PRICE FORMATION AT THE PALMERSTON NORTH FRESH VEGETABLE AUCTION MARKET

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ABSTRACT

The aim was to analyse the short term price fluctuation of fresh vegetables at the Palmerston North auction market. A brief review of the theoretical and methodological aspects in relation to this topic is outlined.

An econometric recursive model was developed in the "inductive phase" to represent the past behaviour of the industry. The simulation model was developed in the "deductive phase" for testing the sensitivity of the model and policy assessment.

The results indicated that :

1) The wholesale demand for cabbages and cauliflowers is relatively inelastic (-0.5034 and -0.8142 respectively) while that of lettuces (-1.434) was elastic. Carrots showed non-significant positive relationship between quantity purchased and price (+1.935).

2) The simulation model was relatively insensitive to changes in its parameters. It was proved that the supply of fresh vegetables was mainly governed by the seasonal factor.

3) The policy of supply rationalisation could reduce price variance and supply variance by 18% and 45% respectively, while the gross income and unweighted mean price could be increased by 8.7% and 0.3% respectively.

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CHAPTER 1

INTRODUCTION

The fresh vegetable industry in New Zealand faces many problems, of which price instability is one. The analysis of this problem cannot be completed without full knowledge of the industry's production features and marketing structure.

This chapter discusses the organisation of vegetable production and marketing in New Zealand. The objectives of this study and its scope are outlined. Finally, the thesis guide provides a general outline of the contents of this thesis.

1.1 The New Zealand Fresh Vegetable Industry

1.1.1 Geographic distribution

There are three major vegetable production areas: (a) Auckland, (b) Wellington, and (c) South Island [77, p.39]. Vegetable growing areas in the North Island are mostly concentrated at Auckland, Northland, Franklin, Manawatu and Horowhenua, while those of the South Island are scattered around Nelson, Oamaru and Christchurch.

The Pukekohe district provides the Auckland area with a considerable amount of its vegetable requirement, as well as being the main onion-growing area of the North Island. The Manawatu/Horowhenua districts send most of the vegetables they grow to Wellington City, while Ohakune supplies both Auckland and Wellington with cabbages, carrots and broccoli [76].

In the South Island, market gardening is mainly carried out near Christchurch, Oamaru, Dunedin and Nelson cities. Nelson also produces considerable quantities of fresh and processed vegetables, most of which are marketed in Wellington.

1.1.2 Trends in grower numbers, acreages and production

A field survey by Philpott and others [20] in 1964 indicated that there were approximately 2,600 growers engaged in the vegetable industry [26, p.1].

The New Zealand Department of Statistics 1966 Census showed that approximately 2,200 growers were engaged in the industry [78], while the New Zealand Official Year Book, 1972, stated that approximately 2,700 growers cultivated 18,211 hectares in 1964 [76]. The discrepancies in the statistics in the different reports cannot indicate the trend of the growers in the industry. These differences may be partly due to the inclusion of process vegetable growers or potato growers.

The Department of Agriculture estimated that in 1970 approximately 17,623 acres of vegetables (excluding potatoes) were grown for the fresh market, and 30,280 acres for processed production. Based on these acreages 179,540 tons of vegetables were produced for the fresh market and 85,500 tons for processing. These levels were both lower than the figures for 1969, but still considerably higher than those for 1968[1].

Most of the fresh vegetable production is consumed within New Zealand, only 20,542 tons, or 11%, being exported[2].

1.1.3 Types of production

The vegetable production in New Zealand may be divided into three types:

1) Outdoor production,
2) Hothouse (glasshouse) production,
3) Production for processing (mostly outdoor).

The first two groups provide for domestic fresh vegetable consumption, while the process production is canned or frozen.

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1. See Appendix A.1
2. See Appendix A.2

Glasshouse production is scattered over both Islands. Most glasshouse production is a monoculture, though some growers do cultivate a second crop. Tomatoes and cucumbers are the two crops grown in the glasshouse.

Vegetables for processing are beans, peas, outdoor tomatoes and sweet corn. All the produce is sent to canners on a contract basis.

Outdoor growers are less specialised, growing from six to ten of the twentyfive vegetables, mainly cabbages, carrots, cauliflowers, lettuces, tomatoes and onions.

The 1964 Survey showed that outdoor production accounts for 57% of total growers as compared with 26% for glasshouse production and 17% engaged in both types of growing (26, p.17).

1.1.4. The consumption of vegetables

The vegetable industry is a comparatively small part of New Zealand's primary industry, but it is the third largest producer for the domestic food market.

In household expenditure only 3% of the total income is allocated to vegetables [26, p.3]. The trend is for consumption of fresh vegetables to decline, while that of processed vegetables is increasing, the main reason probably being the "convenience" of using the processed vegetables. It is found that New Zealanders consume more of the cheaper vegetables, such as root crops, cabbages, pumpkins, and so on, than the "luxury vegetables" (tomatoes, lettuces, and sweet corn).

1.1.5. The grower's income

Some of the vegetable growers complain that their income is unsatisfactory as compared with that of other primary producers. The recent Report on Economic Trends in the Industry [81] showed that incomes in market gardening were low, but there was no evidence of seriously declining trends. Instead the Report found that the production of vegetables has markedly increased by about 5% per annum [81, p.11].

1.2 The Marketing System for Fresh Vegetables

1.2.1 The marketing channel

Several channels are available for distributing the fresh vegetables from producers to consumers:

1) Direct sale through or to wholesaler,
2) Direct sale to retailers,
3) Direct sale to consumers (road stall or "over the gate" method),
4) Direct sale to institutional users (hotels and restaurants),
5) Direct sale through a grower market.

All these relationships are shown in Figure 1.1. No recent data is available to indicate the actual volume of vegetables going through these channels. However, most fresh vegetables are handled by the wholesalers. The 1964 Survey [26, p.89] showed that two-thirds of the growers moved their produce through wholesalers, the remaining one-third using other channels.

By and large, the wholesale market is the most important channel for cabbages, cauliflowers and lettuces, but Bourke [10, p.8] in a detailed survey of Auckland city found that only a limited range of vegetables was bought direct to any extent, these being bulk lines of carrots, cabbages, onions and tomatoes. The detailed values in his Survey for various fresh vegetables through different channels are shown in Table 1.1.

It is obvious that fresh vegetables distributed through the auction (including the Commission buyer) amount to 69.8%, while direct selling amounts to only 22.9% and other channels, such as "road stalls" and direct sales to institutional users, share the balance.

FIGURE 1.1 DISTRIBUTION OF COMMERCIALLY GROWN VEGETABLES IN NEW ZEALAND

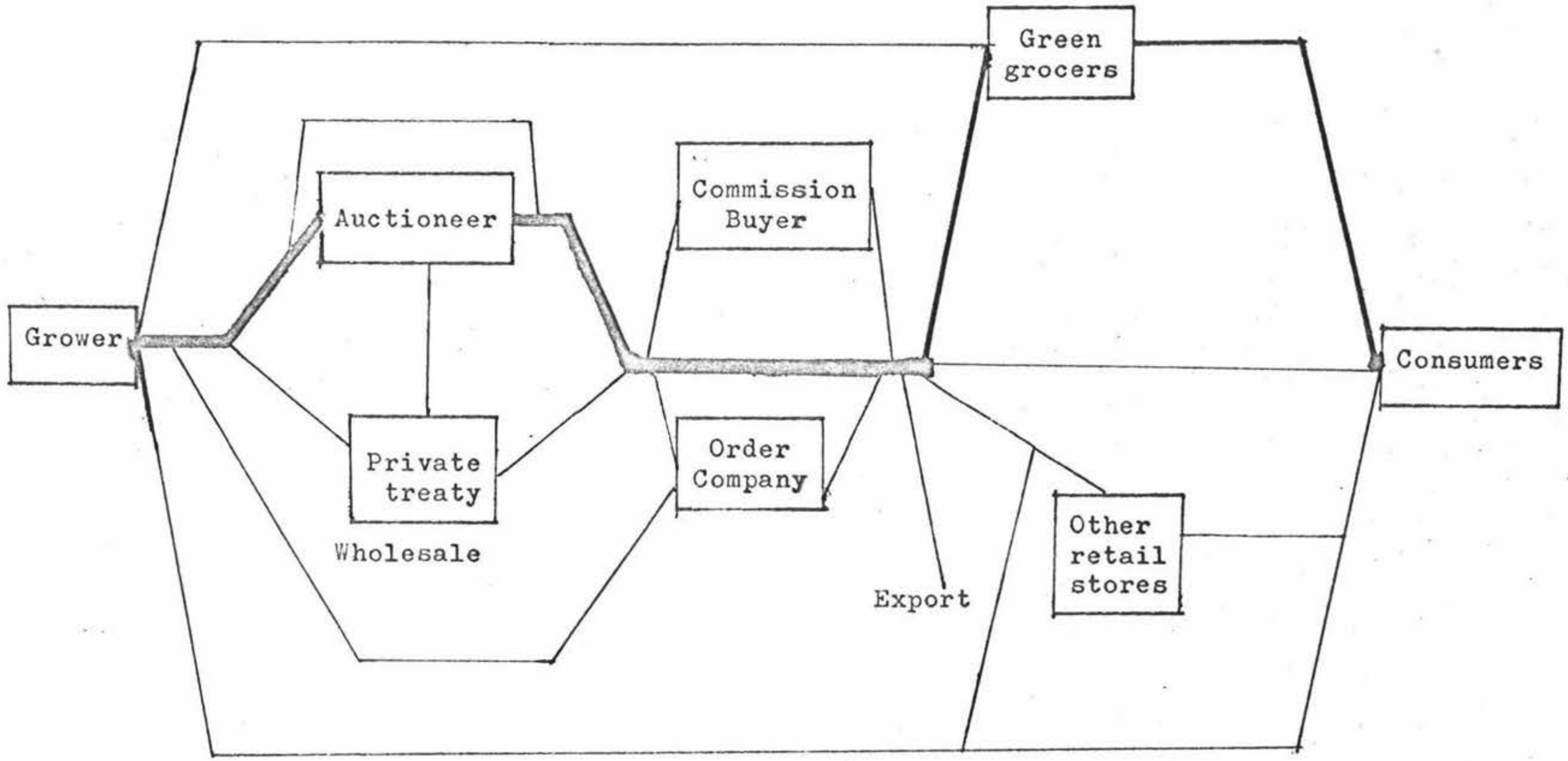

TABLE 1.1 SOURCE OF FRESH VEGETABLES

	Auction		Private Treaty		Grower Direct		Commission Buyer		Other	
	R	S	R	S	R	S	R	S	R	S
Asparagus	4	2	-	-	1	1	9	1	1	-
Beans - Broad	6	-	-	-	-	1	9	-	-	1
Green	6	-	-	-	-	-	9	1	2	-
Beetroot	6	-	-	-	-	-	10	-	2	-
Brussels Sprouts	6	-	-	-	-	-	9	1	2	-
Cabbage	-	3	-	-	16	2	-	4	-	-
Carrots	-	3	-	-	16	2	-	5	-	1
Cauliflower	5	1	-	-	1	5	9	1	2	-
Celery	6	-	-	-	1	1	10	-	2	-
Cucumber	5	1	-	-	2	6	10	-	2	-
Lettuce	3	2	-	-	2	10	9	1	2	-
Parsnip	6	-	-	-	-	-	10	-	2	-
Peas	6	-	-	-	-	1	9	1	1	-
Sweet Corn	6	-	-	-	-	3	10	-	2	-
Tomatoes	4	2	-	-	2	8	10	-	2	-
Kumara	6	-	-	-	1	-	10	-	2	-
Onions	4	2	-	-	4	10	9	1	1	-
Potatoes	3	3	-	-	1	6	10	-	1	-
Pumpkin	5	1	-	-	1	5	10	-	2	-
Spinach	6	-	-	-	-	-	9	-	1	-
Swedes	6	-	-	-	-	-	10	-	2	-
Silver Beet	6	-	-	-	-	-	10	-	2	-
TOTAL	125		0		109		208		35	
Percentage	26.2		0		22.9		43.6		7.3	

R = Regularly S = Sometimes

Source: Bourke, I.J., "A Survey : The Direct Buying of Fresh Vegetables in New Zealand", Massey Occasional Paper No.2, Agricultural Economics and Farm Management Department, 1971, p.9.

1.2.2 Auction system and price formation

The auction system involves the consignment of fresh vegetables to the auction floor and the presence of buyers bidding on the produce which they hope to purchase.

Produce is transported to the wholesale firms usually on the evening before the next auction session commences, transport being carried out either by growers themselves or by transport firms. On arrival at the auction floor, the produce is stacked on various parts of the floor, in order of sequence of arrival. Most of the produce is grouped by the wholesalers in lines[3], the grower's name being indicated on every line of produce. Before the auction commences at 7 to 8 a.m., the buyers gather on the auction floor to inspect the produce for quality and quantity. When the auctioning commences, the interested buyers bid against each other for a particular line as it is offered for sale by the auctioneer.

The method of auction is the "ascending type" (English auction) [14, chap.5]. The sale involves buyers bidding successively higher amounts until the top price is reached. The buyer is allowed to state the quantity that he will take (for example, he may specify to take 5 out of 20 cases in the whole line). Since there is no formal grading system, the successful bidder selects the best from the line. The remainder is then offered to the second highest bidder, and the rest of the bidders at the same price. Should the line not sell at that price, it is offered to the bidders at successively lower prices, until the whole line is disposed of.

Possible limitations of this system are:

If the number of bidders is not numerous, some unethical practices can exist, such as "ring buying" [26, p.98] - where one buyer bids for a group of, say, four or five buyers, and they split the line between them. In fact, this practice will

3. A line represents one grower's produce.

depress the price of that particular line of vegetables quite markedly as competitiveness in the price-making process is reduced [83, p.191].

The buyers are aware of each other's buying power. If a big buyer is present (such as a supermarket) the small buyers have to bid actively to acquire the produce, because - should the big buyer obtain that particular line - there may be none available for the small buyers. In this case, the price of produce is increased singificantly.

On the other hand, where a top bidder is a small buyer, who is obviously not able to take the whole line, the remaining bidders may hold back in anticipation of acquiring the remainder of the line at a lower price. It is obvious that this practice will depress the price of the produce.

However, the quantities of supply definitely contribute some activity in bidding as varying supplies are scarce or plentiful.

After the line of produce has been sold, a document indicating the particulars of each line, including price, is handed to the office for processing. The produce can be taken out subject to a check by the storeman. The bills are sent to the buyers weekly.

The aution firm deducts 10% commission from the total value of the produce consigned by the growers.

1.2.3 Types of buyer

Several types of buyer are present at a vegetable auction:

1) Small retailers buying on their own account,
2) Commission buyers
3) Buyers employed by big retail firms (supermarkets)
4) Order company (in the wholesale firm).

Most of the buyers in attendance at the auction are small retailers buying for their own shops. The commission buyers buy on behalf of large users (institutions, hotels, restaurants and distant buyers).

Order companies act as wholesalers and are owned by the auction firm. It has been argued that auctioneers may use these to manipulate bidding [93, 76a].

Auctioneers deliver produce to buyers for a 10 percent surcharge.

1.2.4 Retailers

A decade ago most of the produce was sold by fruit and vegetable stores. Nowadays, the structure of the retail selling of vegetables has significantly changed. Several retail outlets are available such as:

1) Greengrocers (fruit and vegetable stores)
2) Grocers
3) Dairies
4) Variety stores
5) Produce markets
6) Other stores.

Statistics show that the 5,577 stores handling fruit and vegetables in 1963 had declined to 4,928 stores by 1968, and the turnover and sales of the fuirt and vegetable stores had declined from 62% to 57% during this period [79]. This reflects the change in the structure of the retail trade in that the number of traditional small fruiterers and green grocers is declining, while the large stores are gaining a greater share of the market.

1.3 The Vegetable Industry in Manawatu

The number of vegetable growers in the Manawatu district was quite stable throughout the years under study, e.g. from 1969 to 1972 being about 300-330[4]. Nearly one-third of the growers have their properties within 15 miles of Palmerston North[5], such as Longburn, Aokautere, Te Matai Road and Napier Road areas.

The total acreage of planting and production for fresh vegetables is shown in Table 1.2.

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4. N.Z.Horticultural Statistics, Manawatu district, unpublished.
5. Names and addresses acquired from the wholesale markets in Palmerston North.

TABLE 1.2 ACREAGES AND PRODUCTION OF FRESH VEGETABLES FOR MARKET

	ACRES			TONS		
	1969	1970	1971	1969	1970	1971
Asparagus	1	1	1	1	1	1
Beans - green	15	20	15	45	65	45
Beetroot	15	20	15	75	80	80
Brussels sprouts	40	60	50	140	240	200
Cabbages	210	210	160	1680	1600	1280
Carrots	800	1000	800	9600	12000	8000
Cauliflower	400	450	375	3150	3200	2250
Celery	30	30	30	300	300	300
Lettuce	150	200	150	900	1100	750
Onions	180	190	110	1800	1900	1100
Parsnips	400	400	250	3200	3200	1500
Peas	15	15	5	22	22	10
Tomatoes (outdoor)	60	55	35	600	400	280
TOTAL	2316	2641	1996	21513	24103	15796

Source : Annual Statistics, N.Z.D.A., Manawatu District.

It can be seen that the total acreage of planting throughout the years 1969-1972 declined from 2,316 acres to 1,996 acres and production from 21,513 tons to 15, 796 tons[6]. Since the numbers of growers has remained stable, the only explanation of this is that individual growers have reduced their acreage of planting.

