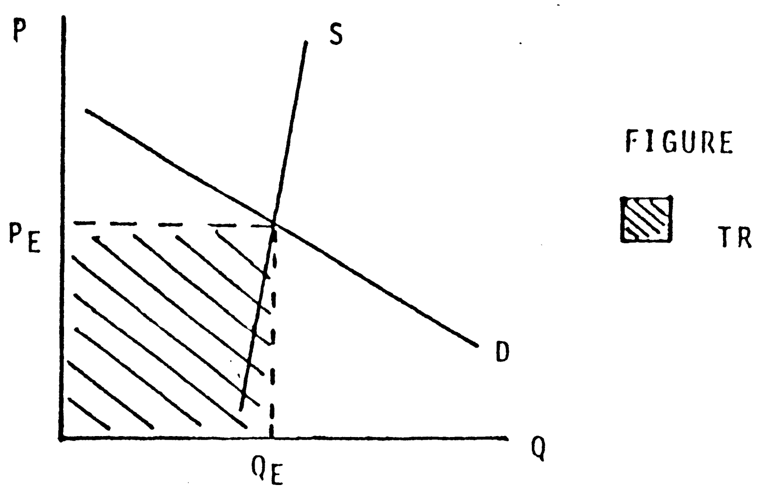

FIGURE 1

Several variables effect the location of the demand curve, and these variables are known as demand shifters. Similarly, there are several variables that effect the location of the supply curve and these variables are known as supply shifters. One of the more common demand shifters is a change in disposable income. Increases in income shift the demand curve, D_A, out to D_1 while decreases in income shift the demand curve to D_2 (see Figure 2). One of the more common supply shifters is a change in crop size. Similarly, increases in annual crop size would shift the supply curve, S_A to S_1 while decreases in annual crop size would shift the supply curve, S_A to S_2. The shifting of these curves obviously result, in new equilibrium prices and quantities and in some cases effects changes in total revenue (see Figure 2).

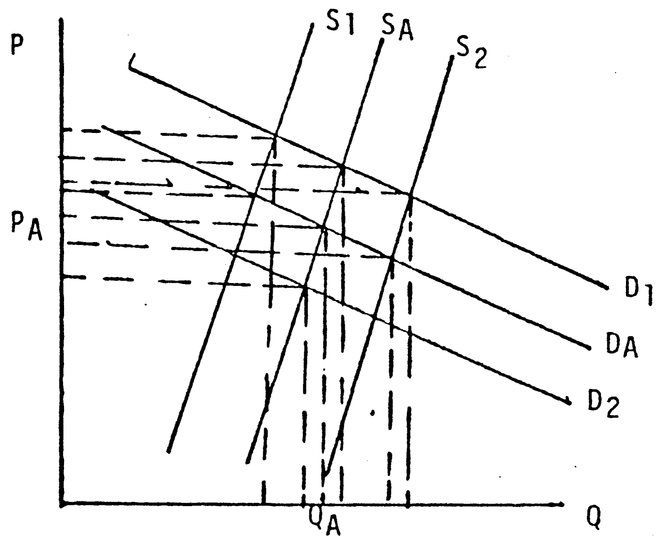

FIGURE 2

To better understand the effects of shifts in demand and supply on total revenue it is necessary to include the concept of price elasticity of demand, E_p. The price of elasticity of demand considers the responsiveness of consumers to changes in the price of a commodity. We measure the percentage change in quantity demanded given a 1% change in price, i.e., $\%\Delta Q_D/\%\Delta P$.

A quantitative summary of price elasticities is shown in Table 1.

Table 1. Price elasticity of demand.

Elastic	Unitary	Inelastic
$\%\Delta Q_D > \%\Delta P$	$\%\Delta Q_D = \%\Delta P$	$\%\Delta Q_D < \%\Delta P$
$E_p > 1$	$E_p = 1$	$E_p < 1$

In a graphical sense we are measuring the slope of the demand curve within the relevant range of prices. As the demand curve moves from a relatively "flat" slope to a relatively "steep" slope it is moving from an elastic position to an inelastic position (see Figure 3).

