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WINTER SEASON DEMAND FOR FRESH VEGETABLES: A CASE STUDY OF CUCUMBERS, PEPPERS AND TOMATOES IN THE UNITED STATES

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WINTER SEASON DEMAND FOR FRESH VEGETABLES : A CASE STUDY OF CUCUMBERS, PEPPERS AND TOMATOES IN THE UNITED STATES

ABSTRACT

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Chairman : Dr. Joel R. Hamilton

The United States winter season fresh vegetable market is dominated by supplies from Florida and Mexico. In order to assess the implications of changes in market demand for fresh vegetable suppliers, this study examined month-to-month behavior of demand for fresh cucumbers, peppers and tomatoes.

The market quantities of fresh cucumbers, peppers and tomatoes reflect a pattern with relatively less consumption in the winter compared with non-winter periods. Within the winter season the study revealed monthly changes in the demand function with more price-sensitive demand schedules in December, January, and April relative to February and March.

The shifting behavior of the demand functions for all the three vegetables indicates potential for increases in producers income through supply adjustments. The analysis showed that Mexican producers are likely to increase their revenues, especially for tomatoes, by entering the U.S. market early in the winter season and by holding back supplies in February and March.

CHAPTER I

INTRODUCTION

This study is concerned with seasonality of demand for fresh cucumbers, peppers and tomatoes in the United States. This introductory chapter is devoted to providing a statement of research objectives, reviewing pertinent background information about the research area, and, finally, setting up of the hypotheses to be tested in the analysis.

1.1. RESEARCH OBJECTIVES

The purpose of this research is to examine short-term changes in the demand for fresh cucumbers, peppers and tomatoes during the winter season in the United States. It is hypothesized that the winter season demand functions for these vegetables exhibit shifts on a month to month basis, which when transmitted to the producers through price mechanism should be expected to result in adjustments in the production planning process. The behavior of the demand function over the winter period could thus provide useful information to the producers which, in conjunction with climatic and production cost considerations, could be utilized in synchronizing planting dates with the most favorable demand periods.

Additionally, the producers' risk considerations emanating from price uncertainties can be assessed by examining the short-term behavior of own-price demand elasticities.

This study, accordingly, examines the behavior of the demand functions for fresh cucumbers, peppers and tomatoes during the winter season, defined from December to April. Using secondary source time series data for the period 1971-1981, the research estimates monthly

demand relations, tests the equations for intercept and slope differences through time, and computes monthly own-price elasticities.

1.2. BACKGROUND

The distinctive features of the winter season market for fresh cucumbers, peppers and tomatoes are that imports form a major proportion of the total market quantities, and Florida and Mexico have a near monopoly position in supplies originating, respectively, in the U.S. and overseas. These broad characteristics are portrayed in Figures 1-3 and in Table 1 which summarizes 1978/79 through 1980/81 based monthly unloads for 41 U.S. markets. As can be seen from these data, the market shares held by imported cucumbers and peppers begins to rise around December, reach a peak during the mid-winter January to March period, and start to taper off thereafter. Simultaneously, there is a sharp reduction in the market share of U.S. suppliers, with Florida remaining as the lone contender against imported, primarily Mexican, supplies. This pattern of supply applies equally to tomatoes with the exception that imports continue to be heavy, at least in absolute terms, during May as well.

These significant seasonal changes in the market share of the suppliers during a year are a continuation of the pattern set largely in 1968 when the Culiacan and Fuerte Sur regions in the Mexican state of Sinaloa emerged as Florida's main competitors. Although some Caribbean and Central American countries, Texas, California and several other lesser U.S. producers provide market supplies in late fall and early spring, the Florida-Mexico monopoly remains a continuing characteristic of the U.S. fresh vegetable winter season market. Both these regions have developed the resources necessary to supply the required quantities and

Table 1: Quantity of Cucumber, Pepper and Tomato Unloads in 41 Markets : Average 1978/79 through 1980/81

(Thousand Hundredweights)

Month	Originating Abroad			Originating in U.S.			
	Total	Mexico	Others	Total	Florida	Others	Total
A. Cucumbers							
May	34	31	3	643	441	202	677
June	4	1	3	682	173	509	686
July	3	2	1	568	36	532	571
August	1	(x)	(x)	459	4	454	460
September	1	(x)	1	389	6	383	390
October	1	(x)	(x)	459	116	343	460
November	30	29	1	387	236	151	417
December	152	149	3	174	144	30	326
January	319	311	8	66	56	8	386
February	300	293	7	34	26	8	334
March	361	353	8	41	29	12	402
April	183	179	4	235	185	50	419
B. Peppers							
May	46	45	1	291	253	38	337
June	12	11	1	322	132	190	334
July	8	7	1	312	16	296	320
August	9	7	2	293	0	293	302
September	10	8	2	292	0	292	302
October	8	7	1	326	3	323	334
November	9	8	1	294	64	229	303
December	54	53	1	206	127	79	260
January	161	160	1	141	124	17	303
February	162	161	1	95	91	4	257
March	184	182	2	96	95	1	281
April	114	113	1	171	166	5	285
C. Tomatoes							
May	505	504	1	1,089	1,018	71	1,594
June	141	140	1	1,373	617	756	1,514
July	47	47	0	1,539	55	1,484	1,586
August	33	33	0	1,214	2	1,212	1,247
September	29	29	0	1,010	2	1,008	1,039
October	39	39	0	1,306	52	1,254	1,345
November	53	53	0	1,058	430	628	1,111
December	78	78	0	1,015	761	254	1,093
January	381	381	0	747	694	53	1,128
February	597	597	0	412	405	7	1,009
March	759	758	1	359	351	8	1,118
April	754	754	0	599	584	15	1,353

(x) Denotes less than one.

Source: USDA, AMS, F&V D, Fresh Fruit and Vegetable Unload Totals for 41 Cities, issues 1978-81.

Figure 1 : Origin of Quantity of Fresh Cucumbers : Average 1978/79 through 1980/81

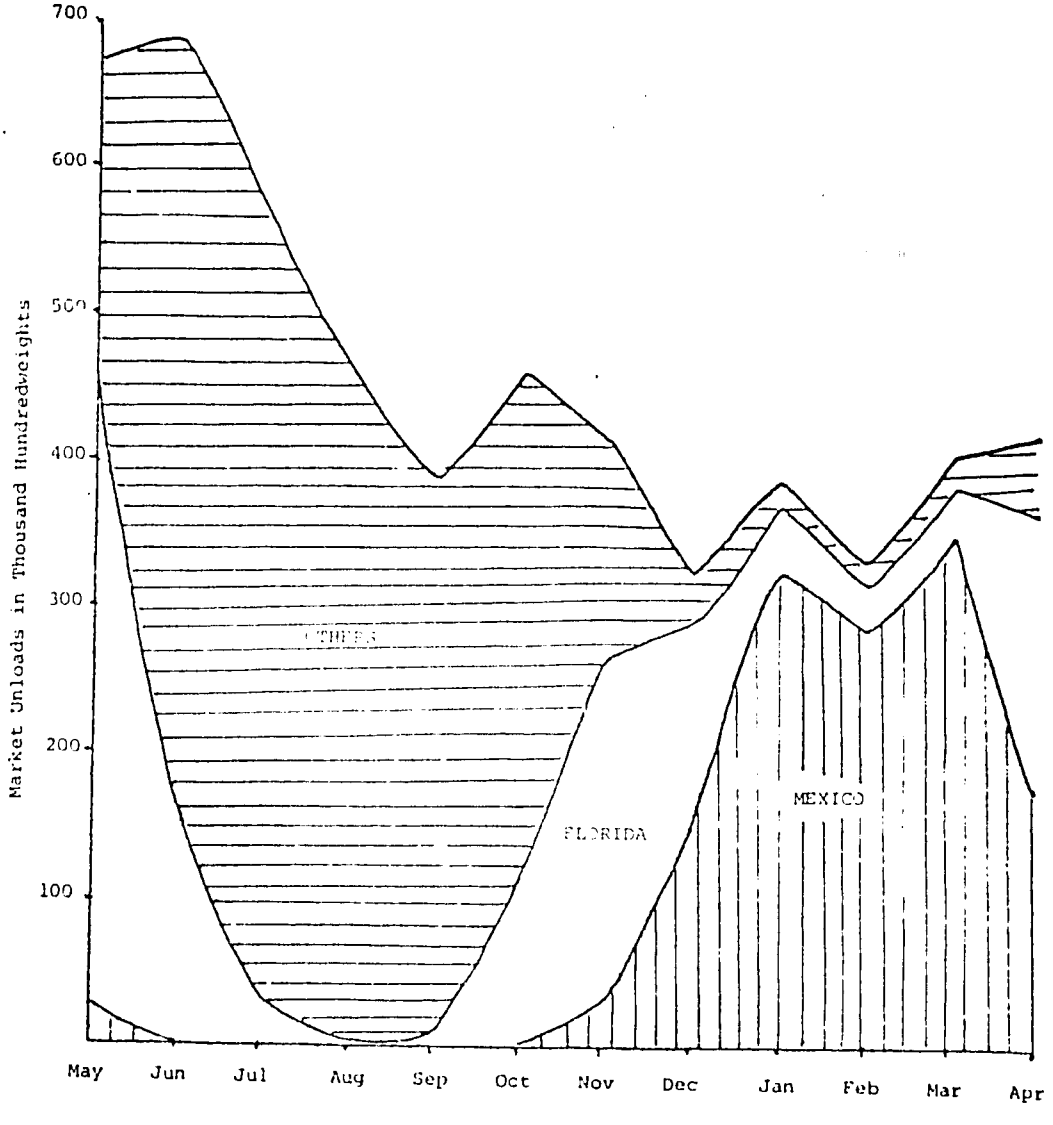


Figure 2 : Origin of Quantity of Fresh Peppers : Average 1978/79 through 1980/81

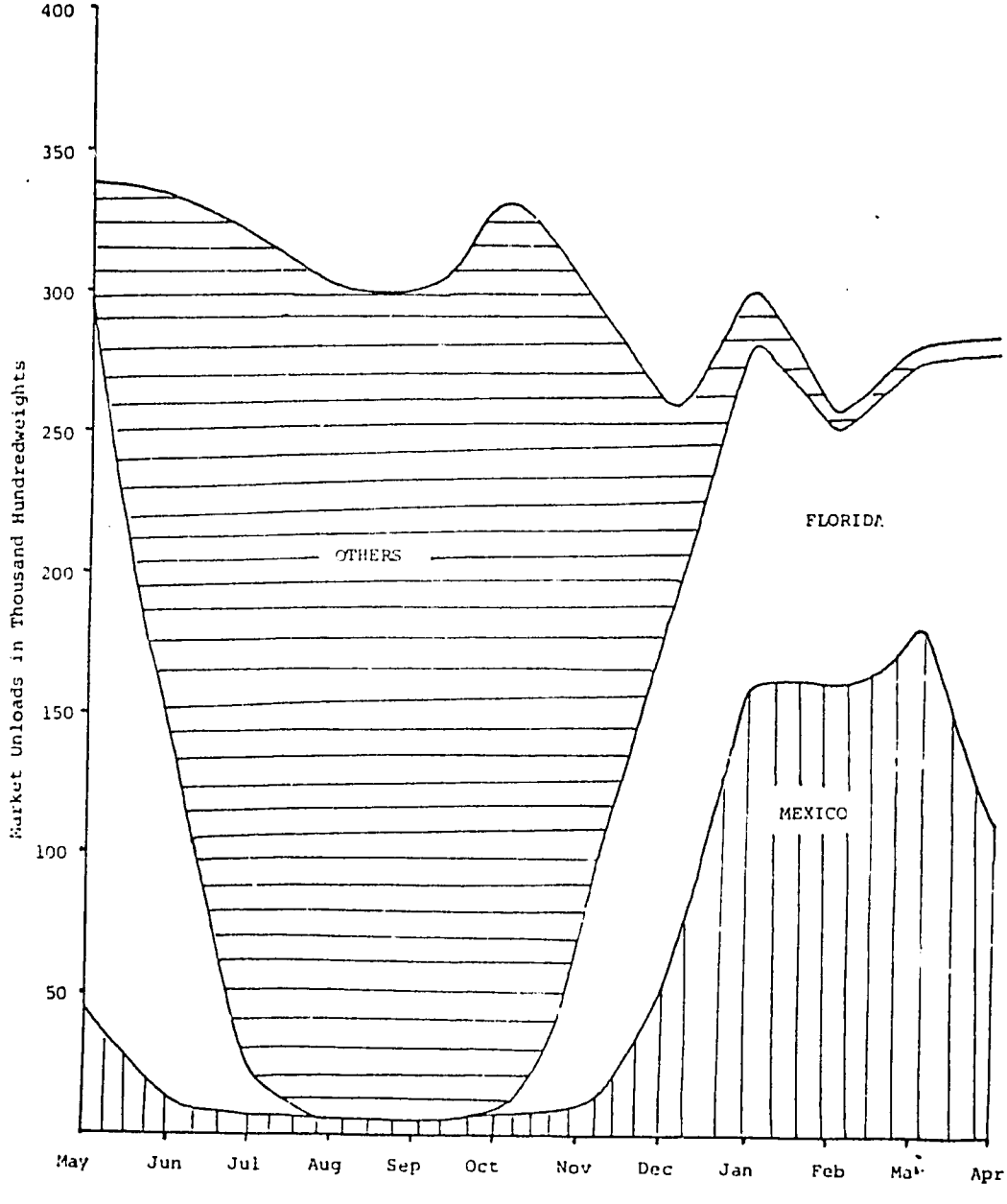
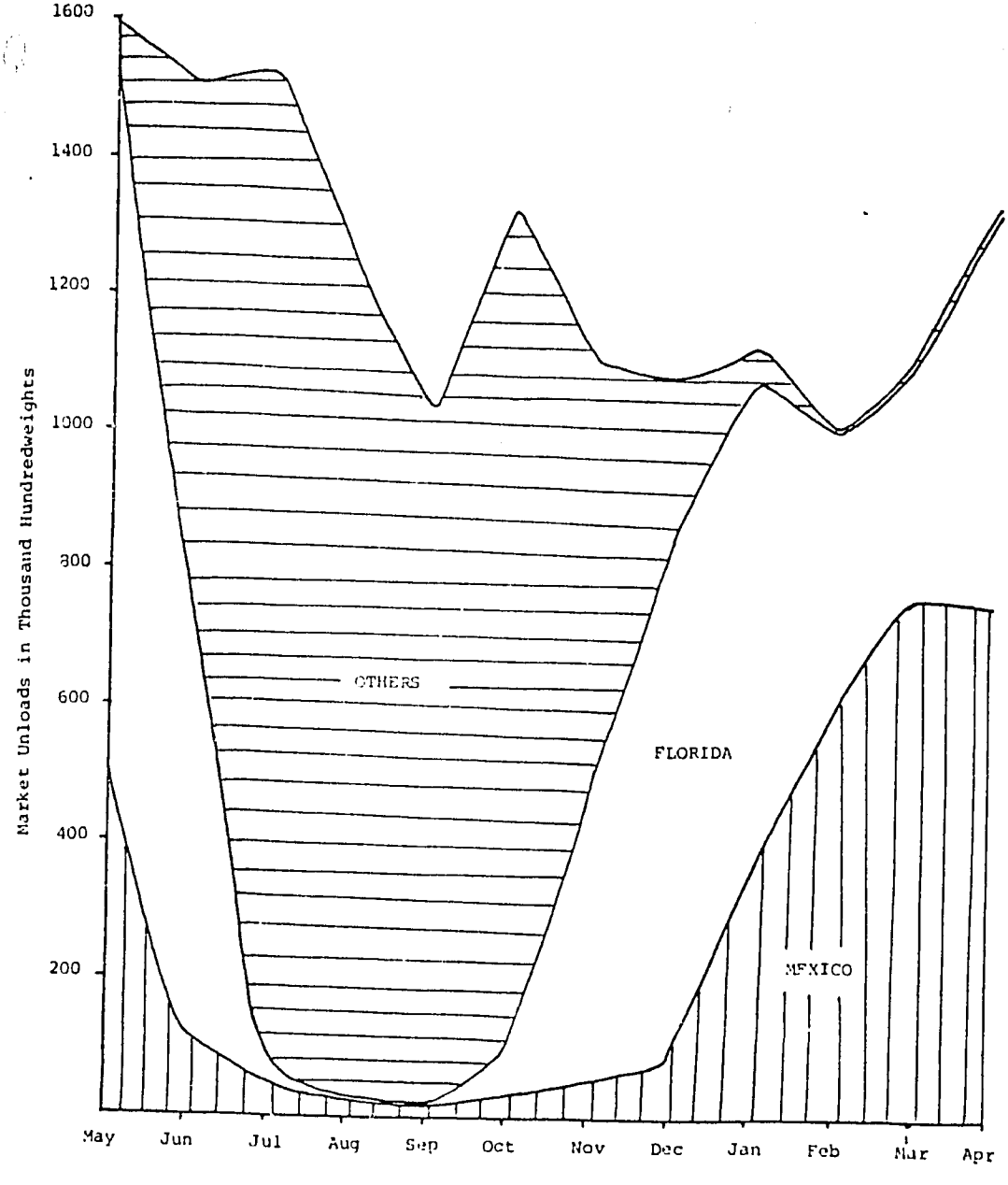