Most of the produce is sent to the wholesale firms in Palmerston North. But, from personal discussions with different growers, some indicated that they do send produce out of the Palmerston North area to Auckland, Wellington and Wanganui districts. The volume of vegetables sent out of the local area is not available.

1.3.2 The Wholesale Market in Palmerston North

There are two wholesale firms in Palmerston North. The procedures of auctioneering have been discussed in section 1.2.2 of this thesis.

The structure of the two firms is quite similar. They both provide marketing services and some loans to growers (under certain mutual agreement). That is, the growers under such contract must send agreed amounts of produce to the firm at each auction sale. Part of the proceeds is deducted from the credit of the grower to repay the loan as well as the interest.

The only differing feature between the two wholesalers is that one firm provides a market information service to the growers. A department was set up to inform the growers of the recent auction prices of different vegetables around the Central North Island (Auckland, Hamilton, Wanganui and Wellington). Sometimes they advise the growers to send produce to a particular centre where, owing to scarcity of supply, high prices are likely to be gained.

1.4 The Main Problem of the Vegetable Industry

The most severe problem of the vegetable industry is "price instability". The term "price instability" in a price series data may, for analytical purposes, be divided into four categories of

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6. Refer to Table 1.2

variations, namely secular trends, the cyclical, the seasonal and the irregular.

A trend refers to long term persistent direct of changes in prices which may be due, for example, to income and population growth, technological changes, and taste. Price variations due to such trends are not considered "price instability". Rather, price instability is regarded as that part of variations which superimpose upon the trends caused by cyclical, seasonal and irregular variations. The cyclical variation is a more or less normal year to year variation. The seasonal variation is a more or less normal within year change, and the irregular variation is random variation due to changes in demand, supply and weather. In the context of this study we are interested in the short term price fluctuation - that is the irregular component in price instability.

The prices of vegetables exhibit a much greater short term price fluctuation than do the prices of some other agricultural primary products, when they encounter a period of glut and low prices, followed by a period of shortages and high prices [26, p.62]. In turn, this leads to social waste and prevents the efficient planning of production by growers.

Again, to examine the annual price fluctuations in the fresh vegetable industry, the recent Report states:

> "Further evidence of cyclical instability in New Zealand is given by an updating of annual prices for a number of vegetables.......... Cabbages retail prices varied widely, annual variations of 20% to 60% being common, the spring and winter crops showing greatest variation. Carrots and cauliflowers showed price variations also, but not to the same degree as cabbages." [81, p.33].

Since auction price is closely correlated with retail price, the extent of fluctuation in auction price was more severe than in retail price. The Report /81, p.24/ showed that cabbage prices at auction varied up to 280%. Therefore, the extent of variation in the grower's price would be much more severe than in either auction or retail price.

There is very little research on the short term price fluctuation in the fresh vegetable industry. This research void may have stemmed from the difficulty in obtaining and handling weekly time series data. However, this present study aims to give some indication of the short term price analysis in the fresh vegetable market.

The cause of price fluctuation will be discussed in more detail in Chapter 2.

The following section discusses the principles involved in supply manipulation to avoid price fluctuations and improve the grower's income.

1.5 The Principles of Supply Manipulation

There are two ways in which manipulation of supply can smooth out short term price fluctuations, namely marketing cooperatives (self help by the producers themselves) and marketing agreements and orders (government action strengthening the marketing organisation) /29, pp.22-23/.

1.5.1 The Marketing Cooperative

When a group of growers market their produce together through their own organisation as one unit, this is the basis of cooperative marketing. Such cooperatives have been in existence throughout the nineteenth century and at present are important in the fresh produce market. They may carry out some important marketing functions such as classifying, assembling, packing, cold storage, shipping and selling. In addition "it will be possible for the association to perform an effective role in disseminating accurate price information or information regarding the actual behaviour of the market which will enable the producers to adjust their production schedule to avoid either a glut or a shortage in the market". [94, p.118].

However, "..... by and large, marketing cooperation in the fresh fruits and vegetable industry centre their activities upon the handling and marketing of the produce of their members." [96, p.112].

But there are several limitations for cooperative marketing as a method of efficient marketing:

1) Cooperative marketing cannot eliminate the middleman's functions;
2) Cooperatives cannot reduce marketing costs to any great extent. Any small reduction results from economies of group action.
3) A cooperative marketing agency cannot guarantee its members a profit on sales because price is governed by demand and supply, and the cooperative has no control over demand and does not fully control supply.
4) Cooperatives cannot guarantee higher prices, or even fixed prices for its members, but it may be able to influence price to a certain degree by withdrawing supplies from the market. [36, p.19]

Therefore, probably the most difficult field for horticultural cooperatives is that of cooperation in supply and production. Since cooperatives need to market produce of uniformly high quality, they are achieving this to an increasing extent by exercising varying degrees of control over their members' production [62, p.16]. In this case, the above limitations will be relaxed to a certain extent.

Since technical advances in recent years have brought cold stores into wider use, the cold storage facilities in the marketing cooperatives of the fresh vegetable industry may be employed to regulate supply in the short term - for example, to keep Friday's output for Monday's market. The aim is to extend the season and even-out the grower's day-to-day supply. It is particularly desirable when a crop matures more quickly than can be absorbed by the market. [62, p.18].

If further excesses of supply cannot be absorbed by local markets, the cooperatives can transfer the produce to other centres to avoid oversupply locally.

With powers of production control, cold storage facilities, and the manoevring of excess supplies, the objective of supply manipulation can be achived by market cooperation.

1.5.2 Marketing Agreements and Orders

These are the two methods by which the agricultural industry in the United States has attempted to increase producers' nett return. Various types of provisions include control of volume marketed; quality, size, grade, pack or container regulations; advertising and sales promotions; research and investigation; and prohibition of unfair trade practices. The aim is to improve the marketing of supplies produced.

A marketing agreement is a voluntary arrangement between the Secretary of Agriculture and the handler of the agricultural commodities, such as farmers' cooperatives, who sign the agreement. On the other hand, marketing orders are regulations which can be issued by the Secretary of Agriculture on the approval of two-thirds of the handlers, and which name the terms of the "agreement" compulsory upon all handlers of the products.

> "Marketing orders and agreements differ from the major crop control programmes in that they do not include provisions for government payments to growers and they do not control directly the amount any farmer may produce.

This enables an industry to manipulate supply and demand in such a way as to bring about a balance at a level which yields a higher net return than would otherwise result." [33, p.17].

There are two problems in employing marketing orders. Firstly, the increase in price does not mean that producers' total returns are necessarily increased. If consumers respond to increases in price by buying relatively less of the produce, that is elastic in demand, the total return will be no greater - in fact, it will be less. [48, p.258].

Secondly, "marketing orders do not provide for control of production. Hence continued restriction to the volume marketed, if it does result in higher returns to producers, can lead over time to an expansion in production. This, in the long run, is apt to defeat the attempt to raise producers' total returns. Thus, if the excess supply problem that the industry faces, is temporary or seasonal, a marketing order can help. But marketing orders by themselves are not likely to solve chronic surplus problems." [87, p.147].

Since the chronic over production is not a major problem in the fresh vegetable industry in New Zealand, marketing agreements or orders may be possible to even-out the daily or seasonal price fluctuations to a certain degree. But, the usual procedure for initiating marketing agreements and orders commences with a request from some group or organisation (producers' cooperatives or handlers) for a program and for its consideration at a public hearing.

Therefore, the first task is to organise the producers' market. Then the marketing cooperative can be a basic means of manipulating the supply.

1.6 Objectives of this Thesis

The thesis has the following objectives:

1. To estimate short term supply and demand relationships for fresh vegetables at auction, with emphasis on the short term price elasticity of demand.
2. To determine the effects on prices of using various short term marketing policies by growers and retailers.
3. To determine the effect on prices of rationalising supply.

This embodies an econometric analysis of the market structure and the development of a simulation model to investigate the impact of various problems of supply on prices and growers' incomes.

1.7 The Scope of The Study

Four fresh vegetables (cauliflowers, cabbages, lettuces and carrots) are chosen in this study because they are grown by most outdoor growers and are subject to seasonal influences. The area with which this study is concerned, is the Palmerston North wholesale market.

There are two aspects of the study:

1. An estimation of the supply and demand models by using econometric analysis to obtain the structural parameters and the estimated short term price elasticities of demand at the local wholesale level for the selected fresh vegetables.

2. A computer simulation model is used to duplicate the supply and demand patterns of the selected vegetables at the particular market. Experimenting on this model by changing the marketing policies of the growers and buyers to see the effects on prices and incomes is one of the aspects of this study.

1.8 Thesis Guide

This thesis comprises six chapters. Chapter 2 reviews theoretical causes of price fluctuations (the Cobweb Theorem) and some empirical studies in price elasticities of fresh vegetables. Chapter 3 outlines some previous approaches to evaluation of economic policy alternatives. The techniques of model building for this study are determined. Chapter 4 develops the econometric model for the selected fresh vegetables and the results of the short term price elasticities of demand are examined. Chapter 5 outlines the construction of a computer simulation model based on the existing econometric model, and experimentations on various short term marketing policies and the rationalisation of supply are conducted. The results are presented and discussed.

Finally, Chapter 6 presents the conclusions of the study.

1.9 Summary

The fresh vegetable industry in New Zealand produces a large range of vegetables. Production is carried out by some 2,700 growers in both Islands, the predominant areas being Auckland, Franklin, Manawatu and Horowhenua. Most of the production is for local consumption, very little being exported. More of the cheaper vegetables (cabbages, root crops) than of the luxury ones (tomatoes and lettuces) are consumed.

Owing to the instability of incomes and prices, many growers complain of their income being lower as compared with other primary industries.

Vegetables distributed from the growers to consumers go through several channels, but the main one is the wholesale market where the produce is sold by the auction method. The auction is conducted in the presence of buyers bidding against each other. The price formation of the system may lack competitiveness if collusion in buying practices does occur. Prices can be depressed or increased, thus inducing more fluctuations in income for the growers.

Price instability of fresh vegetables is the main problem of the industry - especially short term price fluctuation, which could be smoothed out by means of supply manipulation. Two ways to even-out the short term supply are marketing cooperation and marketing agreements and orders, which have been discussed. The primary task is to organise the producer market (marketing cooperative) to achieve the objective.

The study was conducted to find a possibility of reducing the price instability for fresh vegetable growers. The method of doing so was in two steps : first, the supply and demand function needed to be estimated by econometric analysis. The estimated model can then be converted to a computer simulation model by which we can experiment on the various short term marketing policies on the effects of prices.

CHAPTER 2

Causes and Theory of price fluctuation with emphasis on vegetables .

2.1 Introduction

The theoretical basis of price fluctuation in horticultural and agricultural commodities has been described and analysed by many agricultural economists in terms of the Cobweb Theorem. This theorem is discussed and its implications for price instability in the vegetable industry is discussed in section 2.

Section 3 reviews some of the empirical studies of the price elasticity of demand for vegetables.

The final part of this chapter is devoted to an explanation of factors such as marketing margins, and market competition which could accentuate fresh vegetable price variation.

2.2 The cobweb phenomenon in the vegetable industry.

2.2.1 Empirical studies of Cobweb Theorem

The Cobweb Theorem was expounded by Ezekial [27a] in 1938. Three conditions must be fulfilled before the theorem can be applied.

i) Production is entirely determined by producers' response to price under conditions of pure competition, and they have a price expectation model which implies that they expected prices in period (t) to be the same as in period (t-1).

ii) At least one full period is required before the production can be changed.

iii) The price is set by available supply.

For fresh vegetables producers are able to reduce their supply in the "long term"[1] by adjusting planting; in the "intermediate term"[2], by ploughing up portions of their acreages if the prices

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1. Refers to production adjustment year by year.
2. Refers to a period of several months.

are too low to cover the harvesting cost; and in the "short term"[3], by adjusting the weekly market supply which is the case considered in this study.

In the case of commodities which are sold under some form of government price intervention, the third condition of the cobweb theorem is violated. However, Waugh [101] has shown that, in spite of the price interference, cobweb effects may persist in a modified form.

The major criticism of the cobweb theorem is that Ezekial implicitly assumes a reversible long-run supply curve. Instead this model has generally been applied in most of the short run analysis. Akerman [4], by using a family or group of short run supply curves (including the "short term" supply and "intermediate term" supply mentioned above), argued that the theorem does not give enough explanation of fluctuation involving explosive disequilibrium. Nerlove [75] demonstrated, with the adaptive expectation concept, and using the Marshallian distinction between the long run and the short run, that the explanatory power of the Cobweb Theorem may be able to cover Akerman's objections.

It has been argued that the periodicity of cycles observed in hog production is better explained by a harmonic motion model than the cobweb theorem [52], [55].

This brief review of the empirical studies of the cobweb theorem reflects the controversy concerning the theoretical and empirical basis of the theorem.

2.2.2 The Cobweb theorem and price fluctuations

Recent econometric studies have found strong cobweb phenomena for onions and watermelon [89],[90], in the United States of America and acreage response to lagged prices for potatoes in South Australia [64].

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3. Refer to weekly market supply

It is generally believed that annual crops, such as vegetables have a two-year production cycle [6, p.4], [83, p.184], [81, p.22].

To consider the cobweb effect on vegetable output and prices, the mechanism of the cobweb theorem will be outlined in this section. Many economic texts have a full coverage of the topic, [86, p.123] and [6, p.39].

The operation of the cobweb cycle is as follows:

Some initial disturbance in the system increases the price above equilibrium. Growers expect that this price will continue into the future and plan to produce more. The production of vegetables in the next period will increase to an extent that consumers expect to pay a lower price, which will cause producers to plan for reduced production. After an appropriate time lag, the smaller supply into the market will fetch a higher price and result in increased production in the next period, and so on.

There are two possible cases :

(1) Converging cycle. The fluctuation of the output and prices becomes smaller and smaller, ultimately restoring equilibrium.

(2) Exploding cycle. The fluctuation of output and prices become larger and larger and tends towards disequilibrium.

Obviously, the difference between these two cases is differences in the slopes of the demand and supply curves. In case 1, the slope of the demand curve is greater than the slope of the supply curve. Case 2 represents a situation in which the slope of the demand curve is less than that of the supply.

2.2.3 <u>Exogenous influences on the cobweb effect</u>

Supply and demand curves are not static through time. Factors such as weather, disease, seasonality in demand, and change in purchasing power, cause supply and demand curves to move. The ratio of the slopes of the curves may also change.

The most likely case would be a trend towards both supply and demand curves shifting to the right over time, the supply curve shifting faster than demand.

In reality, the supply and demand schedules represent a dynamic process. On the supply side, the planned production, incooperating with the yield effect, would accentuate the fluctuation of output and prices. In fact, the fluctuation of prices appears to be mainly caused by cyclical variation in planned acreages and by moderate extent of yield variation [6, p.88], [26, p.66].

In the context of this study, price fluctuations are not only caused by the planned production and yield variation which determine the weekly available supply, but are also caused by the short term market supply decision of growers.

2.3 Price elasticities of Demand for vegetables

2.3.1. Definitions of price flexibility and price elasticity of demand.

Price elasticity of demand is defined as :

$$n = \frac{dQ}{dp} \times \frac{P}{Q} \qquad (2\text{-}1)$$

where n = price elasticity of demand,

p = price

Q = quantity

Demand is said to be elastic when the absolute value if n is greater than one and inelastic when n is less than one.

The term "Price flexibility" is quite often used in this study. It is the inverse of price elasticity of demand, defined as:

$$f = \frac{dP}{dQ} \times \frac{Q}{P} \qquad (2\text{-}2)$$

where f = price flexibility.

2.3.2 Empirical investigation of price elasticity of demand for vegetables

Most research on price elasticity of demand for vegetables has been confined to the long-term. Little work has been conducted using a model based on daily or weekly data.

The following three studies of the demand and price structure of vegetables were based on the longer term model.

In the analysis of demand and price structure for vegetables in United States between 1920-1950, Schuffett [85] estimated the price elasticity of demand for lettuces, onions, potatoes, cabbages, peas and tomatoes by using single equation analysis [32, pp.9-14]. The model was:

$$X_1 = \alpha + \beta X_2 + \gamma X_3 \qquad (2\text{-}3)$$

where X_1 = the average price per crate (ton)

X_2 = production per capita

X_3 = per capita disposable income

= constant

α, β and γ are structural coefficients.

All the variables were expressed as first difference of logarithms. The results are shown in Table 2.1.

Schuffett carried out a similar analysis using monthly data and the price flexibility for lettuces was -0.139 [85, p.28] instead of -0.387 as shown in Table 2.1. This implied that the price elasticity of demand for lettuce was larger using monthly data.

Kulshreshtha [50], in the analysis of demand for fruit and vegetables in Canada, formulated an aggregate demand model of the form:

$$PD_t = f(Q_t, I_t, PM_1, t, CPI_t) \qquad (2\text{-}4)$$

where PD_t = price of fruit or vegetable in a given time period

I_t = income of consumers

Q_t = quantity consumed

CPI_t = the consumer price index of all non-food items

PM_t = retail price of meat - a competing product.