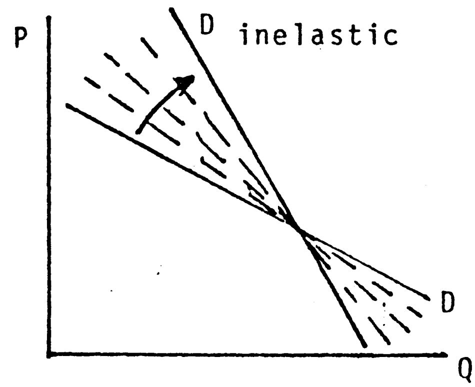

FIGURE 3

But, changes in total revenue resulting from changes in price, cannot be quantified without knowing the E_p, in the relevant range of prices. The subsequent effect on total revenue of changes in prices is summarized in Table 2.

Table 2. Relationship of TR to price elasticities.

	Elastic	Unitary	Inelastic
P↑	TR↓	TR = constant	TR↑
P↓	TR↑	TR = constant	TR↓

The relationship between price elasticities and changes in total revenue can be explained by the law of demand in conjunction with the definition of price elasticity. The law of demand states simply that as price increases, quantity demanded decreases and vice versa. But if the $\%\Delta P$ is greater than the $\%\Delta Q_D$, i.e., inelastic, then total revenue will increase. The same logic can be used to explain the relationship for an elastic demand.

Since many food items are considered necessities, the demand for agricultural commodities is traditionally considered inelastic (Tomek and Robinson). In other words, in the case of many food items, consumers are not terribly price conscious and increases in the price do not result in significant decreases in the quantity demanded. This can be contrasted to the demand for different items which are elastic, where consumers are more price responsive and increases in the price result in significant decreases in consumption.

Analagous to the concept of demand elasticity is the concept of supply elasticity. Supply elasticities measure producers' responsiveness to changes in the price and is defined as $\%\Delta Q_S/\%\Delta P$. Different from price elasticities, supply elasticities will always be positive because of the direct relationship of price and quantity supplied. In the case of agricultural commodities, supply is highly inelastic in the short run (Tomek and Robinson). This is reflected in the fact that growers cannot adjust production in the short run to take advantage of changes in the market price, supply is fixed or perfectly inelastic. The processor, on the other hand, possesses a more elastic but still highly inelastic supply curve (see Figure 4).

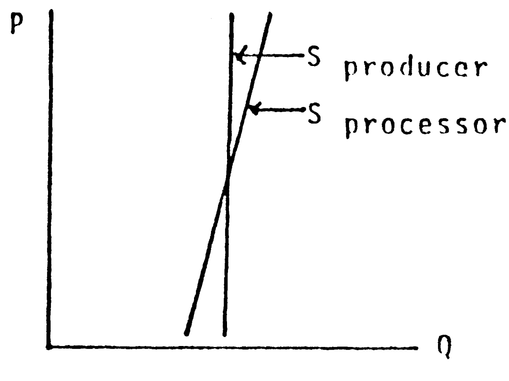

FIGURE 4

To consider once again our primary question, has the structure of the market demand-supply relationship for the Florida citrus product changed over the years? The market observations following the 1976-77 freeze indicated that while there was a decrease in the supply of citrus creating upward pressure on prices, the quantity demanded by consumers was not curtailed as was expected. These observations suggested that a structure shift has occurred in the demand for Florida Citrus from elastic to inelastic (see Figure 5).