Figure 3 : Origin of Quantity of Fresh Tomatoes: Average 1978/79 through 1980/81



qualities on a regular basis ... [and] have the capacity to readily increase supplies in response to higher expected prices" [Simmons et al, 1976, p.1]. Several factors on the supply as well as on the demand side could affect the competitive advantage of these two suppliers. On the supply side, these factors are climatic suitability, input price inflation, technological changes, foreign exchange rates, and U.S. trade regulations governing imports from Mexico. On the demand side, in the situation where producers are confronted with a set of different demand schedules within the winter season, competitive advantage would be governed by the ability to schedule production and time shipments so as to take fullest advantage of the demand changes. It is this issue of short-term shifts in demand that this study specifically addresses.

1.3. COMMODITY DESCRIPTIONS

This section provides summary statistics on monthly behavior of market price and quantity for the three commodities under investigation. All price data pertains to the New York City market and has been converted into real terms using the Consumers Price Index (1967=100). The description of quantity statistics is based on the USDA published data on actual unloads in 41 major U.S. markets.

1.3.1. Cucumbers

Collier, Henry and Lee counties in south-west Florida and the Culiacan region in Sinaloa, Mexico, are the major suppliers to the U.S. winter market. Generally, Florida's shipments are heavy during early and late winter, while Mexican supplies are concentrated in the mid-winter months. This appears to be a reflection of the cold weather susceptibility of cucumbers which increases the risk of Florida

producers. Shipments are generally made in 1-1/9 bushel boxes or crates of about 55 pounds. There are three market grades -- super select, select, and plain -- with prices varying with quality [Simmons, 1984].

1.3.1.1. Real Prices

Cucumber real prices exhibit, as is indicated in Table 2, considerable volatility. In absolute terms the highest mean prices are in March, followed by April. The coefficients of variation for these highest mean price months, however, are larger compared to the other months. January and February exhibit the most stable prices.

Table 2: Real Wholesale Prices of Cucumbers at New York City: 1971/72 through 1980/81

Month	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
	(--Dollar/Hundredweight--)				
December	11.19	8.68	17.49	2.79	24.93
January	11.55	9.68	15.45	1.94	16.80
February	13.88	9.42	18.46	2.73	19.67
March	16.75	9.98	24.20	4.57	27.28
April	14.13	8.55	19.86	3.74	26.47

Source: USDA, AMS, Fresh Fruit and Vegetable Prices, issues 1971-1981.

1.3.1.2. Market Quantities

Pertinent statistics on quantities marketed, presented in Table 3, indicate the highest mean quantity in April, followed by January, December, March and February in that order. The coefficients of variation suggest increasing variability in market unloads from December onwards. No relationship is apparent between the level of the mean values and the corresponding standard deviations.

Table 3: Quantity of Cucumber Unloads at 41 Markets: 1971/72 through 1980/81

Month	Mean (Thousand Hundredweight)	Minimum	Maximum	Standard Deviation	Coefficient of Variation
December	341	293	448	44.26	12.98
January	347	248	406	50.49	14.55
February	293	223	378	48.66	16.61
March	329	277	410	62.50	19.00
April	407	311	578	93.29	22.92

Source: USDA, AMS, Fresh Fruit and Vegetable Unload Totals for 41 Cities, issues 1971-81.

1.3.2. Peppers

Since 1978, the published quantity unloads data report peppers as bell peppers and others with the former constituting an overwhelming proportion of the total. Bell peppers are grown extensively in Florida's southeast and southwest areas [Zepp and Simmons, 1980]. Mexico's major producers are Culiacan, followed by Fuerte Sur and Gausave regions [Simmons et al, 1976]. Bell peppers follow a supply pattern similar to cucumbers with Mexico dominating in the mid-winter period and Florida at the tails. Peppers classified as others, however, are a Mexican monopoly during the winter as well as other seasons. The market attaches significant price differences according to the size of bell peppers -- larger sizes carry a higher price [Simmons, 1984].

1.3.2.1. Real Prices

Real pepper prices, as shown in Table 4, rise progressively from December through April. The price variability, however, is significant with the coefficients of variation ranging from about 21 to 38 percent. Price variability is particularly large from February to April.

Table 4: Real Wholesale Prices of Peppers at New York City: 1971/72 through 1980/81

Month	Mean (Dollar/Hundredweight)	Minimum (Dollar/Hundredweight)	Maximum (Dollar/Hundredweight)	Standard Deviation	Coefficient of Variation
December	19.84	13.71	29.98	4.47	22.53
January	22.26	17.35	28.19	4.70	21.11
February	24.52	16.18	42.55	7.63	31.12
March	28.53	17.33	49.04	10.94	38.35
April	29.85	16.70	41.13	8.85	29.65

Source: USDA, AMS, Fresh Fruit and Vegetable Prices, issues 1971-81.

1.3.2.2. Market Quantities

Monthly market quantities have coefficients of variation as shown in Table 5, in the 15-19 percent range. Mean quantities are maximum in January, followed by April, March, December and February. The month of January also has the least quantity variability.

Table 5: Quantity of Pepper Unloads at 41 Markets: 1971/72 through 1980/81

Month	Mean (Thousand Hundredweight)	Minimum (Thousand Hundredweight)	Maximum (Thousand Hundredweight)	Standard Deviation	Coefficient of Variation
December	229	158	279	34.05	15.31
January	265	220	327	39.07	14.74
February	223	183	282	38.23	17.14
March	242	181	305	45.21	18.68
April	244	148	282	46.52	19.07

Source: USDA, AMS, Fresh Fruit and Vegetable Unload Totals for 41 Cities, issues 1971-1981.

1.3.3. Tomatoes

Tomatoes are produced and marketed as staked vine-ripe fruit as well as unstaked green fruit. Mexico's exports are predominantly in vine-ripe form, while Florida markets green tomatoes in significant quantities as well. Quality indicators -- color, firmness, degree of ripeness -- affect market prices. The prices also vary with size and higher prices are

associated with large size tomatoes.

1.3.3.1. Real Prices

Tomatoes real wholesale prices are highly volatile. Price volatility increases progressively from December onward through April (Table 6). Although mean price is highest in January, April appears to be the best month for a risk averting producer.

Table 6: Real Wholesale Prices of Tomatoes at New York City: 1971/72 through 1980/81

Month	Mean (Dollar/Hundredweight)	Minimum (Dollar/Hundredweight)	Maximum (Dollar/Hundredweight)	Standard Deviation	Coefficient of Variation
December	6.31	3.50	8.14	1.57	24.88
January	7.70	4.03	10.14	1.92	24.94
February	6.91	3.89	11.87	2.42	34.88
March	7.37	4.25	15.03	3.01	40.84
April	7.48	5.32	10.45	1.59	21.26

Source: USDA, AMS, Fresh Fruit and Vegetable Prices, issues 1971-81.

1.3.3.2. Market Quantities

The Market quantities of tomatoes demonstrates much less fluctuation compared with cucumbers and peppers. The coefficients of variation, tabulated in Table 7, are in 7-11 percent range. This when considered in the context of high real price variability suggest, prima facie, a somewhat steeper demand schedule.

1.4. HYPOTHESES TO BE TESTED IN THIS STUDY

The principal hypothesis of this study is that a new price-quantity relationship emerges each month so that there is not one but a set of demand curves within the winter season. From an operational standpoint this fundamental hypothesis can be expressed in three distinct

Table 7: Quantity of Tomato Unloads at 41 Markets: 1971/72 through 1980/81

Month	Mean (Thousand/Hundredweight)	Minimum (Thousand/Hundredweight)	Maximum (Thousand/Hundredweight)	Standard Deviation	Coefficient of Variation
December	1,040	961	1,275	114.03	10.96
January	1,060	948	1,185	75.88	7.16
February	983	850	1,094	78.85	8.02
March	1,181	1,014	1,318	106.76	9.04
April	1,267	1,010	1,457	137.29	10.84

Source: USDA, AMS, Fresh Fruit and Vegetable Unload Totals for 41 Cities, issues 1971-81.

variants: first, that the intercepts of the monthly demand curves are statistically different; second, that not all the slopes are same; and, third, that both intercepts and slopes are different. These hypotheses, as explained in chapters III and IV, have been translated into corresponding Null form and tested using 1971-1981 data.

1.5. CHAPTER SUMMARY

Florida and Mexico provide the bulk of the vegetable supplies to the U.S. markets during the winter season defined over December to April period. Both the real wholesale prices and actual market unloads indicate significant month-to-month variation. The coefficients of variation for prices show highest price variability for tomatoes, followed by peppers and cucumbers while the corresponding coefficients for quantity indicate larger quantity fluctuation for cucumbers, followed by peppers and tomatoes in that order. Further, both prices and quantities are generally more volatile in late compared to the early winter period. This study hypothesizes that these monthly price and quantity fluctuations represent demand changes as opposed to expansion or contraction along a single demand curve.

CHAPTER II

LITERATURE REVIEW

The summary review of the voluminous past works appearing in this chapter is geared towards highlighting those theoretical and empirical dimensions that are considered of direct relevance to the present study. This includes a discussion of demand functions in general as well as of studies specifically on fresh cucumbers, peppers and tomatoes.

2.1. COMMODITY BACKGROUND STUDIES

The bulk of the analytical literature available on the winter season market of fresh cucumbers, peppers and tomatoes is in the context of Florida-Mexico competition. A detailed description of the production and marketing facets of these vegetables in Florida and Mexico is available, among other studies, in Simmons [1976] and Zepp and Simmons [1979].

Simmons et al [1976] examine the relative competitive advantage of Florida and Mexico for tomatoes, bell peppers, cucumbers, eggplants, strawberries and cantaloupes. For each of these commodities, the study discusses production practices and provides production cost comparisons. Also included is a review of the historical market shares of Florida and Mexico in the U.S. market based on 1962/63 to 1973/74 market unloads data.

Zepp and Simmons' [1979] study is an updated and expanded version of the study by Simmons et al [1976]. Although the central thrust is on estimating production costs, this study details production trends, cultural practices, marketing regulations and marketing shares separately for tomatoes, bell peppers, cucumbers, and eggplants. The study affirms Florida's cost advantage in cucumbers and bell peppers, and for tomatoes

concludes that neither Florida nor Mexico appears to have a clear cut cost advantage in the mid-winter period.

2.2. MARKET PRICE ANALYSIS

Simmons [1984] presents a detailed price analysis for fresh cucumbers, bell peppers, tomatoes, and other selected commodities. The study, using New York City wholesale prices deflated by the Wholesale Price Index, derives discrete probability distributions for weekly real prices. Also computed are the monthly price means, standard deviations, and coefficients of variation for the period November to May. Assuming one standard deviation as a measure of producers' risk costs, the study subtracts one standard deviation from the mean price to compute the producers expected price. This measure of expected price is then ranked to identify "best month" from the perspective of a risk averting producer. The "best months" thus identified are: April for tomatoes and February for both cucumbers and peppers.

2.3. DEMAND RELATIONSHIPS

Demand analysis, theoretically as well as empirically, is an extensively explored area. In the context of agricultural products, Tomek and Robinson [1977] summarize the post-War developments in demand analysis highlighting critical theoretical and empirical issues. From the perspective of the present study, three facets of the literature on demand functions, apart from a cursory review of a typical demand analysis, may be addressed: first, the nature of cause and effect in price-quantity relationships; second, imposition of theory-based restrictions in empirical work; third, standard procedures for evaluating

demand seasonality and the relevant empirical issues. Each merits separate discussion.