TABLE 2.1 THE PRICE ELASTICITIES OF DEMAND OF SELECTED VEGETABLES IN U.S.A., FOR 1920-1950 AT FARM LEVEL (ANNUAL DATA)

	Price Flexibility	Price Elasticity
Lettuces	-0.387	-2.58
Onions	-2.855	-0.35
Potatoes	-4.028	-0.25
Cabbages	-2.398	-0.42
Peas	-0.353	-2.83
Tomatoes	-0.215	-4.65

Source: Shuffett, D.M.: "The demand and price structure for selected vegetables", U.S.D.A. Tech.Bull.No.1105.

The equation product was transformed into a logarithmic form. The results are shown in Table 2.2.

TABLE 2.2 PRICE FLEXIBILITY COEFFICIENTS FOR FRUIT AND VEGETABLES AT RETAIL LEVEL IN CANADA

	Coefficient of price flexibility
Fresh fruit	-2.006
Processed fruit	-1.810
Fresh vegetables	-4.163
Processed vegetables	-3.110

Source: S.N.Kulshreshtha "The Demand for Major Fruit and Vegetables in Canada", Can.J. Ag.Ec. 18, p.54.

To estimate the eight major fresh fruits and a vegetable he formulated another model:

$$P_t^1 = f^1(Q_t^1, P_t^J, I_t, t) \qquad (2\text{-}5)$$

where P_t^1 = the price of fruit 1 at t time period

P_t^J = the price of fruit J at t time period

I_t = consumer income at time t

t = trend variable

The functional form was in linear logarithmic form. The estimated results, showing that the demand for fresh and processed peaches, citrus fruit, fresh grapes and processed strawberries was highly price sensitive, generally were not very convincing.

Suit and Kaizumi [90], used a dynamic cobweb model, consisting of three equations (supply, demand and harvesting) to study the United States market. All the variables in the equations were expressed as first differences in logarithms. The demand of onions at farm level was relatively inelastic at -0.44.

The literature briefly reviewed the above trials to estimate the price elasticity of demand for various vegetables, but is not very conclusive. An explanation is suggested by Allen [6. p.56]:

> "Estimates of price elasticity of demand are statistically less satisfactory...... and calculation for individual commodities often appear to be conflicting."

Actually, the numerical value of price elasticity for a particular commodity is not fixed. There is a range of price elasticities, depending on the time period, sort of data available, model estimation and estimation procedure.

1) Time period

An estimate of price elasticity of demand based on daily, weekly or monthly data is more likely to be greater in value than one based on annual data and yet the price elasticity calculated from data for a period greater than one year will be greater than annual data. These differences can be explained by the adjustment of the consumer's behaviour, change in taste, in population, and in the real income of consumers for different time periods.

2) Model estimation

Model estimation involves establishing relationships between the variables within the system. If the uncontrolled variables outside the system are highly correlated with the variables under study the estimated result will be biassed. The relationship between the independent and dependent variables also has an influence on the estimate. For example, Hoos [39], in a study of lettuce demand found a conflicting result for the same set of data by interchanging the relationship of dependent and independent variables between prices and quantities.

In estimating the relationship of the model, various functional forms can be used. Only the logarithmic function will yield a constant elasticity throughout the whole estimated relationship. Other functional forms need to state a particular price and quantity point for the estimate.

3) Estimation procedure

The statistical procedures, used for the estimation also gave various results for the same set of data. Koopman [49], showed that under certain condtions least squares estimates are biased. Wold, using a recursive model [47, pp.75-77] found that the estimated price elasticity was less in the recursive system than in an interdependent system [103].

Finally, the estimates of the elasticities differ at different levels of the marketing process. The numerical values are increased in the following order : farm gate level, wholesale level and retail level. This is due to the influence of the marketing margin. Suppose the marketing costs are fixed absolute and the demand curve assumes to be a straight line after the marketing costs are incurred. The the demand curve at retail will be -

$$P = A-BQ \qquad (2\text{-}7)$$

where

Q = quantities,

P = prices

A = constant

B = coefficient of the structural parameter.

The demand curve at the farm gate is -

$$P = A-BQ - C \qquad (2\text{-}8)$$

where

C is the fixed absolute marketing cost.

The price elasticity of demand at retail is -

$$n_1 = \frac{1}{B} \times \frac{P}{Q}$$

From equation (2-7) we can get -

$$n_1 = \frac{A - BQ}{BQ} \qquad (2\text{-}9)$$

The price elasticity of demand at farm gate is -

$$n_2 = \frac{1}{B} \times \frac{P}{Q}$$

From equation (2-8) we have

$$n_2 = \frac{A - BQ - C}{BQ}$$

Obviously n_2 is smaller than n_1.

Suppose we assume that marketing costs are a constant proportion of a final retail price. R is the ratio of the farm gate price over the retail price.

The price elasticity of demand at farm gate in this situation is:

$$n_3 = \frac{1}{RB} \times \frac{P}{Q} \qquad (2\text{-}10)$$

$$= \frac{RA - RBQ}{RSQ}$$

$$= \frac{A - BQ}{BQ}$$

and $n_3 = n_1$

Therefore the fixed absolute marketing margin is the root cause of the difference in estimating the price elasticity at different marketing levels.

To sum up the above discussion, wherever the price elasticity of demand is estimated, the time periods, the functional form, the estimation procedure and the place in the marketing chain at which the estimate is made must be clearly stated.

2.3.3 The role of price elasticity of demand

If demand is elastic, the cobweb effect of the system will be less severe; in other words, the variation of prices and output from period to period will be less than those with an inelastic demand schedule.

Furthermore, when a vegetable has an elastic demand, lower prices will bring larger gross income and, conversely, with an inelastic demand for vegetables, lower prices will bring lower gross income.

Most fresh vegetables are perishable. Their price flexibility is quite high and correspondingly the price elasticity may be quite low or inelastic at the farm level. In order to raise the grower price elasticity of demand for the vegetables, flexible marketing margins must be employed.

2.4 Marketing Margins

2.4.1 Marketing margins in the vegetable industry

Allen [5], indicated that marketing margins for most vegetables in the United Kingdom are inflexible.[4] The vegetables which tend to have the most inflexible margins are carrots, cauliflowers, lettuces, onions and tomatoes.

Agarwala [1] indicated that the marketing cost of the cabbage in Malaysia is fixed in nature. The percentage of the marketing cost is 40% as compared with the farmer share of 60% of the consumer's dollar.

In the United States, in the statistics collected by the U.S.Department of Agriculture (Marketing and Transport situation at 1966-1969 period), the marketing costs show a grower/retail spread as shown in Table 2.3.

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4. Allen [5, p.8] used regression line $Y = A + BX$

where Y = retail price

X = wholesale price

B = the structural coefficients

A = constant

to represent the trend of the margin

if $A = 0.0$ is a percentage margin

$B = 1.0$ is a fixed margin

TABLE 2.3 MARKETING CHARGE AND FARMER SHARE OF CONSUMER'S DOLLAR SPENT ON VEGETABLES

Vegetable	Marketing Charge % of Consumer's $	Farmer share % of Consumer's $
Cabbages	69	31
Carrots	64	36
Celery	67	33
Cucumbers	63	37
Lettuces	64	36
Onions	66	34
Potatoes	71	29
Tomatoes	63	37

Source : U.S.D.A. Statistics : Marketing and Transport Situation, February 1967-1970 issues.

In New Zealand, a recent study by Philpott and Bourke [81], showed that during the 1965-69 seasons the retail mark-ups expressed as percentages for fresh vegetables were very high, ranging from 38% to 377% for hothouse tomatoes and lettuces respectively [81, p.39, Table 5].

Kirton [46], found that, in Auckland and Christchurch, the margins (at retail price) range from 25% to 33% for fresh vegetables.

However, the above surveys on marketing margins are based on long term data such as monthly or yearly data. In the shorter term, retailers may use a "price averaging system" under which margins are reduced when auction prices are high and increased when auction prices are low. This would result in auction prices being less elastic than retail and, in part, less elastic than under a fixed margin situation.

2.4.2 The effect of marketing margins on price fluctuations

When the market supply of vegetable changes, the price changes to producers is determined by the elasticity of retail demand and the size and flexibility of the marketing margin. The price elasticity of demand is relatively less at the farm gate level than at the retail level (refer to section 2.3.1.) When the margin is large and inflexible, the elasticity coefficients will be considerably lower for growers than those facing the retailers.

The consequence is that year to year fluctuations in the wholesale prices and production will be magnified.

2.4.3 Marketing competition and the marketing margin formation

By using market structure analysis and theory of competition Bourke [9,pp.47-48] deduced theoretically that the New Zealand vegetable market could be classified as an oligopsony on the buying side facing monopolistic competition on the selling side.

This type of marketing structure implies a situation in which there is a limited possibility of non-price competition in selling vegetables with some pressure to keep retail prices relatively stable in the short term. On the buying side, the day-to-day fluctuations in auction prices and other limitations of the auction system discussed in Chapter 1, result in the variability of the price paid by a retailer being considerably greater than the variability of the price received. That is, the market structure is one which is conducive to a "price averaging" type of margin policy. The limited empirical evidence available suggests that this is, in fact, the most common margin policy used by retailers [Kitson, 46].

As discussed in section 2.4.1, this type of policy will result in wholesale demand being considerably less elastic than that at retail and its' effect will be to magnify the impact of variation in short-term vegetable supplies on price fluctuations.

2.5 Summary and Conclusion

The cobweb phenomenon in the vegetable industry has long been regarded as the main influence on the instability of production and prices in a purely competitive market. The basic cause of long-term vegetable price instability is due to planned acreage changes. In the short run, it is mianly caused by the marketing (short-run) decisions of the growers.

The theoretical background of cyclical price fluctuation is dependent on the slopes of the demand and supply curves and empirical investigations on the demand for fresh vegetables have been reviewed.

The price elasticity of demand plays an important role in price fluctuations. If demand is elastic, the cobweb effects of price fluctuations and output variation will be less severe.

The marketing margin also contributes to grower price fluctuations and to production variations. The structure of fresh vegetable retailing is one with oligopsony on the buying side, facing a monopolistic competition on the selling side. Therefore, in the short run, a retailer dare not charge too high a margin if he is to clear his stock. In other words, the margin policy would be expected to be of the "price averaging" type. The impact of this type of margin policy is to accentuate the impact of supply variation on auction prices.

To gain insight into policies which could be used to modify price and income fluctuations, a discussion of possible methodological approaches is outlined in the next chapter.

CHAPTER 3

Approaches to Model Construction

3.1 Introduction

The first section of this chapter outlines the concept of model building in general terms. The second section reviews different approaches which could be used in this study. The third section covers some of the advantages and disadvantages of some particular techniques.

3.2 The concept of Model Building

Construction of a model involves expressing the original economic system into a series of numerical equations so that the characteristics of the economic structure can be represented significantly.

A mathematical model of the economic structure consists of three well-defined elements. They are : variables, components and relationships [80, p.898].

The components can be defined as those entities of a system that are to be independently identified, and whose collective performance determines the output of the system. The variables are used to relate one component to another. In other words, each component may consist of one or more types of variables. The types of variables involved in the component are dependent on the judgment of the researcher.

Conventionally, the variables that appear in an economic model may be classified as exogenous, endogenous and status variables (lagged endogenous variables).

The exogenous variables are the inputs and independent variables of the model and are assumed to have been predetermined and given independently of the system modelled. The status variables or lagged endogenous variables describe the state of a system or components either at the beginning of a time period or at the end of a time period, or during a time period. Endogenous variables are generated from the interaction or performance of components of the system. Whether a particular variable should be classified as an exogenous variable, a lagged endogenous variable, or an endogenous variable depends on the purpose of the study.

The functional relationship specifying the interaction of variables and components can be classified into two broad groups, identities and operating characteristics. An identify is an accounting or tautological statement about the components of the model. An operating characteristic is a hypothesis, usually a mathematical equation, relating the endogenous variable to the lagged endogenous variables and the exogenous variables, in the system.

3.3 The classification of the models

Anderson [7, p.11], suggests that mathematical models for agricultural economic research have been of diverse types and levels of mathematical sophistication, but practitioners do not appear to have made any summary review of their endeavours. He outlined the limitations of his classifications of different types of models. He concluded that the model classifications tended to be problem-orientated rather than technique-orientated. [7, p.12].

However, Orcutt [80], points out that building a model of real phenomena probably needs a combination of all the techniques available. "While building a model it is, of course, important to give some thought to its actual solution and use. However, any particular model might be expressed in any one of the various languages and might be solved and used by means of more than one approach. This being the case, it does not seem very useful for most purposes to classify models either according to the intended techniques of solution alone, or even simply according to the language in which they happen to be expressed." [80, p.893].

The building of models to analyse economic problems has a long history in economic research, from the simple static supply and demand model to the most sophisticated simulation model. The main concern for selecting the type of model should be based on the type of solution required.

With this reason in mind, this review is not concerned with different categories of models, but according to the approaches used and the objectives of the model builder.

In Chapter 1 the objectives of this study were:

1) to estimate short term supply and demand relationships for fresh vegetables at auction;

2) to determine the effects on prices of various short-term marketing policies;

3) to determine the effects on prices of rationalising supply.

Basically, the process of model building and using models for the above three objectives would involve two phases.

First, for the first objective, <u>an inductive phase</u>, in which we seek to represent the economic structure in the form of a system of equations, and to describe the past behaviour of the system. This could be achieved by using the traditional econometric approach. Secondly, for the second and third objectives, a <u>deductive phase</u>, in which we seek to determine the impact of various policy alternatives - in particular the manipulation of exogenous variables on some measure of performance of the system. The alternative approaches for this phase are the operations research approach, the "multiplier" and the simulation approach.

Models constructed under both phases are reviewed in the following sections.

3.4 Inductive phase models

Under this phase, the aim is to estimate the structural relationship of the parameters under study. The econometric studies of vegetables by Schuffett, Kulshreshtha and Suit and Kaizumi cited in section 2.3.2 of this thesis, are examples of the use of statistical methods to estimate structural parameters in the vegetable market. Their work used annual data and a single-equation model. Very few short-term models for vegetables have been developed.

Simultaneous systems also had been employed by many researchers [40, 51, 11]. The recursive system is a special case of the simultaneously determined system and is of a very general scope in supply and demand analysis, especially of the cobweb model [47, p.75; 102, p.14]. Wold [102], Dhrymes [23] and Foote [30] maintained that the parameter estimation may be carried out for each equation separately and that the method of ordinary least squares method is adequate to acquire unbiassed estimates. On the other hand, a simultaneous model may be necessary to ensure unbiassed estimates [8a, p.153; 102, p.51; 23, p.305].

Ultimately, the choice of different models, either a single equation or a simultaneous system, or a recursive system, depends on the market structure under study.

3.5 Deductive phase models

In the deductive phase, the researcher seeks to investigate the sensitivity of the performance parameters of the model to variation in the structural parameters or effects of the manipulation of the values of exogenous variables. Basically, three approaches could be used - the operations research approach, the "multiplier" approach, and the simulation approach.

A basic feature of the operations research approach is that it seeks to obtain an optimal solution in terms of some objective function. This approach will not be discussed further for two reasons: first, very few operations research techniques have been employed in policy evaluation. Secondly, the assumptions of optimising techniques limit their application for this particular study.

The following sections review the models built using the "multiplier" approach and the simulation approach.

3.5.1 The "multiplier" approach

Reutlinger [82] used short-run and long-run multipliers in a model for estimating future supply, demand and prices. He claimed that his model could be used to assess the effects of changes in - private or government policies, industry structure, or consumer behaviour. Reutlinger demonstrated the multiplier concept by using a simple three-equation beef model. After estimating the values of the reduced form structural parameters, he tested the model's performance by estimating the endogenous variable for each period, using calculated values for the lagged endogenous variable and the historical values for the exogenous variables. The model may be considered acceptable if the time path of the endogenous variable generated by it is highly correlated with the actual time series.

Reutlinger also indicated that in order to examine the stability of the system, the latent root of the matrix must be deduced. The dominant latent root of the matrix derived from the reduced form determines the behaviour of the system. A positive dominant root implies monotonic convergence. If the dominant root is negative, the system oscillates each period. A complex dominant root implies that cycles will occur in the system. These are the effects of short-run multipliers on the endogenous variable.

The long-run multipliers were derived to show the impact of a once-and-for-all change in the exogenous variable. A long-run multiplier matrix can be used for appraising the effects of controlling certain policy variables at different constant levels. If it was desired to investigate the effect of varying the rates at which certain exogenous variables change over a period of time, another long-run multiplier matrix can be derived.

Vandenborre [99], used the same method to study the demand for soya beans in the United States. Reduced form estimates were used: first, to evaluate the impact of government support programs by suspension of the P.L.480 program; secondly, to study the impact of changes in exogenous variables such as local supply and imported soya beans, and finally, to observe the effect of increased demand, owing to increases in population and change in tastes while supply held constant.

Hence, the multiplier technique may be used to study the problems similar to those of this study. But one disadvantage of the technique is that the system is non-stochastic because it abstracts from random effects. In a deterministic system, only the expected values of the endogenous variables are considered. This deficiency may be serious since the time path generation may be significantly affected by the disturbance terms, especially when the disturbance error terms are strongly autocorrelated. Therefore, an alternative technique, simulation, which includes the stochastic value of the disturbance error terms, is used in this study.

3.5.2 The simulation approach

The term "to simulate", in general usage, means the process of conducting experiments on a model of a system, in lieu of either:

1) direct experimentation with the system,
2) direct analytical solution of some problems associated with the system [63, p.1].

Naylor [67, p.3], defines computer simulation more clearly as

"A numerical technique for conducting experiments on a digit computer which involves a mathematical and logical model that describes the behaviour of an economic system over an extended period of time."