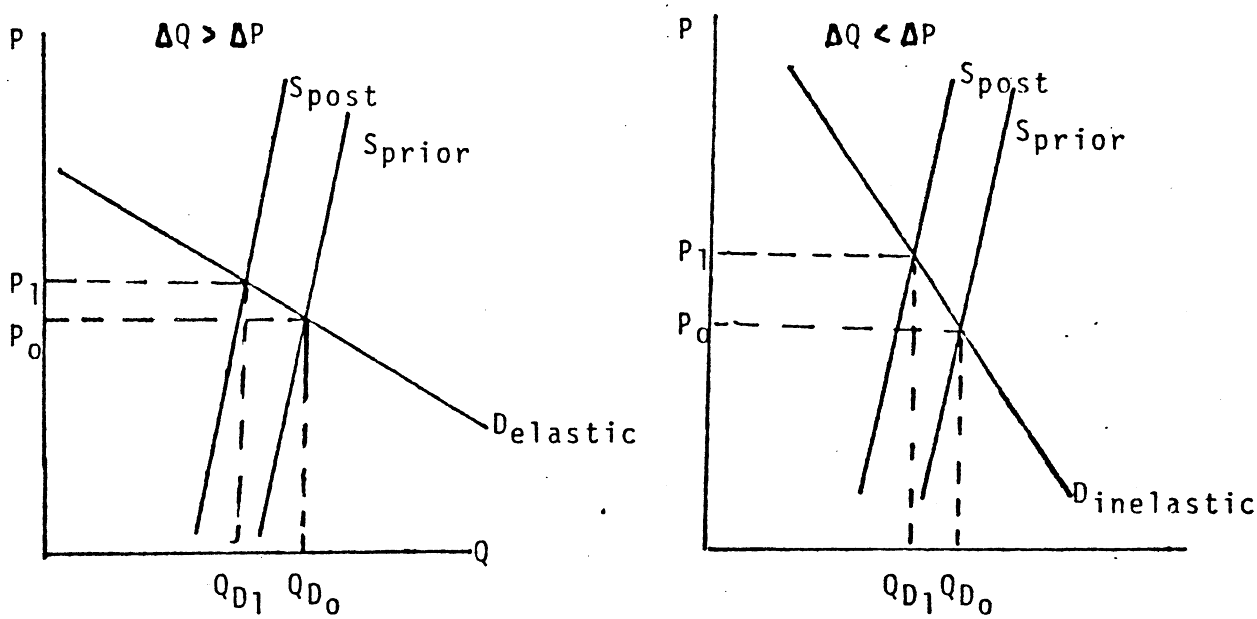

FIGURE 5

The primary objective of this paper is to verify statistically that a structural shift has indeed occurred. The model developed for analysis states that:

$$TR = f(CS, DPI)$$

The value for total revenue (TR) reveived by the Florida Citrus industry was considered to be the sum of the F.O.B. sales of fresh oranges, FCOJ, and COJ, the major contributors of revenue. The annual crop size of oranges (CS), serves as the quantity variable. Aggregate disposable personal income (DPI) serves as the price variable.

DATA SUMMARY

Our time series data consists of 18 annual observations of, the sum of F.O.B. values for fresh oranges, FCOJ, and COJ*, annual crop size of oranges and aggregate disposable personal income. The time series begins in 1958 and extends through 1975. The data is divided into three sets, two sets of 9 observations, 1958-66 and 1969-75 and one set of 18 observations 1958-75. A summary and sources of data are shown in Table 3.

EMPIRICAL MODEL AND RESULTS

Using ordinary least squares regression the following revenue function was estimated for the three periods:

$$Y = \alpha + \beta X_1 + \beta X_2 + e \text{ where;}$$

Y = TR (Dependent variable)

α = some constant

X_1 = CS (Independent variable)

X_2 = DPI (Independent variable)

e = error term

A summary of the estimated coefficients, R^2 values and t-statistics are shown in Table 4.

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*COJ was not introduced until 1966.

Table 3. Data

Year	Total Revenue (F.O.B.) in Thousands of Dollars	Annual Crop Size in Thousands of Boxes	DPI in Billions of Dollars
58	286,100	81,000	317.1
59	309,200	82,800	336.1
60	301,000	87,600	349.4
61	324,800	82,700	362.9
62	309,700	108,800	383.9
63	341,500	72,500	402.8
64	332,100	54,900	437.0
65	291.800	82,400	472.2
66	367.500	95,900	510.4
67	373,100	139,500	544.5
68	469,400	100,500	588.1
69	483,400	129,700	630.4
70	455,100	137,700	685.9
71	551,700	142,300	742.8
72	640.400	137.000	801.3
73	670,400	169,700	903.1
74	758,300	165,800	983.6
75	907,900	173,300	1076.7

Sources: Revenue and Annual Crop Size; Florida Citrus Mutual Annual Statistical Report 1976-77; DPI; Survey of Current Business.

Table 4.--Results OLSQ.