2.3.1. Cause and Effect Sequence

There are two alternative views on the cause and effect sequence in demand analysis: simultaneity versus recursiveness in price-quantity relationships. Simultaneity can exist under circumstances where current price affects production actually harvested; where the market is affected by the presence of significant inventories; where there are available choices for allocating a product among possible alternative uses; and in situations where the time lag in the supply response to a price change is "short relative to the unit of observation" [Tomek and Robinson, 1977, p.333].

The alternative sequential explanation of price-quantity relationship has found popular expression in price-dependent demand functions where the quantity supplied is treated as a predetermined exogenous variable. Leading representatives of this sequential view are cobweb-type models which treat cyclical behavior in prices and quantities as a self-generating process. The classical cobweb model is based on four principal assumptions: first, current production decisions are based on current prices; second, there is a significant time lag between the decision to produce and the realization of actual output; third, current production determines current prices; and, fourth, supply and demand functions are linear and static. Though it is possible to argue against the plausibility of these assumptions, especially against ex-ante and ex-post equality of production, the cobweb type models highlight an important fact particulaly relevant to perishable and semi-perishable agricultural products: that the current supply exerts a strong influence

on current prices. It is appropriate to mention that the time lapse between the cause and the observed effect, because of psychological, institutional or technological rigidities may be distributed over a period of time. Nerlove [1958] discusses in great detail various stock adjustment and adaptive expectation models that could be employed to handle such situations in demand analysis.

2.3.2. Theory Based Restrictions in Empirical Work

In empirical analysis, often because of lack of degrees of freedom as well as intercorrelation amongst the explanatory variables, it is difficult to generate a complete matrix of demand interrelationships. Generally, cross price elasticities amongst a set of commodities are small, but the "aggregate cross effects for a group of products may not be negligible" [Tomek and Robinson, 1977, p.348]. The practical solution to this problem has been found by imposing theory based restrictions on elasticities -- the homogeneity condition, Engel aggregation, the Slutsky condition, and Cournot aggregation -- and by assuming separability which greatly reduces the number of parameters to be estimated. The assumption of separability permits a two stage utility maximization procedure: in the first stage utility is maximized by allocating expenditures amongst separable groups of commodities and in the second stage group utility is maximized "subject to the restriction that group expenditures equal the amount determined at the first stage" [George and King, 1971, p.27]. This two stage utility maximization procedure allows expression of demand for a commodity as a function of the prices of all the items of the group to which the commodity in question belong, price indices of the remaining groups, and total expenditure. George and King's [1971] study of 49 major food commodities (or commodity groups) in the United States provides a

representative example of the application of the two-stage utility maximization procedure as well as of the use of elasticity restrictions.

2.3.3. Elements of "Typical" Demand Analysis

A popular procedure in demand analysis is to model aggregate market behavior based on time series information. Per capita disposable income and the price or quantity of important substitutes or complements are typically chosen as shift variables. Studies based on individual consumer or household behavior typically use household income and expenditure cross section data. In studies based on single cross section of data, consumer preferences and prices are taken as fixed at any given point of time and the impact of "inter-individual differences in income (and other factors) on consumption is estimated" [Tomek and Robinson, 1977, p.346]. Demand studies, however, have also been undertaken by pooling several rounds of cross section data [Mahmud, 1981] or by utilizing both cross section and time series data [Stone, 1954]. Generally, the analysis of consumption pattern in the household budget has taken the form of Engel's functions. Leser [1963] classifies the consideration governing the choice of an appropriate form of Engel's functions into three categories: close connection with the utility functions; plausibility of "the variations in the income elasticity of demand entailed by the formula"; and, finally, statistical reliability. The choice of variables explaining expenditure on a particular commodity is determined largely by the availability of information, though generally total expenditure and household size, with income serving as instrument variable, are important explanatory variables. Massell and Heyer [1969] in their study of Nairobi's 1963 household budget survey, tested total household expenditure, household size, education level, land ownership, and in the case of housing,

whether or not the housing is provided by the employer and found only the first two of significance. Houthaker's [1957] analysis of 40 surveys from 30 countries is strictly in terms of household expenditure and household size.

2.3.4. Seasonality Models and Related Empirical Issues

Seasonality models, based generally on quarterly or monthly observations, take into account the demand differences arising due to seasonal changes. Johnston [1963], Kmenta [1971], and Koutsoyiannis [1983] describe the standard procedure for modelling seasonal variations. Briefly, one season is arbitrarily selected as a base and zero-one (dummy) variables introduced for the remaining seasons. The model thus provides direct parameters for the base class and parameters representing differences from the base for the remaining classes. The statistical significance of the differences can be evaluated by using a Student's t-test or, alternatively, the differences can be set to zero and a new constrained regression estimated for setting up a Chow F-test of the Null hypothesis of no difference in coefficients across the seasons. However, this method, as Judge et al [1985] point out, requires additional computations for calculating the coefficients and the corresponding standard deviations for all the seasons.

The crucial issue in modelling seasonal demand is that the separate equations for individual seasons are only seemingly unrelated and, in fact, are potentially related because of correlations between their disturbances. The presence of this contemporaneous correlation, as Zellner [1962] showed, affects considerably the efficiency of the coefficient estimates obtained using an equation-by-equation application of least squares. Two procedures are available for taking into account

contemporaneous correlation. In the first (Telser) method, the residuals from separate equations are explicitly introduced as explanatory variables in each of the individual equations [Judge et al, 1985]. In the alternative Zellner method, "regression coefficients in all equations are estimated simultaneously by applying Aitken's generalized least squares to the whole system of equations" [Zellner, 1962]. The Aitken's estimator is constructed by using the residuals obtained by application of least squares to separate equations. The algorithm for obtaining the required Aitken's estimator is outlined in Zellner's original [1962] work as well as in Theil [1971].

The underlying assumption in both the Telser and Zellner methods is that autocorrelation is either absent or has been corrected while applying least squares to individual equations. Judge et al [1985] recommends a vector autoregressive model for simultaneous solution to contemporaneous and the most often encountered first-order serial correlation. The essence of this method is to estimate the following error correlation matrix by regressing residuals of equation i against lagged residuals of all the equations in the system :

$$\begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \cdot \\ \cdot\cdot \\ \varepsilon_{it} \end{bmatrix} = \begin{bmatrix} \rho_{11} & \rho_{12} & \cdots & \rho_{1i} \\ \rho_{21} & \rho_{22} & \cdots & \rho_{2i} \\ \cdot\cdot & \cdot\cdot & \cdots & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdots & \cdot\cdot \\ \rho_{i1} & \rho_{i2} & & \rho_{ii} \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t-1} \\ \varepsilon_{2,t-1} \\ \cdot\cdot \\ \cdot\cdot \\ \varepsilon_{i,t-1} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ v_{2t} \\ \cdot\cdot \\ \cdot\cdot \\ v_{it} \end{bmatrix}$$

Once the correlation matrix, ρ, has been estimated, data, except for the first observation in each class, can be transformed as indicated below and least squares applied to estimate the coefficients:

$$Y^*_{jt} = Y_{jt} - \rho_{ji}Y_{1,t-1} - \cdots - \rho_{ji}Y_{i,t-1} \qquad \text{where}$$

$$j = 1, 2 \cdots i \qquad t = 1, 2, \cdots T$$

2.4. APPLIED VEGETABLE DEMAND ANALYSES

Nuckton [1980] summarizes past demand analyses on a number of vegetables including cucumbers, peppers and tomatoes. Of direct relevance to the current research are studies by Castro and Simmons [1974] and Simmons and Pomereda [1975], which may be outlined briefly.

Castro and Simmons [1974] use a cobweb-type single price determined equation and Johnston-Kmenta procedure for evaluating differences in the monthly U.S. demand for fresh cucumbers, peppers and cantaloupes during the winter season based on 1959-1972 data. Personal disposable income, and in the cases of cucumbers and peppers, per capita quantity of lettuce, are included in the demand equations. The estimated equation is constrained in accordance with the Null hypotheses of no difference in the intercept-slope of the demand function across the winter months and Chow F-test performed to test the hypotheses. Based on the Chow test, the authors conclude that the demand for cucumbers and peppers shifts to the right in March and April.

Simmons and Pomareda [1975], used a linear programming production model for Culiacan and Fuerte Sur regions in Mexico to "generate static industry equilibria under a range of alternative specifications

concerning risk, competitive supply structure, and wage rates" [p.472]. As an input to the programming model, the research estimates U.S. and Canadian winter season net import monthly demand functions for cucumbers, peppers and tomatoes. The authors first estimate shipping point linear demand schedules with shipping point price as the dependent and the quantity shipped as the independent variable, and later subtract supplies from Florida and other production areas (average of last three years) ... to obtain the estimated import demand functions" [Simmons and Pomareda, 1975, p.472]. The results of the linear programming model show that Mexican 1970-73 average actual shipments for cucumbers, peppers and tomatoes during the December-May period exceed the corresponding estimated equilibrium quantities. Regarding the pattern of shipments, the study concludes that Mexican actual shipments for cucumbers and peppers are excessive during December and January, while for tomatoes shipments could be increased in December and reduced in February and March.

2.5. CHAPTER SUMMARY

Demand analysis can be undertaken based either on simultaneous or on a sequential view of price and quantity relationship. The later view has been found to be appropriate for a large number of perishable and semi-perishable agricultural products. The choice of variables selected for empirical analysis is governed by the nature of the commodity being investigated as well as by the research objectives, though typically per capita disposable income and price or quantity of close substitutes and complements are included. Statistical evidence pertaining to the 1960s reveal that demand functions for fresh cucumbers, peppers and tomatoes experience changes during the winter season.

CHAPTER III

METHODOLOGY

This chapter attempts to define an appropriate analytical procedure for testing the proposed hypotheses. Accordingly, discussed here are the theoretical framework of the study, model specification, econometric procedure, and, finally, variable operationalization.

3.1. THEORETICAL FRAMEWORK

A demand curve is obtained by expressing quantity demanded as a function of price on the assumption that other arguments in the function are given. It is often assumed that the demand function possess an inverse such that price may be expressed as a unique function of quantity [Henderson and Quandt, 1980, p.21]. This section explores the link between the inverse demand function and the consumers' utility maximizing behavior. Also included here is an exposition of concepts of elasticity and flexibility and the implications that the magnitude of demand elasticity has for the suppliers of a commodity.

3.1.1. Inverse Demand Functions

Utility in its direct form is defined over quantities as objects of choice. The consumer is hypothesized to maximize utility subject to a budget constraint. If U represents utility; $q_1, q_2, \ldots, q_n$ quantities of n goods; $p_1, p_2, \ldots, p_n$ respective market prices; and y total income, the consumers optimization problem is:

$$\text{maximize} \quad U = U(q_1, q_2, \ldots, q_n) \qquad \text{---- (1)}$$

$$\text{subject to} \quad \sum_{i=1}^{n} p_i q_i = y \qquad \text{---- (2)}$$

In Lagrangian form:

$$L = U(q_1, q_2 \ldots ,q_n) - \lambda \left(\sum_{i=1}^{n} p_i q_i - y \right)$$

Differentiating with respect to q_i and λ and setting the derivates equal to zero, we have:

$$\partial L/\partial q_i = U_i - \lambda p_i = 0$$
$$\partial L/\partial \lambda = \sum_{i=1}^{n} p_i q_i - y = 0$$

Solving the (n+1) equations we obtain a set of Marshallian demand functions of the form:

$$q_i = q_i \ (p_1, p_2, \ldots p_n, y) \qquad \text{---- (3)}$$

Substituting (3) into (1) we get the indirect utility indicator:

$$U = U_i [q_i \ (p_1, p_2, \ldots ,p_n, y)]$$
$$= F \ (p_1, p_2, \ldots ,p_n, y) \qquad \text{---- (4)}$$

The function F is a dual representation of U. Demand functions can also be derived from function F by setting up the optimization problem as follows:

$$\text{Minimize} \quad F(p_1, p_2, \ldots ,p_n, y)$$
$$\text{subject to} \quad \sum_{i=1}^{n} p_i \quad q_i = y$$
$$V = F(p_1, p_2, \ldots ,p_n, y) + g\left(\sum_{i=1}^{n} p_i q_i - y \right)$$
$$\partial V/\partial p_i = F_i + g q_i = 0$$
$$\partial V/\partial g = \sum_{i=1}^{n} p_i \quad q_i - y = 0$$

Solving for prices, we obtain inverse demand functions with quantity and income as the arguments for prices, that is

$$p_i = p_i\,(q_1, q_2, \ldots, q_n, y) \qquad \text{--- (5)}$$

In the first optimization problem, the consumers, given market prices, make a choice of quantities such that maximum utility is attained. In the second, the consumer, for given market quantities, minimizes variable prices as a proportion of income to attain the highest utility level. The inverse demand functions, as indicated in Chapter II, are frequently used in agricultural product demand analysis where reasonable grounds exist to treat the market quantity as pre-determined.

3.1.2. Elasticity-Flexibility Relationship

A fundamental concept in demand analysis is elasticity: its counterpart in the inverse demand function is flexibility. The flexibility coefficients indicate a proportionate change in price associated with a proportionate change in quantity (or income), other things remaining the same. Given the inverse demand function as in equation (5) above, the own-quantity, cross quantity and income flexibilities are, respectively, as follows:

$$F_{ii} = [\partial p_i / \partial q_i][q_i / p_i] \;;$$
$$F_{ij} = [\partial p_i / \partial q_j][q_j / p_i] \;; \text{ and,}$$
$$F_{iy} = [\partial p_i / \partial y\;][y\;/ p_i\;] \;.$$

The own-quantity flexibility is usually negative, income flexibility is generally positive, while cross quantity flexibility, unlike the cross

price elasticity, is expected to be positive for complements and negative for substitutes. The absolute values of flexibilities are not necessarily the reciprocal of elasticities since different variables are held constant in taking the partial derivatives. However, as Houck [1965] shows, the reciprocal of the own-quantity flexibility forms the lower limit, in absolute terms, of the own-price elasticity. Only when all the cross effects are zero, does own price elasticity equal the reciprocal of the own-quantity flexibility.