However, McKee [58], pointed out that simulation was not a new approach in concept, but the development and use of more realistic models.

There are two distinct schools of simulation. Some analysts, for example, McMillian and Gonzalez [59] Hayenga, Manetsch and Halter[37], and Suttor and Crom [91], build their simulation models by various means. The initial values of the structural parameters are provided partly by statistical regression analysis, and alternatively by simply using subjective"guesstimate" values. The other school, such as Naylor and others [65, 69, 70, 74, 61, 16], favour more emphasis on the use of statistical methods in model validation, experimental designs, and analysis of the results.

Most of the econometric models reviewed above are linear. Naylor [65] showed that both lieanr and non-linear forms of models could be adapted for simulation purposes. He pointed out that after the structural parameters of the econometric system had been estimated and probability distribution of the error terms had been specified, the simulation model would generate ex ante or ex post time paths for the endogenous variable. Computer simulation usually has been recognised as the tool which has considerable advantages over traditional analytical techniques. However, Howrey and Kelejian [42], raised the question whether the role of computer simulation as a tool of analysis of econometric models, should be reconsidered. They argued that "Once a linear econometric model has been estimated and tested in terms of the known distribution theory concerning parameter estimates, simulation experiments that are undertaken to investigate the model as an interrelated system yield no additional information about the validity of the model." [42, p.207]. Furthermore, they pointed out that "although some of the dynamic properties of linear models can be inferred from simulation results, an anlytical technique (such as dynamic multiplier analysis or spectral analysis) based on the model itself, is available for this purpose." [42, p.208]. However, Naylor [65], refers to an unpublished paper by Howrey and Kelejian entitled "Dynamic Properties of Stochastic Linear Econometric Models" in which they have pointed out that "if the long term properties of an econometric model are to be investigated, it may not be reasonable to disregard the impact of the disturbance terms on the time paths of the endogenous variables. Neither the characteristic root nor the dynamic multiplier provides information about the magnitude on correlation properties of deviation from the expected values of the time path." [65, p.267] The other advantage of having the stochastic error terms is that one can replicate the simulation experiment and make statistical inferences and test hypotheses about the behaviour of the system being simulated.

But, any economic projection or alternative policy evaluation involves uncertainty concerning the future. Crom [20], claimed that any model based on the historical data would provide more information than more informal methods, although models were fallible, due to the random error terms associated with function derivation. Once an error was initiated, the simulation model might thus be forced to operate with accumulated errors. Under this condition, Crom pointed out that only two alternative actions could be taken - either of accepting the projection as generated by the model, or of modifying the model by "operation rules" [20, p.10], to yield projections in line with reasonable expectations. His argument seems to be quite reasonable since no-one could strictly assume that the past behaviour of the system could continue and remain the same in the future.

In support of simulation as a specific research technique, Suttor and Crom [91] and Cohen and Cyert [17] emphasised that computer simulation might be the most efficient approach when the model portrayed a dynamic process, such as recursive systems and numerical answers in the form of time series are desirable.

The other major advantage is that simulation makes it possible to gain insights into the effects of the rate of changes of a particular parameter.

3.6 The selected methodology for the study

In view of the discussions above, the methodological techniques chosen for this study are separated into the following two phases:

3.6.1 Inductive phase

The first objective of this study, is approached by using a recursive cobweb-type model, which is used for two reasons:

First, estimates of the structural coefficients that are statistically consistent can be obtained by fitting each equation directly by ordinary least squares, provided that calculated values of the endogenous variable in the supply equation are substituted for the actual values in the demand equation. [30, p.64].

Secondly, it can be handled by computer simulation more efficiently (refer to section 3.5.2). Many simulation studies such as those referred to in the following section, are based on recursive models (for examples refer to articles by Naylor, Wallace and Sasser [71] and Crom [20].

Leuthold [53], developed a recursive model of cobweb type to identify and evaluate the major factors affecting daily fluctuations in hog prices and quantities supplied. Leuthold found that the elasticity of supply for hogs is very high, ranging from 8 - 10. He concluded that hog producers appeared to be extremely responsive to short term changes in price. Small price responses and large quantity responses could have important policy implications for meat packers in controlling stocks and inventories and could be established to reduce price and quantity fluctuations.

3.6.2 The deductive phase

The computer simulation technique, as compared with the "multiplier" approach, was felt to be the most satisfactory approach for achieving the second and third objectives of this thesis. The reasons are:

First, the time paths of the endogenous variable are well-duplicated by including the disturbance error terms. Secondly, the "multiplier" analysis does not provide any information about the expected values of the time paths. Thirdly, with the disturbance error term included, one can replicate the simulation experiments and make statistical inferences. Fourthly, simulation allows us to gain insights into the effects of the rate of change of a particular parameter. Finally, the most important reason lies in the flexibility of simulation.

To gain some idea of the use of simulation techniques, previous simulation studies which have similar objectives to those of this thesis, are outlined in the next section.

3.7 Reviews of simulation studies

Cohen's study [16], entitled "A Computer Models of the Shoe, Leather and Hide Sequence", formulated and experimented with two mathematical models (a one-period-change-model and a "process model") describing the aggregate behaviour of the shoe retailers, shoe manufacturers and cattle-hide leather tanners between 1930 and 1940.

Barnum /8/, conducted a simulation experiment to examine the effect of two policies - the impact of import surpluses and the management of government stock - on India's food grains market over the period 1957 to 1964. The result indicated that importing 28,000 tons of P.L.480 food grains over that period depressed production ability slightly and increased the market availability markedly. With regard to the second policy, the results indicated that Government with good management of inventories, would maintain the desired level of foodgrains consumption and reduce total imports over the simulated period.

To evaluate the impact of the United States government introducing several programs to stabilise the textile industries, Naylor, Wallace and Sasser /71/, formulated a nine equations, recursive, econometric model to simulate the behaviour of nine endogenous variables which described the industry between 1953 and 1962.

Further, Agarwala /2/, developed a simulation model to assess the efficiency of market support operations in the case of the egg market in the United Kingdom during 1958-68 period. He indicated that, in the absence of market support by the British Egg Marketing Board, the long-run average return to the egg producer would have been marginally different from retail, but the instability of the market would have been substantially greater. Agarwala also showed that, owing to the nature of the subsidy arrangements, there were severe limits to the Egg Board's capacity to increase producer price, even in a short run, in spite of an inelastic demand for eggs. He concluded that the Egg Marketing Board should aim at keeping close to the long run producer price rather than aim for short run profit maximisation.

The above four studies by Cohen, Barnum, Agarwala and Naylor <u>et al</u>, deal with ex post policy devaluation. The next two studies review ex ante policy assessment.

Agarwala and Ball [3], used a simulation model for the egg market in the United Kingdom. Their objective was to examine the effect of the different rates of diversion of eggs to manufacturing price fluctuations and the long run equilibrium. This was done by a fairly simple six monthly model. They also used a monthly model to assess the implication of different pricing policies in different months of the year.

Finally, Crom [19, 20], and Crom and Maki [21], have carried out a simulation study on a dynamic recursive model of the United States beef and pork sectors. The simulation model was used in two ways. First, the model could be altered, or policy constraints could be imposed and the new structure could be simulated over time. Alternatively, the model might be used to project prices and output in a future period. Thus, simulation experiments could be performed for both ex post and ex ante policy evaluation.

The above reviews indicate the type of problems which can be approached using computer simulation. An important question, which has not been discussed in detail, is the realism of the model and the aplicability of the results to the real world situation. This validation aspect of computer simulation is a largely unresolved methodological problem. It is discussed in more detail in Chapter 5 of this thesis.

3.8 Summary

The concept of model building has been discussed. Basically, model building and the use of models involves two phases. First, an inductive phase and secondly, the deductive phase. These two phases have been defined in relation to the objectives of this study. Some relevant literature has been outlined.

For this study a recursive model was chosen in the inductive phase while simulation was selected in the deductive phase. The reasons for choosing these techniques have been outlined, and previous simulation studies have been reviewed.

The formulation of the econometric model is discussed in the next chapter.

CHAPTER 4

AN ECONOMETRIC MODEL OF THE FRESH VEGETABLE MARKET

4.1 Introduction

This chapter includes a statistical derivation of a weekly supply and demand model for the selected vegetables (cauliflower, cabbage, lettuce and carrots). This will be used as a simulation model in the next chapter.

The first section of this chapter discusses the theoretical basis of the supply and demand model used.

The second section describes the data collection techniques and the estimation procedure.

Finally, the results are presented and discussed.

4.2 The economic model

4.2.1 The supply structure for vegetables

The annual supply of vegetables follows the classical cobweb theorem in that the marketed volume is predetermined by biological, climatic and economic forces prior to the marketing day. It is postulated that a similar model operates in the short term. That is, the supply of vegetables in any week is determined by the previous week's price, but not by current price.

Since the supply is determined prior to the next auction session, it is assumed that the growers operate on an expectation model in which the expected price is generated by the price at the previous auction sale. Thus, price lagged one period is included as an independent variable or explanatory variable in the supply equation. A cobweb model would imply a positive sign although hypotheses could be put forward.

Several studies [12, 92] have shown that vegetable production is seasonal. This phenomenon is represented by zero-one dummy variables which shift the supply function according to seasons [57, 95].

The ideal variable to represent the influence of weather on supply is the "Stalling Weather Index" [88]. However, this index is not available in New Zealand on a weekly basis. It is difficult to obtain a single factor to account for weekly weather variation. For the sake of simplicity, temperature expressed in Heat Units[1] is used to account for the weather influence. Two supply models were tested. The first has a lagged (t-1) period of weather index, while the second has a lagged (t-2) period of weather index. It was found that the weather lagged two weeks was the most satisfactory.

A trend variable is included as an independent variable or explanatory variable to allow for increases in production as a result of improved technology or increased use of horticultural inputs.

4.2.2 The demand structure for vegetables

Demand is considered here as the price-quantity relationship for the wholesale market in Palmerston North. It is assumed that the weekly average prices for the selected fresh vegetables are determined by the marketed volume, the current weather index and a time trend variable. The direction of causation is taken as being from quantities to prices, the marketed volume being treated as a predetermined variable in the demand equation. This hypothesis is fully supported by the evidence that the current marketed volume of vegetables is dependent on various exogenous influences prior to harvesting day.

---

1. Heat Unit is expressed as :

$$\frac{(\text{Maximum day temperature} + \text{minimum day temperature})}{2} - 32^{o}\text{F.}$$

Since vegetables are highly perishable, the total quantity presented for auction must be sold each day. Opportunities for storing or moving the produce to another auction are limited. This implies that the quantities of vegetables supplied should equate with the quantity demanded.

There are several other explanatory variables which could affect the prices of the selected vegetables. These include - changes in population, changes in consumers' disposable income, and changes in consumer behaviour. They are represented by the use of time-trend variables.

The weather index is considered as a temperature effect in Heat Units. It was assumed that the weather would affect consumer buying behaviour.

Another variable which may influence the price of any selected vegetables is the price for various other vegetables. For example, the price of tomatoes may have some influence on cabbage [92, pp.56-58][2]. Cross elasticities are not considered in the model because there is no satisfactory theoretical basis for chosing any particular vegetable and there are considerable problems in obtaining adequate data to include a full range of vegetables sold at auction.

4.2.3 <u>The proposed model</u>

The proposed economic model can be shown in functional form as follows:

---

2. Also Enting and others [26, p.4]. "Consumption of tomatoes lettuces and perhaps cauliflower may have expanded at the expense of root crops (including carrots, cabbage, and pumpkin)".

$$SU_t = f(P_{t-1}, W_{t-2}, T_t, S_t)$$

$$P_t = f(T'_t, W_t, Q_t)$$

where

SU_t = Supply of vegetables to Palmerston North auction market in period t (week)

P_{t-1} = Wholesale price of vegetables in week (t-1)

W_{t-2} = Index of weather (in Heat Units) in week (t-2)

W_t = Index of weather (in Heat Units) in week t

Q_t = The quantity demand at period t

T_t = The time trend variable (in years) at period t

T'_t = The time trend variable (in weeks) at period t

S_t = The zero-one seasonal dummy variables.

4.3 The statistical model

The supply and demand functions for the fresh vegetables discussed above, define a recursive model of the cobweb type [30, p.64; 102, pp.74-77; 47, pp.75-77]. In this model, the quantity supplied is determined through the supply function and the price received is determined by the quantities sold through the demand function. The error terms of the supply and demand functions are assumed to be uncorrelated. [30, p.64].

Therefore, with the normal assumption of a stochastic error term, ordinary least square regressions will yield consistent and unbiassed estimates of the parameters of each function [30, pp.75-77; 34, pp.269-271, pp.279-280; 23, pp.303-311].

A linear function is used, based on the assumption that the growers respond to an absolute value change rather than the real value. A cobweb type recursive linear model facilitates the use of a simulation model [91, p.1346].

The entire statistical structure of demand and supply functions can be specified as follows:

Supply function :

$$SU_t = A_4 + B_1P_{t-1} + B_2W_{t-2} + B_3T_t + A_1S_{1t} + A_2S_{2t} + A_3S_{3t} + U_t \qquad (4-1)$$

Demand function:

$$P_t = C_1 + C_2T'_t + C_3W_t + C_4Q_t + V_t \qquad (4-2)$$

Market clearing function:

$$Q_t = SU_t \qquad (4-3)$$

Where

SU_t, P_{t-1}, W_{t-2}, T_t, T'_t, W_t and Q_t have the same definition as in the previous section.

B_2, B_2, B_3, A_1, A_2, A_3, C_2, C_3 and C_4 are the structural coefficients of the parameters

A_4 and C_1 are the constant in the functions

and

U_t, V_t are the disturbance terms in the supply and demand functions respectively.

4.4 The estimation procedures

4.4.1 Data collection

The weekly data series examined were the aggregate weekly quantities of the fresh vegetables (cauliflowers, carrots, lettuces and cabbages) consigned to the auction firms and the weighted average auction price over the period April 1969 to March 1972.

Since the daily data was incomplete, the data from the main auction sales on each Monday and Thursday was used. The supply was expressed on a per container (case) basis and prices were expressed in "dollars per container" (case).

The price and supply data were taken from the official records of the two fresh produce auction firms in Palmerston North.

The original supply data was expressed as per case or bage. No details were supplied for the size of the cases, but it is known that there were two types of containers used for lettuces, cauliflowers and cabbages - apple cases and banana cases[3/]. Further, the weight of produce per case sold was not available.

Banana cases can hold 10-12 heads of lettuce and 8-10 heads of cabbages or cauliflowers, while an apple case can hold a smaller quantity, depending on the size and quality of the produce. Carrots were packed in plastic bags usually weighing 45lbs. per bag. No clear indication of different grades could be obtained from the records because there is no official grading system for vegetables sold at auction.

The price series data was recorded as a range of prices which the growers received. A weighted average of the lower prices and higher price for each lot was used in the analysis.

The final data series consisted of the total weighed average prices of the two firms in a price series and the total volume of produce consigned to the two auction firms during the period under study. The two data sequences are given in Appendix B.

---

3. Apple cases are the types of containers used to pack apples in New Zealand.

   Banana cases are the types of containers in which bananas are imported.

The corresponding graphs are shown in Figures 4.1 to 4.4.

4.4.2 The characteristics of the data series

A marked short term fluctuation can be seen in vegetable prices and supplies with most of the peaks in supply corresponding to the lowest prices and vice versa.

The inter-annual movement of these four vegetables are not quite as obvious. In general, pronounced low peaks were shown in lettuce supplies during winter months (May-July), with higher peaks in November and December. On the other hand, cabbage and cauliflower showed a different pattern with low peaks in January and February and high peaks in May and June.

In the case of carrots, no pronounced high or low peaks were observed throughout the season because carrots, being root crops, can be stored and regulated to supply the market.

4.4.3 The estimation procedure

The procedure for estimating the coefficients of the parameters in the supply function were as follows:

1. Each year was divided into four quarters as shown in table 4.1.

TABLE 4.1

Quarter	Month of the year
1	April-June
2	July-September
3	October-December
4	January-March

Each quarter of the year consists of 13 weeks.