1958-1966	TR = 231.9 - .10 CS + .24 DPI		
	t-statistics:	β_1 →	- .18
		β_2 →	1.84
	R^2 = .365		
1967-1975	TR = 7.88 - 1.87 CS + 1.10 DPI		
	t-statistics:	β_1 →	-2.04
		β_2 →	9.63
	R^2 = .97		
1958-1975	TR = 24.42 - .42 CS + .82 DPI		
	t-statistics:	β_1 →	.63
		β_2 →	7.88
	R^2 = .95		

DISCUSSION AND ANALYSIS OF RESULTS

A cursary glance at the results provides some information about our model. First, the signs of the estimated coefficients appear to be consistent with economic theory which says that crop size and total revenue are inversely related and income and total revenue are directly related. Briefly stated, an increase in citrus produced, i.e., increase in supply, effects a decrease in price, resulting in decreases in total revenue. Conversely, increases in income, i.e., increase in demand, effects and increase in price, resulting in increases in total revenue.

Second, observation of the t-statistics for CS and DPI, for the three time periods, reveals some significant changes. T-statistics are often used to evaluate the explanatory power of a variable used in the model. In other words, how much of the variation in TR is explained by CS or DPI. In general, if the t-statistics is ≥ 2 then the variable provides explanatory power to the model. Referring to Table 4, we find the t-statistics for CS to be, -.18 in the first period. This indicates that CS explains very little, if any, of the variation in TR. From this we might hypothesize that demand for Florida citrus at the F.O.B. level was unitary elastic during this period. This is consistant with economic theory which says, if the E_p is unitary elastic, then TR is constant and changes in supply will not effect changes in TR.

Comparison of the t-statistic for CS in the first period to that in the second period shows the value is now significantly different from zero at -2.04. CS now explains some of the variation in TR. Since the value is significantly different from zero and negative we conclude that the E_p has changed from being near unitary elastic to relatively inelastic.

We now turn our attention to the R^2 values for the three time periods. The R^2 value in contrast to the t-statistic measures the explanatory power of the model as it is defined. In other words how well does our model explain the variation in TR, on a scale of 0-1. The R^2 value corresponding to the first period, .36 suggests our model explains very little of the variation in TR, in contrast to R^2 values of .97 for the 2nd period and .95 for the entire period. In the latter instances the model explains practically all of the variation in TR.

How might we explain the vast differences in these R^2 values? Three possible explanations are offered: 1) in the first period there may have been very little variation in total revenue to explain; 2) it is possible that during the first period relevant variables were excluded from the model, that would explain variation in TR; 3) a structural shift might have occurred between the two periods. We cannot conclusively accept or reject any of the possible explanations without further study.

Toward a more quantitative analysis, The Chow Test, developed by G.C. Chow was used to determine whether a structural shift in the demand-supply relation has occurred between two time periods (Johnston). The test was conducted as follows:

Null hypothesis: the second nine observations obey the same relation as the first nine observation

Degrees of freedom; $(9,6)_{.05}$

Chow Test; $F = \frac{(e'e - e_1'e_1)/m}{e_1'e_1/(n-k)}$ where:

$e'e$ = sum of the squared residuals for the 18 observations

$e_1'e_1$ = sum of the squared residuals for the first nine years

m = # of observations in second time period

n = # of observations in first time period

k = # of parameters estimated

Substituting into the above yields

$$\frac{(28{,}779.3 - 3421.7)/9}{3421.7/(9-3)} = 4.94$$

The critical value is equal to 4.10 $F(9,6)_{.05}$, therefore we reject the null hypothesis. This allows us to state with 95% confidence that a structural shift in the market demand-supply relationship has occurred over the time period analyzed.

Having established that a structural shift has occurred, how might we explain this change? Some insight might be gained by first recalling some of the developments in the Florida citrus industry, during the period. We note that the division of the two time periods falls between the 1965-66 season and the 1966-67 season.

During 1966 some major changes took place in the industry, 1) substantial improvements in product quality (42.8 Brix-45.8 Brix), 2) changes in the advertising strategy (Anita, product integration) and 3) expansion of the market (introduction of COJ). In addition, following these changes record low prices were witnessed in the 1966-67 season, which more than likely served to draw more consumers into the market for Florida citrus products (Myers).