3.1.3. Demand Changes and Producers Incomes

The common determinants of demand are income and its distribution; population size and its structure; prices and supplies of other goods and services; and, above all consumers' tastes and preferences. A change in any of these determinants may either cause a parallel shift in the demand curve, or result in a structural change in the demand function. The influence of these factors generally unfolds over the longer run. Demand can, however, experience seasonality, that is, short term fluctuations in tastes and preferences possibly related to factors like climate and holidays. Seasonality of supply can also exist and arises, in agricultural products, from climatic factors and the biological nature of the production process.

Demand changes, for a given supply, induce price variability and, depending upon the nature of the change, usually argues for supply adjustments as producers attempt to maximize their incomes. If the five months of the winter season are treated as distinct markets and producers are assumed to act as price discriminating collusive monopolists, the profit maximization condition requires, as is shown below, the equality of marginal revenue in each market with the overall marginal cost of

output:

$$\Pi = \sum_{i=1}^{5} r_i(q_i) - C \sum_{i=1}^{5} (q_i)$$

$$\frac{\partial \Pi}{\partial q_i} = r_i'(q_i) - C_i' \sum_{i=1}^{5} (q_i) = 0$$

$$r_i'(q_i) = C_i' \sum_{i=1}^{5} (q_i)$$

where Π is profit, r is revenue and c is cost. Making a simplifying constant cost assumption, the problem reduces to revenue maximization, that is, of finding prices and quantitities where marginal revenue in each market is equal to zero. Since,

$$MR = p(1 + \frac{1}{E})$$

where MR is marginal revenue, p the price and E the own price elasticity, the equality of marginal revenue in different market implies:

$$\frac{p_i}{p_j} = \frac{(1 + \frac{1}{E_j})}{(1 + \frac{1}{E_i})}$$

which means that optimal prices would be lower in markets with a more elastic demand schedule.

The above discussion of price discriminating behavior of producers, however, assumes, in addition to a monopolist market structure, technical control over production, and costless production adjustment and market allocation processes -- assumptions which are not easy to satisfy in production of agricultural commodities. But if the seasonal behavior of the demand function is consistent over time, one can at least make a reasonable case that agricultural producers should have a lower cost

associated with the risk of depressed prices due to expanded production in the elastic demand season. Accordingly, within the parameters of climate and costs, producers may plan higher production levels during the elastic demand season.

3.2. MODEL SPECIFICATION

Specification of the model used in the present research has proceeded in three stages: first, consideration of the nature of the demand relationship on the basis of economic theory and the special characteristics of the commodities under investigation; second, selection of the variables to be used in the demand function in the light of economic theory, objectives of the study, and broad statistical considerations; and, finally, model redefinition in a post-statistical experimentation phase. It is recognized that trials with alternative models are considered inappropriate from the strict point of view of statistical inference. Accordingly, it is deemed necessary to report fully the extent and nature of experimentation in the present study, if only to clarify some issues.

3.2.1. Nature of Demand Relationship

Given the fact that cucumbers, peppers and tomatoes are perishable, a cobweb-type price-dependent demand function appears justified to begin with. It is clear that current prices cannot affect current production. It is also reasonably certain that inventories of fresh vegetables are not carried over to the next production round. However, what does require examination is the possible significance of the impact of current prices on the portion of production actually harvested in the U.S. and on the level of imports from Mexico. Further the presence or lack of ready

alternatives to the U.S. fresh market needs to be ascertained. These assessments are needed to verify the validity of assuming that supply is exogenous for employing a cobweb-type demand model.

3.2.1.1. Current Price and Harvesting Costs

The literature reviewed [Simmons et al, 1976 and Zepp and Simmons, 1979] did not indicate that crop destruction without harvest is a regular feature of Florida's winter season production of cucumbers, peppers and tomatoes. This is (partially) confirmed by Table 8 which present the approximate ratios of Florida's total production and marketing costs to the shipping point prices for these vegetables for the seasons 1973/74 and 1978/79. These ratios indicate shipping point prices favorable to crop harvesting which, in any event, should be expected to be undertaken at all prices above what it may cost to destroy the harvest. Potential of simultaneity, however, exists because of reported occasional destruction of the nonexportable portion of the pepper crop in Mexico [Zepp and Simmons, 1979].

Table 8 : Ratios of Total Production and Marketing Costs to Shipping Point Prices in Florida: 1973/74 and 1978/79

	1973/74			1978/79		
Month	Cucumbers	Peppers	Tomatoes	Cucumber	Peppers	Tomatoes
December	1.28	3.79	1.28	1.23	1.10	1.50
January	1.28	1.00	1.28	1.20	1.31	1.81
February	1.59	1.35	1.59	1.59	1.77	1.78
March	1.44	1.04	1.44	1.56	1.77	2.23
April	1.84	1.82	1.84	1.80	1.80	2.54

Source: Based on production and marketing cost data appearing in USDA, Vegetable Situation , 1979, and price data in USDA, Fresh Fruit and Vegetable Prices, issues 1973, 1974, 1978 and 1979.

3.2.1.2. Current Prices and Imports

The U.S. policy of vegetable imports establishes quality as well as tariff restrictions. It is difficult within the scope of this study to evaluate the impact of these restrictions, especially concerning quality, on actual imports. Our interest here is in the extent of association between the fluctuations in current market prices and changes in tariff rates. The tariff structure for vegetables is variable within a season but the tariff rates (Table 9) have remained unchanged at least since the 1973/74 season.

Table 9, apart from the within-year variability of import duty rates, indicates the stability of the tariff regime' over time. Apparently, there is no evidence that the tariffs are systematically tied to short-term market price fluctuations such as to endogenize prices and quantities.

3.2.1.3. Alternative Markets and Supply Diversion

Canada, in addition to the U.S., is a major winter season market in the region for cucumbers, peppers and tomatoes. Both Florida and Mexico are regular suppliers to the Canadian market. The latter, compared with the U.S., however, has limited import absorption capacity. The Mexican domestic market is still smaller and is fed largely by nonexport quality produce. For Mexican pepper production, the "U.S. mrket is practically the only outlet..." [Zepp and Simmons, 1979, p.28]; for cucumbers, the national market accounts for less than 15 percent of total production; while for tomatoes about 30 percent of the total production is sold in Mexico. Simmons and Pomereda [1974] modelled switching of tomatoes between the Mexican export and national markets, and found that no transfers from the export market to the Mexican market were

Table 9 : U.S. Tariff Rates on Fresh Vegetable Imports: 1973/74 and 1980/81

(Cents/Pound)

Entry Period	Rate
Cucumbers	
December 1 - February 28	2.2
March 1 - June 30	3.0
September 1 - November 30	3.0
Peppers	
Any Time During the Year	2.5
Tomatoes	
March 1 - July 14	2.1
September 1 - November 14	2.1
Any Other Period	1.5

Source: For 1973/74, Simmons et al, Mexican Competition for Fresh Winter Vegetable Market, 1976, and for 1980/81, U.S. International Trade Commission, Supplement 1 to Tariff Schedules of the United States Annotated, 1981.

economical. The normal quantity of nonexportable qualities was sufficient in each month to keep the Mexican prices below U.S. prices and thus prevent price equalization" [p.478].

3.2.2. Variable Selection

Prime candidates for explanatory variables in a price dependent demand function are total consumption, quantities of close complements and substitutes, income, population, and inflation. Including inflation as a separate explanatory variable is justified only if evidence exists that the demand function is not homogenous of degree zero in income and prices. Since no indication supportive of this view is available in the literature reviewed, inflation can be taken into account by deflating both income and prices rather than including it as a separate explanatory variable. Similarly, population can be included by using per capita

consumption and income, which helps to minimize the problem of intercorrelation amongst the explanatory variables. A generalized model can thus be written as:

$$p_i = [(q_1/N), (q_2/N), \ldots, (q_n/N), (y/N)] \qquad \text{--- (6)}$$

where N represents population and both p and y are in real terms. This function states that the real price of a commodity is determined by per capita supply of its own quantity, the per capita quantity of complements and substitutes and per capita income. Since all of the vegetables in question serve as salad components, each of them, in addition to lettuce, could theoretically be included in the equation for the other. A practical consideration, however, prompted departure from this theoretical understanding: the inclusion of these complements and substitutes would cause degrees of freedom problems if demand seasonality is empirically ascertained using the separate equation approach. Alternatively inclusion of all potential complements and substitutes would aggravate multicollinearity if a single pooled equation were employed using zero-one variables. Further, the magnitudes of these cross effects are unlikely to be significant (confirmed subsequently in statistical trials) and hence no substantive information is gained by their inclusion in the current framework. Equation (6) above thus simplifies into the following form:

$$p_i = f[(q_i/N), (y/N)] \qquad \text{--- (7)}$$

that is, prices are a function of per capita quantities and per capita income.

3.3. ECONOMETRIC PROCEDURE

This section sets the analytical procedure designed for estimating the parameters of the demand function and for testing the hypotheses outlined in section 1.4 of Chapter I. Suggested here is a pooled single equation approach for estimating the coefficients and a Chow F test for testing the hypotheses.

3.3.1. Econometric Model

Demand changes can be ascertained empirically either by using a separate equation approach or by employing a single pooled equation. In the former procedure, equations are estimated for each subset and a Chow F-test can be set up to test for equality of corresponding coefficients across all subsets:

$$F = \frac{SSE^{pr} - \sum_{j=1}^{k} SSE^{sr}}{\sum_{j=1}^{k} SSE^{sr}} \quad \frac{\Sigma_{nj} - lk}{l(k-l)}$$

where k = number of subsets;

n = number of observations in each subset;

l = number of coefficients in each equation;

SSE^{pr} = sum of squares of errors of pooled run; and,

SSE^{sr} = sum of squares of errors of separate runs.

If the calculated F is greater than the tabulated $F^{l-\alpha}_{k,n-l}$, the hypothesis of equality of coefficients across subsets is rejected. In the separate equation approach all coefficients across the subsets are allowed to differ. In the alternative pooled single equation approach, it

is convenient to hold, if required, one or more coefficients constant across all subsets and allow the remaining coefficients to differ. This approach also allows preservation of more degrees of freedom compared with the separate equation approach. Accordingly, a pooled single equation econometric model has been specified to observe demand behavior over the winter months:

$$p_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta_i \sum_{i=1}^{5} \left(\frac{q}{N}\right)_t \delta_i + \gamma\left(\frac{y}{N}\right)_t + \varepsilon_{it} \qquad \text{--- (8)}$$

where i = class 1, ..., 5 (i=1, observation for December; ... ; i=5, observation for April);

t = crop year (t=1, 1971/72; ...,t=10, 1980/81);

δ_i = Kronecker delta, 1 if class i and zero otherwise; and,

ε = stochastic error term.

Several aspects of the above model may be briefly noted. First, each winter season, covering the time period December-April, is regarded as belonging to a specific annual time period. Second, within the winter season, each of the five months is treated as a class representing seasonal characteristics hypothesized to be responsible for demand changes. Third, the per capita income coefficient is not expected to be different across the classes. Fourth, the model requires a zero intercept forcing option for estimation. And finally, the model directly provides co-efficient estimates for each of the five months.

3.3.2. Tested Hypotheses

In conformity with the hypothesis statement at section 1.4 of chapter I, the following hypotheses are proposed:

$$H_1: \quad \alpha_1 = \alpha_2 = \cdots = \alpha_5$$

$$H_2: \quad \beta_1 = \beta_2 = \cdots = \beta_5$$

$$H_3: \quad \alpha_1 = \alpha_2 = \cdots = \alpha_5$$

$$\beta_1 = \beta_2 = \cdots = \beta_5$$

The first hypothesis, H_1, sets up a test of equality of intercept coefficients, the second, H_2, sets up a similar test of the slope coefficients, and the third, H_3, tests for differences in both intercept and slope across the five winter months.

3.3.3. Hypothesis Testing

The above hypotheses can be tested, indirectly, by using the Student's t-test and, directly, by using the Fisher's F-test. The t-test can be employed here to undertake a pairwise comparison of coefficients. In effect, this amounts to testing the significance of the difference between two coefficients while holding all the coefficients in the equation at the estimated level. The F-test, on the other hand, can be used here to test directly the joint equality of coefficients but requires estimation of additional equations conforming to each of the hypotheses. These additional constrained equations are:

$$p_{it} = \alpha + \beta_i \sum_{i=1}^{5} \left(\frac{q}{N}\right)_t \delta_i + \gamma\left(\frac{y}{N}\right)_t + \varepsilon_{it} \qquad \text{--- (9)}$$

which imposes a constant intercept on all time periods but allows the slope coefficients to differ;

$$p_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta\left(\frac{q}{N}\right)_t + \gamma\left(\frac{y}{N}\right)_t + \varepsilon_{it} \qquad \text{--- (10)}$$

which imposes constant slopes but allows the intercepts to differ; and,

$$p_{it} = \alpha + \beta\left(\frac{q}{N}\right)_t + \gamma\left(\frac{y}{N}\right)_t + \varepsilon_{it} \qquad \text{--- (11)}$$

which imposes both constant slopes and intercepts.

The Chow F-test then is:

$$F = \frac{SSE^c - SSE^{uc}}{SSE^{uc}} \cdot \frac{n - l}{k}$$

where n = number of observations;

l = number of coefficients in the unconstrained equation;

k = number of equalities required to state the constraint;

SSE^c = sum of squares of errors for the constrained regression; and,

SSE^{uc} = sum of squares of errors for the unconstrained regression.

The above Chow F-test can be set up in two alternative ways. First, starting from the fully constrained equation (11), the restrictions are relaxed (as in equations 8-10) and the drop in the sum of squared errors is observed. In the reverse scenario, a fully unconstrained equation, (8), is subjected to restrictions (as in equations 9-11) and increases in the sum of squared errors examined. The results of these two alternative

settings may not necessarily coincide because of the difference in the underlying assumptions. The latter, in imposing the individual hypotheses, permits other coefficients to vary across subsets. The former, in relaxing the constraints, forces equality of the remaining coefficients amongst the subsets. In the present study the version of starting from the unconstrained regression is relied upon in drawing conclusions because of the flexibility that it offers with regard to the coefficient behavior.