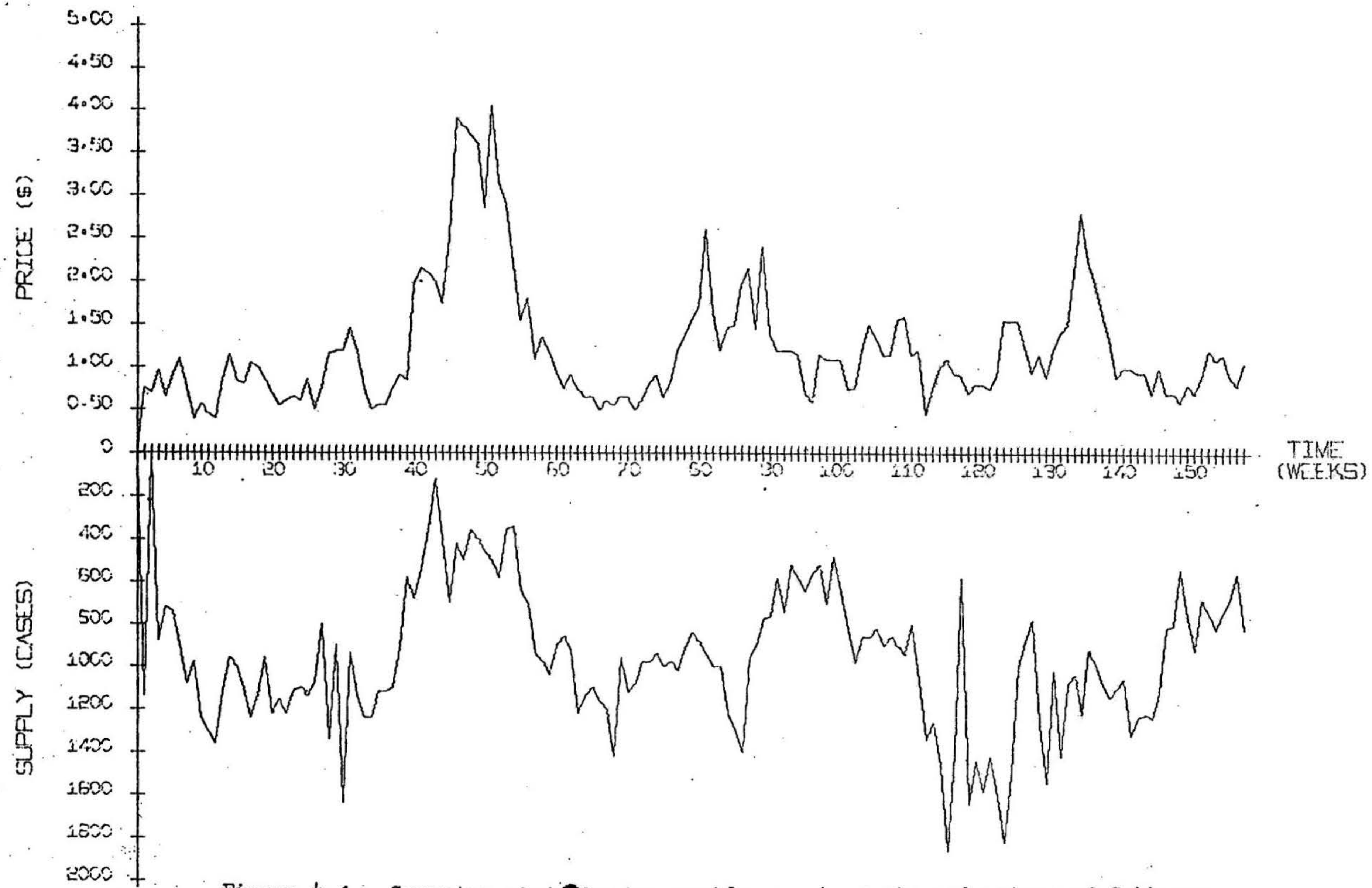


Figure 4.1 Computer plot showing weekly consignments and prices of Cabbages on the Palmerston North wholesale markets 1969-1972

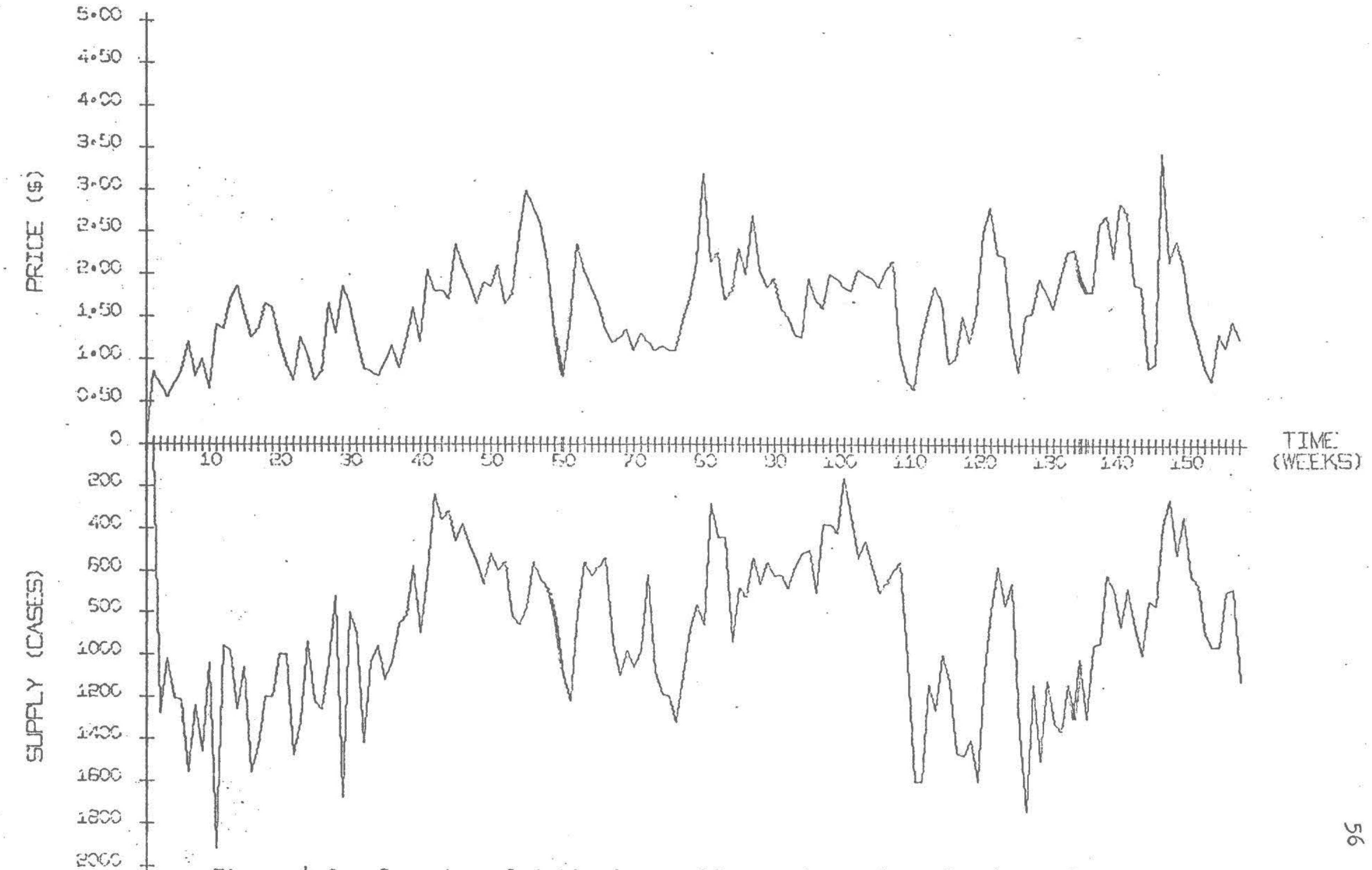


Figure 4.2 Computer plot showing weekly consignments and prices of Cauliflowers on the Palmerston North wholesale markets 1969-1972.

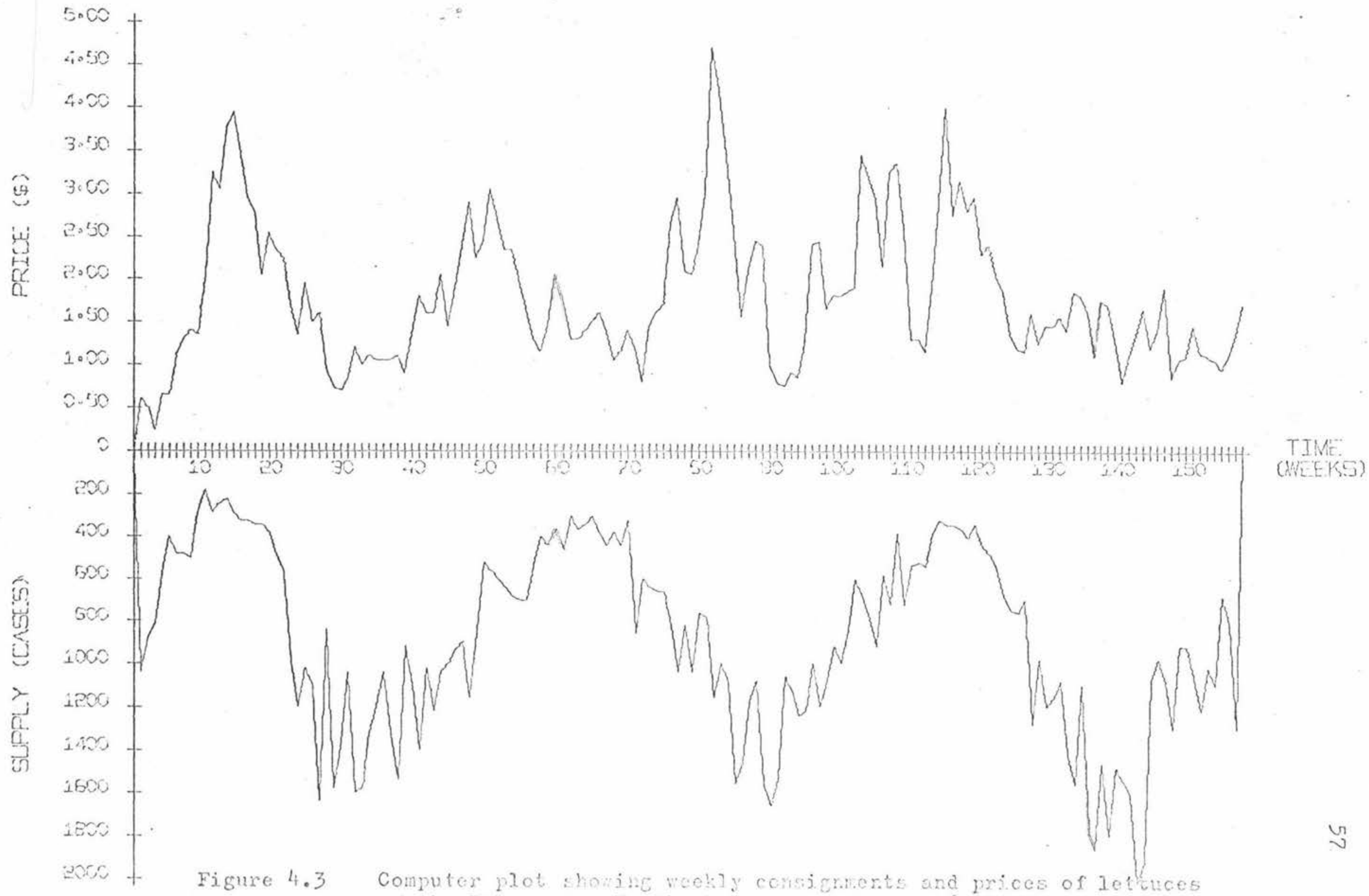


Figure 4.3 Computer plot showing weekly consignments and prices of lettuces on the Palmerston North wholesale markets 1969-1972.

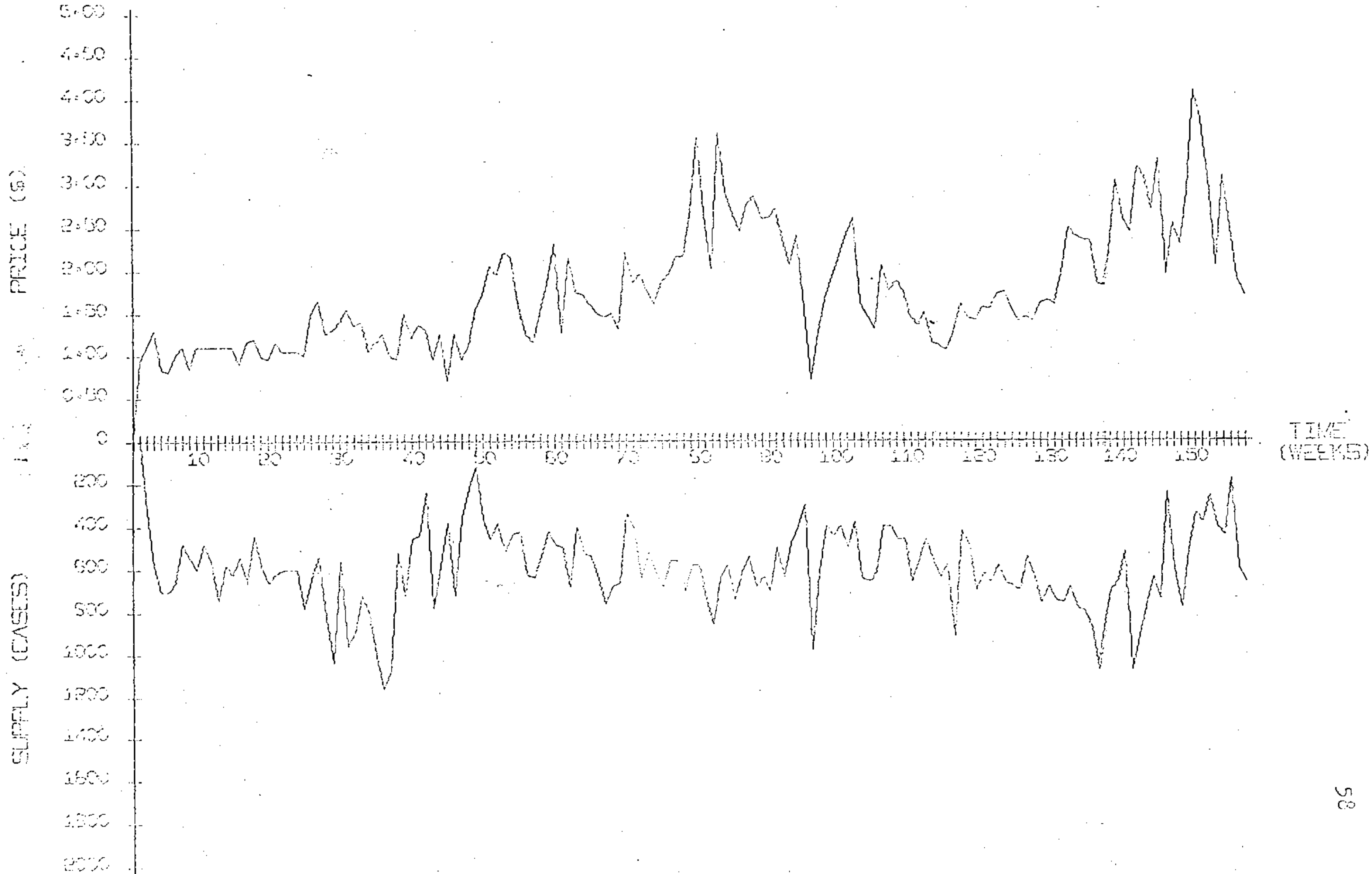


FIGURE 4.4 Computer plot showing weekly consignment and prices of carrots in the Palmerston North wholesale market, 1969-11972.

2. The price data was not deflated, based on the assumption that the growers and buyers respond to the absolute change in price, rather than the nominal change [97, p.160][4].

3. The coefficients of the parameters in the supply model were obtained by regressing quantity on the lagged (t-1) period prices, the lagged (t-2) period weather index, the time-trend variable, and three zero-one seasonal dummy variables.

4. The expected values of SU_t were used as inputs of the independent variable Q_t in the demand model. Then the coefficients of the parameters in the demand function were calculated using an ordinary least square procedure [45, pp.177-192; 35, pp.156-166].

4.5 Results and discussion

4.5.1 The estimated supply function

The results estimated for the supply function are shown in table 4.2.

The variables whose parameters were estimated are defined in sections 4.2.3 and 4.3.

In table 4.2, an asterisk indicates significance at the 5% level. The standard errors are enclosed in a bracket below the respective parameter estimates.

It can be seen that most of the standard errors are significant at the 5% level with the exception of two cases.

---

4. Van der Mulen [16, p.160] in studying the demand of bananas found that "sellers tend to think in terms of absolute change rather than the price adjusted to the price level in the economy as a whole."

TABLE 4.2 THE ESTIMATED COEFFICIENTS OF THE PARAMETERS IN THE SUPPLY EQUATIONS USING WEEKLY DATA

Vegetables	A_4	T_t	P_{t-1}	W_{t-2}	S_{1t}	S_{2t}	S_{3t}	$\bar{R}^2$	d
Cabbages	868.7*	103.4*	-77.6*	-12.1*	276.3*	172.8*	175.8*	0.457	1.077
	(108.3)	(22.7)	(27.9)	(3.5)	(60.6)	(73.5)	(56.4)		
Lettuces	974.2*	69.3*	-115.8*	4.56	-459.7*	-259.8*	394.1*	0.684	1.289
	(106.4)	(24.1)	(23.4)	(3.7)	(63.4)	(77.6)	(60.1)		
Carrots	619.7*	5.4	3.5	-6.9*	11.9	27.3	201.5*	0.275	1.498
	(70.4)	(19.4)	(25.7)	(2.4)	(43.9)	(51.7)	(39.1)		
Cauli-flowers	1203.3*	39.5	-199.2*	-15.0*	270.2*	198.6*	124.5	0.477	1.530
	(119.6)	(27.2)	(39.7)	(4.02)	(69.1)	(84.1)	(64.6)		

The first situation is that four standard errors of the variables are not significant in the carrot supply function. It appears that the supply model does not satisfactorily represent a carrot supply function's behaviour. From section 4.4. of this thesis and some personal observations in the auction markets in Palmerston North, the grading of carrots is divided into many categories, such as animal carrots, loose-packed carrots, first grade and second grade. The various grades receive different prices, but there was no indication of this in the data records available. This lack of quality differentiation is not reflected in the price series.

The second case is the non-significant weather index variable for lettuces. Vegetables such as lettuces, respond to climatic changes rapidly and hence the weather index at period (t-1) showed a significant result for the standard error at the 5% significance level. However, this was not included because of the difficulty of adapting it to the simulation model.

