

THE UNIVERSITY OF MANITOBA  
THE MARKET POTENTIAL  
FOR GREENHOUSE TOMATOES IN MANITOBA

by

WINSTON RUTHVEN RUDDER

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE  
OF MASTER OF SCIENCE

DEPARTMENT OF AGRICULTURAL ECONOMICS

WINNIPEG, MANITOBA

May 1972



ABSTRACT

MARKET POTENTIAL FOR GREENHOUSE TOMATOES IN MANITOBA

by

Winston Ruthven Rudder

The market for fresh vegetables in Manitoba, particularly fresh tomatoes, is almost exclusively served by imports from the United States and Mexico. It is conceivable, though, that many of these vegetables can be profitably grown in greenhouses to ensure year round supplies in this province. However, there is a serious lack of the basic information needed for planning and decision making in regard to the establishment of a greenhouse industry. The present investigation is undertaken with a view to satisfying this deficiency. More specifically, the objectives of the study are to derive the demand function for fresh tomatoes in Manitoba; to use this function as a basis for projecting consumption of fresh tomatoes in Manitoba in 1980; to provide estimates of the demand for greenhouse tomatoes; and to evaluate the feasibility of a greenhouse tomato industry in Manitoba.

The basic model used is of the Cobb-Douglas form:

$$Q_t = \alpha X_{1t}^{\beta_1} X_{2t}^{\beta_2} X_{3t}^{\beta_3} \dots X_{nt}^{\beta_n} \epsilon \dots \quad (1)$$

Per capita consumption ( $Q_t$ ) is regarded as dependent on real retail price ( $X_{1t}$ ), disposable income ( $X_{2t}$ ), real prices of related commodities ( $X_{3t}, \dots, X_{n-1t}$ ) and consumers' preference. The alpha ( $\alpha$ ) coefficient is a constant;  $\epsilon$  represents the true error, and the beta ( $\beta$ ) values denote the elasticities with respect to the independent variables.

The demand function thus derived forms the basis for projecting the demand for fresh tomatoes to 1980. Whereupon, estimates of the market share available to greenhouse producers are made on the assumption of an unaltered seasonal consumption pattern of fresh tomatoes in Manitoba. The major sources of imported field tomatoes are identified, and the potential competition from similar industries in other provinces is evaluated. A review of price developments, together with an assessment of production costs and consumer preference for greenhouse tomatoes, provides the basis for determining the economic viability of a greenhouse tomato industry in Manitoba.

The results indicate that, if the assumptions hold true, total demand for fresh tomatoes in Manitoba is expected to decline by approximately 6.0 percent from 13.3 million pounds in 1969 to 12.5 million pounds by 1980. This implies that the greenhouse tomato industry in Manitoba must develop within a relatively stable fresh tomato market. Nevertheless, the possibility of expansion in greenhouse tomato production appears great since the present share of the total market is so small. In fact, it is estimated that the projected greenhouse tomato market will support an industry of approximately 10 acres.

Fresh tomato prices are depicted as being higher in the spring and fall months (which periods correspond to the marketing seasons of greenhouse tomatoes). This is encouraging to potential greenhouse operators. Moreover, as experience elsewhere in Canada (particularly Southern Ontario) indicates, it seems likely that by adopting vigorous effective merchandising practices, including packaging for retail and consumer information and education, the existing market for higher quality tomatoes may be substantially expanded.

On the basis of cost projections for Manitoba conditions and likely selling prices, it is demonstrated that there is potential for the development of a viable greenhouse tomato industry in Manitoba.

There is need, however, for adequate planning with a view to organizing the marketing functions in order to:

- (i) enlarge the market for the higher priced, higher quality greenhouse tomatoes by undertaking promotional programs;
- (ii) disseminate information to growers on selecting proper varieties and adequately preparing fruits for marketing;
- (iii) ensure the stability of prices; and
- (iv) reduce likely inefficiencies in the distribution system.

## ACKNOWLEDGEMENTS

The author wishes to acknowledge his indebtedness to the many individuals whose efforts were invaluable in the preparation of this dissertation.

Sincere appreciation is extended to his academic adviser, Dr. Norman J. Beaton, for his counsel and advice throughout the study and during the author's entire graduate program at the University of Manitoba. For his invaluable suggestions and constructive criticisms, the author expresses his gratitude to Dr. M. H. Yeh. The assistance and technical advice provided by Dr. J. D. Campbell is also gratefully acknowledged.

The author is also grateful to the government of Canada for the financial support provided, through the Canadian International Development Agency, during his period of study at the University of Manitoba.

Finally, the author expresses his appreciation to Mrs. Betty Anne Ross whose arduous task it was to type the preliminary drafts of this thesis, and to Mrs. A. Sutton who typed the final draft.

## TABLE OF CONTENTS

	Page
LIST OF TABLES . . . . .	ix
LIST OF FIGURES . . . . .	x
 Chapter	
I. INTRODUCTION . . . . .	1
Tomatoes . . . . .	2
CONSUMPTION, PRODUCTION, AND IMPORT TRENDS OF FRESH TOMATOES . . . . .	3
Canada . . . . .	3
Manitoba . . . . .	4
THE CASE FOR GREENHOUSE TOMATO PRODUCTION IN MANITOBA . . .	7
OBJECTIVES AND SCOPE OF THE STUDY . . . . .	9
Limitations . . . . .	10
HYPOTHESES AND ASSUMPTIONS . . . . .	11
Hypotheses . . . . .	11
Assumptions . . . . .	11
ORGANIZATION OF THE STUDY . . . . .	12
II. THE GREENHOUSE VEGETABLE INDUSTRY IN CANADA AND MANITOBA . .	14
SIZE AND LOCATION . . . . .	14
Growth and Significance of the Industry . . . . .	14
NATURE OF THE GREENHOUSE VEGETABLE INDUSTRY . . . . .	16
Some Technological Aspects . . . . .	19
Greenhouse Tomato Production . . . . .	20
Marketing Greenhouse Vegetables in Canada . . . . .	20

Chapter	Page
The Effect of the Tariff Structure . . . . .	22
THE GREENHOUSE VEGETABLE INDUSTRY IN MANITOBA . . . . .	24
Interest in Greenhouse Vegetable Production . . . . .	26
III. THEORETICAL FRAMEWORK . . . . .	28
THE CONCEPT OF A DEMAND CURVE . . . . .	28
Early Statement of the Law of Demand . . . . .	28
Law of Demand Restated . . . . .	29
The Utility Concept . . . . .	30
Modern Development of Demand Theory . . . . .	34
Hick's Contribution . . . . .	34
Samuelson's Approach . . . . .	36
THE STATISTICAL DERIVATION OF DEMAND CURVES . . . . .	38
Conceptual Problems . . . . .	38
Time Series Analysis . . . . .	40
Family Budget Studies . . . . .	41
Aggregation . . . . .	42
Random Disturbances . . . . .	43
The Regression Approach . . . . .	43
Methodological Developments in Demand Analysis . . . . .	49
IV. MODEL FORMULATION AND METHOD OF ANALYSIS . . . . .	55
CHOICE OF VARIABLES . . . . .	55
Sources of Data . . . . .	56
Explanation of Variables and Adjustment of Data . . . . .	57
Data Limitations . . . . .	60
THE MODEL . . . . .	62
THE METHOD OF ANALYSIS . . . . .	65

Chapter	Page
V. INTERPRETATION AND EVALUATION OF RESULTS . . . . .	68
ANALYSIS OF DEMAND FOR FRESH TOMATOES IN MANITOBA . . . . .	68
PROJECTION OF FRESH TOMATO DEMAND TO 1980 . . . . .	73
Assumptions for Prediction . . . . .	76
Statistical Predictions . . . . .	76
MARKET POTENTIAL FOR GREENHOUSE TOMATOES . . . . .	78
FEASIBILITY OF A GREENHOUSE TOMATO INDUSTRY IN MANITOBA . . . . .	82
VI. SUMMARY, IMPLICATIONS AND RECOMMENDATIONS . . . . .	94
Summary . . . . .	94
Implications . . . . .	98
Recommendations . . . . .	100
BIBLIOGRAPHY . . . . .	102
APPENDIX . . . . .	106



LIST OF TABLES

Table	Page
I. Annual Imports of Selected Vegetables Competing with Canadian Production 1960-65 . . . . .	2
II. Apparent per Capita Domestic Disappearance of Tomatoes Canada 1959-69 . . . . .	4
III. Fresh Tomato Imports into Canada 1959-69 . . . . .	5
IV. Fresh Tomato Production in Manitoba 1959-69 . . . . .	6
V. Imports of Fresh Tomatoes into Manitoba 1959-69 . . . . .	7
VI. Area Under Glass and Plastic (square feet) 1959-69 . . . . .	15
VII. Number of Greenhouse Operators According to Size (square feet) Manitoba, 1970 . . . . .	26
VIII. Regression Coefficients, Standard Errors and Other Statistical Results for Demand Functions for Fresh Tomatoes in Manitoba 1954-69 . . . . .	69
IX. Percentage Fresh Tomatoes Imported Each Quarter Manitoba 1959-69 . . . . .	79
X. Fresh Tomato Imports Into Manitoba, April-June and October-December 1959-69 . . . . .	84
XI. Market Share of United States and Mexico Imports, April-June and October-December in Manitoba 1959-69 . . . . .	85
XII. Major Sources of Fresh Tomato Imports Into Manitoba, April-June and October-December 1959-69 . . . . .	87
XIII. Truck Freight Rates on Fresh Tomatoes Unloaded at Winnipeg as a Percentage of Retail Price (1968) . . . . .	87
XIV. Market Share of British Columbia and Ontario Greenhouse Tomatoes in Manitoba 1959-69 . . . . .	89

LIST OF FIGURES

Figure	Page
1. Number of Firms in the Greenhouse Industry Canada 1955-69 . . .	17
2. Types of Greenhouse Operations in Manitoba . . . . .	27
3. Hicks' Compensating Income Variation . . . . .	36
4. The Method of Cost Difference . . . . .	38
5. Scatter Diagram of Monthly Tomato Consumption and Retail Price (Hypothetical) . . . . .	45
6. Relationship between True and Estimated Regression Lines . . .	47
7. Per Capita Consumption of Fresh Tomatoes in Manitoba: Actual and Predicted Quantities (1954-69) . . . . .	74
8. Monthly Average Retail Prices of Fresh Tomatoes Winnipeg 1965-69, 1968, 1969 . . . . .	91

## Chapter I

### INTRODUCTION

The observation has been made that the demand for fruit and vegetables has been a somewhat neglected area of research in Canada. Further, the little attention so far focussed on this topic has dealt with the demand of fruit and vegetables in the aggregate.<sup>1</sup> Yet it is upon the information provided by this type of analysis that governments and other planning agencies concerned with the development or improvement of the fruit and vegetable industry largely depend. This study is undertaken with the aim of partially bridging this information gap. An estimate of the current demand for fresh tomatoes in Manitoba is made, as well as the projected level of demand for 1980.

Vegetable production is not a major enterprise for most Canadian crop producers. The proportion of cash income derived from the sale of fruit and vegetables to total cash farm income varied between 3.7 and 4.1 percent during 1965 to 1969. The bulk of the domestic vegetable production is utilized for processing, as much as eighty-five percent in the case of tomatoes.<sup>2</sup>

Another important feature is that domestic consumption depends

---

<sup>1</sup>Kulshrestha, S.N., "The Demand for Major Fruits and Vegetables in Canada", Canadian Journal of Agricultural Economics, No. 2, Vol. XVIII (July, 1970), p. 52.

<sup>2</sup>Ibid. p. 53.

heavily upon foreign supplies. An examination of the pattern of imports of a number of vegetables during the Canadian season reveals an interesting state of affairs. For the years 1965 to 1969 approximately 23.7 percent of the annual imports of tomatoes (twenty-five percent for all vegetables) entered during the Canadian field tomato production season (TABLE I).

TABLE I

ANNUAL IMPORTS OF SELECTED VEGETABLES  
COMPETING WITH CANADIAN PRODUCTION  
1965-69

	1965	1966	1967	1968	1969	Average (1965-69)
	(percent of annual import volume competing with Domestic Production)					
Cucumber	35.2	51.5	38.1	39.1	38.4	40.5
Lettuce	23.7	28.5	27.2	22.3	25.1	25.4
Field Tomatoes	23.9	24.8	23.4	21.9	24.3	23.7
Beans (Green)	11.9	12.8	14.2	9.6	9.4	11.6
Average Total	23.7	29.4	25.7	23.2	24.3	

Sources: CDA Crop and Seasonal Price Summaries. DBS Trade of Canada.  
Adapted from H. Blum. Marketing of Ontario's Greenhouse  
Vegetables in Competition with Imports from Mexico. p. 21.

### Tomatoes

Tomatoes are a very popular vegetable in North America and in many parts of the world. It is generally believed that the wild species probably originated in South America around Peru, Ecuador and Bolivia. They were cultivated during the Aztec Empire.

Although botanically a fruit, the tomato was classified by the

United States Supreme Court (1893) as a vegetable for commercial purposes because of its common use for salads. The fruits vary in size from one half inch to four inches and more, and are usually red, scarlet or yellow with variations in white, pink or purple. They provide an excellent source of vitamins A and C.<sup>1</sup>

CONSUMPTION, PRODUCTION AND IMPORT  
TRENDS OF FRESH TOMATOES

Canada

In Canada, tomatoes are a most favoured vegetable, being consumed mainly in processed form. TABLE II indicates the annual consumption of tomatoes and tomato products. Fresh tomato consumption in 1959 was the highest on record during the observed period. Apparent per capita consumption steadily declined from 18.1 pounds in 1959 to 9.2 pounds in 1969. Meanwhile, consumption of tomato products maintained a remarkably stable level.

Tomatoes, like most other vegetables, are consumed in Canada in fresh and processed form on a year round basis. Imports of fresh tomatoes from the U.S.A. and Mexico are large and constituted an import value of about \$22 million in 1969. Tomatoes occupy first place among imports of fresh vegetables.

Total shipments of fresh tomatoes into Canada increased from 156 million pounds in 1959 to 214 million pounds in 1969. (TABLE III). In most years, United States and Mexican imports accounted for close to 99 percent

---

<sup>1</sup>Blum, H., Marketing of Ontario's Greenhouse Vegetables in Competition with Imports from Mexico, (Farm Economics and Statistics Branch, Ontario Dept. of Agriculture and Food, May 1969), p. 27.

TABLE II

APPARENT PER CAPITA DOMESTIC DISAPPEARANCE  
OF TOMATOES, CANADA  
1959-69

Year	Fresh Tomatoes	Processed Tomatoes	Total
	(pounds)		
1959	18.1	42.6	60.7
1960	17.6	41.7	59.3
1961	17.8	40.8	58.6
1962	16.8	42.8	59.6
1963	13.4	47.8	61.2
1964	13.4	40.4	53.8
1965	12.4	48.5	60.9
1966	11.7	43.2	54.9
1967	12.3	47.3	59.6
1968	11.3	49.2	60.5
1969	9.2	45.8	55.0

Source: DBS Catalogue. 32-226

of the total shipments. The Bahamas, Cuba, Spain and the Netherlands occasionally ship smaller quantities of fresh tomatoes into the country.

Over the same period, production of fresh tomatoes, which stood at one hundred and thirty-five million pounds in 1959, peaked at 145 million pounds in 1961, thereafter falling continuously until by 1969 production was a mere 84 million pounds. Except for 1965 when the value of fresh tomato production soared to \$16 million, the annual value of tomato production has tended to remain relatively stable. This figure was \$5.8 million in 1959 and \$6.2 million in 1969.

#### Manitoba

There is heavy reliance on imports to satisfy the demand for fresh

TABLE III

FRESH TOMATO IMPORTS INTO CANADA  
1959-69

Year	Mexico -000 lbs.	Percent Mexico	U.S.A. -000 lbs.	Percent U.S.A.	Total -000 lbs.	Percent Total
1959	63,454	40.5	92,487	59.1	156,487	99.6
1960	75,897	48.7	78,094	50.1	155,891	98.8
1961	49,739	30.6	106,784	65.6	162,756	96.2
1962	56,922	35.5	101,556	63.3	160,349	98.8
1963	53,613	31.7	114,948	68.0	169,144	99.7
1964	52,840	31.3	115,179	68.3	168,560	99.6
1965	56,151	32.9	113,508	66.5	170,689	99.4
1966	67,364	36.3	117,628	63.5	185,497	99.7
1967	75,391	39.1	114,764	59.5	192,822	98.6
1968	67,972	35.0	125,259	64.5	194,197	99.5
1969	104,992	49.0	107,166	50.1	213,837	99.1

Source: DBS publication Trade of Canada, Imports.

tomatoes throughout the year in Manitoba. Domestic field production of tomatoes in this province, as for the rest of the country as well, is restricted to the short summer months. Local supplies usually disappear from the market by late September. Even so, during the domestic field production season, supplies must be supplemented by U.S. field producers.

As TABLE IV illustrates, annual field production in Manitoba fluctuates tremendously. The 1959 crop yielded 824,000 pounds valued at \$42,000. This represented 19.5 percent of the total amount of fresh tomatoes consumed in the province during the domestic season. During the observed period, production peaked at 3,380,000 pounds in 1963, and after a series of fluctuations slumped to 1,127,000 pounds in 1969, valued at \$113,000. The 1969 crop accounted for 24.8 percent of the fresh tomatoes consumed during the domestic season. It is quite noticeable that the per

TABLE IV

FRESH TOMATO PRODUCTION IN MANITOBA  
1959-69

Year	Yield -000 lbs.	Acreage	Farm Value -\$000
1959	824	150	42
1960	2,070	100	99
1961	3,360	140	188
1962	2,460	120	144
1963	3,380	130	220
1964	1,560	130	105
1965	2,835	140	208
1966	2,835	135	227
1967	2,700	135	235
1968	1,296	135	98
1969	1,127	120	113

Source: DBS Catalogue 22-003.

acre value of tomatoes increased by 236 percent from \$280 in 1959 to \$942 in 1969.

Annual shipments of fresh tomatoes into Manitoba, as indicated in TABLE V, have tended to remain fairly stable over the period 1959 to 1969. This may be attributable to the fact of the relatively slow increase in population growth (10%) over the period. As is true for the country as a whole, the bulk of the annual imports was made up of shipments from the U.S.A. and Mexico. Imports from Mexico accounted for 41.9 percent of annual imports of fresh tomatoes in 1969. The Mexican shipments appear on the market from December to June. United States supplies, which constituted 58.1 percent of annual imports in 1969, are unloaded throughout the year. Florida is the main source of United States supplies during the winter and spring seasons, while California shipments predominate during the summer



TABLE V  
IMPORTS OF FRESH TOMATOES INTO MANITOBA  
1959-69

Year	United States -lbs.-	Mexico -lbs.-	Total -lbs.-
1959	6,357,438	4,405,067	10,762,505
1960	5,468,638	5,566,383	11,035,021
1961	7,302,025	3,990,401	11,294,016
1962	6,060,275	4,897,364	10,957,639
1963	5,162,278	4,461,772	9,624,050
1964	6,798,262	4,390,609	11,188,871
1965	6,569,645	4,389,537	10,959,182
1966	6,292,156	4,225,590	10,517,746
1967	4,652,318	5,152,343	9,804,661
1968	6,300,936	4,527,767	10,828,703
1969	6,357,000	5,847,032	12,204,032

Source: DBS unpublished data.

and fall.

As TABLE V indicates, the total demand for fresh tomatoes in Manitoba has been remarkably stable. While, at present, most of the Province's needs are supplied by imports from Ontario, the United States and Mexico, there is evidence to indicate that this crop may be produced economically in local greenhouses.<sup>1</sup>

#### THE CASE FOR GREENHOUSE TOMATO PRODUCTION IN MANITOBA

Tomatoes produced in greenhouses will not compete effectively with

---

<sup>1</sup>Beaton, Norman J., "Economic Aspects of Greenhouse Tomato Production in Manitoba", (paper presented at the Fourth Annual Manitoba Horticultural Council Meeting, December 7, 1971, Agricultural Auditorium, University of Manitoba).

domestically grown field crops, thus production should not coincide when locally field grown tomatoes are on the market. However, the production of greenhouse tomatoes during the winter months is favored because of their superior freshness and more delicate flavour compared with post ripened imported field tomatoes. Indeed, tomatoes grown in greenhouses can valuably contribute to the fresh vegetable diet of Manitobans during the winter months.

As an indication of the potential economic significance of greenhouse tomato production, it should be pointed out that during 1969 greenhouse tomato production accounted for more than sixteen percent of tomatoes available for the fresh market in Ontario.<sup>1</sup> Meanwhile in Nova Scotia, growers produce almost 100 percent of the required tomatoes and export from 40 to 60 percent of their production, depending on seasonal demand, to other Maritime Provinces.<sup>2</sup> The Ontario and Nova Scotia experience should serve as a guide to the likely performance of a greenhouse tomato industry in Manitoba.

Satisfactory price quantity relationships are fundamental to decision making in regard to the establishment of a greenhouse tomato industry in Manitoba. Producers need this information to determine the feasibility of undertaking such an enterprise.

---

<sup>1</sup>Calculations based on CDA publication Annual Unload Report Fresh Fruits and Vegetables, 1969.

<sup>2</sup>Nova Scotia, Department of Agriculture and Marketing, The Greenhouse Industry in Nova Scotia, 1970.

## OBJECTIVES AND SCOPE OF THE STUDY

The overall objective of this study is to determine whether the potential exists for the establishment of a greenhouse tomato industry in Manitoba. The approach taken is to, first of all, ascertain the extent of the demand for fresh tomatoes in this province. On the basis of this demand, some estimate of a greenhouse industry's likely share is determined.