3.4. VARIABLE OPERATIONALIZATION AND DATA SOURCES

The paragraphs to follow outline the specifics of the variables of equation (8) as actually employed in the regression analysis. The variable operationalization here suffers from the usual failure to achieve a perfect harmony between the theoretical concepts and the data actually used to express these concepts. It is nonetheless believed that data as actually used represent reasonable proxies of the corresponding concepts.

3.4.1. Market Price

The variable price has been operationalized as the nominal wholesale market price prevailing in the New York City market. It has been assumed here that the vegetable marketing system is competitive and price differentials across markets represent only transfer costs. Accordingly, the price in any market place can serve as a proxy for the U.S. market price. This assumption of competitive market structure appears reasonable in view of the high degree of intercorrelation between the prices prevailing in New York City and in other major marketing centers. The choice of the New York City market is based on the fact that it is the

single largest marketing center for cucumbers, peppers and tomatoes in the U.S.

New York City monthly wholesale prices are taken from various issues of USDA's Fresh Fruit and Vegetable Prices. These published prices are for produce of generally good market quality and condition. Cucumber and pepper prices are found on 1-1/9 bushel basis, while prices of tomatoes are available for various weights and sizes. Since the quoted prices are reported according to the source of supply, for cucumbers and peppers, a simple average of all entries in a month has been taken to represent the monthly price. Similar averages have been computed for tomatoes based on three categories -- Florida, 30 pound carton green, 6 x 6s; Florida, 20 pound carton 4 x 5s - 5 x 6s; and, Mexico, 20 pound carton pink, 4 x 5s - 5 x 6s. The monthly prices thus obtained have been converted into cents per pound and, finally, deflated by the Consumers Price Index (1967=100) obtained from the TROLL package data base.

3.4.2. Per Capita Quantity

There are two sets of published data that can be taken to represent the total market quantity. The shipment data refers to movements from major shipping centers and includes exports, Mexican overland shipments to Canada, and some imports repacked and shipped from within the U.S. The alternative unloads data provides actual market supplies to 41 major U.S. markets. The difference between the two series is significant with shipments understandably being greater than unloads. Castro and Simmons, while opting for use of adjusted shipment data, suggested that "since there is no way to reconcile the difference one must choose between the two sources". [Castro and Simmons, 1974, p.52]. In our study the unloads data set has been used.

The market unloads data have been obtained from various issues of USDA's Fresh Fruit and Vegetable Unload Totals. The published data, since 1978, classifies peppers and tomatoes under two headings each: bell peppers and peppers, others; and, tomatoes and tomatoes, cherry. To retain data uniformity these post-1977 classifications have been merged in obtaining totals for peppers and tomatoes. The groupings peppers, others and tomatoes, cherry, incidentally, account for less than 10 percent of the respective totals. The vegetable unloads totals have been first converted from rail carlot equivalents to weight units (for the pre-1978 period) employing conversion factors reported in Appendix A, and subsequently expressed in pounds per person using total population series obtained from the TROLL package data base.

3.4.3. Per Capita Income

The per capita income variable has been operationalized as per capita U.S. disposable income. Disposable income was obtained from the TROLL data base and translated into real per capita disposable income using population and the Consumer Price Index.

The data coverage extends from December 1971 to April 1981, that is, ten observations each for the five winter months. These data are reported in Appendix B.

3.5. CHAPTER SUMMARY

Inverse demand functions, derivable from consumers' utility maximizing behavior, are appropriate in situations where the quantity is exogenously determined. The evidence on scant instances of crop destruction without harvest; the stable U.S. vegetable import tariff; and, finally, lack of alternative markets to which supplies from Florida

or Mexico could be readily diverted, overwhelmingly points out to a recursive demand relationship. A price-dependent demand function with per capita quantity and per capita disposable income as explanatory variables is specified. The nominal variables have further been translated into real terms. For the purpose of variable operationalization, the U.S. is treated as a single market with New York City wholesale price serving as a proxy for the U.S. price.

CHAPTER IV

ECONOMETRIC ANALYSIS

This Chapter presents the results of the regression analysis, tests the proposed hypotheses, and computes the direct flexibilities and elasticites. The opening sections, however, are devoted to presentation of statistical experimentation undertaken in the course of econometric analysis.

4.1. PRIOR ECONOMIC AND STATISTICAL EXPECTATIONS

Based on economic theory, the signs of the coefficients for per capita quantity and per capita disposable income are expected to be, respectively, negative and positive. In terms of magnitude, the quantity coefficients should be statistically significant while the income coefficients should most likely be significant. The evident lesser emphasis on the expectation of significant income coefficients stems from the fact that expenditure on these vegetables forms a relatively small proportion of the total consumer budget and, more importantly, per capita consumption of fresh vegetables in the U.S. has not shown any appreciable increase over the period under investigation. Statistically, the model is expected to indicate contemporaneous (and possibly first order) autocorrelation, heteroscedasticity as well as multicollinearity. The first expectation is founded on the likely correlation among the class residuals, while the second and third are based on the extensive use of zero-one variables in the econometric model.

4.2. STATISTICAL EXPERIMENTATION

Three unsuccessful attempts may be stated at the outset -- inclusion of a squared term for per capita quantity on the assumption of a non-linear relationship; merger of deflation and heteroscedasticity considerations by developing a satisfactory Glejser form equation with Consumer Price Index and heteroscedastic variables explaining absolute residuals of the model with nominal prices and incomes; and, generation of a residual matrix of the form given at section 2.4.3. of Chapter II. In the light of these unsuccessful attempts, it was decided to use the model in linear form, deflate the monetary variables, and, as detailed in the following section 4.2.1, develop an alternative model for the behavior of error terms of monthly equations included in the system.

In examining the results of the model, initital attention was focussed on multicollinearity. This was necessary because of the need to decide whether to retain per capita disposable income as an explanatory variable given that its estimates were not statistically different from zero in the cucumber and tomato equations. Practically, the issue was to assess the change in the adjusted coefficient of determination and multicollinearity caused by dropping the income variable from the two equations. Multicollinearity is well known to damage the efficiency of regression estimates, yet no definitive formal test exists to ascertain the extent of the damage. A workable solution here is to compare the condition indexes of regressions with and without the income variables. Belsley et al [1980] provide the following rules-of-the-thumb in interpreting the magnitude of condition indexes:

> Most of the experimental evidence show that weak dependencies .. begin to exhibit themselves with Condition Indexes around

> 10, and in some cases as low as 5. An index in the neighborhood of 15-30 tends to result from an underlying near dependency ... usually considered to be the borderline of tightness in informal econometric practice. Condition Indexes of 100 or more appear to be large indeed, causing ... great potential harm to regression estimates [p.153].

For each of the three vegetables, regression results were obtained both with and without per capita disposable income and corresponding improvements/deterioration in the coefficient of determination and Condition Indexes compared. These results are summarized in Table 10.

Table 10: Principal Features of Regression Results With and Without Per Capita Real Disposable Income as an Explanatory Variable

	With $(\frac{Y}{N})_t$			Without $(\frac{Y}{N})_t$	
	Significance of γ	$\bar{R}^2$	Maximum Condition Index	$\bar{R}^2$	Maximum Condition Index
Cucumbers	Insignificant	0.975	90.2	0.975	16.6
Peppers	Significant	0.959	78.1	0.956	16.7
Tomatoes	Insignificant	0.949	76.9	0.948	35.5

The exclusion of per capita disposable income can be interpreted from the above indicators to result in containing multicollinearity without appreciably changing the adjusted coefficient of determination. As such, it was decided to drop the per capita disposable income as an explanatory variable from the cucumbers and tomatoes equation, where, in any event, it figured at a level not statistically different from zero.

4.3. SUMMARY OF SECOND ORDER TESTS

The efficiency of the least squares estimates requires fulfillment of two major assumptions: first, successive values of residuals are

temporally independent; and, second, the variance of the errors is homoscedastic. Serial correlation has been checked here by using auto-regressive models while for identification of heteroscedasticity, Spearman Rank Correlation test [Koutsoyiannis, 1983] has been employed. Errors in none of the three regressions indicated the presence of serial correlation. The residuals of the equations for cucumbers and tomatoes, however, revealed heteroscedasticity which required the use of weighted least squares.

In addition to serial correlation and heteroscedasticity, the efficiency of the regression estimates in the present study can also be affected by the presence of likely contemporaneous correlation. The regressions for cucumbers and peppers indeed indicate statistically significant contemporaneous correlation coefficients, which, as is explained in section 4.3.1., have been used in data transformation.

4.3.1. Contemporaneous and Serial Correlation

Residual analysis in the present study is complicated due to two factors: first, each class, that is month, form a part of the time continuum; and, second, there is discontinuity in data set because of omission of the May to November time period. The analytical procedure employed to handle these difficulties rests on one fundamental assumption: the disturbances in any single time period are related to previous period disturbances in the same equation and current period disturbances in the immediately preceding contiguous class, that is:

$$\varepsilon_{it} = \rho_1 \varepsilon_{i,t-1} + \rho_2 \varepsilon_{i-1,t} \qquad \text{--- (12)}$$

This model proposes, for instance, that the errors for the month of January are related to errors for December, one month previous, and January, one year previous (there was no evidence of higher order auto-correlation). Additionally, in view of the implausibility of the results from our attempt to estimate separate serial correlation coefficients for each of the classes, another simplifying assumption of the equality of such coefficients across all the classes have been made.

For the three vegetable regressions, residuals were lagged in conformity with equation (12) above; the non-matching December-April observations deleted; and, correlation estimates made both through simple and multiple regressions. These results are summarized in Table 11.

The results presented in Table 11 indicate absence of first-order serial correlation among residuals of regressions for all the three vegetables. Contemporaneous correlation coefficients for the cucumber and tomato equations, however, are significant. There is apparently a one month pattern in the residuals, but no twelve month pattern. The coefficients -- 0.40 for cucumber and 0.41 for tomato equation -- have been applied to transform the data deleting in the process the non-matching December-April observations plus the first observation in each month.

4.3.2. Heteroscedasticity

Heteroscadasticity has been identified using the Spearman Rank Correlation test. The explanatory variables appearing significant in such an identification process have been employed in developing a Glejser form equation for absolute residuals and, subsequently, using the predicated value of absolute residuals to weight the observations. Weighting was not

Table 11: Estimated Contemporaneous and Serial Correlation Coefficients

Vegetable	Estimated Equation	F-Ratio	Degrees of Freedom
Cucumbers	$\varepsilon_{it} = \underset{[0.58]}{0.09}\ \varepsilon_{t-1}$	0.34	44
	$\varepsilon_{it} = \underset{[2.48]*}{0.40}\ \varepsilon_{i-1,t}$	6.17	39
	$\varepsilon_{it} = \underset{[2.49]*}{0.44}\ \varepsilon_{i-1,t} - \underset{[0.46]}{0.08}\ \varepsilon_{t-1}$	3.11	34
Peppers	$\varepsilon_{it} = \underset{[0.80]}{0.14}\ \varepsilon_{t-1}$	0.64	44
	$\varepsilon_{it} = \underset{[1.42]}{0.24}\ \varepsilon_{i-1,t}$	2.06	39
	$\varepsilon_{it} = \underset{[1.28]}{0.23}\ \varepsilon_{i-1,t} - \underset{[0.26]}{0.05}\ \varepsilon_{t-1}$	0.84	34
Tomatoes	$\varepsilon_{it} = \underset{[0.86]}{-0.15}\ \varepsilon_{t-1}$	0.74	44
	$\varepsilon_{it} = \underset{[2.94]*}{0.41}\ \varepsilon_{i-1,t}$	8.66	39
	$\varepsilon_{it} = \underset{[2.82]*}{0.41}\ \varepsilon_{i-1,t} - \underset{[1.73]}{0.31}\ \varepsilon_{t-1}$	5.89	34

Figures in parentheses are t-values with those carrying an asterik significant at the 5 percent level.

required in the pepper equation as the Spearman Rank Correlation test failed to reveal heteroscedasticity. The weighting function employed for heteroscedasticity correction for the cucumber and tomato equations are, respectively, as follows:

$$|\varepsilon| = 1.93 - 8.05\left(\frac{q}{N}\right)_t \delta_2 + 7.53\left(\frac{q}{N}\right)_t \delta_4 \qquad \bar{R}^2 = 0.59$$

$$|\varepsilon| = 1.60 + 2.62\left(\frac{q}{N}\right)_t \delta_1 - 1.25\left(\frac{q}{N}\right)_t \delta_4 \qquad \bar{R}^2 = 0.69$$

In the first equation above the variability of absolute residuals is explained by the dummy variable representing January and per capita quantity pertaining to March. The model errors are relatively small in January and large in March. In the second equation, absolute residuals from the tomato regression are similarly associated with the dummy variable representing the month of December and the per capita quantity pertaining to March. In this case, however, the smaller absolute residuals are in March, with large residuals in December.