The coefficients of multiple determination R^2 (shown in table 4.2, column 9) range from 0.28 to 0.68 for carrots and lettuces respectively. This implies that approximately 28% of the variation in supply for carrots and 68% for lettuces could be explained by the changes in the exogenous variables. However, the numerical value of R^2 could be increased by defining more relevant exogenous variables, or through the use of a longer time unit [27].

Because of the large sample size, the Durbin-Watson (d) statistic [24] (shown in column 8 of the table) can only approximate as a test for the presence of auto-correlation in the residual. Using 100 observations as a guideline, any d statistic below 1.50 would indicate that positive auto-correlation is present. This outcome occurred in three situations and one test was inconclusive i.e., the d statistic fell between du and dl values. The values are shown in Appendix C.

Three reasons for expecting auto-correlation in the residual are given by Cochran and Orcutt [15].

1) Given an auto-correlated series, the choice of an incorrect functional form will result in auto-correlated errors.

2) Errors arising from the omission of economic and non-economic variables will tend to be auto-correlated.

3) Errors of measurement present in the data are often auto-correlated.

However, the positive auto-correlation in the residue does not yield biassed estimates except that they may be less efficient [30, p.64; 102, p.52; 45, p.179].

The coefficients of the dummy variables for the four quarters indicated two types of trend in supply. Cabbages and cauliflowers showed a decreasing trend, while the carrots and lettuces exhibited an increasing supply trend from quarter 1 to quarter 4.

The multi-collinearity in the system is not very high, [43, p.121]. The highest correlation was between $S2_t$ and W_{t-2}. The details are shown in Appendix D.

One point of interest is that the price coefficients for cauliflowers, cabbages and lettuces indicated an unexpected negative sign which contradicts a cobweb hypothesis. Their standard errors are all significant at 5% level. This implies that the growers reacted to past experience and sent less produce to the market when the lagged price was high. Conversely, they supplied more when the lagged price was low. This type of response is explained in Heady's "Extension Model" [38, pp.483-484]. The negative sign for these coefficients is also supported by Allen's "speculation effect" [6, p.48].

On the other hand, the carrots have a positive non-significant coefficient.

4.5.2 The estimated demand function

The results of the estimates are given in table 4.3.

The coefficient of multiple determination, R^2 (shown in column 5 of the table) is rather low, ranging from 0.187 for carrots to 0.361 for cauliflowers. This implies that exogenous variables only explain 18% to 36% of the variation in the average wholesale prices. Other explanatory variables, such as the quality of the vegetables and the price of other competing vegetables, may increase the power of R^2, but the data for those variables was not available.

Again, the Durbin -Watson statistic test can be used as an approximate test of autocorrelation. All equations were positively auto-correlated. The values are shown in Appendix D.

However, time series data are usually autocorrelated [22, p.480], but by using a recursive system the estimates should not be biassed [23, p.179; 30, p.64].

The coefficients of the Q_t variable have the expected sign in all cases with the exception of carrots. The regression coefficient of the variable Q_t for carrots possesses a significant positive sign. Although the positive sign appears contradictory to the theoretically expected relationship, a possible explanation is that quality and price are positively related and more produce will be sold when the quality is higher. This is related to the problem of accurate description in the absence of a formal grading system [50, p.57].

Most of the estimated coefficients are significant at the 5% level except those associated with the weather index variable (as shown in table 4.3). The price quantity variables are all significant at 5% interval.

TABLE 4.3 THE ESTIMATED COEFFICIENT IN THE DEMAND FUNCTION

Vegetable	C_1	T'_t	W_t	Q_t	R^2	d^2
Cabbages	3.9773)0.4758)	-0.0054 (0.0048)	-0.0126 (0.0089)	-0.0025* (0.0003)	0.353	0.25236
Lettuces	2.5332* (0.1696)	0.0215* (0.0062)	-0.6022 (0.0101)	-0.0014* (0.0024)	0.192	0.4733
Carrots	0.3437 (0.3712)	0.0176* (0.0043)	0.0031 (0.0092)	0.4015* (0.0005)	0.187	0.5723
Cauliflowers	4.3124* (0.3392)	-0.0104* (0.0039)	-0.0294 (0.0073)	-0.0022* (0.0003)	0.3616	1.4379

The multicollinearity in the demand function is not very high. The variables with the highest correlation are Quantity/trend with 0.14 for carrots to 0.75 for cauliflowers. The detailed values are shown in Appendix D. Overall the supply and demand functions do show the expected relationships between the variables and represent the market situation to an acceptable level.

4.5.3 The estimated short term price elasticities of demand and price flexibilities.

The short term price elasticity of demand calculated at the mean for the four selected vegetables is presented in table 4.4.

The price elasticities of demand range from -0.5 for cabbages to -1.434 for lettuces. The price elasticity of carrots possesses a positive sign, as explained in section 4.5.2.

It can be seen from table 4.4 that the demand for cabbages and cauliflowers is inelastic while the demand for lettuces is elastic.

The elastic demand for lettuces is in agreement with Shuffett [85] and Coles [24]. Cole concluded that, in most years, lettuces were a luxury or semi-luxury item for many consumers. The 1964 survey [26, p.4] indicated that lettuces are more or less a luxury item for New Zealanders. Another study made by Hoos [39], related commercial lettuce prices to production, non-agricultural income and time for 1918-1946 and found an elastic demand for lettuces at farm level. The opposite was found by Kiston [46, p.28], from surveys at Auckland and Christchurch.

However, the present model is based on the short term data. The estimated coefficients would be expected to be more elastic than those from the long term model. In view of the difficulties

TABLE 4.4 ESTIMATED SHORT TERM PRICE ELASTICITY OF DEMAND AND PRICE FLEXIBILITY AT THE POINT OF MEAN

Vegetables	Price elasticity	Price flexibility
Cabbages	-0.5034	-1.986
Cauliflowers	-0.8142	-1.2281
Lettuces	-1.434	-0.697
Carrots	+1.935	+0.519

in measuring price elasticity of demand (refer to section 2.3.2), the numerical value of -1.4 in the short term price elasticity of demand for lettuces is acceptable.

4.6 Summary and Conclusions

In this chapter an econometric model consisting of supply and demand functions was estimated. The objectives of using econometric analysis were two-fold. First, it provided the required quantiative relationships as an input to the simulation model discussion in Chapter 4 . Secondly, it providdd a method to gather information on the short term price elasticity of demand for the various selected vegetables.

The study was oriented towards the estimating of the supply and demand model in specifying the important variables associated with the variation in supply which, in turn, led to price fluctuations. It was assumed that the unknown price and quality relationships could be approximated by the empirical functions fitted to the available data.

The negative coefficients, associated with lagged (t-1) period prices, indicated that most growers do learn from experience of price behaviour.

The results of the four selected vegetables did shown the average relationship that existed among the selected variables during the period under study. Although the derived functions do not correspond to the theoretical demand schedule, they do provide a satisfactory basis for developing a simulation model of the vegetable market.

The construction of and experimentation with this simulation model are covered in the next chapter.

CHAPTER 5

THE SIMULATION MODEL OF THE FRESH VEGETABLE MARKET

5.1 Introduction

An econometric model was developed and tested in chapter 4. It was shown that the model satisfactorily represented the supply and demand situation and was suitable for simulation. To assess the impact of the various short term marketing policies and the rationalisation of supply on prices, the econometric model is converted into a simulation model.

The first section of this chapter describes the complete simulation model.

In the second section, the validation of the model is discussed and the validation results are presented.

The third section covers the experimental design. The experiments were carried out in two parts. The first part was an evaluation of the impact of different short term marketing policies while the second part assessed the effect of rationalisation of supply on prices.

The results of the simulation runs are presented and discussed in the fourth section.

In the final section the conclusions and summary of this chapter are presented.

5.2 The computer simulation model

The equations from the econometric model were :

Supply equation:

$$SU_t = A_4 + B_1P_{t-1} + B_2W_{t-2} + B_3T_1 + AS_{1t} + A_2S_{2t} + A_3S_{3t} \quad (5-1)$$

Demand equation:

$$P_t = C_1 + C_2T'_t + C_3W_t + C_4SU_t \quad (5-2)$$

where the definition of the variables is as in section 4.2.3.

The coefficients of A_4, B_1, B_2, B_3, A_1, A_2, A_3, C_1, C_2, C_3 and C_4 for the above equations are given in chapter 4.

Therefore we can transform the above econometric model into the following system:

$$SU_t = A_4 + B_1P_{t-1} + B_2W_{t-2} + B_3T_t + A_1S_{it} + A_2S_{2t} + A_3S_{3t} + U_t \quad (5\text{-}3)$$

$$P_t = C_1 + C_2T'_t + C_3W_t + C_4Q_t + V_t \quad (5\text{-}4)$$

$$S_t = Q_t \quad (5\text{-}5)$$

where

U_t, V_t are the disturbance terms,

which is the complete system for the computer simulation program, the construction of which is discussed in more detail in the following sections.

5.2.1 The independent variables

The independent variables or exogenous and lagged endogenous variables are the inputs to the system. There are 8 independent variables in the equations describing the supply and demand relationships at the wholesale market. These independent variables consisted of three zero-one dummy seasonal variables, two time trend variables, two lagged endogenous variables and one weather index variable.

The zero-one dummy variables were represented by S_{1t}, S_{2t} and S_{3t} describing the seasons where S_{1t} was equal to one and zero elsewhere in the first quarter of the season. The value of S_{2t} was equal to one and zero elsewhere in the second quarter of the season, and so on.

Two time trend variables were T_t in year and T'_t in week, where T_t was counted from April 1969 to March 1970 as the first year and up to the third year at March 1972, and where T'_t was counted for 156 weeks during the period being simulated.

All the independent variables were supplied from outside the simulation program as the historical data, except the initial lagged price which was arbitrarily fixed by the experimenter.

The model is a recursive system, by definition [19, p.3] as the quantity demanded at period t is given by equation (5-5). Equation (5-3) consists of a lagged (t-1) period endogenous variables (P_{t-1}) throughout 156 weekly iterations over four quarters. The output of one period (week) becomes the lagged endogenous value for the next period.

5.2.2 The random disturbance term

The disturbance terms specified in equations (5-3) and (5-4) were U_t and V_t for supply and demand functions respectively. These random disturbance terms were generated within the computer program by the subroutine RANDU. The pseudo-random numbers which were generated were converted to random variables by linear interpolation using the rectangular approximation method [25, pp.181-2].[1]

---

1. Emshoff and Sisson[25,p.181 Figure 7-9], showed that the psudo-random numbers can ne converted into random variates in the following ways : The figure (5-1) referred to Figure (7-9) which was specified by Emshoff and Sisson.

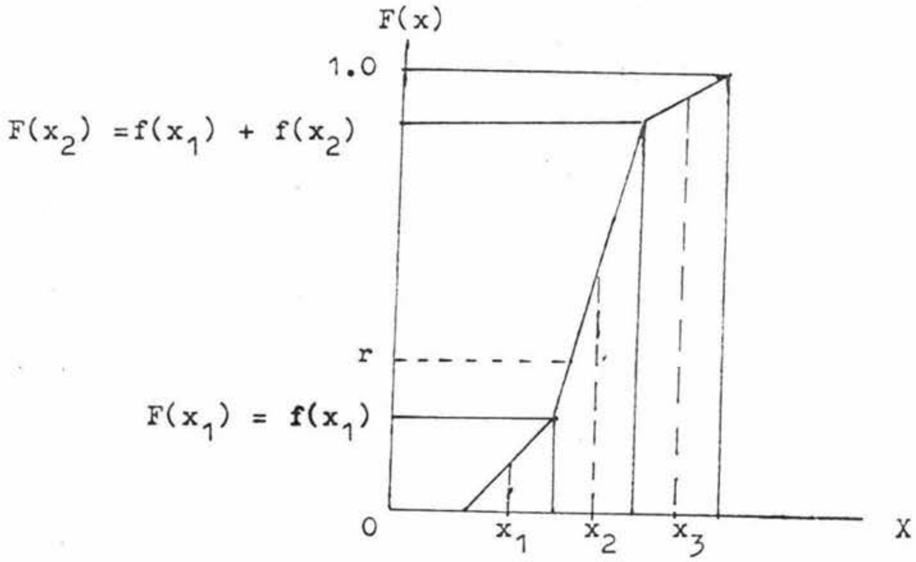


Figure 5.1 Cumulative density function approximation

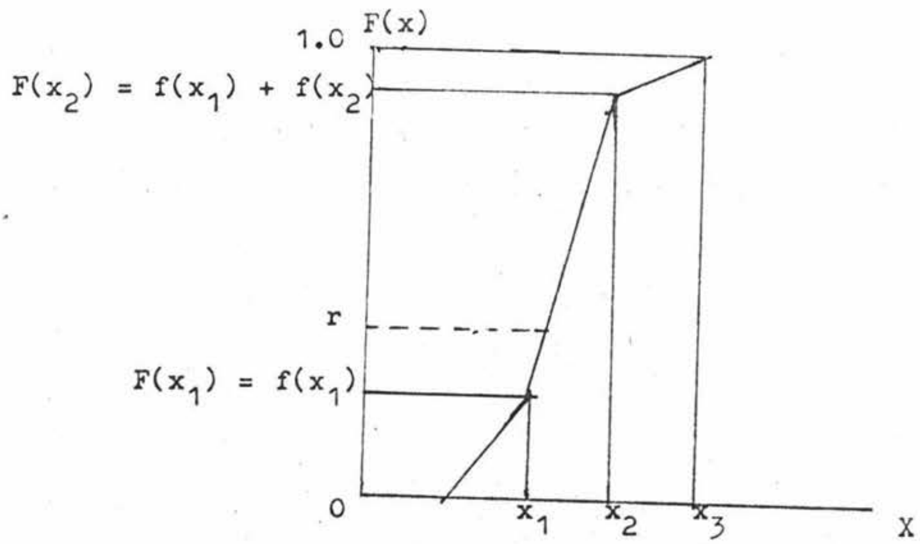


Figure 5.2 Modified cumulative density function approximation

This method was used because it was found that the disturbance terms of the functions for the selected fresh vegetables were not normally distributed as had been postulated in the assumption of the econometric analysis. Their probability functions and cumulative probabilities distribution are shown in Appendix E.

The advantage of using the rectangular approximation method is twofold. Firstly, it is more efficient since it requires less random numbers. Secondly, this method is available when no explicit function form represents the probability density function.

After the linear interpolation was generated, the random disturbance terms were added on to each function so that the time path of the endogenous variables could be traced.

Footnote 1 (cont.)

If $F(x_1) \lesssim r \lesssim F(x_2)$

The random variate x would be approximated by the following interpolation :

$$x = x_1 + (x_2-x_1) \times \frac{r - F(x_1)}{F(x_2) - F(x_1)} \qquad (5\text{-}6)$$

where x_1, x_2 and x_3 are the sample intervals.

$f(x_1), f(x_2)$ are the probability density function of distribution

$F(x_1), F(x_2)$ are the cumulative density function of distribution

r is the pseudo-random number.

Probably there may be a mistake in the original figure (5-1). In order to get the interpolation equation (5-6) the figure (5-2) should be used.

5.2.3 The computer program

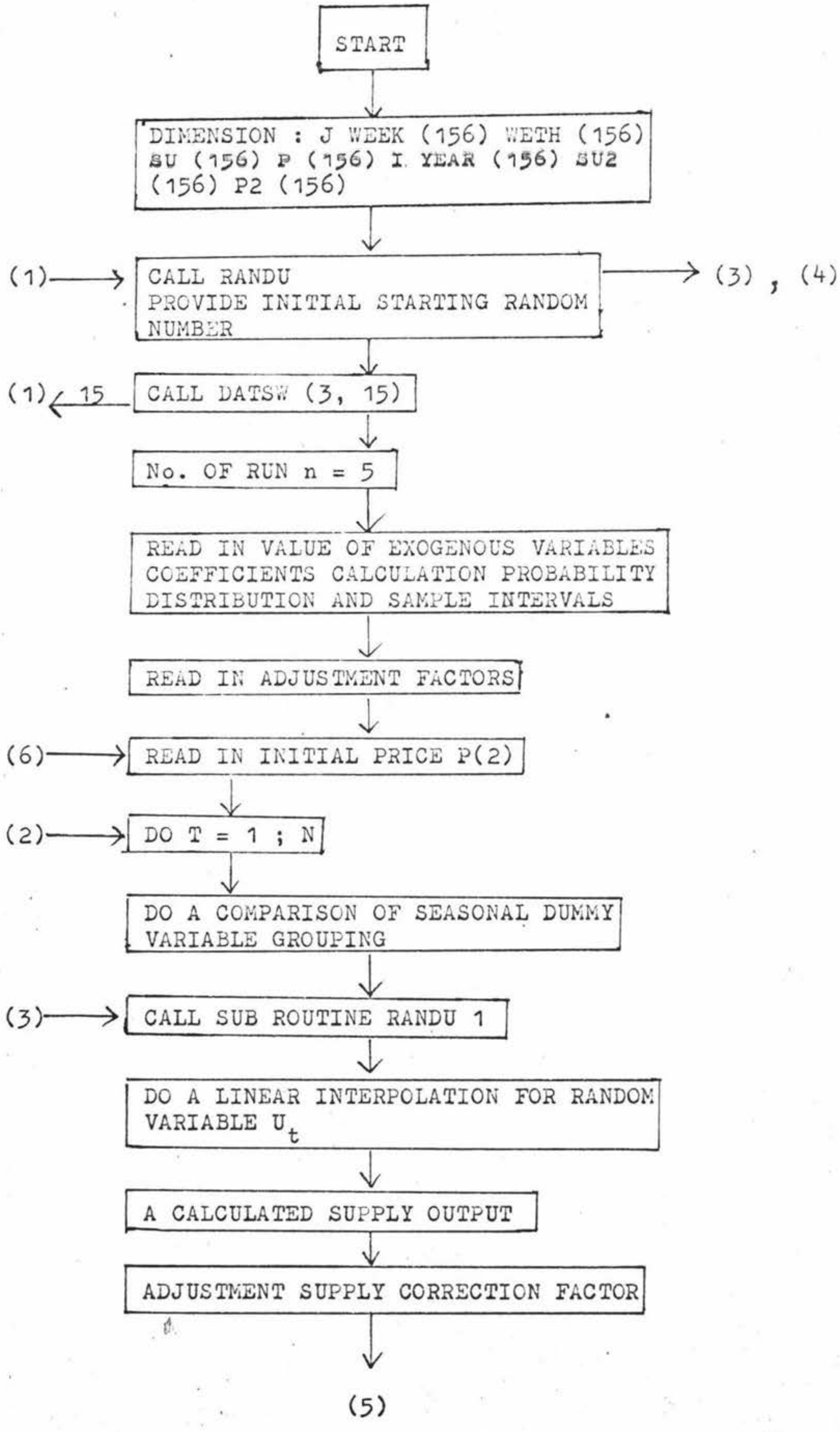
The computer simulation program, consisting of a main program and two sub-routines, was written in FORTRAN and run on an IBM 1130 machine. The logic of the program is shown in the flow charts in Figure 5.3 and the original program is shown in Appendix F.