The specific objectives of the thesis are:

1. To study the demand and price structure for fresh tomatoes in Manitoba.
2. To estimate the present and future demand for fresh tomatoes in Manitoba.
3. To provide statistical estimates of the demand for greenhouse tomatoes.
4. To evaluate the feasibility of a greenhouse tomato industry in Manitoba.

The study is largely a statistical analysis determining the feasibility of establishing a greenhouse tomato industry in Manitoba. Cursory projections indicate that the market area which could be practically served from Manitoba consists of Thunder Bay to the eastern border of Alberta.<sup>1</sup> However, the analysis is confined to the province of Manitoba since complicated data problems are otherwise anticipated.

---

<sup>1</sup>Manitoba, Department of Industry and Commerce, Food Production Branch, An Opportunity for the Commercial Growing of Greenhouse Tomatoes and Cucumbers, Nov. 1970, p. 4.

The scope of the study is limited to:

1. Determining the demand for fresh tomatoes in the seasons which make greenhouse production a viable enterprise.
2. Determining the major extra-provincial sources of imports of fresh tomatoes during the likely greenhouse season.
3. Ascertaining for each major source the production, transportation, and storage costs and the tariff rates. Given these, comparisons are made with greenhouse production costs in Manitoba which will provide certain policy implications.

#### Limitations

One limitation of this study is the fact that annual rather than monthly (or even quarterly) data are utilized in the demand analysis. It is preferable to estimate seasonal demand functions (rather than an annual function) for fresh tomatoes in Manitoba. Such functions facilitate a clearer understanding of the market conditions prevailing during the domestic production seasons of greenhouse tomatoes. However, reliable monthly or quarterly data are not available. Consequently, the function derived does not take explicit account of the seasonal fluctuations in demand for fresh tomatoes.

Another shortcoming arises out of the fact that there is very little information available on consumer preference for greenhouse tomatoes in Manitoba. In this study, therefore, it is assumed that consumers in Manitoba react equally favorable to greenhouse tomatoes as those in Ontario and the United States. To the extent that research in this area proves otherwise, the conclusions arrived at will need to be modified.

## HYPOTHESES AND ASSUMPTIONS

Hypotheses

The basic hypotheses underlying the procedures to be adopted in this study are:

1. The quantity of fresh tomatoes consumed and its price are inversely related.
2. The quantity of fresh tomatoes demanded and disposable income are inversely related.

Assumptions

The assumptions upon which the empirical analysis is based are:

1. There exists a routine in the demand behavior of human beings. This implies that over the period covered by the data there have been no significant changes in the tastes and desires of consumers so that the demand function formulated holds for the entire period. Moreover, this assumption provides the rationale for utilizing the basic demand function thus formulated for making projections. The occurrence of any abrupt, significant changes in tastes and desires of consumers will cause any projections based on the demand function to be misleading.
2. Retail prices, disposable income, population growth and the decreasing purchasing power of money are the most influential quantifiable variables reflecting changes in consumer demand. The latter two variables may be explicitly introduced by incorporating them into the quantity, price and income variables. This assumption is basic to any attempt to derive demand curves from statistics. It implies not only the existence of a routine in consumer demand but also the absence of a single equilibrium

position which is maintained throughout the period under consideration. If this were the case, then the data would not provide sufficient observations on the demand function to determine its probable shape.

3. The third assumption is that the unknown theoretical demand function can be approximated by the statistically derived curve. This requires that the demand curve and its derivatives be continuous within the range investigated. This assumption is necessary to validate the statistical procedures used.

4. The fourth assumption is that the demand for fresh tomatoes is relatively stable whereas supply is variable. This ensures that over time a clearly defined demand relationship may be identified for study.

#### ORGANIZATION OF THE STUDY

The study consists of three main sections. The first section provides a descriptive analysis of the greenhouse industry in Canada and Manitoba. The size, location and growth of the industry are indicated. The nature and significance of the industry are also discussed, emphasis being placed on greenhouse tomato production. It is important to have a good overview of the nature of the greenhouse industry, and to understand the level of technical knowledge required; this, in the first instance, provides the initial interest for a greenhouse industry.

The major concern of the second section is to develop a statistical model to determine the demand for fresh tomatoes in Manitoba. Here the important variables affecting consumer behavior are outlined. This model provides the basis upon which the projected demand to 1980 is made.

The final section deals with the evaluation of the feasibility of a greenhouse industry in Manitoba. Comparisons are made of costs of production between Manitoba and the major competing sources of fresh tomatoes. Transportation and storage costs together with tariff rates are also analysed.

The remainder of the study is organized as follows: Chapter II provides general background information of the greenhouse industry in Canada and Manitoba. Chapter III deals with the relevant economic and statistical theory used in formulating the demand model and making the projections. An analysis of demand theory is undertaken and the operations of the multiple regression technique are described.

Chapter IV provides a description of the data. The choice of variables and the formulation of the model are discussed. The analysis of demand for fresh tomatoes in Manitoba follows in Chapter V. Here the feasibility study of a greenhouse tomato industry is also undertaken.

Chapter VI sets forth the conclusions and implications of the study. Recommendations are also put forward in this chapter.

## Chapter II

### THE GREENHOUSE VEGETABLE INDUSTRY IN CANADA AND MANITOBA

#### SIZE AND LOCATION

Greenhouse production of vegetables for the consumer market is a well established industry both in Europe and the United States. In Canada, however, the greenhouse vegetable industry has so far been confined to very few areas, and limited to the production of two important vegetable crops, cucumbers and tomatoes. This is understandable since very few areas are climatically suited to the commercial production of greenhouse commodities.

The major part of the greenhouse industry in Canada is concentrated in the southern most tip of Ontario, particularly in Essex County. During the period 1959 to 1969, Ontario increased its share of production facilities under glass and plastic from 61.5 to 75.1 percent of the nation's total. British Columbia has most of the remaining greenhouse growing area in Canada, while Manitoba's share ranged from 1.08 percent in 1959 to 0.99 percent in 1969. (TABLE VI).

#### Growth and Significance of the Industry

The greenhouse industry in Canada has grown at a rapid rate over the past decade and a half. In 1955, there were 329.4 acres under glass and plastic. The value of crops produced that year stood at \$13,819,597. By 1969 the industry had expanded by 116 percent to 711.2 acres. Total production in 1969 was valued at \$42,546,100 an average of \$59,840 per acre and a production increase of 208 percent over 1955.



TABLE VI

AREA UNDER GLASS AND PLASTIC (SQ. FT.)  
1959-69

Year	Manitoba	Ontario	Canada
1959	170,355	9,709,434	15,788,177
1960	170,665	10,061,919	15,672,066
1961	200,840	12,500,483	18,474,888
1962	183,824	13,364,018	19,734,129
1963	222,899	15,502,745	23,735,418
1964	170,390	15,661,196	24,026,279
1965	303,368	16,639,930	24,446,007
1966	276,068	18,646,867	25,743,948
1967	248,730	20,922,710	29,323,661
1968	264,930	22,605,194	29,130,539
1969	309,519	23,384,898	31,158,297

Source: DBS Catalogue 22-202.

The present size of the industry and the magnitude of the increases have not been wholly due to growth in the production of greenhouse vegetables. The floricultural industry valued at \$25,668,440 in 1969 accounted for 53.4 percent of the value of the increase in greenhouse production over the period. In addition, many growers have been producing bedding plants for home and commercial garden customers. The value of greenhouse vegetable production rose to \$11,061,860 in 1969 representing an almost seven-fold increase over 1955 and 26.5 percent of the value of greenhouse production that year.

It is to be noted whereas the value of the greenhouse industry has increased tremendously, there have not been similar increases in the number of firms operating. As a matter of fact in 1955 the number of commercial establishments reported was 1,250. Between 1955 and 1969 the number firms

fluctuated annually reaching a low of 887 in 1967 and rising again to 1,215 by 1969. (See Figure 1) Production increases have largely been due to improved management and the increase in acreage. Moreover, the industry which employed 3,203 in 1959, provided employment for an additional 957 in 1969. Hundreds more are employed in satellite industries which service the greenhouse industry. Another measure of the increasing stature of the greenhouse industry is the fact that the gross from greenhouse enterprises has risen to about 1.01 percent of the overall gross farm income in 1969 from 0.54 percent in 1955.

Despite these rapid strides, however, the volume of greenhouse vegetable production in the various provinces is not large enough to satisfy the demand within the province. Even in Ontario, which accounts for more than three-quarters of the Canadian production of greenhouse vegetables, the production of greenhouse tomatoes is far less than consumption during the spring and fall marketing seasons.<sup>1</sup> Moreover, only from Ontario, British Columbia and Nova Scotia are greenhouse vegetables regularly shipped outside the province. Ontario does this on a fairly large scale, the market for its produce extending from the Atlantic to the Pacific coasts, although it is heavily concentrated in Ontario and Quebec. Ontario and to a lesser extent British Columbia often export greenhouse vegetables to neighbouring areas in the United States of America.

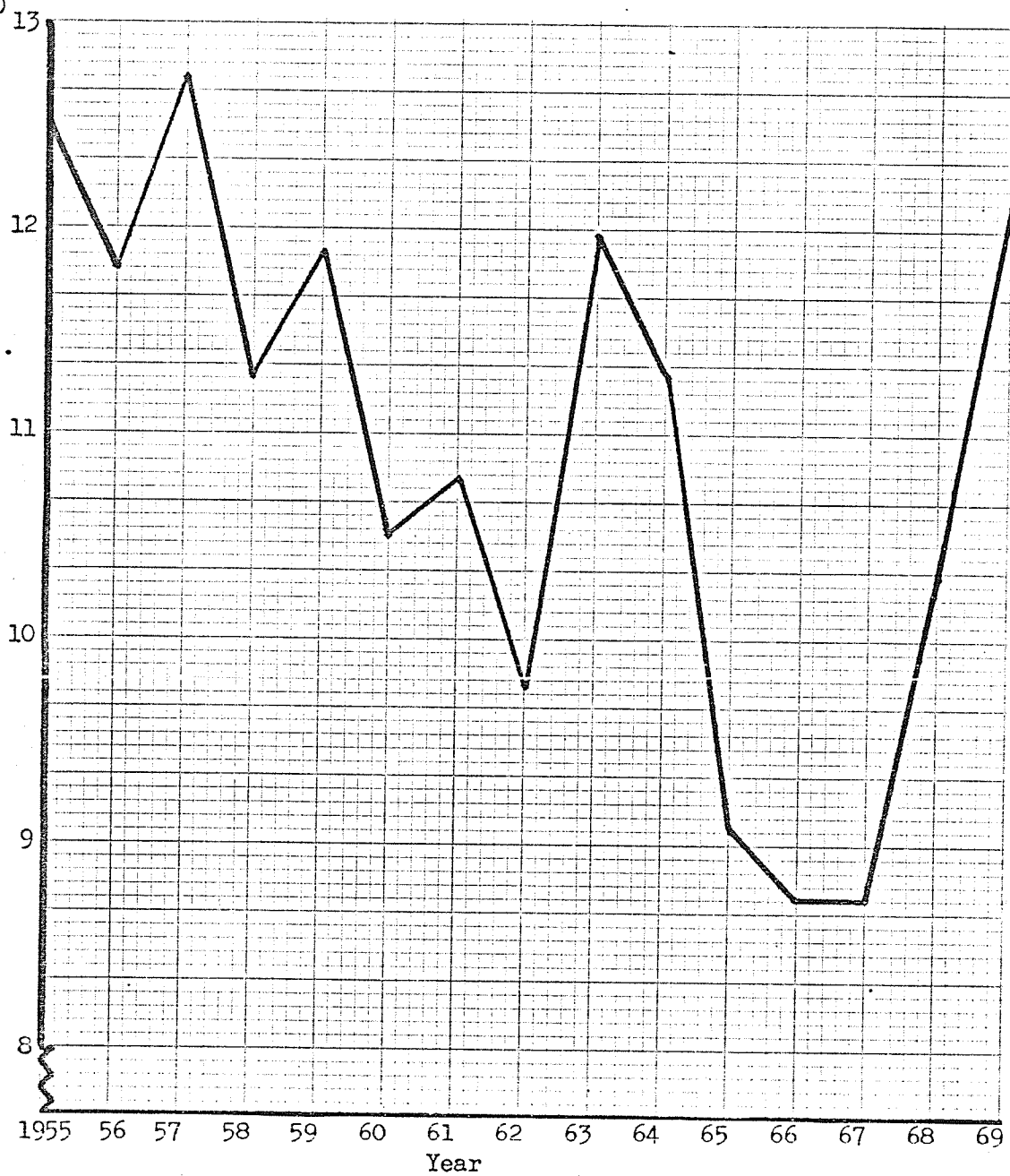
#### NATURE OF THE GREENHOUSE VEGETABLE INDUSTRY

A prominent feature characterizing greenhouse production is that it

---

<sup>1</sup>Canada, Greenhouse Vegetables; Report by the Tariff Board Relative to the Investigation Ordered by the Minister of Finance, Ref. No. 140, (Queen's Printer, 1969), p. 36.

Number of  
Firms  
'00



Number of Firms in the Greenhouse Industry:  
Canada 1955-69

Figure 1

lends itself ideally to family operation. A one acre greenhouse enterprise can be operated by two laborers with additional help at peak periods.<sup>1</sup>

Further support for the family operation concept comes from the fact that economies of scale only seem to affect greenhouse operations to a moderate extent. The variable costs expended for labor, fuel and related charges account for more than seventy percent of total costs. In addition, whereas cost reducing mechanization serves as a boon to other forms of agricultural activity, greenhouse operations are limited in this regard. Present technology does not allow for the use of labor saving devices in harvesting operations.<sup>2</sup>

In a study of Leamington (Ontario) greenhouse vegetable production in 1961, Dr. W.G. Phillips concluded that:

... a technically well organized greenhouse can survive on even even terms with its larger competitors.<sup>3</sup>

He observed further that this was the likely reason why the main import competition in Canada comes from southern field grown crops rather than from the greenhouse industry in Ohio:

The considerably larger scale on which the latter operate ... has never been sufficient to enable them to overcome the advantage of the Canadian industry in lower labor rates....<sup>4</sup>

---

<sup>1</sup>Blum, H., Marketing Ontario's Greenhouse Vegetable Products in Competition with Imports from Mexico, (Farm Economics and Statistics Branch, Ontario Department of Agriculture and Food, May 1969), p. 21.

<sup>2</sup>Ibid. p. 2.

<sup>3</sup>Phillips, W.G., The Greenhouse Vegetable Industry, (Windsor, Ontario, September, 1961), p. 16.

<sup>4</sup>Ibid. pp. 16-17.

### Some Technological Aspects

Greenhouse vegetable production very closely resembles the process of production in manufacturing industries. The control over climatic conditions permits control of the production process to a greater extent. This results in reducing the uncertainty in expected output. All production problems are not thereby resolved, however, for even in the controlled environment, production is subject to limitations of the growing conditions which prevail during plant development. Greenhouse vegetable production requires considerable skill, because raising plants in a controlled environment creates technical problems. In addition, high plant population generates conditions that invite diseases and fungi.

Because greenhouses permit virtually complete control over the environment of plants, it is logical to assume that a greenhouse can be constructed anywhere and be used to produce any common fruit or vegetable. In practice, vegetable greenhouses tend to be concentrated in very few parts of Canada. This is, in part, due to the fact that fuel costs are a very large proportion of operating expenses (one-third or more); thus warmer localities and areas where fuel costs are low possess a comparative advantage. Further, the considerable amount of technical knowledge of cultural practices and plant requirements needed restrict the establishment of greenhouses to areas where experienced labor and management are available. A final consideration is the desirability of locating vegetable greenhouses in relatively close proximity to major markets.

Theoretically, greenhouse production could be so planned to be ready for sale at any time during the year. In practice, however, the timing of production is of critical importance. The operator needs to weigh

costs of production and quality on the one hand, and prices and share of the market on the other. Tomatoes require long periods of sunshine to attain maturity, thus greenhouse operations are restricted in the dark fall months when yields are adversely affected. The producer must also consider the price situation as determined by the competition of imported field crops, and by the fact that the marketing period must end with the appearance of the domestic field grown crop.

#### Greenhouse Tomato Production

Normally two crops of greenhouse tomatoes are grown per year. The spring crop is planted in December and January in flats, and after two transplantings the young plants are set out in the greenhouse. This crop is harvested mainly in April, May and June. The plants continue to produce in July and even August, however at this time domestic field grown tomatoes are ready for the market.

For a fall crop of tomatoes, the plants must be set out in the greenhouse late in July or early August. Harvesting of the fall crop usually begins in October, and ends by the beginning of December. Fall yields are usually very much lower than in spring. It is generally accepted that the lower light intensity in the fall, and its effect on the process of photosynthesis largely contribute to the decreased yields of the fall crop.

#### Marketing Greenhouse Vegetables in Canada

There is a multiplicity of agencies handling the marketing of greenhouse vegetables in Canada. These agencies manifest their influence mainly through the fees charged for their services, and through their statutory powers to determine the terms and conditions of trade. As a result, each

has some effect on the prices received by growers, and those paid by the growers of greenhouse or field grown tomatoes.

So far, only in Ontario has a marketing board been established under provincial authorization, with powers to regulate the marketing of greenhouse tomatoes and cucumbers. The Ontario Greenhouse Vegetable Producers' Marketing Board (hereafter called the Ontario Board) created in 1967, was empowered to:

... determine from time to time the price or prices that shall be paid to producers for greenhouse vegetables or any class, variety or size of greenhouse vegetables, and to determine different prices for different parts of Ontario.<sup>1</sup>

The Board's powers were considerably expanded later by Federal Order which authorized it to:

... regulate the marketing of greenhouse vegetables in inter-provincial and export trade and for such purposes may, with respect to persons and property situate within the Province of Ontario, exercise all or any powers like the powers exercisable by the Board in relation to marketing of greenhouse vegetables locally within the province of Ontario....<sup>2</sup>

In addition to the Ontario Board, the Canada Department of Agriculture administers various controls over the trading in fruits and vegetables throughout Canada. Every broker or dealer engaged in the inter-provincial or international produce trade must be licensed by the federal authorities. Moreover, the federal Department of Agriculture also undertakes the inspection of cars to determine damage, spoilage or incorrect grading, and maintains a marketing information service. The latter involves the collection of prices in all parts of Canada, and supplying information to those

---

<sup>1</sup>Canada, Greenhouse Vegetables, op. cit. p. 61.

<sup>2</sup>Ibid.

interested in production and marketing conditions.

### The Effect of the Tariff Structure

Canadian field producers of fruit and vegetables had been lobbying for some form of tariff protection, long before the greenhouse vegetable industry had progressed beyond the experimental stage. This resulted from the fact of the short Canadian marketing season, and that production in the United States is generally well advanced by the time the Canadian field crop matures. Continuous representation by growers over the years led eventually to the development, in Canada, of a distinctive tariff structure for fruit and vegetables which combines ad valorem with specific duties.

For tariff purposes Canada is divided into three regions:

1. West of the Great Lakes
2. Ontario and Quebec
3. The Maritime Region

This division is consistent with the seasonal differences in production patterns. The selection of the periods of application of the seasonal specific duties in each region is made on the recommendation of the Horticultural Council of Canada acting on the advice of the regional growers' association.

Tariff provisions do not distinguish between greenhouse and field production. In recent years, the rapid expansion of the greenhouse vegetable industry has lengthened the domestic marketing period for fresh cucumbers and tomatoes. This has given rise to problems regarding the duration and application of specific seasonal duties.

The existing tariff structure for fresh tomato imports provides for:



- (a) application of seasonal duties of 1 1/2 cents per pound for an indivisible period of up to 32 weeks,
- (b) a free period from January 1st to March 1st, and
- (c) ad valorem duties of 10% for the balance of the year.<sup>1</sup>

The tariff on fresh tomatoes is basically designed to protect growers of field tomatoes, any measure of protection derived by hot-house growers is incidental. During 1966-67, for example, the rates were applied as follows:

- (a) West of the Great Lakes: August 5th to October 24th,
- (b) Ontario and Quebec: August 4th to October 24th, and
- (c) The Maritime Region: Not applied.

Obviously the spring crop of greenhouse tomatoes did not enjoy any measure of protection from seasonal duties, whereas the fall crop benefited only to a very slight degree.

Tariff protection against imports from Mexico and the southern United States has therefore become a thorny problem for greenhouse vegetable producers. After an exhaustive investigation of the greenhouse industry in Canada, the Tariff Board, in 1968, rejected proposals submitted by the Ontario Board that the specific duty on tomatoes be increased from 1 1/2 cents to 5 cents per pound, and be maintained during the months April to June and October to November.

In its report, the Tariff Board contended that any increase in prices will necessarily result in some decrease in consumption particularly among lower income groups. This not only has consequences for producers but also:

---

<sup>1</sup>Blum, H., op. cit. p. 43.

... such a decrease in consumption has undesirable aspects in a country deprived of field production for so many months by climatic conditions and in which greenhouse production cannot meet total demand.<sup>1</sup>

In addition, the Tariff Board argued that the increased costs to consumers (as a result of increased tariff duties) appear disproportionate to the benefits afforded to producers.

Because 85 percent of the tomato consumption is supplied by imports, the cash costs are far in excess of any probable cash benefits to Canadian producers.<sup>2</sup>

Even in Ontario, where the benefits from duties are the greatest, the cash costs at wholesale were \$394,000 in 1967 compared with cash benefits to Ontario producers of \$133,000.

In conclusion, the Tariff Board observed that the accelerated growth of the greenhouse industry bears sufficient testimony to its long term viability and profitability. It was also noted that Canadian greenhouse vegetables have competed successfully in the United States market, in direct competition with field grown and greenhouse vegetables produced in the U.S.A. Moreover, not only do greenhouse producers receive adequate protection by distance and the existing Custom Tariff, but even more significant protection is provided by consumers' differentiation between greenhouse tomatoes and field grown imports.