4.4. REGRESSION RESULTS

This section presents the results of the regression analysis separately for each of the three vegetables. In addition to recording the regression estimates and the results of the Chow F-tests, the monthly demand schedules for each of the vegetables are graphed in Figures 4-6. The estimated coefficients are statistically significant at a 5 percent level with the notable exceptions of the per capita quantity coefficients pertaining to December and January in both the cucumber and tomato equations. Though from the strict point of view of research objectives, the statistical significance (or otherwise) of the difference between the two coefficients rather than the significance of the coefficients *per se*, is of primary interest, the t-values of the coefficients have also been ascertained through a single equation approach to see whether or not such t-values alter the conclusions relating to the significance of coefficients obtained by using a pooled single equation procedure. Heteroscedasticity-corrected data was segregated and separate monthly equations estimated both for cucumbers and tomatoes. The t-values obtained from these separate equations do not alter the conclusions as to

Figure 4 : Monthly Demand Schedules for Cucumbers

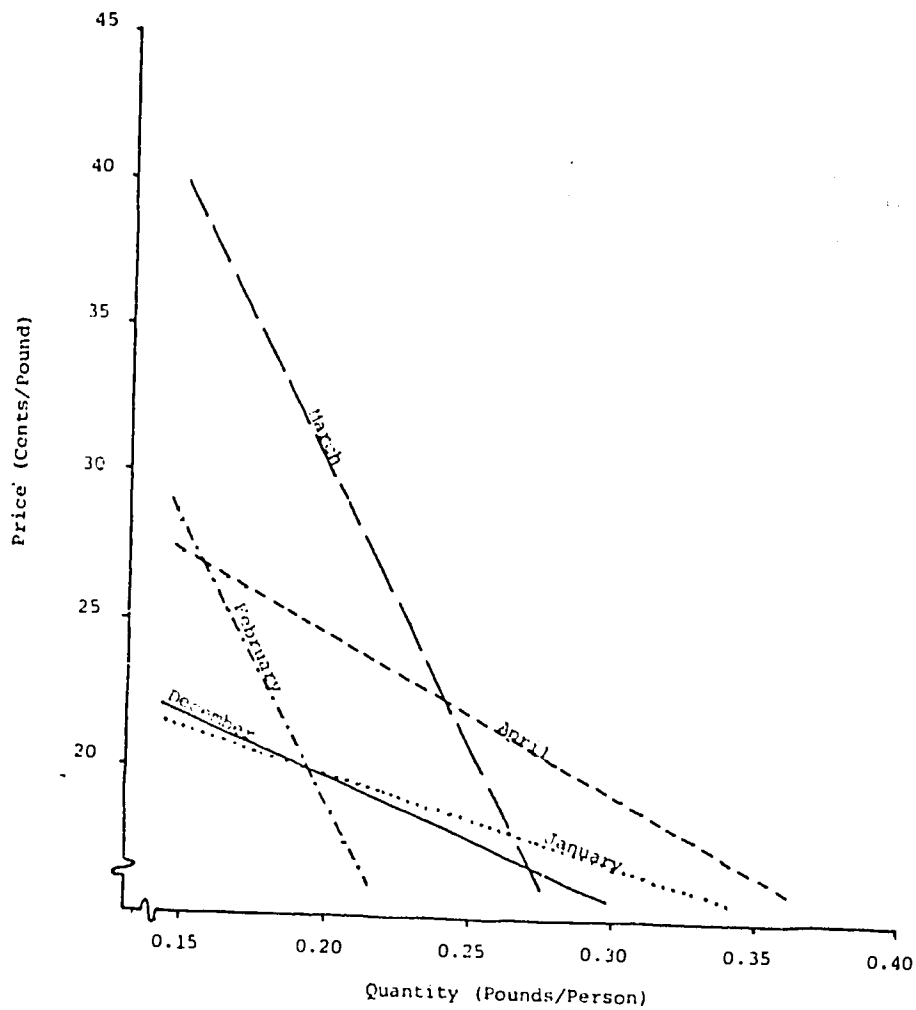


Figure 5 : Monthly Demand Schedules for Peppers

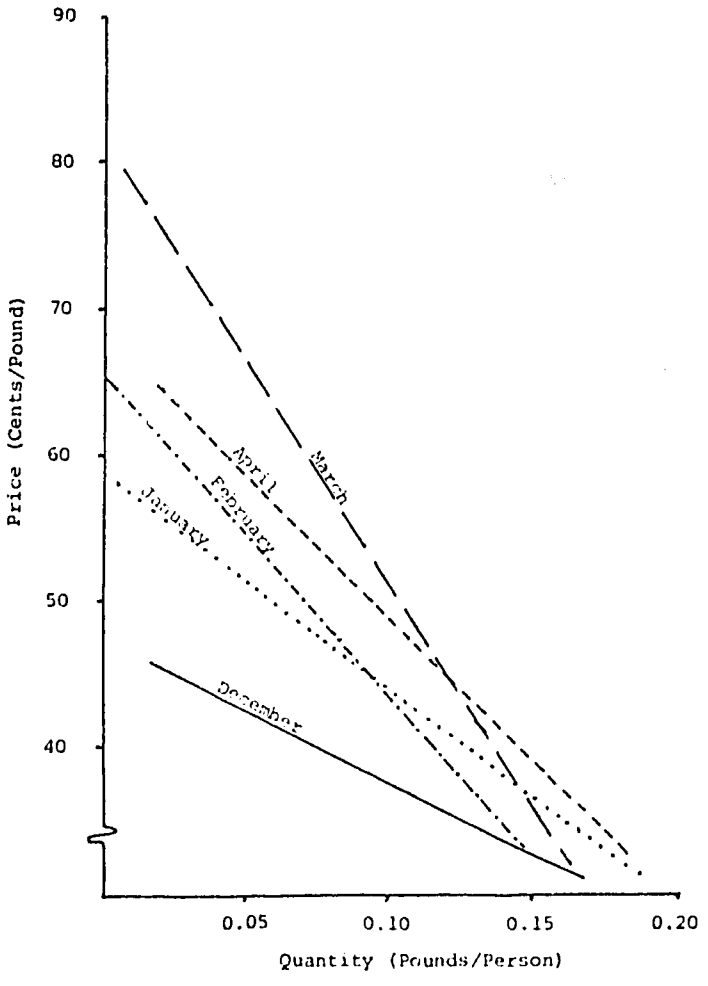
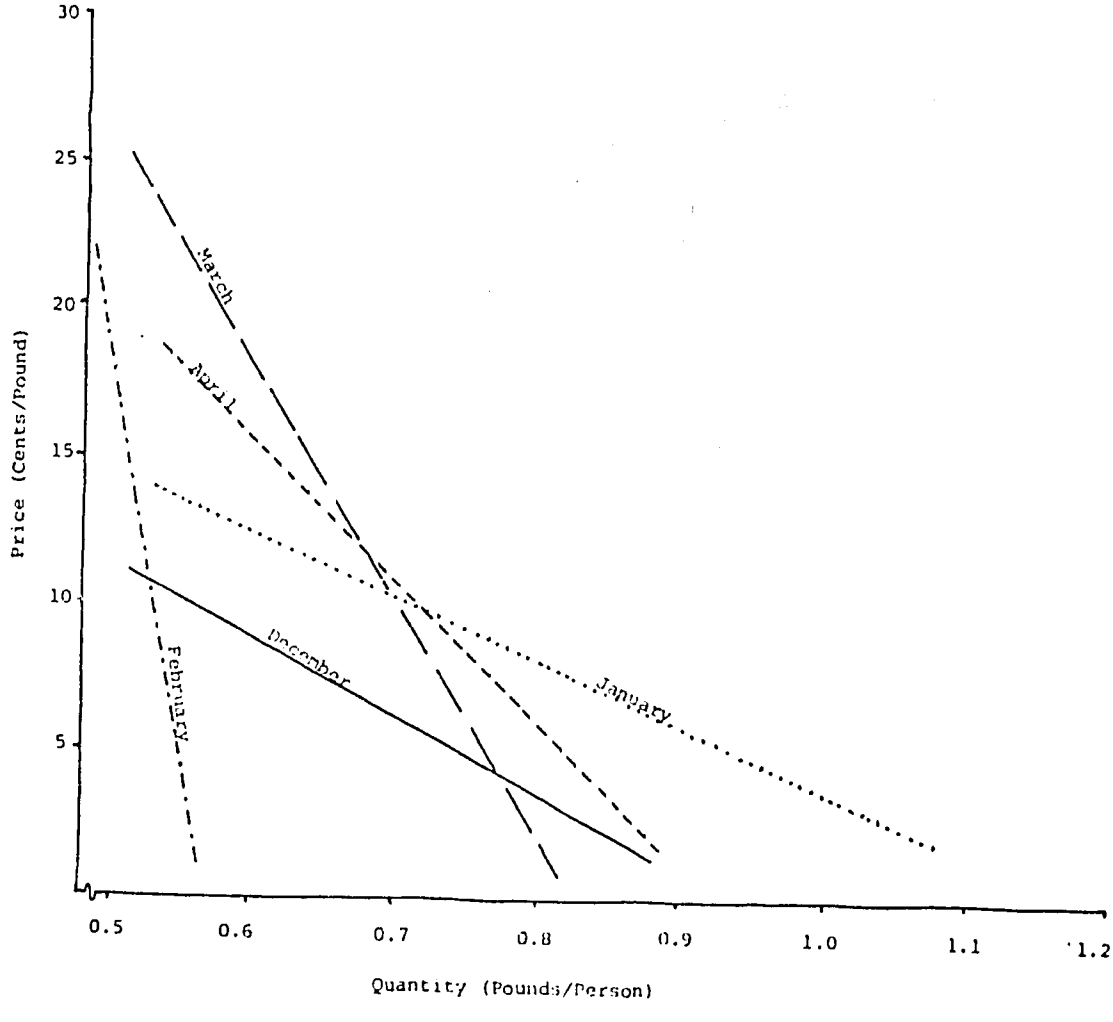


Figure 6 : Monthly Demand Schedules for Tomatoes



the significance of the coefficients with two exceptions -- the t-value of the coefficient of per capita quantity pertaining to January in the cucumber equation, and of the coefficient of the dummy variable pertaining to December in the tomato equation, improves to enter the zone of significance. The conclusions as to the significance of the remaining coefficients remained unchanged.

4.4.1. Cucumbers

The regression results for the cucumber equation are summarized in Table 12. The given t-values indicate significant dummy variables (monthly intercepts) for all the months. The coefficients for the per capita quantity are also significant at 5 percent level except for December and January which indicate significance only at the 20 percent and 10 percent levels, respectively. The Chow F-test (Table 13) leads to the rejection of all the three hypotheses concerning intercept and slope differences across the five months. The corresponding t-test of paired differences for monthly intercepts and slopes (Tables 14 and 15) show that March is different from December, January and February in terms of intercept, and both March and February are different from January in terms of per capita quantity coefficient.

These results conform to the expectation of structural changes in the demand function within the winter season. It appears that the demand function for cucumbers start flattening in January, sharp steepening in February (increase in the absolute value of slope), a more or less parallel outward shift in March, and a slope reflattening (decrease in the absolute value of slope) in April. Figure 4 graphs the changing demand behavior.

Table 12 : Cucumbers : Regression Result

Month	Weighted Least Squares Estimates					
	α_i		β_i			
December	22.54	-	71.67	+		
	[2.96]*		[1.48]			
January	21.99	-	61.31	+		
	[4.20]*		[1.94]		$\bar{R}^2$	0.979
February	31.83	-	143.90	+	$\bar{R}^2$	0.974
	[11.99]		[6.91]*			
					F Ratio	164.99
March	43.37	-	153.52	+		
	[8.98]*		[5.22]*			
April	28.35	-	76.69			
	[4.78]*		[2.70]*			

Figures in parentheses are t-values with those carrying an asterik significant at the 5 percent level. Further, the per capita quantity coefficient for January is significant based on t-values obtained from separate monthly equations.

4.4.2. Peppers

Estimates for the pepper equation (Table 16) show that none of the dummy variables are statistically significant -- December even has a negative sign -- and seems to have been overshadowed by the positive significant income coefficient. The per capita quantity coefficients, however, are significant. Constraining the estimated equation and conducting the required Chow F-test (Table 17), it transpires that individually neither monthly intercepts nor slope are statistically different within respective sets. This result tallies with the paired difference t-test (Tables 18 and 19) which show that, individually, intercepts and slope differences across the five months are not statistically different from zero. The Chow F-test, however, does lead to

Table 13: Cucumbers: Test of Hypotheses

Model	SSE	DF	Hypotheses Tested	Calculated F	Tabled F	Conclusion
$\hat{p}_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta_i \sum_{i=1}^{5} (\frac{q}{N})_t \delta_i$	80.15	35				
$\hat{p}_{it} = \alpha + \beta_i \sum_{i=1}^{5} (\frac{q}{N})_t \delta_i$	105.36	39	$\alpha_1 = \alpha_2 = \cdots = \alpha_5$	2.75	2.65	Reject Hypothesis
$\hat{p}_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta (\frac{q}{N})_t$	111.06	39	$\beta_1 = \beta_2 = \cdots = \beta_5$	3.37	2.65	Reject Hypothesis
$\hat{p}_{it} = \alpha + \beta (\frac{q}{N})_t$	247.80	43	$\alpha_1 = \alpha_2 = \cdots = \alpha_5$ $\beta_1 = \beta_2 = \cdots = \beta_5$	9.15	2.22	Reject Hypothesis

Table 14 : Cucumbers : T-test of Paired Differences for Dummy Variables (Monthly Intercepts)

	Dec	Jan	Feb	Mar	Apr
Dec	0	-0.54 [0.06]	9.29 [1.15]	20.83 [2.31]*	5.81 [0.60]
Jan		0	9.84 [1.68]	21.37 [3.00]*	6.36 [0.80]
Feb			0	11.54 [2.09]*	-3.48 [0.54]
Mar				0	-15.02 [1.96]
Apr					0

Figures in parentheses are t-values with those carrying an asterisk significant at the 5 percent level.

Table 15 : Cucumbers : T-test of Paired Differences of Quantity Coefficients Monthly Slopes)

	Dec	Jan	Feb	Mar	Apr
Dec	0	10.36 [0.18]	-72.22 [1.37]	-81.85 [1.44]	-5.01 [0.09]
Jan		0	-82.58 [2.18]*	-92.21 [2.14]*	-15.38 [0.36]
Feb			0	-9.63 [0.27]	67.20 [1.91]
Mar				0	76.83 [1.88]
Apr					0

Figures in parentheses are t-values with those carrying an asterik sigificant at the 5 percent level.

the rejection of the joint hypothesis of no difference in intercepts and slopes. These results can be interpreted to indicate that the demand function experiences changes in the winter season though these changes cannot be ascribed specifically to either intercept or slope. It can be seen from the visual presentation in Figure 5, that the structural changes in the demand function are in upwards direction with the slope of the demand curve becoming relatively steeper through March and flattening somewhat in April.

4.4.3. Tomatoes

The regression results shown in Table 20, indicate significant zero-one variables (monthly intercepts) and the per capita quantity coefficients for February, March and April while both coefficients for the remaining December and January are not statistically significant. The conclusions that can be drawn from the Chow F-test (Table 21) and the t-test (Tables 22 and 23) are identical to that for peppers -- the individual hypotheses of no difference in either intercept or slope cannot be rejected while the joint hypothesis is rejected at the 5 percent significance level. Broadly, the demand function for tomatoes follows a behavior pattern similar to that for cucumbers with steepening of the demand curve in the mid-winter season and a noticeable reflattening during late winter (Figure 6). These changes, however, cannot be associated specifically with either intercept or slope with any reasonable degree of statistical certainty.