To better understand the effects of these changes on market demand, it is necessary to discuss expenditure elasticities (e_{xy}). George and King show that demand can be defined in terms of expenditures on a commodity. Expenditures being synonomous with total revenue (PxQ). An expenditure elasticity measures the %Δ in TR given a %Δ in income. It can be interpreted as a measure of the quality consciousness of consumers. This expenditure elasticity is divided into an income elasticity and a quality elasticity.

$$(A) = \frac{\%\Delta TR}{\%\Delta Y} = \frac{\%\Delta Q_D}{\%\Delta Y} + \frac{\%\Delta P}{\%\Delta Y}$$

It is reasonable to assume that the income elasticity of demand for citrus has remained constant or been declining. This is consistent with our earlier argument, that the demand for Florida citrus has become inelastic, i.e., consumers have become less price conscious, which implies the nature of the commodity has changed from one of a luxury to a necessity. Sjo states that because of the essential nature of many food items, income elasticities decrease, as income increases.

What we have now is:

$$(B) \quad \frac{\%\Delta TR}{\%\Delta Y} (\text{-or+}) = \frac{\%\Delta Q_D}{\%\Delta Y} (\text{Kor-}) + \frac{\%\Delta P}{\%\Delta Y} (\text{-or+})$$

The e_{xy} was then calculated for the 1st (1) and 2nd time periods (2), by using the mean values of TR and DPI for both time periods to convert the DPI coefficient ($\partial TR/\partial y$) to an expenditure elasticity.

$$(1) \quad \partial TR/\partial y \times \frac{TR}{DPI} = .239 \times \frac{396.87}{318.18} = .298$$

$$(2) \quad \partial TR/\partial y \times \frac{TR}{DPI} = 1.1 \times \frac{772.93}{589.97} = 1.44$$

These calculations show a substantial increase in e_{xy} from the 1st nine years to the 2nd nine years. Referring back to equation (B) we now assert the following:

$$(C) \quad \frac{\%\Delta TR}{\%\Delta Y} (+) = \frac{\%\Delta Q_D}{\%\Delta Y} (\text{Kor-}) + \frac{\%\Delta P}{\%\Delta Y} (+)$$

Since the e_{xy} has increased and the income elasticity has remained constant or been declining, then it follows that the quality elasticity has been increasing.

As George and King define the term, quality elasticity is "a measure of consumers' desire for improved quality, given a present average or standard of quality. Also, a general upgrading of diets with increases in income is reflected in the fact that changes in quantities consumed may not be so large as changes in expenditures on food items." This suggests that consumers may be responding to improvements in the quality of the Florida Citrus product, as well as upgrading their diets as a result of increases in DPI, that advertising has affected changes in consumers' tastes, preferences and habits, and the sum total of these has served to shift and change the structure of the demand for Florida Citrus. (See Figure 6).

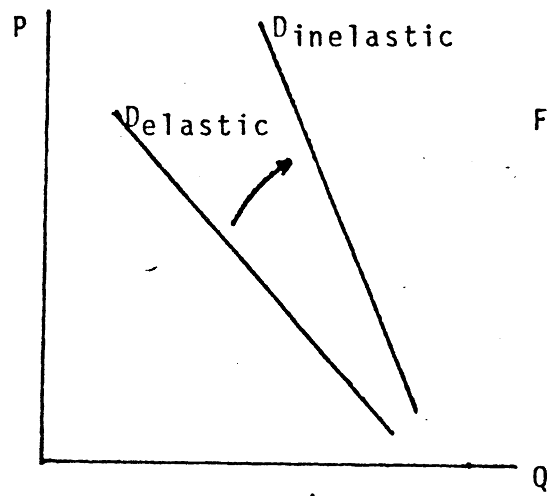

FIGURE 6

CONCLUSIONS

Returning again to the primary question, has a structural shift in the market demand-supply relationship for the Florida Citrus product over the years? Based on the analysis presented in this paper, I believe the answer is yes. In what direction? The shift has occurred largely in the market demand curve, having shifted out and having become more inelastic over the years. What implications does this have for the Florida Citrus industry? Largely through the industry's improvements in the quality of the product, changes in advertising strategy and their expansion of the market, coupled with increases in DPI observed through the years, consumers attitudes, tastes, and preferences for the Florida Citrus product have been affected in such a way as to change the structure of the market demand curve for Florida citrus.

Given the structural shift that has occurred along with increasing demand for the Florida Citrus product, the questions posed to the industry are: 1) Should expanding production be maintained to keep up with the increasing demand? or 2) Should expansion be stopped and should growers begin to shake the oranges off the trees?

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