#### THE GREENHOUSE VEGETABLE INDUSTRY IN MANITOBA

Highly specialized greenhouse operations are not large in Manitoba in terms of the overall agricultural industry. The gross from such

---

<sup>1</sup>Canada, Greenhouse Vegetables, op. cit. p. 136.

<sup>2</sup>Ibid.

enterprises represented about one-fifth of one percent of overall gross farm income in 1969. Greenhouse vegetable production, in particular, is not a significant operation in the province. Between 1955 and 1969, the most valuable greenhouse vegetable crop reported was the 1957 crop valued at \$7,372.

These statistics do not tell the whole story about the greenhouse industry in Manitoba. It is to be noted that over the period 1955 to 1969, the value of greenhouse production increased almost four-fold from \$156,770 to \$558,870. This tremendous increase has been largely due to the expansion in floricultural crops, which, in 1969, accounted for approximately 74 percent of the value of greenhouse products sold.

The greenhouse industry also has a high per acre employment ratio. The 137 employees reported in 1969 represents more than ten persons per acre, and a 153 percent increase over the total number employed in 1955. In addition, a considerable number of part time and seasonal helpers are employed.

A recent survey of the greenhouse industry in Manitoba indicates that there were 111 operators in the province in 1970.<sup>1</sup> Of this number 74 operated within a radius of 20 miles of Winnipeg. The total area enclosed as greenhouses amounted to 680,796 square feet or 15.63 acres. Fourteen growers each with an area of more than 10,000 square feet made up 47.06 percent of the entire 15.63 acres. Of the 111 operators, 29 had a total area between 5,000 and 10,000 square feet, thus 68 operators existed on less than 5,000 square feet. (See TABLE VII).

---

<sup>1</sup>Curle, R. and R. Morrison, Manitoba Greenhouse Survey - 1970  
Manitoba Department of Agriculture.

TABLE VII

NUMBER OF GREENHOUSE OPERATORS ACCORDING  
TO SIZE (SQ. FT.) - 1970

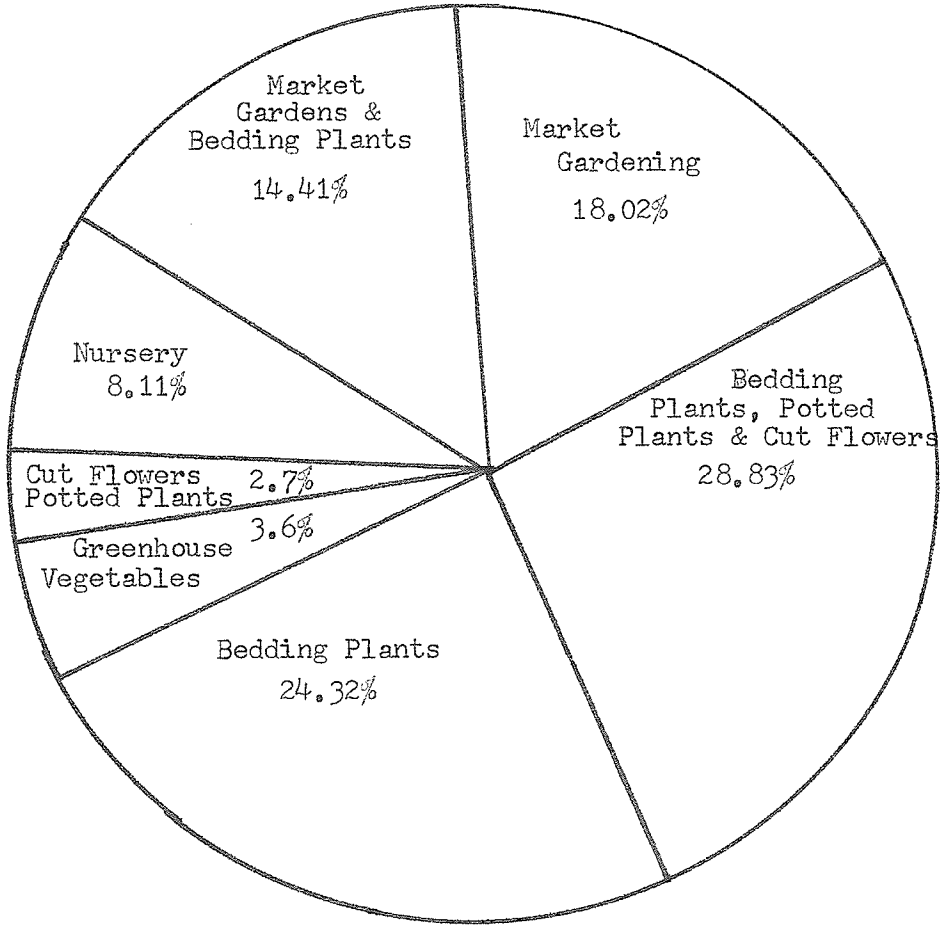
Under 550 sq.ft.	501-2,000	2,001-5,000	5,001-10,000	10,000 & over
2	28	38	29	14

Source: Curle, R., and R. Morrison, Manitoba Greenhouse Survey - 1970.

Figure 2 summarizes the various types of operations undertaken. Some form of bedding plant production, combined either with market gardening, cut flowers or potted plants or operated alone, seems to be the most common type of greenhouse enterprise. As indicated, greenhouse vegetable production accounted for a mere 3.6 percent of the overall operations in 1970.

#### Interest in Greenhouse Vegetable Production

Within the last several years, considerable interest has been revived in greenhouse vegetable production in Manitoba. This is, in part, due to the success of greenhouse operations in Ontario, and to a lesser extent British Columbia and Nova Scotia. Perhaps the main reason for the renewed interest, however, has been the availability of qualified technical advice and assistance for the guidance of growers. In Manitoba it is only quite recently that greenhouse growers have had access to the necessary laboratory equipment for leaf tissue analysis, soil and water testing, and their procedural interpretation.



Types of Greenhouse Operations in Manitoba

Figure 2

Adapted from Curle, R., and R. Morrison, Manitoba Greenhouse Survey 1970

## CHAPTER III

### THEORETICAL FRAMEWORK

In this chapter the relevant theoretical considerations underlying the empirical investigation are discussed. Entire emphasis is placed on the theory of demand. The discussion proceeds under two main subdivisions: The concept of a demand curve; and the statistical derivation of demand curves.

#### THE CONCEPT OF A DEMAND CURVE

##### Early Statement of the Law of Demand

The theory of demand has been revised and modified many times over the past years. The basic underlying concept has not changed however. Over a century ago, economists were able to detect that consumers do respond to changes in prices and disposable income when making purchases. It was observed that, in general, more of a good or service was bought when its price fell, assuming other relevant factors remained constant. However when prices increased, the opposite held true. On the other hand, changes in income had less predictable effect on consumer purchases because of varying tastes and preferences, and perhaps, uneven distribution.

Empirical results and observation over time eventually led to the formulation of the Law of Demand, which was originally stated thus:

The price of goods varies directly as the quantity demanded and inversely as the quantity supplied.<sup>1</sup>

---

<sup>1</sup>Schultz, H., The Theory and Measurement of Demand, The University of Chicago Press, 1938, p. 5.

The Law may be expressed in the following mathematical terms:  $P \propto \frac{D}{S}$   
 where P stands for price, D for quantity demanded, and S for quantity  
 supplied.

Law of Demand Restated:

The foregoing statement of the law was regarded as being ambiguous  
 by many early investigators (notably among whom was Cournot). It was inter-  
 preted to mean:

Price varies directly as the quantity demanded which depends on  
 price, and inversely as the quantity supplied, which also depends on  
 price.

This led Cournot (1838) to reformulate the law:

Let us admit ... that the sales or annual demand is, for each  
 article, a particular function  $F(P)$  of the price  $P$  of such article.  
 To know the form of this function would be to know what we call the  
 law of demand or of sales.<sup>1</sup>

The mathematical expression of Cournot's law is  $D = F(P)$ . Marshall extended  
 and popularized this concept which became known as the Cournot-Marshall Law  
 of Demand.<sup>2</sup> Moreover, the law stated in this form provided the theoretical  
 foundation for most of the early statistical analyses of demand.

Dupuit (1844) and then Gossen (1854) had attempted to elaborate on  
 Cournot's contribution by formally describing price changes as a measure of  
 increments in pleasure.<sup>3</sup> Although the efforts of these writers were never

---

<sup>1</sup>Ibid. p. 6.

<sup>2</sup>Marshall, A., Principles of Economics, 8th Ed. Bk. III,  
 MacMillan, 1964.

<sup>3</sup>Ibid. p. 6.

publicized, Jevons and Carl Menger in 1871 developed and published part of these forgotten works. Jevons' work in particular attracted much attention because of the simplicity and interesting style of his treatment.

Leon Walras (1873) elaborated on these concepts substantially, being accredited as the first to postulate that the quantity of any commodity purchased in a given interval of time must be expressed, not only in terms of its price, but also of all other prices.<sup>1</sup>

The law of demand thus became:  $D = f(p_1, p_2, p_3, \dots, p_n)$  where  $D$  is the quantity of the commodity demanded,  $p_1$  its price and  $p_2, \dots, p_n$  the prices of all other commodities.

The law of demand thus stated includes the Cournot-Marshall formulation as a special case. To obtain the former from the latter, first all factors are taken into consideration, then constant values are assigned to all variables except the price and quantity of the commodity being studied.

### The Utility Concept

In the original utility approach of Gossen (1854), Jevons (1871) and Walras, utility was regarded as a measureable and additive quality of any commodity. Thus the total utility,  $U$ , of specified quantities of  $n$  commodities was given by the sum of their separate utilities.<sup>2</sup>

$U = \sum_{i=1}^n U_i(q_i)$  where  $U_i$  ( $i=1$  to  $n$ ) is the functional relationship between the quantity of the  $i$ -th commodity and the utility derived from it.

Edgeworth (1881), Antonelli (1886) and Fisher (1892) were mainly

---

<sup>1</sup>Schultz. op. cit. p. 8.

<sup>2</sup>Wold, Herman, and L. Jureen, Demand Analysis, John Wiley & Sons, New York 1953, p. 60.



responsible for the further development of the utility concept. The common thread linking their work was the basic assumption that utility in general was a non-additive quality. Thus:  $U = U(q_1, \dots, q_n)$  where  $U$  expresses a functional relationship and  $q_1, \dots, q_n$  denotes the quantity of the particular commodity held. This led Edgeworth to introduce the notion of indifference curves, with the related concepts of contract curves and lines of preference.

In his pioneering effort, Edgeworth explained the utility of a commodity as a function not only of the quantity of it possessed but also of the quantities of other commodities. Thus he pointed out:

If we interpret  $q_1, \dots, q_n$  as a point in Euclidean space  $R$ , the relation  $U(q_1, \dots, q_n) = C$  represents the locus of points of equal utility  $U = C$ . Assuming  $U(q_1, \dots, q_n)$  to be sufficiently regular function, the locus will be an  $(n-1)$ -dimensional surface in  $R_n$  called an indifference surface. The family of such surfaces obtained<sup>n</sup> by allowing  $C$  to vary is called an indifference map. If  $n=2, \dots$ , the surfaces of the map become ordinary curves.<sup>1</sup>

These concepts were extended by Pareto (1906), whose theory of preference fields provided a psychological approach to demand analysis. Pareto proceeded on slightly altered assumptions to that of his fore-runners. He assumed that each consumer had a scale of ordered preferences. Moreover, he argued that only the shape of the indifference map was of importance and that:

The map could be defined on a psychological behaviouristic basis, without making use of the concept of measurable utility.<sup>2</sup>

Thus the consumer could compare any two budgets  $A, B$ , and decide whether  $A$

---

<sup>1</sup>Ibid.

<sup>2</sup>Ibid. p. 61

was preferred, disfavoured or equivalent to B. The total utility function,  $U$ , was now interpreted as a preference index function. It was assumed to be an ordinal rather than cardinal concept.

Another fundamental assumption prevailing at the time, was that if prices  $(p_1, \dots, p_n)$  were constant, then the consumer would expend his income  $Y$  in such a manner so as to maximize satisfaction (subject to said income constraint). The optimal quantities  $q_i$  ( $i=1$  to  $n$ ) of the numerous commodities purchased were thus functions of disposable income,  $Y$ , as well as the relevant market prices  $(p_1, \dots, p_n)$ . The modified demand function of consumers became:  $q_i = f(Y, p_1, \dots, p_n)$  where  $i=1$  to  $n$ ,  $q_i$  referred to the amount of the  $i$ -th commodity demanded,  $Y$  denoted disposable income, and  $p_1, \dots, p_n$  the market prices which confronted the consumer.

Analytically, the demand functions could be deduced by setting  $U(q_1, \dots, q_n)$  at a maximum, subject to the constraint that total expenditure on all commodities did not exceed income, i.e.  $\sum_{i=1}^n p_i q_i \leq Y$  where  $p_i q_i$  is the total expenditure on the  $i$ -th commodity. This permitted the derivation of the optimal solution of the classical system:

$$\frac{\partial U/q_1}{p_1} = \dots = \frac{\partial U/q_n}{p_n}; \quad \sum_{i=1}^n p_i q_i = Y$$

Earlier economists interpreted the foregoing in terms of marginal utilities.

According to Gossen:

For the optimal budget, marginal quantities of equal cost have equal utilities.<sup>1</sup> Thus:  $\frac{\partial U}{\partial q_i} \cdot dq_i = \frac{\partial U}{\partial q_j} \cdot dq_j$  if  $p_i dq_i = p_j dq_j$ . With the development of his general theory of consumer demand, Pareto thus

---

<sup>1</sup>Ibid. p. 62.

completed and extended the work of Walras and others on the relation of utility to demand. His static approach was developed on the now well known axioms of economic behavior:

(a) Axiom of Comparison: The consumer was deemed to possess a definite order of preferences. Given two budget alternatives, A and B; either A was preferred to B; B preferred to A, or A was equivalent to B.

(b) Axiom of Transitivity: Given that the consumer was confronted by three alternative budget choices, A, B, and C. Then if A were preferred to B, and B preferred to C, it followed from the concept of transitivity that A should be preferred to C. Thus the order of preferences must be logically consistent. Reversibility would denote inconsistency which was not presumed to exist for the rational consumer.

(c) Axiom of Choice: The consumer, being rational, would choose the optimal budget (i.e. the one preferred to all others) if he were provided with all the alternatives.

Pareto's contribution was in turn improved upon by Slutsky (1915) who explicitly introduced income into the demand function. He deduced a set of general formulae for the change in the optimal budget ( $q_1, \dots, q_n$ ) with respect to infinitesimal changes in prices  $p_1, \dots, p_n$  and income  $Y$ . These formulae could be directly transformed to price and income elasticities. They formed the basis of what has become known as Slutsky's Relation.<sup>1</sup>

---

<sup>1</sup>Ibid. pp. 103-105.

### Modern Development of Demand Theory

Hicks<sup>1</sup> and Samuelson<sup>2</sup> are accredited as being the foremost contributors to the modern development of demand theory. Both treatments took as their point of departure the preference hypotheses enunciated by Pareto. Hicks, in his exposition, assumed weak ordering, whereas Samuelson assumed "strong" ordering.

Under strong ordering, it was presumed that, given an ordered set of items, each of the set had a fixed place in the order; thus whatever combination of goods was chosen, this was preferred to all other combinations available. Hicks noted that if ordering were strong, preference was always sufficient to explain choice. Contrariwise, weak ordering allowed for two or more combinations which might yield a similar level of satisfaction. Thus there could be indifference among choices. Finally, strong ordering was associated with discrete measurements, while weak ordering introduced the concept of fine divisibility.

Hicks concluded that although the desire for a self-contained theory could be better fulfilled by assuming strong ordering, yet:

I am of the opinion that demand theory ... ought to be based upon weak ordering - chiefly for the reason that weak ordering is the less restrictive assumption.<sup>3</sup>

### Hick's Contribution

Hicks first defined a composite commodity, M, which was an aggregate

---

<sup>1</sup>Hicks, J.R., *Revision of Demand Theory*, Oxford Press, 1959.

<sup>2</sup>Samuelson, P.A., "Consumption Theorem in Terms of Overcompensation Rather than Indifference Compensation", *Economica* Vol. 20, 1953, pp. 1-9.

<sup>3</sup>Hicks, *op. cit.* p. 21.

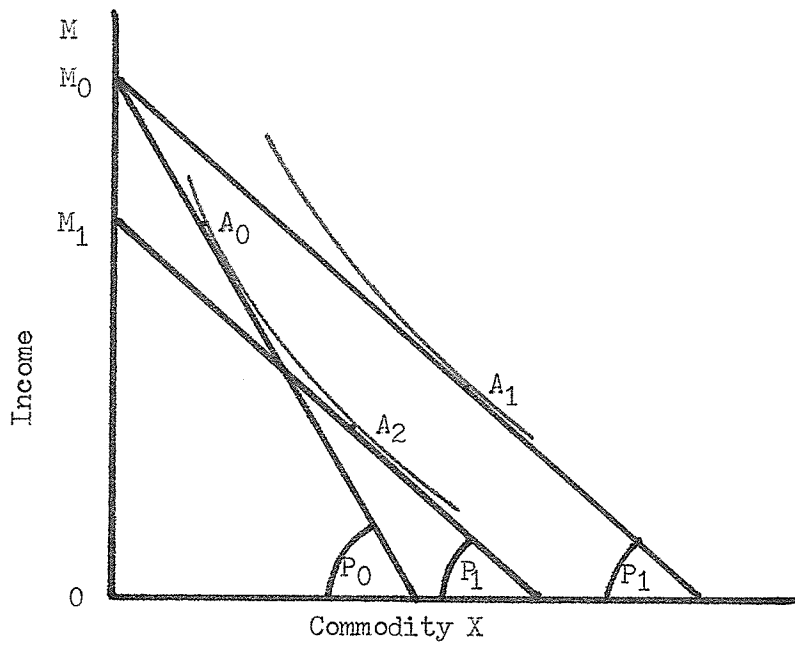
of all commodities other than that for which the price change was being considered. This composite, representative of money, was presumed to be finely divisible, and hence weakly ordered. Moreover, the commodity X (the one being studied) was also regarded as being finely divisible.

In justifying his use of weak ordering, Hicks maintained that the degree of indivisibility of commodity X was negligible. Further, currencies were composed of such very small units that the imperfect divisibility of money (represented by M) was insignificant.

Hicks proceeded with the derivation of the law of demand by dividing the effect of a price change into two parts, namely, income effect and substitution effect. Figure 3 illustrates the Hicksian approach. The commodity X was assumed to be a "normal" good. The composite M was shown on the Y axis. Assume the consumer selected the combination as indicated at point  $A_0$  when the price of X was  $P_0$  and level of income  $M_0$ . If the price fell to  $P_1$  and the income level remained the same, then the consumer was expected to increase the purchase of X and achieve equilibrium at some point  $A_1$ . This followed from the logic of the Marginal Utility Concept according to which:

At equilibrium  $A_0$ ,  $\frac{MU_X}{P_X} = \frac{MU_N}{P_N} = MU_M = C$  which may be interpreted to mean that at the equilibrium point, the Marginal Utility of Commodity X divided by its price is equated to the Marginal Utility of good N divided by its price; these are in turn equated to the constant Marginal Utility of money.

It followed then that:  $P_X \cdot MU_M = MU_X$  (where  $MU_M$  is constant). Thus if  $P_X$  fell,  $MU_X$  must fall so that equilibrium is maintained. For  $MU_X$  to fall more of the commodity X must be purchased.



Hicks' Compensating Income Variation

Figure 3

When the price of X fell, the real income position of the consumer was enhanced. The heart of Hicks' argument was that if the income of the consumer were reduced by the amount  $M_0 - M_1$  (the Compensating Variation in Income) such that the previous level of satisfaction was maintained, the new level of equilibrium would be at some point  $A_2$ . The consumer would be indifferent to combinations  $A_0$  and  $A_2$ . The movement from  $A_0$  to  $A_2$  was termed the substitution effect, characterized by an increase in quantity (if the commodity were a normal good).

If the consumer were now returned that portion of income taken away, the quantity purchased would increase further and the combination  $A_1$  would be selected in preference to  $A_2$ . The movement from  $A_2$  to  $A_1$  was caused, not by substitution, but by increased income, and was thus termed the income effect.

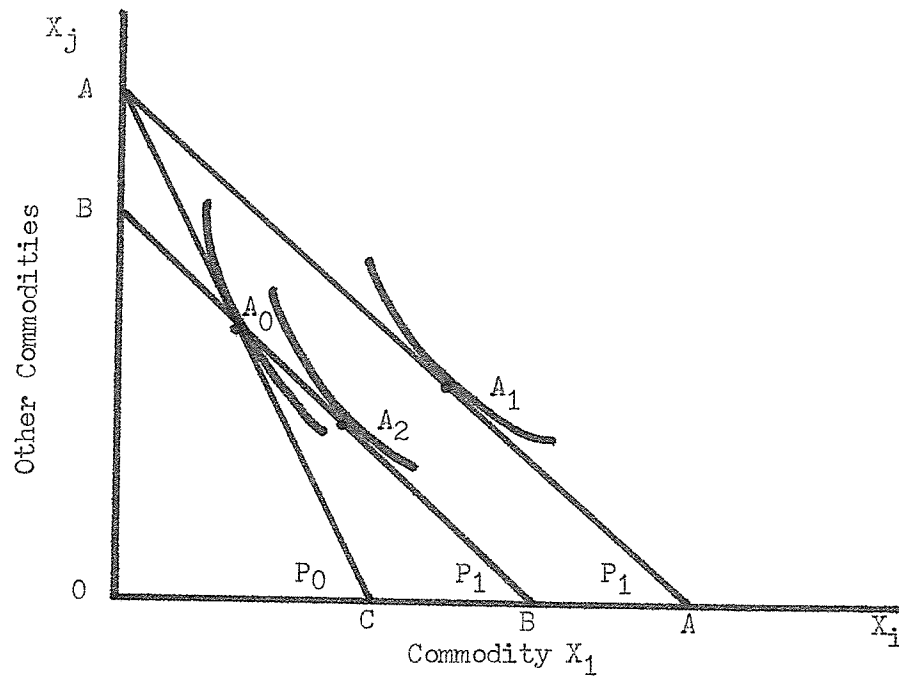
#### Samuelson's Approach

Samuelson's analysis was based on the concept of Cost Difference. For purposes of simplification he, too, aggregated all commodities other than that on which the price changed. His aggregate was symbolized by  $X_j$  ( $j=2$  to  $n$ ). He divided the effect of a price change into an income effect and an overcompensation effect, contending that the act of substituting cheap foods for more expensive should more accurately be described as an over compensation rather than a substitution effect.<sup>1</sup> Figure 4 illustrates Samuelson's method.