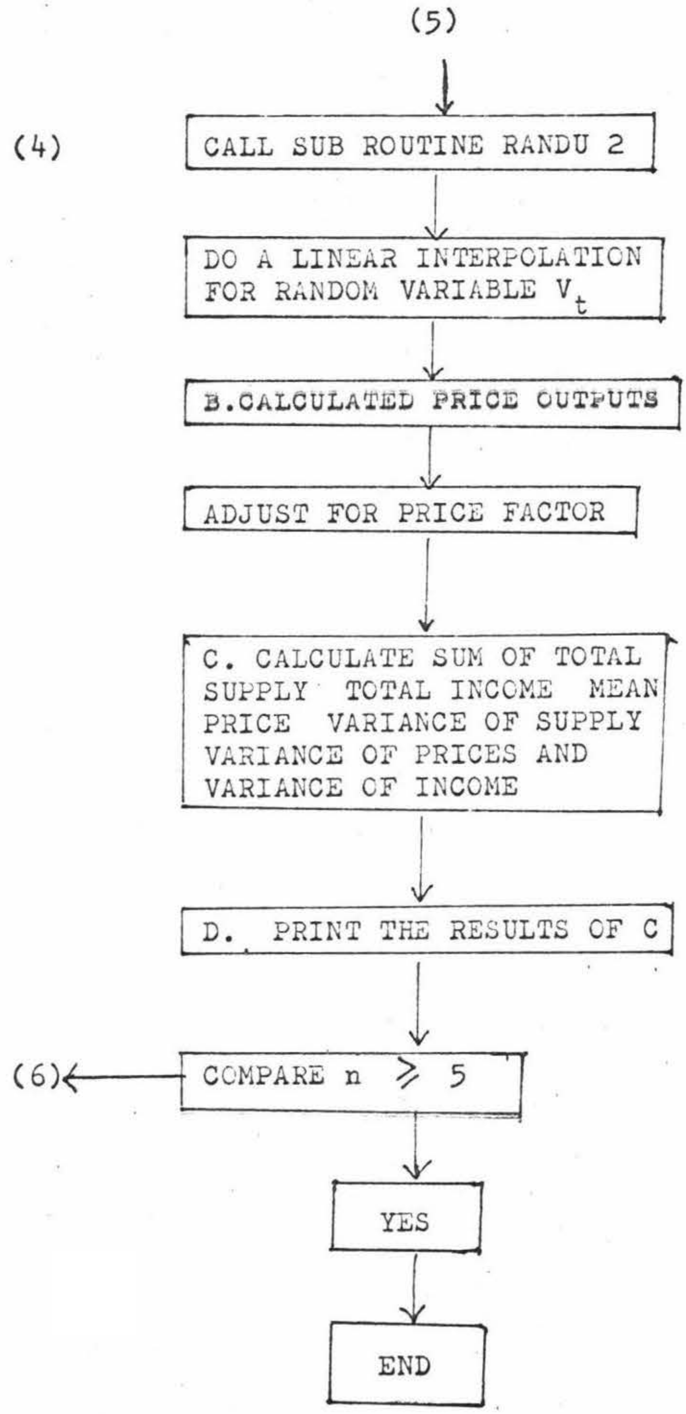
5.3 Validation

The problem of verifying or validating a computer simulation model remains one of the most elusive of all the methodological problems in simulation. To verify or validate means to prove the model to be true. But it is very difficult to provide a set of criteria for the proof. Naylor and Finger /70, p.93/, agree with Karl R. Propper that validation is a series of empirical tests on the degree of confirmation of the ability of the models describing the real world system. In addition, Van Horn /98, p.247/ also confirmed that simulation is a numerical learning process in which validation is the act of translating the "learning" from the simulation to "learning" about the actual process. This means that simulation is a process of gaining more confidence in the model for predicting the future, but this does not mean that once the model is validated for the past it can necessarily produce accurate forecasts in the future.

Naylor /67, pp.311-315/ suggests that four methodological positions on verification in economic models are available. These were, synthetic apriorism, ultraempiricism, positive economic and multistage verification. Naylor and Finger /70, p.95/ argue that multistage verification was more suitable for the validation of computer simulation experiments on economic systems. This approach involves a three stage procedure incorporating the first three methodological concepts mentioned above.

FIGURE 5.3 THE FLOW CHART




(5)
(4)
CALL SUB ROUTINE RANDU 2
DO A LINEAR INTERPOLATION FOR RANDOM VARIABLE V_t
B.CALCULATED PRICE OUTPUTS
ADJUST FOR PRICE FACTOR
C. CALCULATE SUM OF TOTAL SUPPLY TOTAL INCOME MEAN PRICE VARIANCE OF SUPPLY VARIANCE OF PRICES AND VARIANCE OF INCOME
D. PRINT THE RESULTS OF C
(6)
COMPARE n $\geqslant$ 5
YES
END

The first stage is to test a set of postulates or a hypothesis against all the available economic theories and the general knowledge of the system being simulated.

The second stage is to subject the postulates or the hypothesis of the model to a series of statistical tests, but, in the case of simulation of some economic systems, most of the assumptions are difficult to subject to empirical testing. For example, the assumption of profit maximisation or cost minimisation cannot be tested. For this reason, these assumptions can be retained as "tentative postulates" for there is no reason to assume that they are invalid because they cannot be tested.

After passing the verification of these two stages, the proposed model is subjected to the third stage of verification which consists of testing the model's ability to predict the behaviour of the system under study.

Various tests for prediction have been discussed by Naylor [65a, 66], Naylor and Finger [70], Naylor and Wannacott [72] and Van Horn [98]. The statistical techniques used ranged from the simple comparison of means, variances and graphical comparison of distribution of time behaviour to the most sophisticated spectral analysis.

For the present study, the third stage of the validation on the simulation model was to compare the average simulated value of the mean price, price variance, total supply and total income generated with the true historical values. The comparison of the two values was done by statistical t test and F test respectively for mean and variance. These simulated values after validation were used as a basis for comparison of different experimental values in the next section.

The results of the validation runs are presented in Tables 5.1 and 5.2.

TABLE 5.1 RESULTS OF VALIDATION RUN

Vegetable		Total Supply* (cases)	Supply variance**	Price variance	Mean price (dollars)	Total Income $	Income Variance
Cauliflowers							
	Simulated	141144.2	128932.6	0.69917+	1.5859	193115.3	34703.9
	Actual	137541.8	128008.6	0.3351	1.6253		
Cabbages							
	Simulated	150119.4	107655.7	0.77863+	1.2638	154796.3	400556.8
	Actual	149753.	97150.2	0.5176	1.2236		
Lettuces							
	Simulated	139424.2	189234.5	0.7825	1.7734	225009.8	798583.6
	Actual	135005.8	183768.1	0.7029	1.8112	226281.2	
Carrots							
	Simulated	93375.9	35269.6	0.5927	1.7779	174002.9	465477.9
	Actual		33551.3	0.4703	1.7673		

* 10 runs

** 5 runs

\+ Historical and simulated value significantly different at the 5 percent significance level.

TABLE 5.2 TEST OF SIGNIFICANCE

Vegetable	F value on supply variance	F value on price variance	t value on mean prices
Cauliflowers	1.007	2.086*	1.129
Cabbages	1.108	1.504*	1.488
Lettuces	1.02	1.219	0.031
Carrots	1.051	1.242	0.804

*Results significant from the historical value at 1% significance levels

Tables 5.1 and 5.2 show that the simulated values of the mean prices were not significantly different from the actual values at 95 percent of confidence level for all vegetables, while the simulated value of the supply and price variances were not sigificantly different from the actual series at the 1 percent significance level, with the exception of the price variances of cauliflowers and cabbages.

The results of the validation test showed that little difference from the historical values occurred except in two cases. The simulation model has been validated to an acceptable degree. Therefore experimentation with the model is carried out in the next sections.

5.4 Computer Simulation Experimental design

The fact that the computer simulation experimental design has received less attention than physical experimental design has been spelled out by Naylor, Burdick and Sasser [68, p.1315]. They pointed out the relationship between the existing experimental design techniques, techniques of data analysis and the design of computer simulation experiments by using the Samuelson-Hicks model [68, p.1317] as an example. There are four main problems of simulation experimental design that have been outlined and discussed by Burdick and Naylor [13], and Naylor, Burdick and Sasser [68]. They were :

1. The problem of stochastic convergence
2. The problem of factor selection
3. The problems of multi-response surface
4. The problem of motive.

Hunter and Naylor [44, p.423] pointed out that two types of experimental objectives could be identified. The first objective was to find the combination of factor levels at which the response variable was maximised (or minimised) in order to optimise some process, and the second was to make a general investigation of the relationship of the response to the factors in order to determine the underlying mechanism governing the process under study. These objectives must be clearly specified before the researcher selects the type of experimental designs.

The different techniques for both objectives have been discussed by Hunter and Naylor [14] including the full factorial design, the fractional factorial design, the rotatable design, the response surface design and others. For optimisation, techniques such as the one-factor-at-a-time method and the steepest descent or ascent method could be used.

The objectives for this study have been specified in chapter 1. To achieve these objectives, the full factorial design or the fractional factorial design could be used. The selection of experimental design is discussed in the next section.

5.5 Alternative short term marketing policies

The Simulation experiments involve two sorts of experimentations, namely, sensitivity analysis which is presented in this section, and policy evaluation in section 5.6 The sensitivity analysis aims to explore the sensitivity of the model established by varying the coefficients of the independent variables of the model. Each alternation of the coefficients can be interpreted in terms of the change in marketing policies.

The alternative marketing policies are concerned with control of the supply of fresh vegetables in the wholesale market. These were two factors which could be manipulated as referred to equation 5-3, namely the parameter of lagged (t-1) period price variable and lagged (t-2) period weather index variable. On the demand side, only one factor was considered. The factor was the parameter of the quantity variable (the term C_4Q in equation 5-4).

The marketing policies associated with these factors can be stated as follows:

1. Supply policies : the manipulation of supply was achieved through the adjustment of the lagged price (t-1) variable and the lagged (t-2) weather variable. The experimentation involves manipulation of the coefficients B_1 and B_2 in equation 5-3.[1]

Experimental levels of 100 percent decrease and 100 percent increase in the value of B_1 were chosen. The implication of 100 percent increase in B_1 was that the supply policies of the growers were not dependent on any lagged price influence[2]. Conversely, the increase of 100 percent in the factor value implied an increased price sensitivity by growers.

The factors B_2 was manipulated at two levels that were 10 percent increased or decreased. Here the assumption was that the improvement of technology, such as utilisation of the glasshouse, etc., could technically change the weather index value. The supply policies were imposed to investigate the various impacts on price variances, mean prices and total gross income of the growers.

2. Demand Policy: the manipulation of the demand policy is through the retailers changing their margin policy so that the price elasticity of demand at the wholesale level would be more elastic or the price flexibility lower and vice versa.

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1. The definitions of B_1, B_2 and C_4 have been specified in Chapter 4, section 4.3.
2. 100 percent decreased in B_1, i.e. $B_1 = -x-(-x) = 0$
3. More detailed discussion of the influences of marketing margins on price elasticity can be obtained in Chapter 2.

From equation 5-4 the price flexibility can be deduced as follows:

$$f = \frac{dp}{dQ} \frac{\overline{Q}}{\overline{p}}$$

$$= C_4 \, \theta \qquad (5\text{-}7)$$

where

f = price flexibility

$\overline{Q}$ = the mean quantity

$\overline{p}$ = the mean price

θ = a constant.

If the price flexibility was to be increased or decreased the factor C_4 was subjected to manipulation under the experimentation.

The value of C_4 was varied at two levels i.e. increased or decreased by 20 percent.

5.5.1 The experimental design for short term marketing policies

The full factorial design involving 3 variables and 3 levels, a total of 3^3 = 27 cells was required for each fresh vegetable. For four vegetables 108 cells were required. If five computer runs were assigned for each cell (combination) a total of 540 computer runs was needed. In view of this problem, a selected fractional factorial experimental design technique was employed as follows:

Policy 1 involved two experiments in which the values of B_1 were decreased and increased by 100 percent (Experiments Nos.1 and 2 respectively in Table 5.5) while the rest of the factors remained constant.

Policy 2 consisted of two experiments in which the values of B_2 were decreased and increased by 10 percent, other factors remaining constant (Experiments 3 and 4).

Policy 3 embodied two experiments in which the values of C_4 were decreased and increased by a 20 percent level (Experiments 5 and 6).

Policy 4 was the exploration of the two extreme factor levels, that is - 100 percent, - 10 percent and - 20 percent for factors B_1, B_2 and C_4 respectively in experiment No.7, while the last experiment explored the positive levels of the combination of the above three factors.

5.5.2 Correction Factors

Experimentation involving changes in the values of the coefficients associated with the independent variables in equations (5-3) and (5-4) will obviously affect the value of the dependent variable. For example, in the supply equation (5-3), decreasing the absolute value of B_1, (the coefficient of P_{t-1}) will have the impact of increasing the value of SU_t in any period. The aggregate supply of vegetables over the three-year period will also be increased. For experimental purposes, it is desirable to maintain the aggregate supply at a constant level as, in the case of the coefficient B_1, we are concerned only with the impact of changes in the growers' short term response to price. A similar argument applies for experimentation with other coefficients.

In general, if we have a functional relationship of the form:

$$Y_t = A + B_1X1_t + B_2X2_t + \dots + B_iXi_t + \dots B_nXn_t$$

and we experimentally vary the coefficient B_i from its original value to a new value B_i^1, the appropriate correction factor is $\bar{X}_i(B_i \mp B_i^1)$ where $\bar{X}_i$ is a mean value. This correction factor will be added for each simulation period.

The correction factors are W, D, E, H, F and G, where

$W = (B_1 - B_1^1)$
D = the mean value of P_{t-1}
E = the value of $(B_2 - B_2^1)$

H = the mean value of W_t (the index of weather)
F = the value of $(C_4 - C_4^1)$
G = the mean value of Q_t

The series of the above new coefficient inputs (M, D, E, H, F and G) for various fresh vegetables are listed in Appendix G.

The results of the experimentation on the four short term marketing policies are presented and discussed in the next section.

5.5.3 Simulation

The experimental simulation of the four short-term marketing policies were divided into eight experiments. Each of them was simulated for 5 replications except the variances of prices, and mean prices which were calculated for 10 replications over the historical period. The results are presented in Table 5.5 while the summary of the results is listed in Table 5.6.

5.5.4 Discussion of Results

a) Policy 1.

This policy involves experimentation with the B_1 coefficient relating supply with price in the previous period. In Experiment 1, the value of B_1 is set at zero while experiment 2 involves doubling the absolute value of B_1.

It would be expected that decreasing the dependence of supply on the lagged price would decrease the supply and price variances. In general, the results support this hypothesis, with the exception of carrots in which case the variance of supply is increased both with an increase or decrease in the value of B_1.

The growers' gross income (AI) is increased by setting B_1 equal to zero in the case of cauliflower and cabbages. This is as expected, as the more inelastic the demand, the greater the expected impact of reducing the variance of vegetable supplies on aggregate income. (The elasticities are -0.5034 and -.8142 for cabbages and cauliflower respectively. See Table 4.4). On the other hand, the gross income for lettuce, which has both a positive supply response to price lagged one period and an elastic demand, is decreased by setting B_1

equal to zero.

The unweighted mean price is increased by setting the value of B_1 equal to zero in all cases except carrots.

In general, it can be said that a more event pattern of supply would be of benefit to producers in terms of reducing price variance and increasing gross income. However, it should be pointed out that, with the exception of the unweighted mean price for cauliflower, the differences between the experimental treatments and the control were not statistically significant ($\alpha = .05$). This situation could be altered with a larger sample, but basically it reflects the fact that lagged prices play a relatively small role in determining supplies to auction.

b) Policy 2.