4.5. DIRECT FLEXIBILITIES AND MINIMUM ELASTICITIES

The broad characteristics of the demand behavior, as outlined in the preceding sections, finds its reflection in the direct point flexibilities and minimum elasticities computed at respective monthly mean values (Table 24). All the three vegetables indicate a remarkable

Table 16 : Peppers : Regression Results

Month	Least Square Estimates				
	α_i	β_i	γ		
December	-4.02 [0.15]	- 271.96 [2.02]*	+ 0.016		
January	6.72 [0.28]	- 302.74 [2.36]*	+ 0.016	$\bar{R}^2$	0.967
February	13.43 [0.54]	- 403.00 [3.40]*	+ 0.106	$\bar{R}^2$	0.959
March	28.72 [1.14]	- 475.68 [4.85]*	+ 0.016	F Ratio	104.43
April	17.33 [0.64]	- 356.93 [3.93]*	+ 0.016 [2.04]*		

Figures in parentheses are t-values with those carrying an asterik significant at the 5 percent level.

Table 17: Peppers: Test of Hypotheses

Model	SSE	DF	Hypotheses Tested	Calculated F	Tabled F	Conclusion
$\hat{p}_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta_i \sum_{i=1}^{5} (\frac{q}{N})_t \delta_i + \gamma(\frac{y}{N})_t$	1137.34	39				
$\hat{p}_{it} = \alpha + \beta_i \sum_{i=1}^{5} (\frac{q}{N})_t \delta_i + \gamma(\frac{y}{N})_t$	1251.50	43	$\alpha_1 = \alpha_2 = \cdots = \alpha_5$	0.98	2.62	Fail to Reject Hypothesis
$\hat{p}_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta(\frac{q}{N})_t + \gamma(\frac{y}{N})_t$	1201.77	43	$\beta_1 = \beta_2 = \cdots = \beta_5$	0.55	2.62	Fail to Reject Hypothesis
$\hat{p}_{it} = \alpha + \beta(\frac{q}{N})_t + \gamma(\frac{y}{N})_t$	2216.89	47	$\alpha_1 = \alpha_2 = \cdots = \alpha_5$ $\beta_1 = \beta_2 = \cdots = \beta_5$	4.63	2.19	Reject Hypothesis

Table 18 : Peppers : T-test of Paired Differences of Dummy Variables (Monthly Intercepts)

	Dec	Jan	Feb	Mar	Apr
Dec	0	10.73 [0.53]	17.45 [0.96]	32.73 [1.87]	21.34 [1.23]
Jan		0	6.71 [0.36]	22.00 [1.21]	10.61 [0.57]
Feb			0	15.29 [0.97]	3.89 [0.25]
Mar				0	-11.39 [0.77]
Apr					0

Figures in parentheses are t-values.

Table 19 : Peppers : T-test of Paired Differences for Quantity Coefficients (Monthly Slopes)

	Dec	Jan	Feb	Mar	Apr
Dec	0	-30.78 [0.17]	-131.04 [0.75]	-203.72 [1.25]	-84.97 [0.53]
Jan		0	-100.26 [0.61]	-172.94 [1.31]	-54.18 [0.53]
Feb			0	-72.68 [0.49]	46.07 [0.31]
Mar				0	118.75 [0.90]
Apr					0

Figures in parentheses are t-values.

Table 20 : Tomatoes : Regression Results

Month	Weighted Least Squares Estimates α_i		β_i			
December	12.55	-	13.43	+		
	[1.41]		[0.72]			
January	15.11	-	12.97	+		
	[1.43]		[0.61]		$\bar{R}^2$	0.945
February	23.88	-	41.59	+	$\bar{R}^2$	0.931
	[3.95]*		[2.87]*			
					F Ratio	59.87
March	28.10	-	33.90	+		
	[4.98]*		[3.61]*			
April	21.62	-	23.29			
	[8.00]*		[5.56]*			

Figures in parentheses are t-values with those carrying an asterik significant at the 5 percent level. Further, the dummy variable representing the intercept for December is significant based on the t-value obtained from the separate equation.

Table 21: Tomatoes: Test of Hypotheses

Model	SSE	DF	Hypotheses Tested	Calculated F	Tabled F	Conclusion
$\hat{p}_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta_i \sum_{i=1}^{5} (\frac{q}{N})_t \delta_i$	77.58	35				
$\hat{p}_{it} = \alpha + \beta_i \sum_{i=1}^{5} (\frac{q}{N})_t \delta_i$	83.86	39	$\alpha_1 = \alpha_2 = \cdots = \alpha_5$	0.71	2.65	Fail to Reject Hypothesis
$\hat{p}_{it} = \alpha_i \sum_{i=1}^{5} \delta_i + \beta (\frac{q}{N})_t$	84.39	39	$\beta_1 = \beta_2 = \cdots = \beta_5$	0.76	2.65	Fail to Reject Hypothesis
$\hat{p}_{it} = \alpha + \beta (\frac{q}{N})_t$	156.27	43	$\alpha_1 = \alpha_2 = \cdots = \alpha_5$ $\beta_1 = \beta_2 = \cdots = \beta_5$	4.44	2.22	Reject Hypothesis

Table 22 : Tomatoes : T-test of Paired Differences for Dummy Variables (Monthly Intercepts)

	Dec	Jan	Feb	Mar	Apr
Dec	0	2.57 [0.19]	11.34 [1.05]	15.55 [1.47]	9.07 [0.97]
Jan		0	8.77 [0.72]	12.99 [1.09]	6.51 [0.60]
Feb			0	4.22 [0.51]	-2.26 [0.34]
Mar				0	-6.48 [1.04]
Apr					0

Figures in parentheses are t-values.

Table 23 : Tomatoes : T-test of Paired Diffferences for Quantity Coefficients (Monthly Slopes)

	Dec	Jan	Feb	Mar	Apr
Dec	0	0.46 [0.02]	-28.16 [1.20]	-20.47 [0.98]	-9.86 [0.52]
Jan		0	-28.62 [1.11]	-20.93 [0.90]	-10.32 [0.47]
Feb			0	7.69 [0.45]	18.31 [1.22]
Mar				0	10.61 [1.03]
Apr					0

Figures in parentheses are t-values.

Table 24: Direct Flexibilities and Direct Minimum Elasticities

Month	Cucumbers		Peppers		Tomatoes	
	Flexi-bility	Elasti-city	Flexi-bility	Elasti-city	Flexi-bility	Elasti-city
December	-1.00	-1.00	-1.43	-0.70	-1.01	-0.99
January	-0.84	-1.19	-1.65	-0.61	-0.82	-1.22
February	-1.38	-0.72	-1.68	-0.60	-2.70	-0.37
March	-1.37	-0.73	-1.84	-0.54	-2.50	-0.40
April	-1.01	-0.99	-1.33	-0.75	-1.82	-0.55

behavioral uniformity with lower elasticities (in absolute terms) during January and February compared with the elasticities during the beginning and close of the winter season. This conclusion, however, is impaired somewhat by the fact that these computations are based on some statistically insignificant coefficients.

4.6. CHAPTER SUMMARY

The Chow F-test for the three hypotheses show that demand functions for all five months are not the same. The monthly shifts, however, cannot be ascribed specifically to intercept or slope changes in the case of peppers and tomatoes. For cucumbers, these demand changes can be associated specifically with intercept or slope changes. The overall behavior of the demand curve indicates that for all the three vegetables the demand function experiences steepening in mid-winter and reflattening in late winter. The direct flexibilities and direct elasticities follow a similar pattern.

CHAPTER V

SUMMARY AND CONCLUSIONS

This research examines the month-to-month behavior of the demand function for fresh cucumbers, peppers and tomatoes during the winter season defined over the December to April period. Treating the United States as a single market, the study estimates inverse demand functions for these vegetables based on 1971-81 New York City wholesale real prices, per capita vegetable unloads in 41 U.S. markets, and per capita real disposable income. The estimated equations are constrained in conformity with the three hypotheses of no difference in intercepts, no difference in slopes, and, no difference in both intercept and slopes across the five months and Chow F-test performed. To investigate additional dimensions of these demand changes, the study conducts a pairwise t-test of differences between monthly intercepts and slopes. Also computed are monthly direct flexibilities and corresponding minimum elasticities. The results of the statistical investigations show that the demand curves faced by the producers for each of the three vegetables are not all the same during the winter months. Generally, the demand curve tends to become flatter in December, January and April relative to February and March. These changes in the demand curve signifies changing consumer behavior during the winter season. Apparently, tastes and preferences, based probably on consumers diet patterns, are such that the quantity demanded for cucumbers, peppers and tomatoes is more sensitive to prices in December, January and April compared with February and March.

5.1. IMPLICATIONS FOR THE PRODUCERS

To the extent that imports are concentrated in the mid-winter period and that the U.S. domestic producers provide relatively more market supplies during the winter tails, the above stated result has an apparent optimistic meaning for the U.S. producers. The absolute magnitude of the (lower limits) of the own-price elasticities, however, are generally less than unity (except during January for cucumbers and tomatoes) which cast doubts on the advisability of rapid supply expansion. The supplies originating domestically, however, can thus be interpreted to enjoy a timing advantage over imports which, from the perspective of demand, should be expected to result in lower price-uncertainty-related risk costs compared to the situation facing supplies during non-tail periods.

Given the fact that the large proportion of imports are during a relatively inelastic February-March demand period, it is of interest to examine whether the producers in exporting countries could increase their revenues through supply reallocation within the winter season. The price discrimination model outlined in section 3.1.3. of chapter III can be employed to examine the optimal export allocations to the U.S. winter season market, though under somewhat restrictive assumptions. These assumptions are: adjustments in vegetable planting time are technically possible; no additional cost is involved in production adjustments and market supply reallocation; the industry operates under a zero marginal cost situation; the demand functions are linear in the relevant output range; and, most importantly, there is no retaliatory reaction from other suppliers. If these assumptions hold, Mexican producers would be able to allocate monthly supplies to the U.S. winter market such that the

marginal revenue for each market (month) is driven to zero.

Starting from the estimated U.S. demand funtions, the Mexican optimum supplies can be generated by subtracting the supplies of other producers from the demand functions and subsequently solving for revenue maximizing quantities:

$$p = \alpha + \beta q$$
$$= (\alpha + \beta q_1) + \beta q_2 \quad [\, q = q_1 + q_2 \,]$$
$$r = p * q_2 = c\, q_2 + \beta q_2^2 \quad [\, c = \alpha + \beta q_1 \,]$$

where the total quantity, q, is the sum of supplies from Mexico, q_2, and from other producers, q_1, and r is the revenue of Mexican producers. Differentiating the revenue maximizing equation above with respect to q_2, setting the derivatives equal to zero and solving for q_2, we have:

$$q_2 = c \,/\, 2\beta$$

Using this procedure optimum monthly quantities for the three vegetables have been estimated for comparison with the actual three-year average quantities presented in Table 1. Table 25 explains.

The results in Table 25, graphed in Figures 7-9, suggest that the Mexican producers could increase their total revenues through overall supply changes and through supply reallocation across the five winter months. Generally, the estimated optimal pattern suggests that Mexican producers should enter the U.S. market early in the winter season, contract supplies in February and March, and re-expand supplies in April. However, it seems that the actual supplies for cucumbers and

Figure 7 : Actual and Estimated Optimal Mexican Cucumber Supplies to the U.S. Market: Average 1978/79 through 1980/81

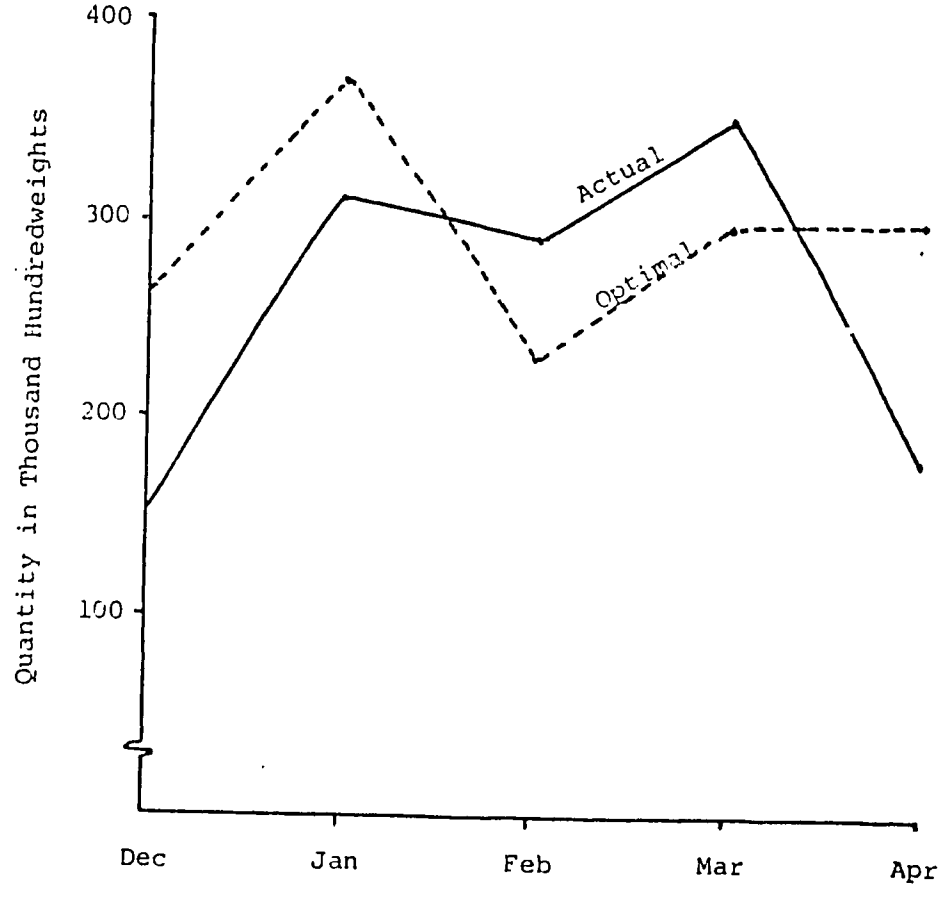


Figure 8 : Actual and Estimated Optimal Mexican Pepper Supplies to the U.S. Market : Average 1978/79 through 1980/81