Commodity  $X_1$  was represented on the horizontal axis, and all others  $X_j$  ( $j=2$  to  $n$ ) on the vertical axis. With the price of  $X_1$  at  $P_0$ , the combination  $A_0$  represented equilibrium. If the price of  $X_1$  fell to  $P_1$ , then

---

<sup>1</sup>Samuelson. op. cit. p. 5.



The Method of Cost Difference

Figure 4



the equilibrium would be expected to change to  $A_1$ . Now the quantity AB (the Cost Difference) could be taken away, enabling the consumer to continue purchasing the same quantity of  $X_1$  as previously.

At the lower price  $P_1$ , however, the consumption of  $X_1$  would be expected to increase, say to the level indicated by equilibrium point  $A_2$ .

The essence of Samuelson's argument was that by not having been deprived of sufficient income, the consumer was undercompensated in terms of income. Undercompensation caused satisfaction to increase thus the consumer would be overcompensated in terms of satisfaction.<sup>1</sup> Utilizing indifference curves it could be shown that the combination  $A_2$  yielded a higher level of satisfaction than  $A_0$ . The movement from  $A_2$  to  $A_1$  was interpreted as the Income Effect (similar to Hicks).

#### THE STATISTICAL DERIVATION OF DEMAND CURVES

##### Conceptual Problems

Many economists have recognized the conceptual difficulties involved in deriving demand curves from statistics. The late Professor Allyn A. Young (1928) noted that:

Economic theory has never professed to deal with the temporal succession or spatial distribution of unique combinations of circumstances, while statistics has to deal, in the first instance, with nothing else.<sup>2</sup>

---

<sup>1</sup>Beckford, M.L. Demand Analysis for Selected Agricultural Commodities Canada 1926-62; Unpublished PhD Thesis, U. of M. 1964, p. 47.

<sup>2</sup>Schultz. op. cit. p. 61.

Thus, in principle, the theoretical demand curve cannot be derived from recorded data. Statistical data by themselves give only one set of observations on the unknown demand curve for each time period, whereas a series of observations relating to the same period are required.

Professor Pigou (1930), commenting on this very problem, observed:

It is ... impossible to derive the demand curve ... in respect of anytime period unless we marry to the statistical data some hypothesis or hypotheses external to them and derived elsewhere.<sup>1</sup>

On this point Schultz concurred, and noted that one crucial hypothesis underlying all methods used to derive curves was that the unknown theoretical demand curve could be approximated by an empirical equation.<sup>2</sup> The other pertinent hypotheses would depend, to some degree, upon the type of data available - whether time series or family budget data.

#### Time Series Analysis

If time series data were being used in the analysis, then a dynamic demand function is suggested:  $Q = f(p_1, \dots, p_n, Y, t)$  where  $Q$  denotes quantity demanded (consumed);  $p_1$  price of the commodity being studied;  $p_2, \dots, p_n$  prices of related commodities;  $Y$ , disposable income; and  $t$ , time. It must then be assumed that either tastes remain constant or that they change regularly and smoothly over time.

These hypotheses are basic to all time series methods. However, additional assumptions must be made as to the properties of the demand curve, and the way in which it shifts position over time. Thus if it is assumed

---

<sup>1</sup>Pigou, A.C. "The Statistical Derivation of Demand Curves", The Economic Journal, Vol. XL, 1930, p. 384.

<sup>2</sup>Schultz. op. cit. p. 61

that the prices of other commodities have negligible influence over the commodity being studied, then the demand function becomes:

$$Q = g(P_1, Y, t).$$

Or the influence of disposable income may also be slight, in which case the demand curve is reduced to:  $Q = h(P_1, t)$ , which is a Cournot-Marshall demand curve shifting its position from time to time. Schultz noted that such a curve may quite satisfactorily represent the demand conditions existing with a large group of agricultural commodities.<sup>1</sup>

Further assumptions may be made about the elasticity of the curve and the rate of shift per time interval. The different methods used can be traced to differences in these subsidiary assumptions.

#### Family Budget Studies

When family budget data are being utilized, other hypotheses become relevant. However, use of this type of data generally restricts the investigator to the derivation of the demand curve for a given time interval (normally a year), since such data are not often available for a consecutive number of years. They reveal nothing about the way the curve shifts from time to time. Under these circumstances then, the general dynamic function cannot be used and the general static demand function becomes relevant:

$Q = f(p_1, \dots, p_n, Y)$ . Here time,  $t$ , does not enter the functional relationship; the quantity of the commodity demanded,  $Q$ , is expressed in terms of all prices  $p_1, \dots, p_n$  and disposable income  $Y$ .

Generally, budget data represent a large cross section of individual

---

<sup>1</sup>Ibid. p. 62.

families, thus the necessity arises for making some hypothesis as to the interrelationship of the variables which constitute the demand function. Thus it may be assumed that the utility of the commodity depends solely on the quantity of that commodity, or that certain prices have negligible effect on the consumption of that commodity. Further assumptions may be made regarding the use of index numbers and the effect of changes in income on the general price level. These subsidiary assumptions adopted will determine the method used.

Conceptually, there is no significant difference between the time series and family budget data approach. However the fact that family budget data are taken to refer to a point in time, whereas time series data cover several points in time, is sufficiently significant to justify separate treatment of each type of approach. The continuing discussion will emphasize the time series approach.

### Aggregation

Time series data are aggregative and, thus unlike those obtained from family budget, do not describe individual consumer behavior. The use of such data must therefore be justified so that estimates derived are in accordance with theoretical demand curves.

Problems arising from the use of aggregative data are resolved by assuming that:

(a) the relevant demand functions facing consumers are linear. Thus prices, incomes and quantities demanded may be aggregated and averaged without serious mathematical implications, and

(b) incomes of all individuals change in the same proportion and the

income elasticity of demand for each individual is roughly comparable.<sup>1</sup>

In demand analyses, non-linear relationships may be transformed into linear forms through logarithmic manipulation.

### Random Disturbances

It has been empirically shown that relative prices and incomes are the chief factors determining consumer demand. These factors do not, by themselves, account for all the variation in consumer demand however. Others, like weather and institutional disturbances, are often relevant, although they are so random in occurrence that they are not quantifiable. It is therefore difficult to explicitly include these effects in a statistical model. However, it is usual in econometric studies to recognize these disturbing influences, and treat them together as error which is normally and independently distributed.

Errors may also arise from inaccurate measurement and faulty observation, tending to further complicate the problem of aggregation. However, with accurate collection, treatment and analysis of the data, it is conceivable that errors may be reduced to a minimum.

### The Regression Approach

In statistical demand analysis, the investigator is confronted with the problem of estimating demand functions from empirical observations. The principal technique utilized in deriving these functions is least squares regression analysis. This device is applicable to studies for which the purpose is to:

---

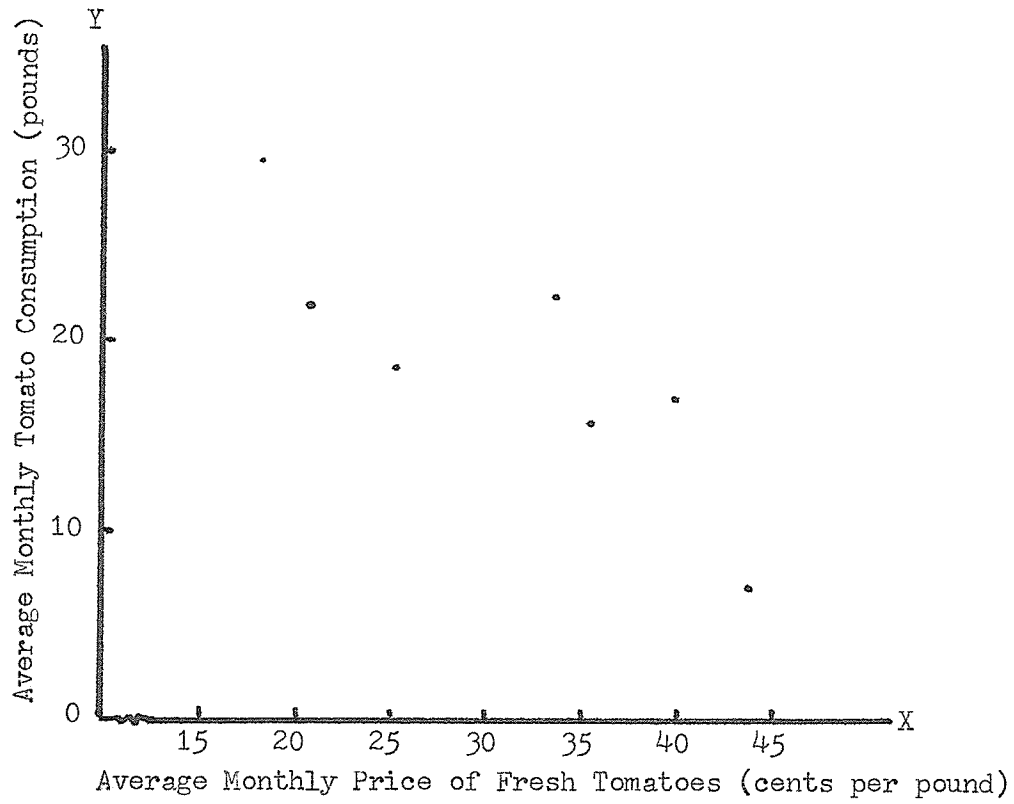
<sup>1</sup>Klein, L.R., An Introduction to Econometrics, Prentice-Hall, Inc., Englewood Cliffs, N.J. pp. 24-28.

- (a) estimate or predict one variable, given one or more other variables;
- or
- (b) obtain a causal explanation of one variable as a function of one or more other variables.

Regression analysis attempts to examine closeness of relationships in a statistical sense by indicating the proportions of variability in the dependent variable which are explained or unexplained by the independent variables.

The following example may be used to illustrate the regression technique. If it is assumed that the average fresh tomato consumption,  $Y$ , is dependent upon the price per unit of fresh tomatoes,  $X$ , the functional relationship may be expressed in the following algebraic model:  $Y = f(X)$ . A set of hypothetical observations on price and quantity plotted on a graph yields the scatter diagram as in Figure 5. A linear relationship may be postulated in which case the form of the regression equation suggested is:  $Y = a + bX + e$  where  $X$  and  $Y$  refer to the price per pound of fresh tomato and average fresh tomato consumption respectively: "a" is a numeric constant indicating average consumption of fresh tomato at zero price; "b" is the regression coefficient or slope of the regression line indicating the marginal change in fresh tomato consumption per unit change in price; "e" symbolizes the unexplained error or residual due either to inaccurate measurement, faulty observation and the effect of omitted variables.

The appropriate regression line is fitted using the form of the equation indicated, and illustrated by the line AB in Figure 6. However this is but an estimate of the true functional relationship which may take the following form:  $Y = \alpha + \beta X + \epsilon$  where the parameters  $\alpha$ ,  $\beta$ , and



Scatter Diagram of Monthly Fresh Tomato Consumption and Retail Price of Fresh Tomatoes (Hypothetical)

Figure 5

$\xi$  are estimated by the coefficients  $a$ ,  $b$  and  $e$  respectively. The true error,  $\xi$ , and the residual,  $e$ , are shown at any point by their departure from their respective regression lines. Thus at point  $O$  in Figure 6,  $\xi$  is the distance from  $O$  to the true regression line,  $CD$ , and  $e$ , the distance from  $O$  to the estimated regression line,  $AB$ . The true error cannot be observed and is governed by some qualifying assumptions.<sup>1</sup> The residual may be interpreted as follows:  $e = Y - \hat{Y}$  where  $Y$  is the actual consumption, and  $\hat{Y}$  the estimated consumption of fresh tomatoes. The simple regression model illustrated above denotes a cause and effect relationship in which  $Y$ , the quantity consumed is the dependent variable and,  $X$ , per unit price, the independent variable.

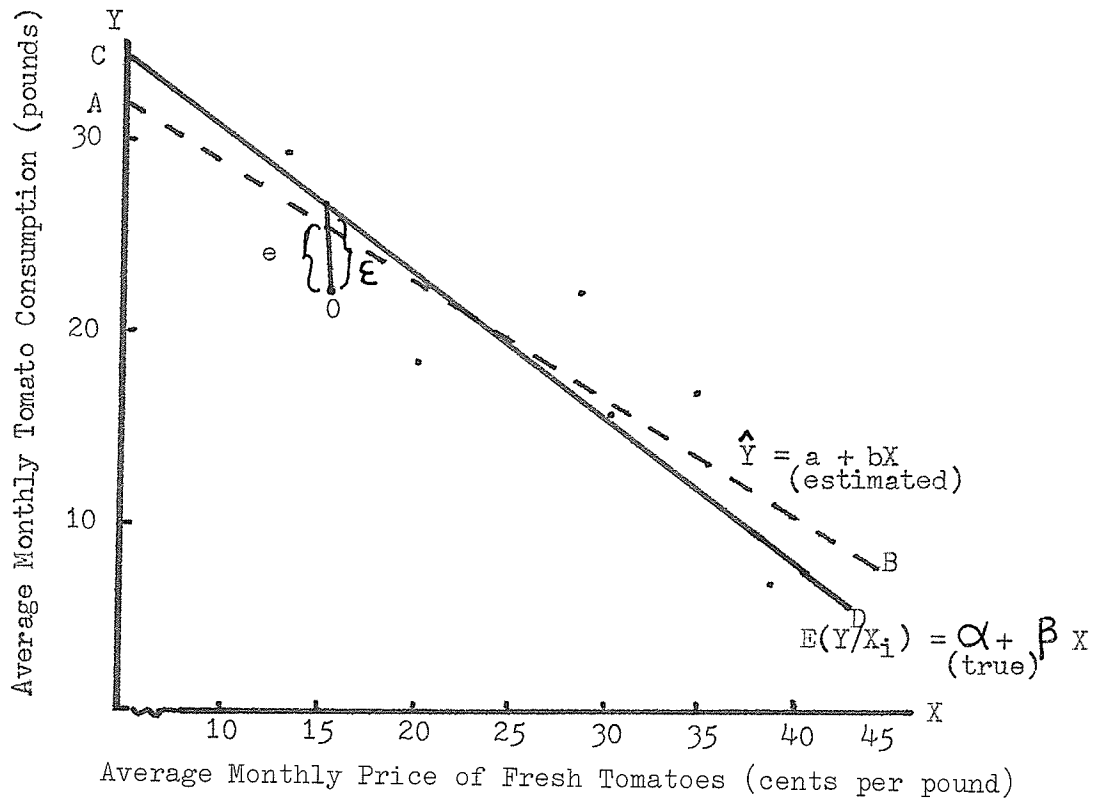
In Figure 6, a linear relationship is hypothesized here the regression coefficient is constant at each point on the line. It is to be noted that functional relationships depicted by regression equations may assume curvi-linear forms.

Many early investigators criticized the adoption of the regression technique in the social sciences, challenging its validity and applicability. They contended that it was unrealistic to assume that observations are from a definite and unchanging universe. Since human traits are constantly undergoing changes, no universe could be assumed to be static. Under experimental conditions, where all extraneous factors were controlled, it was reasonable to forecast on the assumption that relationships holding in the past would continue in the future. However, the social sciences are so characterized by human intervention that such a continuum was never certain

---

<sup>1</sup>Valavanis, S., Econometrics, McGraw Hill Book Co. Inc., New York 1959, pp. 9-17.





Relationship Between True and Estimated Regression  
Lines Fitted to Scatter Diagram (Hypothetical)

Figure 6

and projections were invariably faulty.<sup>1</sup>

The criticism of the regression technique was centered mainly around choice of appropriate regression, bias due to faulty observations, problems inherent in time series data, and complications due to simultaneous relationships.<sup>2</sup> Problems associated with time series data and choice of appropriate regression will be discussed in a subsequent section.

In controlled experiments, the effects of uncontrolled factors may be neutralized by suitable experimental design. The randomization principle is adopted so as to arrange that the influence of these factors enters as a disturbance which is uncorrelated with the controlled variables. Extraneous factors in the social sciences are largely uncontrollable, and tend to pose problems for empirical research. However, they may be similarly interpreted as for controlled experiments, thus in the equation:  $Y = a + bX + e$  where  $bX$  indicates the average influence of the controlled variable  $X$ , and  $e$  is the joint influence of the uncontrolled variables.

It is usual and practical in any analysis to confine interest to one or two causal variables considered most significant. This is consistent with the Proximity Theorem of regression analysis and is justified on the grounds that:

(a) regression attempts to give only a theoretical explanation, this legitimatizes any attempt to simplify the theory as much as possible so as to include only the more dominant causal influences, and

---

<sup>1</sup>Beckford, M.L., op. cit. p. 65.

<sup>2</sup>Wold, H., and L. Jureen, op. cit. p. 28.

(b) statistical data are often only available for a few causal factors.<sup>1</sup>

It has been implicitly assumed up to this point that there are no observational errors. Such errors give rise to disturbances since the independent variables can no longer be presumed to explain all the variability in the dependent variable. This means that the data must be corrected for error prior to analysis. Special techniques have been devised for treating data.<sup>2</sup> With all necessary adjustments undertaken, it is shown that regression analysis leads to unbiased estimates of the basic coefficients, i.e.  $\beta \doteq b$ .<sup>3</sup>

Where a system of moving equilibrium is hypothesized, simultaneous relationships are necessary. This is justified by arguing that if a scatter diagram is formed using market data on quantities and prices, each point may be considered a point of equilibrium between supply and demand. The spread of the scatter is regarded as being due to shifts in the demand and supply curves.

#### Methodological Developments in Demand Analysis

Statistical analysis of demand only gained prominence after the pioneering attempts of Moore (1917) and Lehfeltdt (1914).<sup>4</sup> Moore's work,

---

<sup>1</sup>Ibid. p. 37.

<sup>2</sup>Ibid. p. 38.

<sup>3</sup>Johnston, J., Econometric Methods, McGraw Hill Book Co., Inc., pp. 108-109.

<sup>4</sup>George, P.S. and G.A. King, Consumer Demand for Food Commodities in the United States with Projections for 1980, Giannini Foundation Monograph No. 26, California Agricultural Experimental Station, March 1971, p. 13.

in particular, has served as the point of departure for most of the research effort channeled in this area. His major contributions were:

1. He restated the theoretical, statistical demand curve in a form which permitted empirical testing.
2. He devised ingenious statistical techniques for handling the time variable in demand analysis. Moreover, he helped pioneer the use of multiple correlation in the study of demand.
3. He was the first to derive statistical demand curves for several important commodities.<sup>1</sup>

H. Working's study of potatoes (1922) provided the impetus for a series of studies on individual demand functions.<sup>2</sup> Schultz (1938) combined a review of economic theory with a large number of empirical studies.<sup>3</sup> This effort was widely acclaimed for the completeness of its treatment of the subject of demand analysis. Not very long afterwards Stone (1945), utilizing time series data, adopted the unequational econometric approach to derive numerous demand functions - his efforts culminating in a monumental study of demand in Great Britain.<sup>4</sup> Stone was one of the earliest investigators to note the distinction between estimation of the parameters of the demand function and derivation of the demand function for forecasting. He

---

<sup>1</sup>Schultz, op. cit. p. 65.

<sup>2</sup>Waugh, F.V., Demand and Price Analysis, Tech. Bul. No. 1316, Economic and Statistical Division, Economic Research Service, United States Dept. of Agriculture, Reprinted June 1970, p. 6.

<sup>3</sup>Schultz. op. cit.

<sup>4</sup>Stone, R.J., The Analysis of Market Demand, Journal of the Royal Statistical Society, Vol. 108, III - IV, 1945, pp. 286-382. See also Measurement of Consumers' Expenditure and Behavior in the United Kingdom, 1920 - 1938, Vol. 1, Cambridge University Press, 1954.

contended that, when forecasting, it is not strictly necessary to approach the theoretical structural relationship; so long as past interrelationships are expected to hold then:

... an expression which is useless for analytical purposes may be quite serviceable for forecasting.<sup>1</sup>

Important articles by E. Working (1927) and Haavelmo (1943) had pointed out the hazards of using the usual least squares analysis and time series to estimate the true demand curve of economic theory.<sup>2</sup> Since those theoretical articles, various statistical methods have been developed to try to estimate true demand curves. These are explained in detail in two reports of the Cowles Commission.<sup>3</sup> Although much of the literature on this subject is abstract, the methods developed have been applied in empirical analyses. Foote, for example, directed many studies utilizing the simultaneous approach. Moreover, he prepared a detailed handbook explaining the methods used in undertaking structural analyses through a system of simultaneous demand and supply equations for various farm products.<sup>4</sup>

Such statistical studies are invaluable to an understanding of the structure of agricultural markets. Fox (1953), however, found that, in

---

<sup>1</sup>Stone, Ibid. p. 312.

<sup>2</sup>Working, Elmer, What Do Statistical Demand Curves Show? Jour. Econ. XLI, 1927; see also Haavelmo, Trygve, The Statistical Implications of a Set of Simultaneous Equations, Econometrica, Vol. 11, Jan. 1943.

<sup>3</sup>Koopmans, T.C., ed. Statistical Inference in Dynamic Economic Models, Wiley and Sons, New York, 1950. See also Hood, W.C., and T.C. Koopmans, ed. Studies in Econometric Method, Wiley & Sons, New York, 1953.

<sup>4</sup>Foote, R.J., Analytical Tools for Studying Demand and Price Structures, United States Dept. of Agric. Handbook 146, 1958.

actual practice, least squares equations for agricultural products were practically identical with those obtained from elaborate methods.<sup>1</sup> Consequently, he argued that simultaneity was of minimal importance in the analysis of demand for farm products. Fox further contended that the single equation complete model, though not frequently used in practice, was applicable for studying a perishable crop which is marketed and consumed in a very short time period.<sup>2</sup>

Wold (1953) added another dimension to the methodological issue by analysing the simultaneous approach and then settling for recursive systems.<sup>3</sup> In a recursive system, the current value of each variable depends on previous values of other variables. Wold indicated that in fully recursive models, simple least squares equations gave the best estimates (assuming no errors of measurement).

Many researchers, recognizing the limitations of both time series and cross section analysis, have attempted to supplement one method with the other. Goureaux (1960) analyzed consumption behavior based on data derived from household surveys and time series of national averages. In this way, he compared consumption of households at a given period, average consumption in different countries at a given period, and change in average consumption over time.<sup>4</sup> Wold and Jureen (1964) utilized income elasticities obtained

---

<sup>1</sup>Fox, Karl A., The Analysis of Demand for Farm Products, United States Dept. of Agriculture, Tech. Bul. 1083, 1953.

<sup>2</sup>Fox, Karl A., Econometric Analysis for Public Policy, Iowa State College Press, Iowa, U.S.A. p. 34.

<sup>3</sup>Wold, Herman and Lars Jureen, op. cit.

<sup>4</sup>George, P.S. and G.A. King, op. cit. pp. 18-19.

from budget studies in conjunction with time series data to estimate demand functions by "conditional regression analysis."<sup>1</sup> Mundlak (1961 and 1963) and Ben-David and Tomek (1965), among others, have used analysis of covariance for estimating regional demand characteristics, both at a given period of time and over time.<sup>2</sup> However, a major limitation of all these approaches is the high data requirements.

Brandow (1961) selected twenty-four food items and obtained the complete structure of demand relationships in terms of direct elasticities and cross elasticities in a synthesized model.<sup>3</sup> This "demand matrix" is useful for describing the long run tendencies exhibited by the markets for certain farm products. In addition, it provides a framework within which the effects of proposed changes in farm policy may be estimated. Brandow's study has been criticized on the ground that most of his direct elasticities were derived from statistical estimates obtained from other studies and, as a result, they do not follow a consistent pattern of estimation. George and King (1971), utilizing Brandow's approach, expanded the demand matrix to include forty-nine commodities.<sup>4</sup> In this study, the coefficients were obtained using a uniform estimation procedure. Perhaps the major contribution of both these recent developments in demand analysis is that they may

---

<sup>1</sup>Ibid.

<sup>2</sup>Ibid.

<sup>3</sup>Brandow, G.E., Interrelations Among Demands for Farm Products and Implications for Control of Market Supply, Pennsylvania Agricultural Experimental Station Bulletin 680, University Park, 1961.

<sup>4</sup>George, P.S. and G.A. King. op. cit.

serve to bridge the gap between partial equilibrium analysis and the general equilibrium approach.

Within the past two decades, developments in data availability, improved data processing and developments in econometric theory have facilitated rapid progress in empirical demand analysis. There is now a much wider understanding of simultaneous systems and the multiple equation approach. The use of recursive models in explaining consumer demand is also becoming more widespread.<sup>1</sup> However, these developments still do not invalidate the use of the single equation model in demand analysis. Given the nature of the problem being investigated, the single equation model is used in this study.

---

<sup>1</sup>Fox, K.A., Intermediate Economic Statistics, John Wiley and Sons, Inc., New York, 1968, pp. 405-412.



## Chapter IV

### MODEL FORMULATION AND METHOD OF ANALYSIS

The demand function for a particular commodity will, on a prior grounds, include the following factors:

(i) quantity demanded of the given commodity; (ii) its price; (iii) prices of closely competing substitutes; (iv) related prices of other goods and services; (v) consumers' income; (vi) their liquid assets; (vii) their commitments; and (viii) numerous other attributes including age, sex, and occupation. These factors are posited by economic theory as the important determinants of the rate of purchase per unit time for the given commodity.

The inclusion of all these variables still does not preclude the occurrence of minor disturbances (due to other less significant left out variables), and of major disturbances caused by factors external to, but influencing, the economic system. However, complicated statistical problems arise on the introduction of more than four variables in the demand equation especially when time series data are being used.

### CHOICE OF VARIABLES

The variables chosen as being most pertinent in analyzing this topic are: real price of fresh tomatoes (retail price), real disposable income per capita, prices of related commodities and taste. Some consideration was given to the inclusion of the price of lettuce explicitly in the demand relation, this commodity being regarded as being complementary in use to

fresh tomatoes. Data limitations deterred this effort.

As indicated in Chapter I (TABLE II) statistics on the apparent per capita domestic disappearance of tomatoes for Canada suggest that per capita consumption of fresh tomatoes has been steadily declining. Meanwhile, apparent per capita domestic disappearance of all tomato products (including fresh tomatoes) has tended to remain stable, indicating that over time other tomato products have become increasingly important in the diet of Canadians.<sup>1</sup> Consideration therefore was given to the inclusion of a variable representing consumption of all other tomato products.

#### Sources of Data

Demand analyses may be conducted on data from family budget and market statistics. In this study, time series will be utilized in view of the period of coverage, availability of data and costs involved. Marschak has suggested a method which involves combining time series with budget data on family expenditures and income distribution.<sup>2</sup> However data deficiency precluded such an analysis.

The main sources of data are the Dominion Bureau of Statistics and Canada Department of Agriculture publications. None of these sources provided data on retail prices of fresh tomatoes in Manitoba, thus newspaper

---

<sup>1</sup>Fisher, G.A., The Economics of Processing Tomato Production in Ontario, 1966 to 1970, (Farm Economics and Statistics Branch, Ontario Dept. of Agriculture and Food, May, 1971), p. 35.

<sup>2</sup>Marschak, J., "Money Illusion and Demand Analysis", Review of Economic Statistics, Feb. 1943, pp. 40-48.

advertisements covering the period under review were used.<sup>1</sup>

#### Explanation of Variables and Adjustment of Data

It is recognized that factors other than disposable income and price are sometimes responsible for changes in the quantity consumed of a particular commodity. Inflation and population growth are perhaps the more significant examples. Such changes can be accommodated by treating the raw data. Thus quantity figures are reduced to a per capita basis, the variables used being annual per capita consumption of fresh tomatoes in Manitoba, and annual per capita consumption of other tomato products. The price and income variables are similarly adjusted so as to eliminate the declining value of money by using consumer price indices.

Stigler has argued strenuously against the use of deflators, maintaining that quantity and price are related in monetary values, thus if the value of money changes then all demand and expenditure curves change.<sup>2</sup> The tenor of this argument is that elimination of changes in the value of money has no effect on demand elasticity, provided that the prices of all commodities change proportionally, although all curves will be shifted in terms of money. However, if only the prices of consumption goods change proportionally, the real change in demand due to income change will not be

---

<sup>1</sup>Most grocery stores advertise in either the Wednesday or Thursday newspaper (Winnipeg Free Press) of each week. Consequently, average annual fresh tomato prices were calculated from the second and fourth Wednesday and Thursday newspapers of each month for the years 1954 to 1969.

<sup>2</sup>Stigler, G.J., "The Limitations of Statistical Demand Curves", Journal of the American Statistical Association, Vol. 34, No. 207, Sept. 1939, pp. 469-481.

eliminated.<sup>1</sup>

There is no data series representing either consumption of fresh tomatoes or tomato products in Manitoba. The former is computed from the following formula:  $M_t + F_t + C_t = Q_t$  where  $M_t$  denotes the quantity of fresh tomatoes produced in Manitoba in a given year;  $F_t$  refers to foreign imports of fresh tomatoes; and  $C_t$ , the amount imported from other provinces. By thus combining production and import statistics, the variable  $Q_t$  is obtained, which accurately interpreted represents apparent domestic disappearance of fresh tomatoes in Manitoba in a given year. Since fresh tomatoes is a highly perishable commodity with little storage capability, it is assumed that all production in and imports into the province are consumed within a short time period.

It is rather more difficult to collect statistics on the consumption of tomato products in Manitoba. The problem is circumvented by constructing an index representing the consumption of tomato products on the assumption that Manitobans consume tomato products in the same proportion to fresh tomatoes as do other Canadians. On this basis the data series on the consumption of tomato products in Manitoba is generated, (Appendix A).

Ideally, the retail price of fresh tomatoes and the prices of other food products should be treated as separate variables. Indeed, since the time period is relatively short (1954-69), deflating by the price index may have little effect on the results obtained. Moreover, by combining the price of fresh tomatoes and the consumer price index in the manner, it is

---

<sup>1</sup>Ibid. p. 472.

implicitly assumed that consumers react to changes in the prices of other foods. The deflated price of fresh tomatoes is used, however, since there is usually little independent variation in the price of individual commodities over time.<sup>1</sup>

Real disposable income per capita is used to take explicit account of any changes in population over the period. Failure to explicitly allow for change in population will bias the estimates of the parameters of the other determining variables to some extent.<sup>2</sup>

In most demand analyses, it is customarily assumed that tastes and habits are constant. However in so far as these change gradually over time, they will introduce variations that ought to be taken account of. By including taste, it is possible to evaluate changes in preference for fresh tomatoes over time. Thus changes in consumer preference was determined by introducing time as an explanatory variable. This variable is presumed to take account of:

Sources of continuous systematic variation which have not been introduced explicitly and which together, tend to push the dependent variable up or down through time.<sup>3</sup>

This is but an arbitrary assumption which may be deemed rather unsatisfactory, since no adequate consideration is given to cyclical fluctuations or sudden changes or discontinuities.<sup>4</sup> The variable may best be interpreted as

<sup>1</sup>Prest, A.R., "Some Experiments in Demand Analysis", Rev. of Econ. Stat., Vol. 31, 1949, pp. 34-35.

<sup>2</sup>Ibid.

<sup>3</sup>Stone, R.J., "The Analysis of Market Demand", Journal of Royal Statistics Society, Vol. 108 III-IV. p. 291.

<sup>4</sup>Prest, A.R., op. cit. p. 35.

as reflecting miscellaneous changes rather than being truly representative of changes in taste. Treatment of this variable is by entering absolute numbers 1 to n for successive years. The direction of the sign preceding the coefficient of this variable indicates increase or decrease in preference over time. The magnitude of change is measured in terms of the statistical significance of the coefficient.

#### Data Limitations

Problems of multicollinearity and autocorrelation usually attend the analysis of time series data. Multicollinearity exists when there is such a high degree of correlation between some or all of the explanatory variables in a functional relationship that it is impossible to determine their separate influences, and obtain precise estimates of their relative effects on the dependent variable. Thus in estimating the demand function, correlation may be expected between prices and disposable income since they both reflect the business cycle. High correlation between determining variables leads to imprecise estimates of the coefficients, and may ultimately lead to indeterminacy. Indeterminacy may be remedied if one of the elasticities is known a priori where upon the least squares method may be used to determine the others. The device thus employed is termed Conditional Regression Analysis.<sup>1</sup>

The problem of auto-correlation arises where there is correlation between successive observations in the series so that the residuals are not randomly distributed. This may occur in analyses of this type where the price of the commodity in one time period shows some relationship to prices

---

<sup>1</sup>Wold, H., and L. Jureen, Demand Analysis, John Wiley & Sons Inc., New York 1953, p. 47.

in preceding and/or succeeding periods. The ideal situation is where there is serial independence of the residuals, that is, residuals in time  $t$  are not influenced by those at time  $t-1$ , and do not in turn affect results in time  $t+1$ . It is preferred then that successive disturbances are generated independently of previous values.

Failure to adjust the data for these disturbances results in imprecise estimates of coefficients, and thus misleading results. Multicollinearity may not be too serious a problem when forecasting however, if it is expected to continue in the same degree in the future.<sup>1</sup> Thus while a high degree of intercorrelation between two independent variables may be undesirable, if this interrelationship is likely to exist in the future, then intercorrelation can be tolerated if the function being derived is to be used for forecasting. Moreover, reduction of the number of variables is an effective measure against multicollinearity.

Techniques have been devised to verify the presence of autocorrelated errors before undertaking to adjust for them. The device most commonly used is the Von Neumann ratio ( $k$ ) which involves calculating the ratio of the mean square of successive differences to the variance of estimate.<sup>2</sup> The ratio is given as:

$$k = \frac{\sum_{t=1}^{n-1} (\hat{U}_{t+1} - \hat{U}_t)^2 /_{n-1}}{\sum_{t=1}^n (\hat{U}_t - \bar{U})^2 /_n}$$

<sup>1</sup>Johnson, J., Econometric Methods, McGraw Hill Book Co. Inc., New York 1963, p. 207.

<sup>2</sup>Ezekiel, M., and Fox, K.A., Methods of Correlation and Regression Analysis, John Wiley & Sons Inc., New York 1961, p. 339.

where  $U_t$  is the residual at time  $t$ , and  $\hat{U} = \frac{\sum_{t=1}^n \hat{U}_t}{n}$ . Critical  $k$  values have been calculated and tabulated for one and five percent levels of significance.<sup>1</sup> If the calculated  $k$  value is less than the lower critical value, positive auto-correlation is indicated. If the value is greater than the upper critical value, negative auto-correlation is present. A calculated  $k$  value which falls within the range of the upper and lower critical values suggests that the amount of auto-correlation is tolerable. The method of first differences is an effective device for reducing the degree of auto-correlation.

#### THE MODEL

The problem of fitting a demand curve to data raises several difficult mathematical questions. In the pure theory of demand, the demand curve is taken as a unique functional relation between the quantity sold (demanded) and the price paid. Thus the average change in quantity corresponding to a given change in price, and the average change in price corresponding to a given change in quantity are assumed to be given by one and the same regression. In an empirical analysis, the data usually exhibit variation are affected by disturbing factors.

The question arises then, which of the two regressions - price on quantity or quantity on price - is to be taken as the relevant demand curve. In the following analysis, quantity is taken as the dependent variable. It is assumed then that there is greater reliability in the price series, and that an observed point fails to fall on the demand curve primarily because

---

<sup>1</sup>Ibid. p. 341.



of deviations in the quantity data. This assumption is justified on the grounds that the source material for quantity data (production and import statistics) may not fully reflect consumption figures. Moreover, the primary objective of the analysis is to explain quantity demanded.

The Cobb-Douglas formulation is chosen as the form of the model for deriving the demand function for fresh tomatoes in Manitoba. The use of the model is justified on the following valid theoretical grounds:

- (a) its inherent simplicity makes for relatively easy calculation of coefficients and it usually affords a "good fit" to the data;<sup>1</sup>
- (b) moreover, compared with other methods, income and price elasticities may be calculated directly.

The basic algebraic form of the model is:

$$Q_t = \alpha X_{1t}^{\beta_1} X_{2t}^{\beta_2} X_{3t}^{\beta_3} 10^{\beta_4} X_{4t}^{\beta_4} \varepsilon \dots \quad (1)$$

Expressed in logarithmic form the model becomes:

$$\log Q_t = \log \alpha + \beta_1 \log X_{1t} + \beta_2 \log X_{2t} + \beta_3 \log X_{3t} + \beta_4 X_{4t} \log 10 + \log \varepsilon \dots \quad (2)$$

$$\text{or } \log \hat{Q}_t = \log a + b_1 \log X_{1t} + b_2 \log X_{2t} + b_3 \log X_{3t} + b_4 X_{4t} \dots \quad (3)$$

The model thus indicates linearity in variable  $X_{4t}$  and in the log of the other variables  $X_{1t}$ ,  $X_{2t}$  and  $X_{3t}$ . It is implied then that the catch-all variable  $X_{4t}$  changes at a constant instantaneous percentage rate.

Equation (3) is derived from equation (2) on the assumption that the "a" and "b" values are unbiased estimates of the  $\alpha$  and  $\beta$  coefficients and the estimated quantity,  $\hat{Q}_t$ , is evaluated rather than actual quantity,  $Q_t$ .

The variables in equation (3) are:

---

<sup>1</sup>Prest, A.R., op. cit. p. 36.

- $Q_t$  = per capita consumption of fresh tomatoes in time  $t$ .  
 $X_{1t}$  = average retail price (real) per pound of fresh tomatoes paid by consumers at time  $t$ .  
 $X_{2t}$  = real disposable income per capita at time  $t$ .  
 $X_{3t}$  = per capita consumption of tomato products in time  $t$ .  
 $X_{4t}$  = variable reflecting change in tastes and preferences.  
 $a$  = numeric constant.  
 $b_1, b_2$  and  $b_3$  = elasticities with respect to price, income and consumption of tomato products respectively.

The data will be pretested for auto-correlation and multicollinearity by varying the basic form of the model.<sup>1</sup> Coefficients will first of all be derived on the basis of equation (3). Should auto-correlation and multicollinearity be indicated then an iterative procedure will be used to estimate the value of the auto-correlation coefficient,  $\rho$ .<sup>2</sup> This coefficient is used to adjust the data. If  $\rho$  is equal to one, then the method of First Differences will be applied and the following equation adopted:

$$\log \hat{Q}_t = \log a + b_1 \Delta \log X_1 + b_2 \Delta \log X_2 + b_3 \Delta \log X_3 + b_4 X_4 \dots (4)$$

where the delta ( $\Delta$ ) indicates first differences between two successive years:  $\Delta \log X_1 = \log X_{1t} - \log X_{1t-1}$  and the variables  $X_1, X_2, X_3$  and  $X_4$  are interpreted as for equation (3). Selection of the model to be used Equation (3) or (4) will depend, then, on how satisfactorily each handles problems of auto-correlation and multicollinearity as indicated by the  $k$  values and partial correlation coefficients, respectively.

Forecasting will be made on the basis of the demand function derived.

<sup>1</sup>The Correlation Matrix is presented in Appendix B.

<sup>2</sup>Craddock, W.J., Autocorrelated Errors in Single Equation Least Squares Regression, Dept. of Ag. Econ. and Farm Management, Univ. of Man. Tech. Bul. No. 9, Jan. 1968, pp. 9-15.

The criteria used in selecting the function on which forecasts will be made are:

- (a) levels of significance of the regression coefficients, and
- (b) size and levels of significance of the multiple coefficient of determination ( $R^2$ ).

#### THE METHOD OF ANALYSIS

The technique employed in undertaking the empirical demand analysis and making the forecast to 1980 is Multiple Regression Analysis based on the principle of least squares. In his discussion on regression analysis, Wold concluded that least squares regression, as traditionally used, was an adequate tool and may be legitimately used for purposes of demand analysis.<sup>1</sup> The validity of this method has also been supported by Foote, who noted that the application of least squares regression to time series data provides direct estimates of direct and cross elasticities, which were both reliable and statistically consistent.<sup>2</sup>

The uni-equational model was considered complete enough for undertaking such an analysis. Prest suggested that complicated forms should only be used if great advantages are to be derived.<sup>3</sup> Working supported this contention claiming that the simultaneous approach does not provide more

---

<sup>1</sup>Wold, H., and L. Jureen, *op. cit.* p. 58.

<sup>2</sup>Foote, R.J., Analytical Tools for Studying Demand and Price Structures, Agricultural Handbook No. 146, U.S.D.A. Agric. Marketing Service, Washington D.C., Aug. 1958, p. 88.

<sup>3</sup>Prest, *op. cit.*

reliable elasticities in a majority of cases.<sup>1</sup> It has been noted earlier that regression analysis is applicable where there is reason to suspect causal relationships among variables. It is generally assumed in demand analyses that the quantity of a commodity demanded is functionally related to prices and incomes. In this study the "cause" variables, prices, incomes, and consumption of tomato products are termed independent variables, whereas the effect variable, quantity, is the dependent variable.

The basic procedure adopted for the projection of demand is also the multiple regression approach. This projected level of demand is based on a few assumptions. The crucial ones are that no significant changes in the economic structure would occur due to government policies, war or depression and that the economic magnitudes related to the consumption of fresh tomatoes will persist in the future. The structural equation previously derived forms the basis of the projection of demand.

If it is assumed that the prices for fresh tomatoes would maintain a similar relationship to that held between them and the consumer price index, then the only independent variables which need projection up to 1980 are personal disposable income, the consumer price index, and the index of consumption of tomato products.

The consumer price index is projected using a time variable in a linear form:  $CPI_t = \beta_0 + \beta_1 t$  where  $t$  is the time variable. This form of relationship is justified on the basis that future rate of inflation would increase at the same rate rather than taper off.

---

<sup>1</sup>Working, E.J., "Progress in the Study of Demand for Farm Products", Journal of Farm Economics, Vol. 37, 1955, p. 971.

Per capita personal disposable income is estimated by first projecting total disposable income:  $PDI_t = \alpha 10^{\beta t}$  where  $\alpha$  and  $\beta$  are parameters, and  $t$  is the time variable. Thereafter, estimates of the Manitoba population in 1980 are obtained.<sup>1</sup> The projected income figure is then divided by the estimated population and consumer price index to yield real personal disposable income per capita.