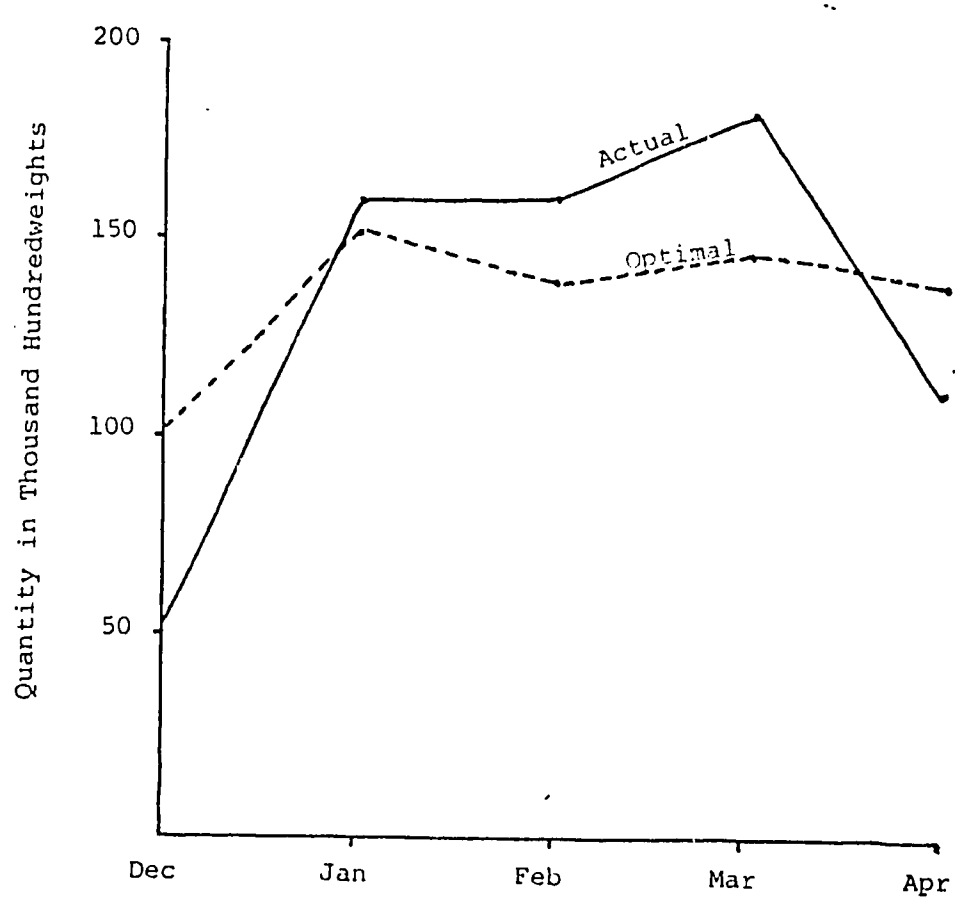


Figure 9 : Actual and Estimated Optimal Mexican Tomato Supplies to the U.S. Market : Average 1978/79 through 1980/81

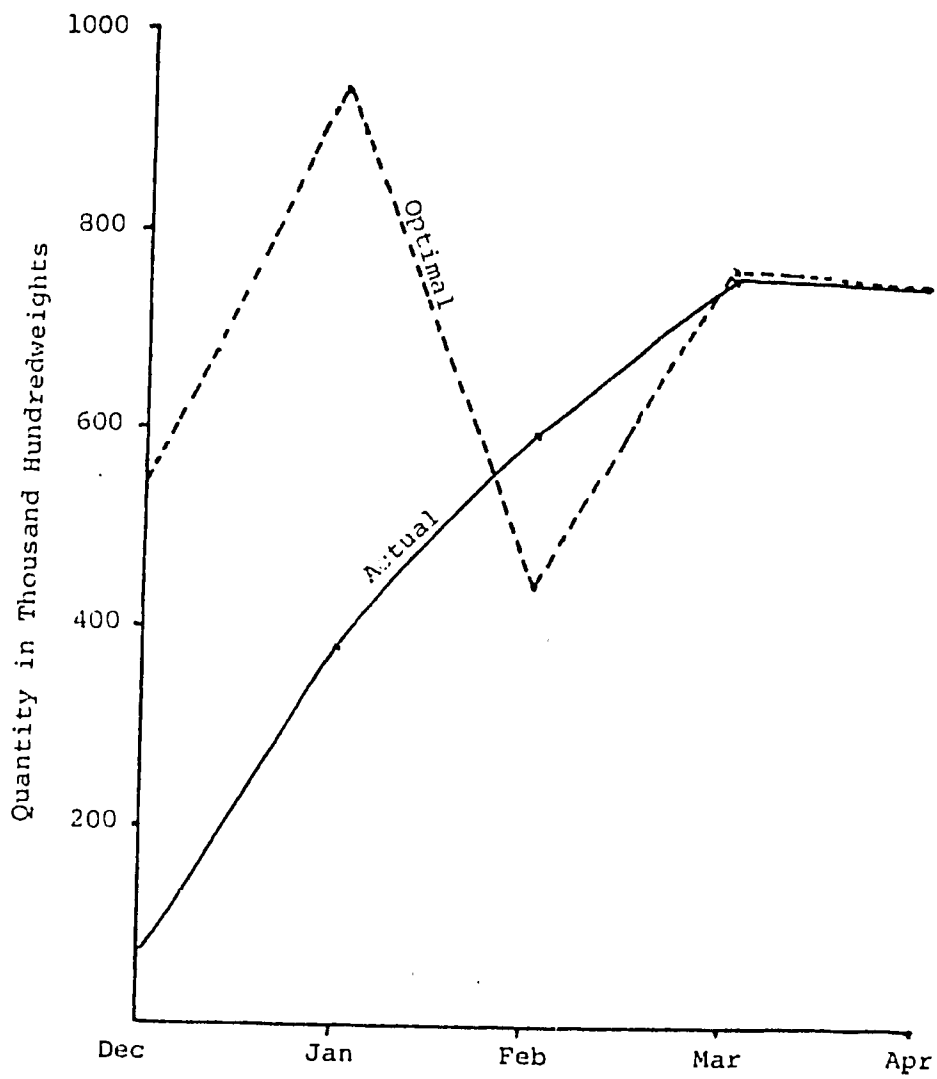


Table 25 : Comparison of Actual and Estimated Optimum Mexican Vegetable Supplies to the U.S. Market: Average 1978/79 through 1980/81

Month	Cucumbers		Peppers		Tomatoes	
	Actual	Optimum	Actual	Optimum	Actual	Optimum
	Thousand Hundredweights					
December	149	267	53	101	78	549
January	311	368	160	152	381	945
February	293	230	161	139	597	445
March	353	296	182	146	758	760
April	179	299	113	139	754	754
Total	1285	1460	669	677	2568	3453

peppers are not markedly different from the estimated optimal supply pattern which indicates that the potential of revenue increases through supply changes are unlikely to be significant for these two vegetables. In the case of tomatoes, the computations indicate that Mexican producers could increase their revenues through supply contraction in February and supply expansion in December and January. Table 26 shows the estimated change in total (real value of) revenues resulting from the difference between the actual and the optimal Mexican supplies.

Table 26: Estimated Difference in Total Revenue Between Actual and Optimal Mexican Vegetable Supplies

Month	Quantity Difference			Revenue Difference		
	--Thousand Hundredweights---			--- -- Thousand Dollars ---		
	Cucumbers	Peppers	Tomatoes	Cucumber	Peppers	Tomatoes
December	+ 118	+ 48	+ 471	+ 443	+ 281	+ 1319
January	+ 57	- 8	+ 564	+ 89	+ 8	+ 1823
February	- 63	- 22	- 152	+ 251	+ 85	+ 425
March	- 57	- 36	+ 2	+ 222	+ 275	+ (x)
April	+ 120	+ 26	0	+ 490	+ 102	0

(x) Insignificant

The extent to which the projected increase in total revenue would actually be channelled to the Mexican producers depends upon the behavior of the marketing margins. It must be conceded that the specific optimal quantitites shown in Table 25 and the revenue computations appearing in Table 26, were obtained under a restrictive set of assumptions and require further study for refinement. The general conclusion that there are possibilities for Mexican producers to increase their revenues through supply adjustments, nonetheless, remains valid. Such a potential appears to be significant for tomatoes, probably moderate for cucumbers, and minimal for peppers.

5.2. LIMITATIONS OF THIS STUDY

This study focussed on a restricted purpose of ascertaining demand behavior through the winter season. This narrowly targetted approach has inevitably led to several inadequacies some of which may be mentioned. First, the study does not examine the monthly demand behavior in the context of the consumers' budget, that is, it does not generate a matrix of demand interrelationships. Second, the research treats the United States as a single market and does not take into consideration the possibilities of geographical market specialization within the U.S., with Florida serving the Eastern and Mexico serving the Western parts of the country. Thirdly, the study indulges in considerable data averaging by not specifically including vegetable quality considerations in the demand analysis. Lastly, the assessment of optimal Mexican exports to the U.S. markets, as already indicated, is based on fairly restrictive assumptions which require considerable further investigations.

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APPENDICES

Appendix A : Factors Used for Converting Rail Carlot Equivalents to Weight Units

Vegetables	Bushel or Carton per Railcar	Pounds per Bushel or Carton
Cucumbers	700 a/	55 b/
Peppers	850 a/	25 b/
Tomatoes	1000 a/	40 a/

Sources: a/ USDA, AMS, Fresh Fruit and Vegetable Unload Totals for 41 Cities, 1977.

b/ USDA, AMS, Fresh Fruit and Vegetable Unload Totals for 41 Cities, 1978.

Appendix B : Data Used in the Regression Analysis

Market Price a/ (Cents/Pound)			Market Unloads b/ (Million Pounds)			Disposable Income c/	Population c/
Cucumbers	Peppers	Tomatoes	Cucumbers	Peppers	Tomatoes	(Billion Dollars)	(Thousand)
9.42	16.05	7.94	33.6	20.7	96.1	775.0	208740
9.62	23.15	8.22	30.8	22.0	94.8	775.4	208917
15.20	24.65	5.48	27.1	19.6	103.9	784.0	209061
17.32	25.00	5.27	30.5	19.6	131.8	787.1	209212
17.64	38.36	7.09	31.1	14.8	124.1	792.0	209386
7.50	17.66	6.98	34.9	20.2	95.1	858.4	210821
13.61	26.00	10.14	30.4	22.1	105.2	863.9	210985
18.46	22.64	6.47	22.3	19.0	101.5	881.1	211120
20.49	23.88	6.10	27.7	20.9	129.0	891.6	211254
13.66	37.77	6.94	34.8	20.6	137.3	898.8	211420
10.02	29.98	8.14	30.6	15.8	87.6	955.9	212785
10.41	19.21	7.46	35.2	26.1	111.1	958.9	212932
13.25	19.70	9.37	27.4	21.2	85.0	963.7	213074
12.26	20.35	5.88	31.6	25.4	120.8	969.1	213211
13.58	27.27	8.29	35.8	24.4	110.1	977.6	213361
17.49	18.92	7.08	29.3	21.8	105.4	1031.7	214782
15.95	28.19	7.71	24.8	23.1	98.7	1029.7	214931
17.93	30.31	7.56	21.6	21.3	88.6	1035.7	215065
24.20	26.06	6.76	20.9	23.0	116.6	1040.4	215198
11.84	16.70	5.63	41.4	30.9	132.2	1068.2	215353
13.31	22.92	7.22	34.4	24.0	107.9	1139.7	216931
11.66	20.25	5.82	33.7	25.5	105.9	1154.4	217095
12.51	21.71	4.87	30.1	21.7	109.4	1165.9	217249
15.54	36.94	8.50	35.0	23.0	117.2	1170.9	217381
8.55	38.57	6.14	57.8	26.2	138.2	1175.5	217528
11.47	18.70	7.05	35.3	23.8	107.8	1240.6	219006
12.32	31.15	8.98	36.3	25.5	96.2	1247.9	219179
13.66	27.83	8.41	32.1	18.3	94.6	1244.7	219344
21.94	43.88	8.66	31.3	18.1	102.3	1273.1	219504
17.72	31.56	8.60	51.6	23.3	118.6	1281.2	219684
8.68	13.71	6.01	44.8	27.9	112.8	1386.8	221303
10.88	17.35	6.02	40.5	32.5	109.9	1388.8	221477
13.88	18.05	5.08	31.8	28.0	97.3	1403.2	221629
18.57	18.59	6.17	30.9	30.5	128.3	1425.1	221792
19.86	41.13	10.45	29.2	21.4	101.0	1441.8	221991
10.78	18.29	4.56	35.2	24.5	94.3	1560.5	223682
10.30	18.80	9.69	39.7	32.7	112.6	1571.8	223880
12.73	21.61	6.05	32.2	26.6	100.1	1585.7	224066
13.21	24.22	7.04	39.0	28.3	111.0	1604.9	224234

Appendix B, continued

Market Price a/ (Cents/Pound)			Market Unloads b/ (Million Pounds)			Disposable Income c/	Population c/
Cucumbers	Peppers	Tomatoes	Cucumbers	Peppers	Tomatoes	(Billion Dollars)	(Thousand)
12.54	25.66	7.57	40.3	26.3	126.2	1614.6	224431
10.92	19.87	4.64	29.4	23.8	106.1	1728.3	226234
10.29	19.18	4.03	40.6	26.3	118.5	1759.8	226444
9.42	16.18	3.89	37.8	28.2	107.9	1765.2	226636
9.95	17.33	4.24	41.0	31.1	123.2	1775.9	226811
16.52	20.12	5.32	36.3	28.2	133.9	1773.2	227020
12.29	22.29	3.50	33.2	26.1	127.5	1920.9	228667
10.39	19.35	8.89	35.4	29.6	107.3	1940.9	228831
11.74	42.55	11.87	30.3	19.3	94.6	1959.1	228979
14.06	49.04	15.03	40.6	21.7	101.4	1976.2	229121
9.37	21.36	8.75	49.0	28.2	145.7	1986.3	229285

Sources: a/ USDA, AMS, Fresh Fruit and Vegetable Prices, issues 1971-1981.

b/ USDA, AMS, Fresh Fruit and Vegetable Unload Totals for 41 Cities, issues 1971-1981.

c/ TROLL package data base.