The index of consumption of tomato products is projected using time variable in the linear form:  $TP_t = \alpha + \beta t$

The projected levels of these independent variables are plugged into the forecasting equation and the projected level of demand for fresh tomatoes in Manitoba is obtained.

This leads to the next phase of the study, where it is necessary to determine what proportion of this projected demand may be served by a proposed greenhouse industry. Here, the likely production season of the industry as determined by technical and economic considerations will be defined. On the assumption that the total demand during this season may be supplied by the greenhouse producers, consumption trends will be analysed to ascertain what proportion of annual consumption of fresh tomatoes takes place during this period. These findings are projected to determine the size of market available to greenhouse producers in 1980.

---

<sup>1</sup>The projected estimate for the population in 1980 is made by applying a growth factor of 1.5% per annum to the 1969 population estimate. This is based on the observed population growth rate over the previous eighteen years.

## Chapter V

### INTERPRETATION AND EVALUATION OF RESULTS

This chapter provides and evaluates the demand function for fresh tomatoes in Manitoba. The empirical results estimated cover the period 1954-69 and were derived by the method of least squares utilizing the Cobb-Douglas form of equation.<sup>1</sup> The chapter consists of four sections. First the demand function for fresh tomatoes in Manitoba is discussed. The demand projections are made in the second section. Next, the market potential of greenhouse tomatoes is analyzed. Finally the feasibility of greenhouse tomato production is dealt with in the last section.

#### ANALYSIS OF DEMAND FOR FRESH TOMATOES IN MANITOBA

The single equation least squares estimates of the demand functions for fresh tomatoes in Manitoba are presented in TABLE III.<sup>2</sup> The estimated standard error of each coefficient appears beneath in parenthesis. The coefficient of multiple determination,  $R^2$ , and the estimated standard error of regression,  $S$ , are also provided in the same TABLE. The von Neumann statistic for measuring serial correlation in the disturbances is denoted by  $k$ .<sup>3</sup>

---

<sup>1</sup>The year 1956 was omitted from the analysis because of lack of data on the consumption of tomato products.

<sup>2</sup>The data on the variables used in the regression analysis are presented in Appendix A.

<sup>3</sup>Craddock, W.J., Autocorrelated Errors in Single Equation Least Squares Regression, Dept. of Agricultural Economics and Farm Management, Univ. of Manitoba, Tech. Bul. No. 9, January 1968, p. 7.

TABLE VIII

REGRESSION COEFFICIENTS, STANDARD ERRORS, AND OTHER STATISTICAL RESULTS  
FOR DEMAND FUNCTIONS FOR FRESH TOMATOES IN MANITOBA  
1954-68

Equation	Constant	Real Price of Fresh Tomatoes	Real Dispos- able Income	Index: Tomato Products	Time	R <sup>2</sup>	S	k
		X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>			
N1	4.0382	-0.2958 <sup>++</sup> (0.3035)	-0.9373 <sup>+</sup> (0.5221)	0.3205 <sup>**</sup> (0.1356)	0.0005 (0.0092)	0.669 <sup>**</sup>	0.029	2.176(i)
N2	3.9683	-0.3046 <sup>+</sup> (0.2404)	-0.9120 <sup>***</sup> (0.1994)	0.3240 <sup>**</sup> (0.1128)		0.669 <sup>***</sup>	0.027	2.168(i)

Note: 1. Levels of significance:

- \*\*\* = 1 percent
- \*\* = 5 percent
- \* = 10 percent
- + = 20 percent
- ++ = 25 percent

2. The letter in parenthesis following the value of the k statistic refers to the results of the test for measuring the extent of serial correlation in the disturbances: (i) indicates no serial correlation.

Two equations have been estimated for the period, namely:<sup>1</sup>

$$\log Q_t = \log a + b_1 \log X_{1t} + b_2 \log X_{2t} + b_3 \log X_{3t} + b_4 X_{4t} \dots N1$$

$$\log Q_t = \log a + b_1 \log X_{1t} + b_2 \log X_{2t} + b_3 \log X_{3t} \dots N2$$

The demand function postulated in Chapter IV included an independent variable,  $X_{4t}$ , relating to time or trend. The empirical results provided by this function are as indicated by equation N1, in which the dependent variable,  $Q_t$ , refers to per capita consumption of fresh tomatoes;  $X_{1t}$ , average retail price per pound of fresh tomatoes;  $X_{2t}$ , real disposable income per capita; and  $X_{3t}$ , per capita consumption of tomato products. A second equation, N2, which estimates the demand function for the same period, includes all the variables of N1 except the trend variable. (TABLE VIII).

The results yielded by equation N1 show that the  $R^2$  value is about 0.67 and is significant at the five percent level. This indicates that approximately 67 percent of the variation in the consumption of fresh tomatoes is explained by the independent variables, namely; the real price per pound of fresh tomatoes,  $X_1$ ; real disposable income per capita,  $X_2$ ; the index of consumption of tomato products,  $X_3$ ; and time,  $X_4$ . The remaining 33 percent of variation of the dependent variable may have been due to variables not included in the equation studied. However, only one of the regression coefficients estimated by this equation is significant beyond the 20 percent level.

The value of the  $R^2$  statistic for equation N2 is also 67 percent, and is significant at the one percent level. In this equation, the

---

<sup>1</sup>Other formulations which were fitted to the data are presented in Appendix C.



regression coefficients for real disposable income per capita and the index of consumption of tomato products are significant at the one percent and five percent levels respectively, while that for price was significant at the 20 percent level.

The mean elasticity for the price of fresh tomatoes was  $-0.30$ . Price elasticity measures the percentage change in quantity associated with a one percent change in price. The estimated coefficient thus indicates that a one percent change in fresh tomato price in one direction has resulted in a 0.30 percent change in tomato consumption in the opposite direction for the time period covered. In other words, a one percent decrease in the price of fresh tomatoes will, ceteris paribus, cause a 0.30 percent increase in per capita fresh tomato consumption and vice-versa. The estimate of the direct price elasticity given by this model may not be reliable due to the influences of tastes and other variables not explicitly accounted for by this particular formulation.

In terms of influence, real income per capita appears to affect demand more significantly than price. The magnitude of the income coefficient ( $-0.91$ ) and its level of significance (relative to price) indicate that while price affects consumption of fresh tomatoes, consumers are much more responsive to a change in their real income, than to a change in the price of fresh tomatoes. The negative sign on the coefficient of the income variable,  $X_2$ , implies that fresh tomatoes fall into the category of an inferior good. While this is not impossible, evidence from previous

research on this topic is inconclusive.<sup>1</sup> This outcome may have been due to the confounding influences of trend. The data series show that, over the period covered, per capita consumption of fresh tomatoes in Manitoba has been steadily declining while per capita disposable income has been rising.

The regression coefficient for the index of consumption of tomato products is 0.32. Thus a one percent increase in the consumption of tomato products is predicted to increase fresh tomato consumption by 0.32 percent. These findings would indicate a complementary demand relation between fresh tomatoes and other tomato products represented by this index.

The results yielded by equation N2 show that about 33 percent of the variability in the consumption of fresh tomatoes is unexplained. The standard error, 0.027, indicates some variation about the line of regression. It is to be noted that the inclusion of the trend variable in equation N1 did not significantly improve the overall "fit" - the  $R^2$  value in both equations was approximately 0.67. In fact, the levels of significance of the regression coefficients pertaining to the other independent variables are adversely affected when time is included (TABLE VIII). This is, no doubt, due to the high degree of intercorrelation between time and per capita income, and time and the index of consumption of tomato products as indicated by the partial correlation coefficients (0.96 and 0.83 respectively). (Appendix B).

In general, given the data limitations, the results of the

---

<sup>1</sup>Beckford, M.L., Demand Analysis for Selected Agricultural Commodities Canada, 1926-62. Unpublished PhD. Thesis, Univ. of Man. Oct. 1964, p. 98; See also Kulshreshta, S.N., "The Demand for Major Fruits and Vegetables in Canada", Canadian Journal of Agricultural Economics, No. 2, Vol. XVIII (July 1970), p. 57.

estimation process appear to be fairly reasonable. Most of the structural coefficients estimated by equation N2 are statistically significant at acceptable levels. Moreover the demand function expressed by this equation gives a reasonable explanation of the demand for fresh tomatoes in Manitoba over the period 1954 to 1969 (Figure 7). There is evidence of some degree of multicollinearity between the income variable,  $X_3$ , and the index,  $X_4$ , (as indicated by the partial correlation coefficient 0.8). This is tolerable, however, in view of the fact that the significance of the variables are not adversely affected and that the estimated demand function is used primarily for forecasting.<sup>1</sup>

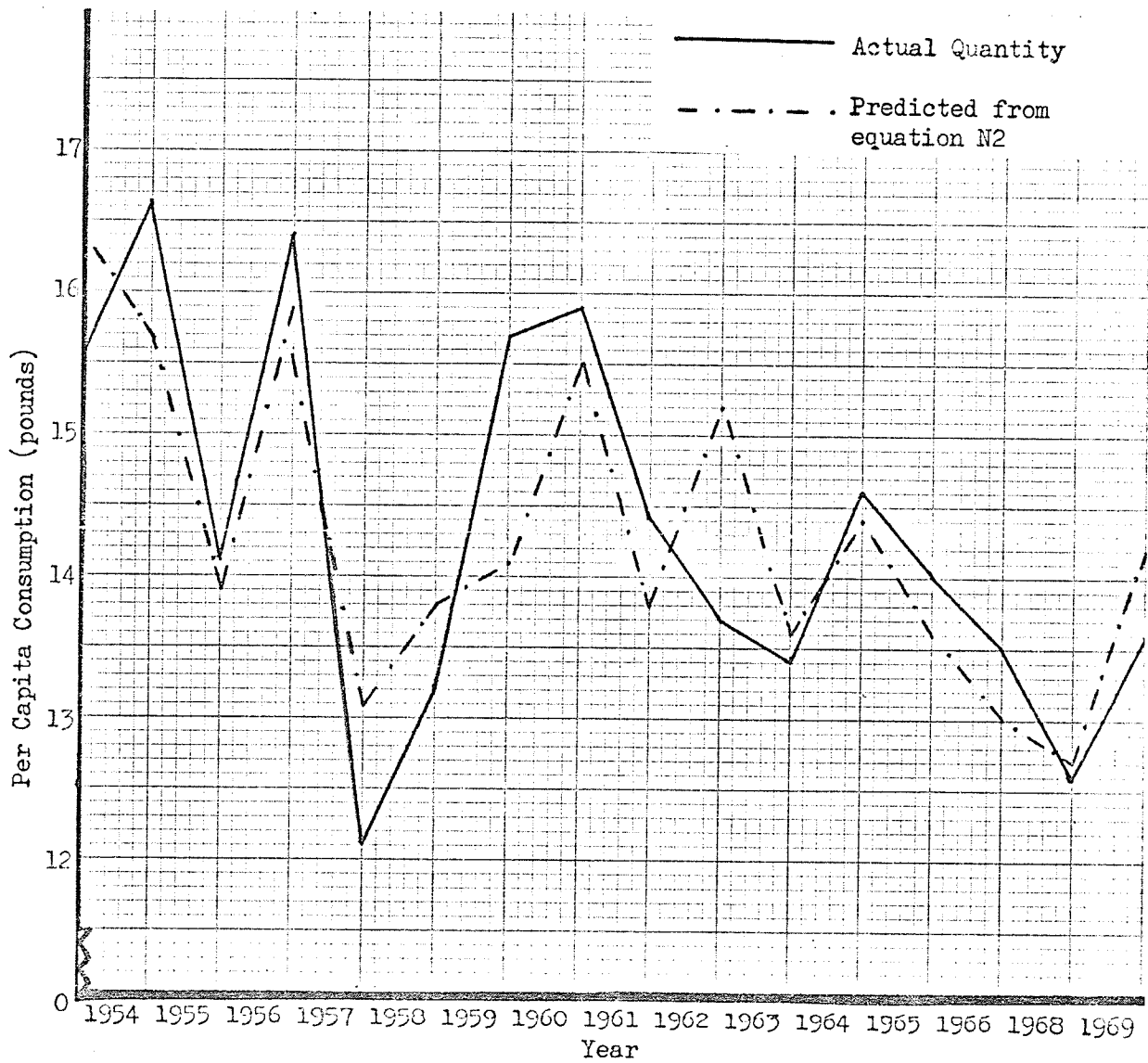
The major interest in the foregoing analysis is to project the future level of demand for fresh tomatoes in Manitoba on the basis of past trends and structural coefficients.

#### PROJECTION OF FRESH TOMATO DEMAND TO 1980

Of the two demand functions presented in the preceding section, equation N2 will be used as the basis for predicting the demand for fresh tomatoes in Manitoba. On the assumption that the model derived is logical, and that the results obtained in the previous section are reasonable, this function should provide reliable estimates of the demand for fresh tomatoes in the future. However, incomplete specification, resulting in some relevant variables being omitted from the model, might give rise to errors, and thus seriously impair the accuracy of the predictions. The cumulative effects of such errors make projections over rather long periods extremely

---

<sup>1</sup>See earlier discussion on Multicollinearity in Chapter IV.



Per Capita Consumption of Fresh Tomatoes in Manitoba:  
Actual and Predicted Quantities (1954-69)

Figure 7

hazardous. Forecasting in this study is limited to 1980.

The following criteria were relevant in the selection of the predicting equation.

1. The number of significant independent variables and the levels of their significance: The regression coefficients of the independent variables in equation N2 were more significant than those in equation N1. Thus, in a statistical sense, more significance was attached to the coefficients of N2 in estimating the variation in demand.

2. The size of the coefficient of determination ( $R^2$ ) and its significance: Since the  $R^2$  value indicates the approximate proportion of variation in the dependent variable which can be explained by the independent variables in the demand function, the larger  $R^2$  value might be taken to indicate the equation which is more appropriate for prediction. There was no appreciable difference in magnitude between the values of the  $R^2$  statistic of the two functions estimated. However, the higher level of significance exhibited by the  $R^2$  coefficient associated with equation N2 makes this the slightly superior function.

3. The magnitude of the standard error of estimate: The standard error of estimate also serves as a guide to select the more adequate demand function for prediction, because its magnitude indicates the dispersion of actual observations about the regression line. Consequently, the value of the standard error of estimate is taken to show the closeness of the estimated regression to the true line. In this instance, there was little to choose between the two equations.

In light of the criteria discussed above, equation N2 appears to be a more adequate basis for making the statistical prediction of demand for

fresh tomatoes.

#### Assumptions for Prediction

The forecast made was based on the following assumptions:

1. That the observed rate of change in the basic parameters of the demand function prior to 1969 is maintained in the interval 1969 to 1980.
2. That there will be no sudden changes (economic, technological or political) to seriously disturb the normal working of the economy.

Further, it is assumed that tastes and preferences will not change significantly.

On the basis of these assumptions, the forecast of fresh tomato consumption for 1980 is made by projecting past trends of the independent variables into the future. The trends of the independent variables are estimated by fitting different types of equations to the data from 1954 to 1969 as shown in Appendix D.

#### Statistical Predictions

Since there were only fifteen observations available in the period 1954-69, all the data were utilized in obtaining the least squares estimates of the model. Consequently, none of the years in the sample period could be used to test the efficiency of the model for predictive purposes. It was not possible to make forecasts using observations not in the sample since the values of the independent variables for 1970 and 1971 were not known. Moreover, using data from which estimates are generated as a basis for evaluating the performance of the model leads to mistaken conclusions about the generality of the model. Under these circumstances, where few observations are available, it is necessary to wait for additional observations to

be generated before the model can be tested.

The projected values of the independent variables are given in Appendix E. On the assumption that the price of fresh tomatoes in Manitoba will maintain a relationship similar to that held between it and the consumer price index, the real price per pound of fresh tomatoes is predicted to increase about 22 percent over the 1954-69 average. The predicted price of fresh tomatoes in 1980 is 33.9 cents per pound.

In 1969, total population in Manitoba was approximately 979,000 persons, with real disposable income per capita of \$1,938.60. It is projected that by 1980 population will have increased to about 1.2 million and real disposable income per capita to approximately \$2,590.00. The index representing consumption of tomato products is projected by extending the 1954-69 linear trends.

It is estimated that if population, disposable incomes and consumer tastes continue to change on the average as they did during the period 1954-69, per capita consumption of fresh tomatoes may be expected to decrease from 13.6 pounds (1969) to about 10.4 pounds in 1980. On the basis of these predictions, total fresh tomato consumption in Manitoba may be expected to be 12.5 million pounds in 1980, a decrease of approximately 6.0 percent over the total consumed in 1969. With a standard error of estimate of 0.027 it is reasonable to expect about 99 percent of the error to fall between 0.081 and -0.081. Thus total consumption of fresh tomatoes in Manitoba in 1980 is projected to be between 12.4 and 12.6 million pounds.

The anticipated change in consumption of fresh tomatoes in Manitoba appears to be minimal given the twelve year time interval. However, this seems to be consistent with what has been obtained over the

preceding eleven years when total consumption of fresh tomatoes in Manitoba fluctuated between 11.7 million pounds in 1959 and 13.3 million pounds in 1969. Total consumption of fresh tomatoes is therefore predicted to remain fairly stable for the period forecasted under present circumstances: projecting the existing situation, over 98 percent of the fresh tomato market will be satisfied by imports from Mexico and the United States at all times of the year. If these projections are correct, greenhouse growers must be prepared to become sufficiently competitive to cause consumers to substitute the locally produced for the imported tomatoes.

#### MARKET POTENTIAL FOR GREENHOUSE TOMATOES

TABLE IX indicates the quarterly pattern of imports of fresh tomatoes into Manitoba over the period 1959-69. The quarter April to June approximates the harvesting period for a spring crop of greenhouse tomatoes in Manitoba.<sup>1</sup> Over the eleven years 1959-69, imports during this quarter ranged from 22.5 to 32.4 percent of total annual imports. The average for the entire period was 28.5 percent. Meanwhile imports between October and December - which months coincide with the fall harvesting season of greenhouse tomatoes - varied between 11.5 and 18.8 percent, averaging 16.1 percent for the period.

Assuming that the seasonal consumption pattern of fresh tomatoes does not change appreciably over the projected period, then the prospects for greenhouse producers in Manitoba remain reasonably attractive despite

---

<sup>1</sup>To be more accurate, the spring crop of greenhouse tomatoes is harvested in Manitoba between May and July.



TABLE IX

PERCENTAGE OF FRESH TOMATOES IMPORTED EACH QUARTER  
MANITOBA 1959-69

Year	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.
1959	19.8	29.7	36.0	14.0
1960	21.3	26.2	34.7	17.8
1961	20.6	30.1	31.8	16.7
1962	25.5	26.6	32.1	15.8
1963	20.5	31.5	31.8	16.1
1964	23.9	26.9	32.6	16.6
1965	24.2	27.8	29.8	17.2
1966	16.8	22.5	23.0	11.5
1967	23.8	29.7	27.5	18.8
1968	19.1	30.1	32.4	18.4
1969	29.4	32.4	24.0	14.2
Average 1959-69	22.3	28.5	30.5	16.1

Source: Calculated on the Basis of CDA Annual Unload Report Fresh Fruits and Vegetables.

the levelling off of total annual consumption. Thus in 1980 the expected imports during the April-June period are approximately 3.6 million pounds, while between October and December, fresh tomato imports are expected to be 2.0 million pounds. Climatic conditions during both these periods preclude the production of locally grown field tomatoes. In terms of competition or import substitution, therefore, this entire market is available to greenhouse producers.

Experience in Ontario has been that the share of hot-house grown tomatoes on a per capita basis in the April to June market increased from 0.19 to 0.91 of a pound between 1960 and 1966.<sup>1</sup> In percentage terms,

<sup>1</sup>Blum, H., Marketing of Ontario's Greenhouse Vegetable Products in Competition with Imports from Mexico, (Farm Economics and Statistic Branch, Ontario Dept. of Agriculture and Food, May 1969), p. 36.

consumption of greenhouse tomatoes, which represented a mere 5.8 percent of per capita consumption of fresh tomatoes during the period April to June in 1960, rose to 24.2 by 1966. Meanwhile greenhouse tomatoes comprised approximately 28.5 percent of the October to December market over the same period.

It is reasonable to assume that the development of a greenhouse tomato industry in Manitoba could parallel that in Ontario. On this assumption, it is estimated that by 1980 greenhouse producers could supply 20 to 25 percent of the April-June market and 25 to 30 percent of the October-December market. This represents a market size of between 720,000 and 900,000 pounds in the spring and a fall market of 500,000 to 600,000 pounds.

With the present level of technical know-how in the greenhouse vegetable industry, it is conservatively estimated that a greenhouse tomato plant will average at least 12 pounds of tomatoes in the spring and six pounds in the fall season. Since each plant requires approximately four square feet of growing space, it is calculated that a total growing area of about 368,000 square feet will be required to satisfy the expected greenhouse market in 1980. This represents an increase of over 14 times the area presently being cropped with commercial greenhouse vegetables. A greenhouse of the size recommended for Manitoba conditions will provide approximately 6,516 square feet of effective growing space.<sup>1</sup> Assuming then, that the

---

<sup>1</sup>Campbell, J.D., J.S. Townsend and N.J. Beaton, Guidelines for Greenhouse Tomato Production in Manitoba, (Faculty of Agriculture, Univ. of Man. April 1971), p. 10.

projections are accurate, and the greenhouse industry in Manitoba develops as anticipated, about 55 greenhouses of the stipulated size will be needed by 1980.

In discussing the market potential of greenhouse vegetables in Manitoba, and establishing similarities with the development of the industry in Ontario, one point has been so far overlooked. Much of the success of the greenhouse tomato industry in Ontario may be attributed to a recognition of the need to coordinate and organize the marketing functions.<sup>1</sup> Prior to the establishment of the Ontario Greenhouse Vegetable Producers' Marketing Board, the sales function was performed by numerous independent dealers, each operating in competition with the other. The price rivalry that resulted eventually led to general instability of the price structure. Greenhouse tomato growers, with their highly perishable product, were particularly vulnerable to the wide price fluctuations. The board not only assumed an effective role in stabilizing prices, but also became actively engaged in promoting the greenhouse product.

It would seem, then, that the successful performance of a greenhouse tomato industry in Manitoba is contingent upon the development of an efficient marketing system for handling the commodity. Price-regulating mechanisms need be established and adequate promotional programs must be adopted to reach the consumer. It is conceivable that in the early stages the small number of operators existing would have little difficulty in disposing of their produce, through contractual arrangements with chain stores for example. As the industry grows, however, the need for

---

<sup>1</sup>Blum, op. cit. pp. 37-39.

organization will become more pressing. Ideally, a producer-type board, as established in Ontario, might be more desirable than the existing Manitoba Vegetable Marketing Commission.<sup>1</sup> However, it is beyond the scope of this study to determine the best marketing channel for greenhouse tomatoes.

#### FEASIBILITY OF A GREENHOUSE TOMATO INDUSTRY IN MANITOBA

Preliminary research has already established that, from a technical viewpoint, greenhouse tomatoes could be successfully grown in Manitoba.<sup>2</sup> Other studies, which examined production costs of greenhouse tomatoes in the province, have indicated a range of average prices which is likely to yield a satisfactory return on investment to producers.<sup>3</sup> In this section, the major sources of fresh tomato imports are identified; the effects of the tariff structure and transportation cost differentials are then assessed. Some consideration is also given to potential competition from similar industries in Alberta, British Columbia, and Ontario. Finally, the price behavior of fresh tomatoes is reviewed with a view to determine whether greenhouse tomatoes could be competitively marketed at the suggested price.

---

<sup>1</sup>Manitoba, Report of the Manitoba Vegetable Marketing Inquiry Commission 1967.

<sup>2</sup>Campbell, J.D., et. al., op. cit.

<sup>3</sup>MacMartin, J.B., The Financial Feasibility of Growing Greenhouse Tomatoes in Manitoba, Unpublished M.B.A. Practicum, Univ. of Man. April 1971; See also Beaton, Norman J., "Economic Aspects of Greenhouse Tomato Production in Manitoba", (paper presented at the Fourth Annual Manitoba Horticultural Council Meeting, December 7, 1971, Agricultural Auditorium, Univ. of Man.).

According to the pattern of imports indicated in TABLE IX, a greenhouse tomato industry in Manitoba seems likely to be faced with much less of a competitive threat in the fall than spring months. Imports during the spring almost always accounted for more than 25 percent of total annual imports, whereas in the fall months, they rarely ever exceeded 18 percent of annual imports.

To understand the nature of the competition facing potential greenhouse growers in the province, imports of fresh tomatoes during the periods of domestic greenhouse production are more closely examined. In 1959, 31.6 percent of the annual United States fresh tomato supplies to Manitoba was shipped during the period April to June (TABLE X). The corresponding figure for annual Mexico-Manitoba imports was 32.8 percent. However, by 1969 the percentage of annual United States-Manitoba supplies imported during April to June had declined some 13 percent to 18.8 percent; meanwhile the percentage of annual Mexico-Manitoba imports had increased by almost 11 percent to 43.6 percent over the same period. It should be noted also that, while the United States share of the April-June market decreased from 57.7 percent to 31.9 percent in 1969, the Mexican share had risen from 41.5 percent to 68.0 percent (TABLE XI).

The market in the fall period is dominated almost exclusively by imports from the United States. The statistics indicate that between 1959 and 1969, United States supplies in October-December increased from 15.6 to 27.8 percent of annual U.S.-Manitoba imports. This represented an increase in market share from 58.3 percent in 1959 to 90.7 percent in 1969. On the other hand, during that period Mexican shipments declined from 16.1 to 3.1 percent of annual Mexico-Manitoba imports. This was reflected in a

TABLE X

FRESH TOMATO IMPORTS INTO MANITOBA,  
APRIL - JUNE AND OCTOBER - DECEMBER  
1959-69

Year		Total per yr. -000 lbs.-	Apr.-June -000 lbs.-	Percent of annual total	Oct.-Dec. -000 lbs.-	Percent of annual total
1959	U.S.	6,357	2,010	31.6	991	15.6
	Mexico	4,405	1,445	32.8	709	16.1
1960	U.S.	5,469	1,192	21.8	1,549	28.3
	Mexico	5,566	2,545	45.7	990	17.8
1961	U.S.	7,302	2,372	32.5	2,122	29.1
	Mexico	3,990	2,045	51.3	129	3.2
1962	U.S.	6,060	1,594	26.3	1,592	26.3
	Mexico	4,897	1,912	39.0	530	10.8
1963	U.S.	5,162	1,785	34.6	1,557	30.2
	Mexico	4,462	2,249	50.4	545	12.2
1964	U.S.	6,798	1,323	19.5	1,364	20.1
	Mexico	4,390	2,090	47.6	768	17.5
1965	U.S.	6,570	1,907	29.0	1,768	26.9
	Mexico	4,390	2,001	45.6	418	9.5
1966	U.S.	6,292	1,690	26.9	1,091	17.3
	Mexico	4,226	1,269	30.0	240	5.8
1967	U.S.	4,652	954	20.5	2,312	49.7
	Mexico	5,152	2,865	55.6	44	1.0
1968	U.S.	6,301	1,301	20.6	1,890	30.0
	Mexico	4,528	2,331	51.5	256	5.7
1969	U.S.	6,357	1,195	18.8	1,767	27.8
	Mexico	5,847	2,549	43.6	181	3.1
Average	U.S.	6,120	1,575	25.7	1,637	26.7
1959-69	Mexico	4,714	2,118	44.9	437	9.3

Source: DBS unpublished data and CDA Annual Unload Report Fresh Fruits and Vegetables.

TABLE XI

MARKET SHARE OF UNITED STATES AND MEXICO IMPORTS  
 APRIL - JUNE & OCTOBER - DECEMBER,  
 MANITOBA 1959-69

Year		April-June	October-December
		(percentages)	
1959	U.S.	57.7	58.3
	Mexico	41.5	41.7
1960	U.S.	31.9	61.0
	Mexico	68.1	39.0
1961	U.S.	53.7	86.6
	Mexico	46.3	13.4
1962	U.S.	44.6	75.0
	Mexico	53.5	25.0
1963	U.S.	43.4	74.1
	Mexico	54.7	25.9
1964	U.S.	38.3	64.0
	Mexico	60.5	36.0
1965	U.S.	48.8	73.1
	Mexico	51.2	17.3
1966	U.S.	55.8	70.5
	Mexico	41.9	15.9
1967	U.S.	24.7	94.6
	Mexico	74.2	1.8
1968	U.S.	35.4	84.1
	Mexico	63.4	11.4
1969	U.S.	31.9	90.7
	Mexico	68.0	9.2

Source: DBS unpublished data and CDA Annual Unload Report Fresh Fruits and Vegetables.

corresponding decrease in the Mexican share of the fall market of 32.5 percent, from 41.7 percent in 1959 to 9.2 percent in 1969 (TABLE XI).

Given the continuing trends, domestic growers of greenhouse tomatoes will be confronted with competition in both marketing periods. Competition in fall lacks the intensity that growers are likely to encounter in the spring. In fact, Mexican imports, which registered heavy gains at the expense of U.S. imports in the spring period, will pose an increasing threat to potential greenhouse operators.

As indicated in TABLE XII, the major sources of United States supplies of fresh tomatoes for the Manitoba market are California, Florida and Texas. Over the five year period 1960-64, outside of Mexico, Texas and Florida were the principal suppliers to the spring market. By the following five year period, however, Florida and California had become relatively more important than Texas. During the fall marketing period, the sources of supplies tended to remain more stable. In both periods, California was the major U.S. supplier, with Florida next in importance.

The feasibility of a greenhouse tomato industry in Manitoba, then, will depend largely on how effectively potential greenhouse operators can deal with competition from Mexico, California and Florida, and to a lesser extent Texas. The present tariff structure offers relatively little protection to the greenhouse industry, and the likelihood of it being revised in the near future appears slight. No doubt, proximity to the local market will be advantageous to the greenhouse tomato industry in Manitoba because of the added costs - transportation and storage - incurred in shipping supplies from the United States and Mexico. However, the present structure of freight rates does not provide significant protection to the local green-



TABLE XII

MAJOR SOURCES OF FRESH TOMATO IMPORTS  
INTO MANITOBA: APRIL - JUNE & OCTOBER  
- DECEMBER, 1960-69

Major Source	5 Yr. Ave. Percentage of Imports			
	April-June		October-December	
	1960-64	1965-69	1960-64	1965-69
Mexico	56.6	59.7	27.9	11.1
California	6.0	10.9	51.9	52.9
Florida	12.8	19.5	13.6	17.3
Texas	24.3	5.7	1.5	6.2

Source: Computed from CDA Annual Unload Report on Fresh Fruits and Vegetables.

TABLE XIII

TRUCK FREIGHT RATES ON FRESH TOMATOES  
UNLOADED AT WINNIPEG AS A PERCENTAGE  
OF RETAIL PRICE (1968)

Source	Rate per Pound (cents)	Percentage of Retail Price	
		April-June	October-December
Ontario	3.1	9.1	10.6
Florida	4.3	12.6	14.7
California	3.5	10.2	12.0
Arizona	3.2	9.4	11.0
Texas	3.1	9.1	10.6

Source: Computed from Tariff Report, Table 61, p. 88. Data on Texas provided by local trucking company.

house operators. As TABLE XIII indicates, the highest freight rates are on Florida shipments - 4.3 cents per pound; this represented about 13 percent of the average April-June retail price of fresh tomatoes in 1968, and about 15 percent of the October-December retail price. Freight rates on Mexican supplies, which are generally shipped out of Nogales, Arizona, represented about 9 percent and 11 percent of the average 1968 April-June and October-December retail price respectively.

There is no substantial interprovincial trade in greenhouse tomatoes between any of the producing provinces and Manitoba. In Alberta, both the spring and fall crops are marketed principally within the province; a very small proportion of the fall production is sold in Vancouver.<sup>1</sup> Moreover, neither British Columbia nor Ontario greenhouse tomatoes have achieved much penetration in the Manitoba market, their competitive position being much weaker than imported field grown tomatoes from Mexico and the United States. This relatively weak market position is demonstrated in TABLE XIV, which indicates the market share of British Columbia and Ontario greenhouses tomatoes during the spring and fall seasons (compare with Mexico and U.S. in TABLE XI).

The effect on prices of transportation costs from the growing regions in Ontario and British Columbia and the time taken for delivery are probable

---

<sup>1</sup>This information was provided through correspondence with officials of the Extension and Colleges Division of the Alberta Department of Agriculture.

TABLE XIV

MARKET SHARE OF BRITISH COLUMBIA  
AND ONTARIO GREENHOUSE TOMATOES  
IN MANITOBA 1959-1969

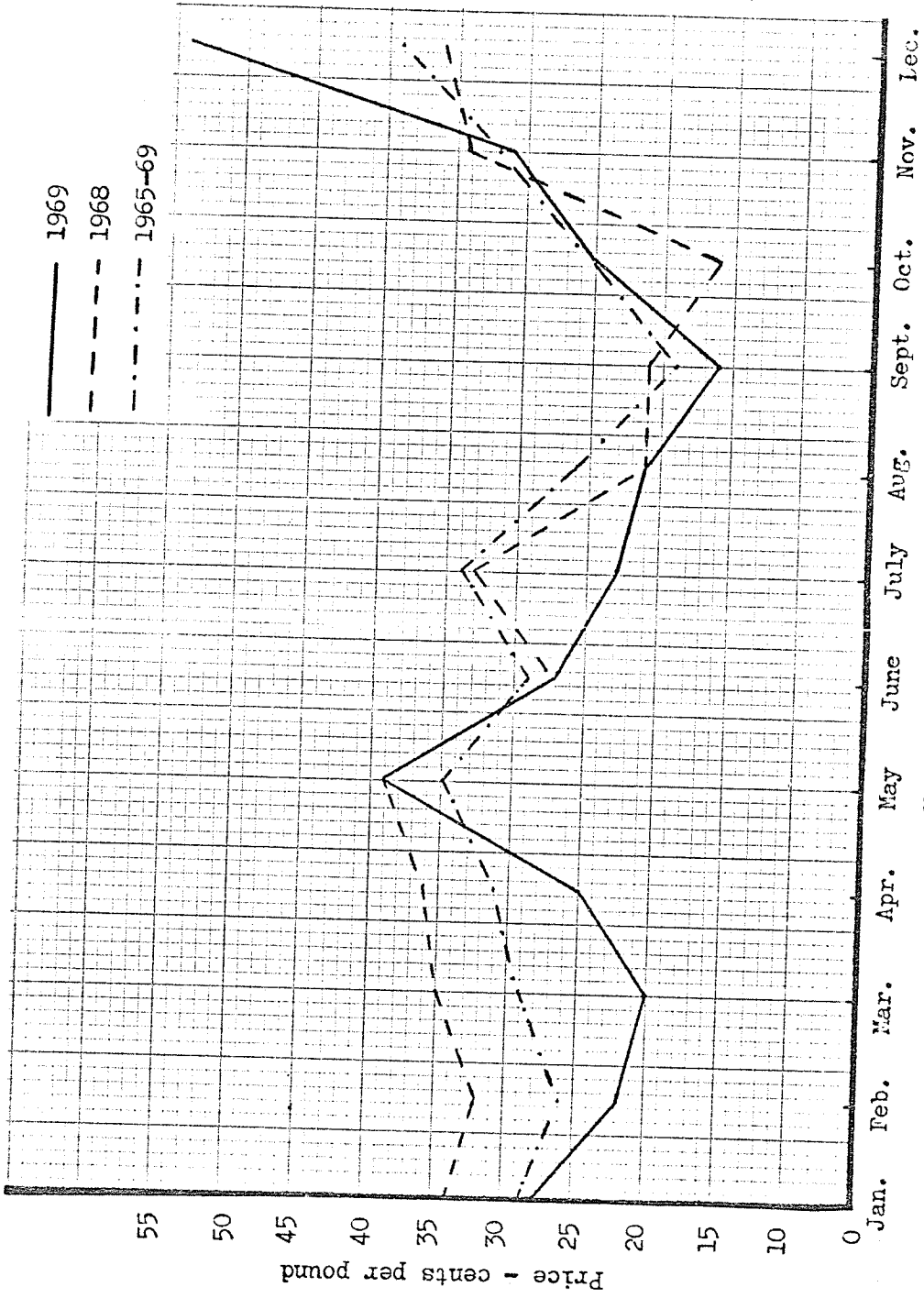
Year		April-June	October-December
		(percentage)	
1959	British Columbia	1	-
	Ontario		
1960	British Columbia	-	-
	Ontario	-	-
1961	British Columbia	-	-
	Ontario	-	-
1962	British Columbia	2	-
	Ontario	-	-
1963	British Columbia	2	-
	Ontario	-	-
1964	British Columbia	1	-
	Ontario	-	-
1965	British Columbia	-	-
	Ontario	-	10
1966	British Columbia	1	-
	Ontario	2	5
1967	British Columbia	-	-
	Ontario	2	-
1968	British Columbia	1	-
	Ontario	1	4
1969	British Columbia	-	-
	Ontario	-	-

Source: Calculated on the basis of CDA Annual Unload Report Fresh Fruits and Vegetables.

limiting factors. Another probable explanation is the large amount of wastage caused by the jarring of the produce over the long haul. In any event, it does not seem likely that greenhouse tomatoes produced in other provinces will provide significant competition to an industry in Manitoba.

As a result of the importance of imports, neither British Columbia nor Ontario greenhouse tomatoes are likely to affect the pattern of prices in Manitoba. Moreover, to the extent that domestic greenhouse and imported field tomatoes become related, the imports are far more likely to establish the pattern of price movements because they account for such a very large proportion of total supplies. In light of this, the price behavior of imported field tomatoes are examined.

Price developments at the retail level are charted in Figure 8. The movement of average monthly prices for 1968, 1969 and the period 1965-69 is illustrated. Prices tend to show a gradual rise between February and May and again between October and December. As anticipated, there is a tendency for prices to decline during the summer months as local field-grown supplies become available. On the whole, prices in 1969 were lower than for the period 1965 to 1969. In 1969, the average spring price for fresh tomatoes was 30.1 cents per pound, compared with 31.5 cents for the 1965-69 period. However, whereas fall prices during 1965 to 1969 averaged 32.0 cents per pound, in 1969, they were 36.8 cents. The overall picture for 1965-69 indicates that the average price in both the spring and fall was higher than the average annual price for the period (29.4 cents per pound). This is of particular significance to potential greenhouse operators, for it indicates that greenhouse tomatoes are likely to be on the market when the average retail prices of imported field grown tomatoes



Monthly Average Prices of Fresh Tomatoes  
Winnipeg: 1968, 1969, 1965-1969

Figure 8

are at their highest.

Because of differences in production technique, greenhouse grown tomatoes invariably cost more to produce than field grown tomatoes. At times the price of the greenhouse grown tomatoes exceed twice that of the imported field tomatoes.<sup>1</sup> The underlying reason for this substantial price differential is essentially personal preference. Market surveys conducted in the United States have indicated a strong consumer preference for greenhouse over greenpicked field tomatoes.<sup>2</sup> Moreover, it has been demonstrated that consumers have been willing to pay a premium up to twenty cents for fresher, superior quality greenhouse product.<sup>3</sup> Given the average spring-fall prices for 1965-69, and assuming similar consumers' reaction in Manitoba, a retail price between 50 to 55 cents would ensure that greenhouse tomatoes are an attractive enough commodity.<sup>4</sup>

In a study noted earlier, it was indicated that the recommended 40 by 200 foot greenhouse structure would be a feasible family run enterprise (assuming a 15 percent required rate of return) if a minimum price of 28 cents per pound could be obtained.<sup>5</sup> This was based on cost projections

---

<sup>1</sup>Canada, Greenhouse Vegetables; Report by the Tariff Board Relative to the Investigation Ordered by the Minister of Finance, Ref. No. 140, Queen's Printer, 1969, pp. 87-88.

<sup>2</sup>Campbell, J.D., et. al., op. cit. p. 16.

<sup>3</sup>Larrelere, H.E. and R.R. Redolph, "Consumer Acceptance of Greenhouse Grown and Southern Field Grown Tomatoes", Michigan Agricultural Expt. Station Quarterly, Bulletin 44, 1962, pp. 554-558.

<sup>4</sup>When available in Manitoba, greenhouse tomatoes regularly sell for 55 to 60 cents per pound, and as high as 70 cents on occasions.

<sup>5</sup>MacMartin, J.B., op. cit., p. 41.

calculated for Manitoba conditions, and yields per plant of 12 pounds in the spring and six pounds in the fall. At the price suggested, this would leave a reasonable margin of 22 to 27 cents for distribution costs, and wholesale and retail mark-ups.<sup>1</sup> In a more recent study, it was calculated that with a selling price of 30 cents per pound (which approximates the minimum of 28 cents) and yields per plant as indicated above, a gross return of \$3,154.00 may be expected from a similar type enterprise.<sup>2</sup>

It is conceivable that as greenhouse technology develops, and the managerial skill of producers improves, increased yields and lower production costs would result. This should enhance the competitive position of locally produced greenhouse tomatoes. However, the substantial price differentials between the latter and imported field tomatoes signify that greenhouse tomatoes are a premium-quality product with special appeal to a certain group of consumers. It is suggested that this high quality, high-priced market can be served by local greenhouse tomato producers; meanwhile, the market for the cheaper, lower-quality product will continue to be supplied almost exclusively by imported field tomatoes.

---

<sup>1</sup>A spring crop of greenhouse tomatoes, yielded by a semi-commercial enterprise operated at the University of Manitoba, fetched 45 cents per pound. It is unlikely, however, that as supply conditions change such handsome returns will prevail.

<sup>2</sup>Beaton, Norman J., op. cit. p. 12.

## Chapter VI

### SUMMARY, IMPLICATIONS AND RECOMMENDATIONS

#### Summary

In Manitoba the demand for fresh vegetables, and in particular fresh tomatoes, has been largely satisfied by imports from the United States and Mexico. With the availability of qualified technical back-up to support growers, it is conceivable that many of these vegetables could be profitably grown in greenhouses to ensure year round domestic supplies in this province. However, the basic statistics needed for planning, forecasting and decision-making in regard to the establishment of a greenhouse industry are seriously lacking. In the light of this, the present investigation was undertaken with the aim of providing information upon which the planning of a greenhouse tomato industry may be formulated.

More specifically the objectives of the study were:

1. To study the demand for fresh tomatoes in Manitoba at the retail level.
2. To predict the consumption of fresh tomatoes in Manitoba to 1980.
3. To provide estimates of the demand for greenhouse tomatoes.
4. To evaluate the feasibility of a greenhouse tomato industry in Manitoba.

The following hypotheses were formulated with a view to providing a manageable framework within which to conduct the study.

1. There is an inverse relationship between the quantity of fresh tomatoes consumed and its price.



2. The quantity of fresh tomatoes demanded and disposable income are inversely related.

In order to test the above hypotheses, and undertake the empirical analysis, it was necessary to make certain qualifying assumptions.

1. Consumers are rational and consistent in their market behavior.
2. Retail prices and disposable incomes are the main quantifiable determinants of per capita consumer demand.
3. The unknown theoretical demand function can be approximated by the statistically derived demand curve.
4. A relatively stable demand but variable supply conditions exist for fresh tomatoes.

The demand function for fresh tomatoes was thereafter derived. The data utilized in the study were obtained from secondary sources, mainly Dominion Bureau of Statistics and Canada Department of Agriculture publications. Quantity consumed was treated as the dependent variable on the assumption that the consumer is a price taker, and is very seldom able to affect the price of fresh tomatoes by virtue of the quantity bought. Disposable income and retail price were considered the most important independent variables affecting per capita consumer demand. On this premise, the independent variables chosen included retail price of fresh tomatoes ( $X_1$ ), disposable income ( $X_2$ ), index of tomato products ( $X_3$ ), and trend ( $X_4$ ). It was realized that other factors such as population growth and changes in the purchasing power of money also cause changes in aggregate consumer demand, thus these were included in the analysis. The effect of population growth was removed by expressing consumption data on a per capita basis.

The effect of changes in the value of money was eliminated by expressing current dollars in terms of real dollars. This was accomplished by deflating the price and disposable income variables by a consumer price index; the index used was based on 1961.

Multiple Regression analysis was chosen as the technique on which the data were analysed. The basic form of the model was of the Cobb-Douglas type which may be expressed algebraically as:

$$Q_t = \alpha X_{1t}^{\beta_1} X_{2t}^{\beta_2} X_{3t}^{\beta_3} \dots 10^{\beta_n X_{nt}} \epsilon \quad \text{where } Q_t$$

denotes per capita consumption at time  $t$ ;  $X_{1t}$  refers to real price at time  $t$ ;  $X_{2t}$ , real disposable income per capita at time  $t$ ;  $X_{3t} \dots X_{n-1t}$ , real price of related commodities at time  $t$ ;  $X_n$  is the variable reflecting changes in taste; and  $\epsilon$  represents the population error. The alpha ( $\alpha$ ) coefficient is the constant expected in the absence of disturbances from the causal variables; the beta ( $\beta$ ) coefficients represent the individual regression coefficients for the respective independent variables  $X_1 \dots X_n$ .

On the assumption that the  $\alpha$  and  $\beta$  parameters may be estimated by the sample statistics "a" and "b" respectively, the basic form of the model as applied to the sample analysed was:

$$\hat{Q}_t = a X_{1t}^{b_1} X_{2t}^{b_2} X_{3t}^{b_3} \dots 10^{b_n X_{nt}}$$

When expressed in logarithmic form this became:

$$\log \hat{Q}_t = \log a + b_1 \log X_{1t} + b_2 \log X_{2t} + b_3 \log X_{3t} + \dots + b_n X_{nt}$$

The demand function thus derived formed the basis for the statistical projections of demand to 1980. Estimates of the market share available to potential greenhouse producers were then computed on the assumption of an unaltered consumption pattern of fresh tomatoes in Manitoba. Major sources of imported field supplies were identified, and the potential competition

from similar industries in other provinces were evaluated. A review of price developments, together with an assessment of production costs and consumer preference for greenhouse tomatoes, facilitated the analysis of the economic viability of a greenhouse tomato industry in Manitoba. The results, provided in the preceding chapter, indicate that the objectives set out earlier have been largely realized.

According to these findings, per capita consumption of fresh tomatoes in Manitoba may be expected to decline, at a rate of about 2.1 percent per year, from 13.6 pounds in 1969 to 10.4 pounds by 1980. This, together with the slow population growth rate anticipated, points towards little change in the total consumption of fresh tomatoes projected for 1980 (over 1969). These results are not inconsistent with past trends. Nevertheless, they do imply that the development of a greenhouse industry in Manitoba must arise chiefly as import substitution in a stable market, rather than as a growing industry in an expanding market. In spite of this, sizeable markets for greenhouse tomatoes are predicted for the spring and fall months. Moreover, given the assumptions outlined in Chapter V, it is estimated that the projected market will support an industry of almost 10 acres.

Price developments charted for the period 1965 to 1969 illustrate that average fresh tomato prices are higher in the spring and fall months. This is encouraging for potential greenhouse operators. If consumers in Manitoba react equally favorably to the superior quality, high priced product, then it seems likely that greenhouse tomato production could be an economically viable enterprise.

This study has demonstrated that there is a potential for expanding the market for greenhouse tomatoes in Manitoba. Whether or not greenhouse tomatoes are actually produced and sold in the quantities estimated, will depend upon the relative profitability which needs further researching before an answer can be given. It has already been mentioned that the greenhouse industry is highly capital intensive. Another study has noted that the initial outlay for capital, equipment and operating expenses required for the first year of operations in a 40 by 200 foot greenhouse tomato enterprise in Manitoba is approximately \$26,000.<sup>1</sup> Consequently, if Manitoba resources will yield higher returns in some other agricultural activity, then it is logical to anticipate less response in the development of a greenhouse tomato industry.

#### Implications

It is to be expected that on the basis of past trends, fresh tomato supplies from Mexico and the United States will offer severe competition to a greenhouse tomato industry in Manitoba. Such competition will harm producers considerably by reducing returns. In the case of the United States, high levels of technological progress have resulted in economies in production and marketing (transportation and storage), and thus lower supply price. Relatively cheap labor costs are mainly responsible for the competitiveness of Mexican supplies. Consequently, the competitive survival of a greenhouse industry in Manitoba will depend on the effectiveness of production and marketing policies adopted. Undoubtedly, this will be

---

<sup>1</sup>MacMartin, J.B., The Financial Feasibility of Growing Greenhouse Tomatoes in Manitoba, Unpublished MBA Practicum, Univ. of Man., April 1971. pp. 18-21.

reflected in its ability to procure and enlarge its market share in Manitoba and perhaps, eventually Saskatchewan and Northern Ontario.

Conceivably, some form of tariff protection (not now available) may reduce the difference in costs between the locally produced greenhouse tomatoes and imported field supplies. This will, in turn, make greenhouse tomatoes relatively more attractive in terms of price. It is suggested that such a measure merely serves to create and maintain an artificially high price (for a nutritionally important commodity).

It is unlikely that greenhouse and imported field grown tomatoes appeal to the same group of consumers. The substantial price differential at the retail level seems great enough to separate the products. Moreover, it has become quite evident, elsewhere in Canada that, the superior quality of the greenhouse product is being increasingly favored by consumers.<sup>1</sup> It is reasonable to expect, then, that the pattern of consumption in Manitoba could be significantly influenced in favor of locally produced greenhouse tomatoes by systematically developing an aggressive promotional program. Such a program must depend heavily on consumer information and education in order to create an image of superiority for the greenhouse product. In this way, it could result in increased consumer acceptance of greenhouse tomatoes at premium prices.

It has been mentioned that greenhouse vegetable operations may be adequately undertaken as family run enterprises. It was also pointed out that in the greenhouse industry, economies of scale are of little

---

<sup>1</sup>Blum, H., Marketing of Ontario's Greenhouse Vegetable Products in Competition with Imports from Mexico. (Farm Economics and Statistics Branch, Ontario Department of Agriculture and Food, May 1969), pp. 35-37.

significance because of the large proportion of variable operating costs. As the greenhouse tomato industry flourishes, it can be envisaged that there will be a relatively large number of growers producing for the greenhouse tomato market. Inevitably, difficulties will arise in regard to meeting the market requirements for a standardized product of uniform quality. Consequently, it would be necessary to establish some system under which growers may be advised and guided in selecting proper varieties, and in adopting recommended production techniques.

In summary, the major implication arising out of this study is the desirability of potential greenhouse producers joining together to form some type of marketing agency. The advantages to the individual producer are substantial. Most important, the agency can function as a price-stabilizing body. In addition, such an agency will have tremendous scope to develop promotional programs and undertake market surveys to ensure that the locally produced greenhouse tomato industry obtains and maintains an adequate share of the market to sustain its viability.

#### Recommendations

The present study has provided some information which may be used for decision making in regard to the establishment of a greenhouse tomato industry in Manitoba. There are apparent weaknesses however, particularly with regard to the failure to explicitly incorporate in the function derived seasonal fluctuations in demand for fresh tomatoes. Perhaps, too, the assumptions underlying the determination of the market potential for greenhouse tomatoes can be challenged. Furthermore, it may be desirable to investigate more thoroughly consumer preference for greenhouse tomatoes and

study consumers' reactions to home brand loyalty, before arriving at definitive conclusions on the feasibility of a greenhouse industry in Manitoba.

On this basis, it is suggested that:

1. As more detailed information becomes available, future investigators might re-examine the estimates derived in the demand analysis with a view to indicating the seasonal fluctuations in demand for fresh tomatoes. Consideration might also be given to the study of marketing margins between wholesale and retail levels of trade.

2. Since the reliability of the data used may be questioned, it might be necessary to have these revised prior to analysis.

3. Future researchers might investigate more thoroughly consumers' reaction to greenhouse grown tomatoes in Manitoba with a view to ascertaining consumer preference and brand loyalty. This would give some indication as to the promotional techniques to adopt in advertising this product.

## BIBLIOGRAPHY

### A. BOOKS

- Ezekiel, M. and Karl A. Fox, Methods of Correlation and Regression Analysis. New York: John Wiley and Sons, Inc., 1961.
- Ferguson, C.E., Microeconomic Theory. Homewood, Illinois: Richard D. Irwin, Inc., 1966.
- Fox, Karl A., Econometric Analysis for Public Policy. Ames, Iowa: Iowa State University Press, 1958.
- \_\_\_\_\_, Intermediate Economic Statistics. New York: John Wiley and Sons, Inc., 1968.
- Hicks, J.R., A Revision of Demand Theory. Oxford: Clarendon Press, 1959.
- Hood, W.C. and T.C. Koopmans, (ed.) Studies in Econometric Method. New York: John Wiley and Sons, Inc., 1953.
- Johnson, J., Econometric Methods. New York: McGraw Hill Book Co. Inc., 1963.
- Klein, L.R., An Introduction to Econometrics. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.
- Koopmans, T.C., (ed.) Statistical Difference in Dynamic Economic Models. New York: John Wiley and Sons, Inc., 1950.
- Marshall, Alfred, Principles of Economics (8th ed.). London: MacMillan and Company Ltd., 1964.
- Schultz, Henry, The Theory and Measurement of Demand. Chicago: The University of Chicago Press, 1938.
- Stone, R.J., Measurement of Consumers' Expenditure and Behavior in the United Kingdom, 1920-38. Vol. 1. Cambridge: Cambridge University Press, 1954.
- Valavanis, S., Econometrics. New York: McGraw Book Company, Inc., 1959.
- Wold, Herman and L. Jureen, Demand Analysis. New York: John Wiley and Sons, Inc., 1953.



## B. RESEARCH REPORTS

- Blum, H. Marketing Ontario's Greenhouse Vegetable Products in Competition with Imports from Mexico. Farm Economics and Statistics Branch, Ontario Department of Agriculture and Food, 1969.
- Brandow, G.E. Interrelations Among Demand for Farm Products and Implications for Control of Market Supply. Pennsylvania Agricultural Experimental Station Bulletin 680, University Park, 1961.
- Campbell, J.D., J.S. Townsend and N.J. Beaton. Guidelines for Greenhouse Tomato Production in Manitoba. Faculty of Agriculture, University of Manitoba, 1971.
- Craddock, W.J. Autocorrelated Errors in Single Equation Least Squares Regression. Department of Agricultural Economics and Farm Management, University of Manitoba, Technical Bulletin No. 9, January 1968.
- Curle, R., and R. Morrison. Manitoba Greenhouse Survey - 1970. Manitoba Department of Agriculture, Winnipeg, 1971.
- Firch, Robert S. and R.A. Young. An Economic Study of the Winter Vegetable Export Industry of Northwestern Mexico. University of Arizona, Agricultural Experimental Station, Technical Bulletin No. 179, October 1968.
- Fisher, G.A. The Economics of Processing Tomato Production in Ontario, 1966 to 1970. Farm Economics and Statistics Branch, Ontario Department of Agriculture and Food, 1971.
- Foote, R.J. Analytical Tools for Studying Demand and Price Structures. U.S.D.A., Marketing Service, Agricultural Handbook No. 146, Washington D.C. 1958.
- Fox, Karl A. The Analysis of Demand for Farm Products, U.S.D.A., Technical Bulletin No. 1083, 1953.
- George, P.S. and G.A. King. Consumer Demand for Food Commodities in the United States with Projections for 1980. Giannini Foundation Monograph No. 26, California Agricultural Experimental Station, 1971.
- Hee, Olman. Demand and Price Analysis for Potatoes. Economic Research Service, U.S.D.A., Technical Bulletin No. 1380, 1967.
- Larrelere, H.E. and R.R. Redolph. Consumer Acceptance of Greenhouse Grown and Southern Field Grown Tomatoes. Michigan Agricultural Experimental Station Quarterly Bulletin 44, Michigan State University, East Lansing, February 1962.
- Phillips, W.G. The Greenhouse Vegetable Industry, Windsor, Ontario, 1961.

- Uhl, J.N. The Demand and Price Structure for Processed Tomato Products: Preliminary Findings and Implications for Inter-regional Research. Department of Agricultural Economics, University of Purdue, 1969.
- Waugh, F.V. Demand and Price Analysis. Economics and Statistical Analysis Division, Economic Research Service, U.S.D.A., Technical Bulletin No. 1316. Reprinted 1970.
- Yeh, M.H. Application of Simple and Multiple Regression Analyses to Economic Problems. Department of Agricultural Economics and Farm Management, University of Manitoba, Technical Bulletin No. 4. Reprinted October 1965.

## C. PERIODICALS

- Haavelmo, Trygve. The Statistical Implications of a Set of Simultaneous Equations. Econometrica: 11 January 1943.
- Houck, J.P. The U.S. Demand for Bananas - A Neglected Topic. Journal of Farm Economics: 46, 1964.
- Kulshreshta, S.N. The Demand for Major Fruits and Vegetables in Canada. Canadian Journal of Agricultural Economics: 18 No. 2, July 1970.
- Marschak, J. Money Illusion and Demand Analysis. Review of Economic Statistics: 25, 1943.
- Pigou, A.C. The Statistical Derivation of Demand Curves. The Economic Journal: 40, 1930.
- Prest, A.R. Some Experiments in Demand Analysis. Review of Economic Statistics: 31, 1949.
- Samuelson, P.A. Consumption Theorem in Terms of Over-compensation Rather than Indifference Compensation. Economica: 20, 1953.
- Stigler, G.J. The Limitations of Statistical Demand Curves. Journal of the American Statistical Association: 34, No. 207, 1939.
- Stone, R.J. The Analysis of Market Demand. Journal of the Royal Statistical Society: 108 Pt. 3-4, 1945.
- Working, E.J. What Do Statistical Demand Curves Show? The Quarterly Journal of Economics: 41, 1927.
- \_\_\_\_\_, Progress in the Study of Demand for Farm Products. Journal of Farm Economics: 37, 1955.

Department of Agriculture and Marketing, Province of Nova Scotia. The Greenhouse Industry in Nova Scotia. Halifax, Nova Scotia.

Food Production Branch, Manitoba Department of Industry and Commerce. An Opportunity for the Commercial Growing of Greenhouse Tomatoes and Cucumbers. Winnipeg, Manitoba, 1970.

Report on the Manitoba Vegetable Inquiry Commission 1967. Winnipeg, Manitoba, 1967.

The Tariff Board. Report by the Tariff Board Relative to the Investigation Ordered by the Minister of Finance Respecting Greenhouse Vegetables. Reference No. 140, Queen's Printer, Ottawa, 1969.

UNPUBLISHED

Beaton, Norman J. "Economic Aspects of Greenhouse Tomato Production in Manitoba", (paper presented at the Fourth Annual Manitoba Horticultural Council Meeting, December 7, 1971, Agricultural Auditorium, University of Manitoba).

Beckford, M.L. Demand Analysis for Selected Agricultural Commodities, Canada, 1926-1962. Unpublished Ph.D. Thesis University of Manitoba, 1964.

MacMartin, J.B. The Financial Feasibility of Growing Greenhouse Tomatoes in Manitoba. Unpublished M.B.A. Practicum, University of Manitoba, 1971.

APPENDIX

## APPENDIX A

## DATA ON VARIABLES USED IN REGRESSION ANALYSIS

Year	Per Capita Consumption of Fresh Tomatoes — pounds —	Real Price of Fresh Tomatoes — cents per pound —	Real Disposable Income per Capita — \$ —	Index of Tomato Products
1954	15.48	28.90	1,185.50	33.57
1955	16.57	27.84	1,245.65	32.70
1956	14.08	33.60	1,368.50	—
1957	16.43	29.85	1,344.44	45.34
1958	12.09	30.95	1,436.57	30.72
1959	13.16	25.32	1,455.57	30.99
1960	15.74	27.54	1,476.90	37.31
1961	15.92	23.90	1,379.61	36.48
1962	14.37	26.50	1,521.40	36.61
1963	13.74	26.65	1,518.18	49.00
1964	13.41	26.52	1,596.94	40.42
1965	14.61	28.07	1,666.53	57.15
1966	13.98	27.20	1,730.07	51.62
1967	13.50	25.98	1,842.22	51.91
1968	12.58	25.87	1,938.62	54.76
1969	13.62	22.42	1,943.33	67.93

## APPENDIX B

## CORRELATION MATRIX

Variables	Q	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>
Q	1.00				
X <sub>1</sub>	0.14	1.00			
X <sub>2</sub>	0.52	0.61	1.00		
X <sub>3</sub>	0.43	0.24	0.82	1.00	
X <sub>4</sub>	0.60	0.54	0.97	0.83	1.00

where Q = per capita consumption of fresh tomatoes.

X<sub>1</sub> = real price per pound of fresh tomatoes.

X<sub>2</sub> = real income per capita.

X<sub>3</sub> = index of tomato products

X<sub>4</sub> = time or trend

APPENDIX C

I. LINEAR FORMULATIONS

$$\hat{Q} = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \dots + b_n X_n$$

Equation	Constant	Real Price of Fresh Tomatoes	Real Disposable Income	Index: Tomato Products	Time	R <sup>2</sup>	S	k
		X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>			
1	25.5167	-0.1594 <sup>+</sup> (0.1663)	-0.0044 <sup>**</sup> (0.0015)	-	-	0.420 <sup>**</sup>	1.148	2.053 (i)
2	27.2169	-0.1571 <sup>++</sup> (0.1373)	-0.0085 <sup>***</sup> (0.0020)	0.1021 <sup>**</sup> (0.0398)	-	0.637 <sup>***</sup>	0.949	2.116 (i)
3	26.9215	-0.1235 (0.1916)	-0.0067 (0.0054)	-	0.1247 (0.2881)	0.430	1.190	2.026 (i)
4	27.2477	-0.1561 <sup>++</sup> (0.1650)	-0.0085 <sup>*</sup> (0.0046)	0.1019 <sup>**</sup> (0.0440)	0.0032 (0.2743)	0.637 <sup>**</sup>	0.995	2.117 (i)

APPENDIX C (cont'd)

II. COBB DOUGLAS FORMULATIONS - Log 10

$$\log \hat{Q} = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 + \dots + b_n X_{nn}$$

Equation	Constant	Real Price of Fresh Tomatoes	Real Disposable Income	Index: Tomato Products	Time	R <sup>2</sup>	S	k
		X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>			
5	78.8822	-0.3687 <sup>++</sup> (9.9730)	-16.0538 <sup>**</sup> (5.4317)	-	-	0.434 <sup>**</sup>	1.135	2.110 (i)
6	3.9683	-0.3046 <sup>+</sup> (0.2404)	-0.9120 <sup>***</sup> (0.1994)	0.3240 <sup>**</sup> (0.1128)	-	0.669 <sup>***</sup>	0.027	2.168 (i)
7	4.7918	-0.1323 (0.3486)	-1.1090 <sup>+</sup> (0.6479)	-	0.0097 (0.0096)	0.469	0.035	2.198 (i)
8	4.0381	-0.2957 <sup>++</sup>	-0.9373 <sup>+</sup>	0.3205 <sup>**</sup>	0.0005	0.669 <sup>**</sup>	0.029	2.176 (i)

Note: 1. Levels of Significance: \*\*\* = 1 percent  
 \*\* = 5 percent  
 \* = 10 percent  
 + = 20 percent  
 ++ = 25 percent

2. The letter in parenthesis following the value of the k statistic refers to the results of the test for measuring the extent of serial correlation in the disturbances; (i) indicates no serial correlation.



## APPENDIX D

## I. PROJECTION OF CONSUMER PRICE INDEX

The consumer price index was projected using a time variable in the linear form:  $CPI_t = \beta_0 + \beta_1 t$

The estimated relationship was:  $CPI_t = 84.70 + 2.12^{***} t; r = .92^{***}$

## II. PROJECTION OF PERSONAL DISPOSABLE INCOME

Total personal income was projected using a curve of the nature:

$$PDI = \alpha_{10} \beta^t$$

The estimated function was:  $\log PDI = 2.9313 + 0.0258^{***} t; r = 0.98^{***}$

## III. PROJECTION OF INDEX OF TOMATO PRODUCTS

The index of tomato products was projected using a linear function:

$$T.P. = \alpha + \beta_1 t$$

The estimated function was:  $T.P. = 26.25 + 2.22^{***} t; r = 0.80^{***}$

Note: Level of significance: \*\*\* = 1 percent.

## APPENDIX E

COMPARISON OF CHANGES IN  
THE INDEPENDENT VARIABLES

Variable	Unit	Value (1969)	Projected Value (1980)	Percentage Change
$X_1$	cents	22.42	33.90	+51.2
$X_2$	dollars	1,943.33	2,590.00	+33.3
$X_3$	pounds	67.93	81.75	+20.3

Note:  $X_1$  denotes real price per pound of fresh tomatoes;  
 $X_2$  real disposable income per capita; and  
 $X_3$  index of tomato products.