This policy involves experimentation with the B_2 coefficient which relates supply to climatic conditions. Experimental variation in the value of B_2 could reflect possible technological changes in vegetable production.

The results of changing B_2 by plus and minus 10 percent are singificantly different from the validation run. In general, direction of the impact on supply and price variance is as expected. That is, the smaller the absolute value of B_2, the smaller the variance of price and income. However, only the case of cabbage, which has the most inelastic demand of the four vegetables studied, was the growers gross income increased by decreasing the absolute value of B_2.

c) Policy 3

Policy 3 involves experimentation with the C_4 coefficient which relates price to quantity supplied in the demand equation. Experiment 5 decreases the absolute value of the C_4 coefficient by 20 percent implying a lower price flexibility and a more elastic demand. Experiment 6 involves increasing the absolute value of C_4 by the same proportion.

Other things being equal, we would expect a more elastic demand to result in a reduction in price variance for a given pattern of supplies. This hypothesis is born out by the results for all four vegetables. However, as quantity supplied is dependent on price lagged by one period, the supply pattern does, in fact, change. In the case of cauliflower and cabbage, the supply variance decreases with a resultant increase in growers' gross income. In the case of lettuce and carrots, there is an increase in the variance of supply and a decrease in gross income.

However, while the results are, in general, as would be expected on the basis of economic theory, there are some exceptions. For example, both an increase and a decrease in the elasticity of demand for cabbages result in a decrease in price variance and an increase in growers' gross income. This is a reflection of the fact that the components of the simulation model inter-act in a complicated and sometimes unpredictable way. It should also be recognised that unexpected results may be due simply to sampling error as none of the differences are statistically significant at the 5 percent level.

d) Policy 4.

This policy involves reducing the impact of both lagged price and weather on vegetable supplies while increasing the elasticity of demand for vegetables. The changes in the supply equation would be expected to reduce price and income variance and to increase gross income. Increasing the elasticity of demand would tend to decrease price variance and decrease the impact of the reduction in the variance of supply on gross income. The results in Tables 5.5 and 5.6 support these hypotheses.

TABLE 5.5 SIMULATION RESULTS

1. CAULIFLOWER

POLICY**	Results summary[2] Expt.No.**	VAR S[2]	DC[3]	VAR P[2]	DC	AMP[2]	DC	WMP[2]	DC	AI[2]	DC	VAR I[2]	DC
1	1	128008.6	-	0.6109	-	1.6584*	+	1.4653	+	201991.3	+	366614.7	-
	2	214859.8	+	0.9623	+	1.6044	+	1.2041	-	167525.7	-	403094.5	+
2	3	128255.1	-	0.6802	-	1.6142	+	1.3434	-	188180.1	-	396465.7	+
	4	138895.2	+	0.7415	+	1.7196	+	1.4974	+	194194.5	+	381208.6	+
3	5	118845.8	-	0.5860	-	1.6801	+	1.4675	+	206054.3	+	396185.3	+
	6	170503.6	+	0.9756	+	1.7633	+	1.3441	-	181779.6	-	296290.7	-
4	7	93414.6	-	0.4860	-	1.5901	+	1.4918	+	206522.3	+	360003.9	+
	8	217790.7*	+	1.0317*	+	1.6479	+	1.3159	-	178836.4	-	249877.4	-

** Policy and Experiments Nos. refer back to section 5.5.1

2 VAR S = the variance of supply
VAR P = the variance of prices
AMP = the unweighted mean price
AI = Growers' gross income
VAR I = the variance of gross income
Also see computer programme in Appendix F & H
WMP = the weighted mean price

D.C. = the direction of change of the experimental result compared with the base run

* Differs from the validated values

+ and - indicate the direction of change of the result, more than and less than the validated value.

TABLE 5.5 (continued) 2. CABBAGES

	Results summary[2]	VAR S^2	DC	VAR P^2	DC	AMP[2]	DC	WMP[2]	DC	AI[2]	DC	VAR I^2	DC
POLICY**	EXPT.NO.**												
1	1	90015.5	-	0.7102	-	1.2724	+	1.0138	-	157071.6	+	420641.7	+
	2	132518.6	+	0.8855	+	1.2406	-	0.9684	-	146578.8	-	430862.5	+
2	3	102666.1	-	0.7539	-	1.2641	+	1.0487	+	158106.2	+	430512.5	+
	4	102039.9	-	0.8069	+	1.2739	+	1.0564	+	158194.4	+	423211.7	+
3	5	100848.7	-	0.6361	-	1.1878	-	1.0491	+	157944.6	+	442486.3	+
	6	107880.2	+	0.7742	-	1.4267	+	1.2022	+	176324.9	+	270805.2	-
4	7	87443.9	-	0.5947	-	1.2100	-	1.0889	+	162843.5	+	457713.1	+
	8	141463.5	+	0.8717	+	1.4716	+	1.1739	+	169927.4	+	243920.9	-

2, **, + and - have been defined in Page 87

TABLE 5.5 (continued) 3. LETTUCES

Results summary[2] POLICY**	EXPT. NO.**	VAR S^2	DC	VAR P^2	DC	AMP^2	DC	WMP^2	DC	AI^2	DC	VAR I^2	DC
1	1	179997.8	-	0.7578	-	1.7959	+	1.5913	+	220431.2	-	766782.4	-
	2	249318.8	+	0.9098	+	1.8036	+	1.4309	-	204804.6	-	753710.3	-
2	3	198340.3	+	0.8256	+	1.7430	-	1.5619	+	216874.2	-	754372.7	-
	4	205001.1	+	0.8094	+	1.8413	+	1.6010	+	217702.5	-	798010.9	-
3	5	196869.2	+	0.7159	-	1.7128	-	1.5309	+	217830.3	-	749696.0	-
	6	209786.1	+	0.8854	+	1.8259	+	1.5195	+	206926.4	-	623451.4	-
4	7	165132.6	-	0.6649	-	1.7877	+	1.6833	+	231903.6	+	832518.8	+
	8	251449.4	+	1.0203	+	1.7536	-	1.3889	-	200291.7	-	677217.4	-

2, **, + and - have been defined in the previous page.

TABLE 5.5 (continued) 4. CARROTS

POLICY**	Results summary[2] EXPT.NO.**	VAR S[2]	DC	VAR P[2]	DC	AMP[2]	DC	WMP[2]	DC	AI[2]	DC	VAR I[2]	DC
1	1	37774.7	+	0.5857	-	1.7588	-	1.8607	-	173842.1	-	488570.5	+
	2	37572.9	+	0.5875	-	1.8057	+	1.8870	+	174101.3	+	481928.1	+
2	3	33822.9	-	0.5566	-	1.7701	-	1.8581	-	172489.7	-	474872.4	+
	4	33721.7	-	0.5551	-	1.7843	+	1.8686	+	173286.7	-	470503.5	+
5	5	36704.1	+	0.5508	-	1.7747	-	1.8418	-	171627.4	-	446518.7	-
	6	34904.4	-	0.6148	+	1.7662	-	1.8867	+	177647.6	+	508427.6	+
4	7	35388.8	+	0.5445	-	1.7921	+	1.8589	-	172738.8	-	453989.1	-
	8	36600.0	+	0.6245	+	1.7759	-	1.8916	+	176816.7	+	555328.6	+

2, **, + and - have been indicated in Page 87.

TABLE 5.6 THE SUMMARY OF THE RESULTS

Policy		AI		VAR S		VAR P		AMP		WMP	
	Experiment No	1	2	1	2	1	2	1	2	1	2
	Cauliflower	+	-	-	+	-	+	+	+	+	-
1	Cabbages	+	-	-	+	-	+	+	-	-	-
	Lettuces	-	-	-	+	-	+	+	+	+	-
	Carrots	-	+	+	+	-	+	-	+	-	+
	Experiment No.	3	4	3	4	3	4	3	4	3	4
	Cauliflower	-	+	-	+	-	+	+	+	-	+
2	Cabbages	+	+	-	-	-	+	+	+	+	+
	Lettuces	-	-	+	+	+	+	-	+	+	+
	Carrots	-	-	-	-	-	-	-	+	-	+
	Experiment No.	5	6	5	6	5	6	5	6	5	6
	Cauliflower	+	-	-	+	-	+	+	+	+	-
3	Cabbages	+	+	-	+	-	-	-	+	+	+
	Lettuces	-	-	+	+	-	+	-	+	+	+
	Carrots	-	+	+	-	-	+	-	-	-	+
	Experiment No.	7	8	7	8	7	8	7	8	7	8
	Cauliflower	+	-	-	+	-	+	-	-	+	-
4	Cabbages	+	+	-	+	-	+	+	+	+	+
	Lettuces	+	-	-	+	-	+	+	+	+	-
	Carrots	-	+	-	+	-	+	+	+	-	+

5.5.5 Conclusions from Sensitivity Analysis Experiments

The results in Table 5.5 and 5.6 suggest that the five performance parameters of the simulation model are not very sensitive to changes in the coefficients of the independent variables of the model. Even in experiments 5 and 6, which involved a combination of extreme changes for three parameters, the results of the experimental runs did not differ significantly from the control.

From a policy point of view, the most valuable type of experiment involves evaluating the impact of a supply pattern for which the variation in vegetable supplies to the Palmerston North auctions is set at a minimum level consistent with seasonal and other constraints. This experimentation is discussed in the next section.

5.6 The Rationalisation of Supply

5.6.1 The Experimental Design

The effect of rationalisation of supply through market cooperatives has been discussed in chapter 1. Although the concept of market cooperatives has been discussed in many texts, in the context of the New Zealand fresh vegetable market no evidence of its existence could be found. In order to investigate its impact on prices and growers gross income, the simulation program was conducted on the past historical data by manipulating the supply data as follows:

For the sake of simplicity one of the fresh vegetables - cabbages - was examined under several assumptions.

1. The rationalisation of supply only restricted to main suppliers, who are, in the present context, defined as the growers who supply the local wholesale market continunously for more than 6 weeks within a quarter. A list of the main suppliers and their

percentage of total supplies for each quarter has been compiled in Table 5.7.

2. The supplies which commenced in the last 3 or 4 weeks of the one quarter for the main suppliers, were not taken into consideration.

3. The market cooperatives, if they were able to be established, would enable smoothing out of the supplies by supply control, cold storage for short periods, transfer of supplies to other centres, and by spreading the harvesting season for as long as possible within the period being simulated. In this sense, the supply data series was reorganised by averaging the main supplier's consignment within each quarter according to the assumption specified above.

Then the computer simulation programme was modified to suppress the generation of the random disturbance term U_t. The modified programme entitled VEGO 2 is shown in Appendix H.

5.6.2 Results and Discussion

The objective of this experiment was to determine the rationalisation of the supply on prices, supply and incomes for cabbages. Since the objectives are to minimise variation in price, vegetable supplies and/or income, the direction of change for supply and price variance to increase gross income, should be negative compared with the validated values. When the variances of price and supply are decreased, the income and unweighted mean price should be increased (compared with the validated values). The results are presented in Table 5.8.

It is obvious that all the variances of supply and price are negative compared with the validated values indicating that the fluctuations of the above factors could be smoothed out, if the rationalisation of the supply could be achieved through the market cooperation. The price variation could be reduced by approximately 18 percent and the supply variance by as much as 45 percent. On the other hand, the gross income and unweighted mean price are positively increased by 8.7 percent and 0.3 percent respectively.

TABLE 5.7 THE PATTERN OF SUPPLY FOR THE MAIN SUPPLIERS

	1969/70				1970/71				1971/72			
	Percentage of the total supply in each quarter											
Quarters / Growers	1	2	3	4	1	2	3	4	1	2	3	4
No.1	4.3	5.8	2.5	12.1	2.4	9.9	5.5	6.9	2.3	5.2	5.2	5.6
2	3.7	5.2	5.3	3.8	7.8	6.1	6.9	4.7	-	7.8	8.1	5.7
3	4.3	2.1	2.0	-	2.4	-	2.7	5.5	-	-	-	-
4	8.7	4.9	3.5	5.3	6.8	2.4	1.7	2.9	4.0	1.6	3.9	2.7
5	6.8	9.6	4.7	-	-	-	-	-	-	-	2.5	-
6	7.3	3.6	-	18.2	10.6	7.7	9.5	11.8	8.9	2.1	5.9	3.5
7	3.8	-	-	3.4	3.2	-	2.5	7.7	19.5	6.9	3.0	16.0
8	1.4	-	-	4.9	1.7	-	-	-	-	-	-	-
9	2.9	-	2.8	3.6	2.9	-	-	3.3	1.8	0.8	3.1	4.7
10	7.9	4.7	6.2	-	-	10.3	8.1	-	5.0	7.6	2.9	2.8
11	6.6	6.4	3.7	-	5.3	1.7	-	11.4	3.2	4.4	5.4	-
12	12.1	7.2	4.2	-	-	18.2	5.7	-	-	-	-	-
13	5.8	-	-	6.6	2.5	-	1.7	2.9	6.5	10.4	7.5	3.0
14	3.2	4.0	3.8	10.5	3.9	6.2	3.2	4.1	6.9	11.1	-	2.7
15	4.8	3.3	-	-	-	-	-	-	-	-	-	-
16	-	4.6	5.3	9.9	3.3	-	2.0	3.3	3.6	5.4	-	-
17	-	4.6	-	-	-	-	-	-	-	-	-	-
18	-		6.4	-	15.1	9.5	2.9	-	5.2	11.7	-	-
19	-	3.7	-	-	-	-	-	-	-	-	-	-
20	-	7.9	5.2	-	4.1	3.4	3.7	5.4	-	-	-	3.6
21	-	3.9	4.1	-	-	3.4	5.0	-	-	-	6.1	-
22	-	-	1.3	0.9	-	-	-	4.7	5.1	-	-	4.9
23	-	-	1.9	-	2.6	-	-	3.4	1.8	-	-	-
24	-	-	6.6	-	-	-	5.6	-	-	-	6.9	-
25	-	-	1.4	-	-	-	-	-	-	-	-	-
26	-	-	-	2.0	5.1	1.5	-	-	-	-	-	-
27	-	-	-	3.3	1.0	-	-	0.7	-	-	-	-
28	-	-	-	-	4.3	3.5	1.8	-	-	-	2.2	2.9
29	-	-	-	-	5.1	2.3	-	-	-	-	-	-
30	-	-	-	-	-	2.6	2.1	-	-	-	-	1.7
31	-	-	-	-	-	-	6.5	5.7	-	-	2.6	2.5
32	-	-	-	-	-	-	3.2	9.5	5.7	6.6	4.7	8.3
33	-	-	-	-	-	-	1.9	-	-	-	-	-
34	-	-	-	-	-	-	5.4	-	-	-	-	-
35	-	-	-	-	0.6	-	-	-	-	2.5	-	-
36	-	-	-	-	-	-	-	-	2.3	2.6	-	-
37	-	-	-	-	-	-	-	-	-	0.9	1.7	-
38	-	-	-	-	-	-	-	-	-	-	5.8	3.5
39	-	-	-	-	-	-	-	-	-	-	1.9	3.7
40	-	-	-	-	-	-	-	-	-	-	-	8.6
Total % supply	83.6	92.6	70.9	84.5	90.7	88.7	87.6	93.9	81.8	87.6	79.4	86.4
No.main suppliers	15	17	18	13	20	15	21	17	15	16	18	18

TABLE 5.8 THE RESULT OF RATIONALISATION OF SUPPLY FOR CABBAGE

	VAR S	D.C.	VAR P	D.C.	A.M.P.	D.C.	W.M.P.	D.C.	A.I	D.C.	VAR I.	D.C
Experimental result	59421.5	-	0.6165	-	1.2489	+	---	---	168205.3	+	384108.7	-
Simulated validated value	107655.7		0.7488		1.2451		---	---	154796.3		400556.8	

Where Var S = the supply variance

Var P = the price variance

AMP = the unweighted mean price (per week)

WMP = the weighted mean price (per case per week)

AI = the sum of gross income (dollars)

Vár I = the income variance

D.C. = direction of changes

The conclusion which can be drawn from this experiment is that the rationalisation of supply is a satisfactory way to iron out price fluctuations and improve the gross return to the fresh vegetable growers if the market cooperative can be established.

5.7 Summary and Conclusion

This chapter outlined the construction of a computer simulation model from the existing econometric model. The validation of the simulation model was discussed and the results were presented. Three alternative short term marketing policies (i.e., two supply policies and a demand policy) and a rationalisation of the supply policy were tested and outlined in the third section. The results were presented in section 4.

In general, the results showed that the model was insensitive to changes in the parameters of its component equations. While the direction of changes in the performance parameters of the system were usually as expected, the results were not statistically significant when compared with the validation run.

The policy of rationalisation of the supply through market cooperatives was shown to be a satisfactory way to iron out price fluctuations and improve the gross return to fresh vegetable growers. However, this was based on the assumption that such cooperatives were able to be established.

CHAPTER 6

SUMMARY AND CONCLUSIONS

In Chapter 1 the principal objectives of this thesis were stated to be : the estimation of the short-term supply and demand relationships for fresh vegetables at auction; the determination of the effects on prices and growers' gross incomes of various short-term supply policies.

The study commenced with a description of the fresh vegetable industry and its problems (chapter 1). The classical cobweb theorem and causes of the price fluctuations relevant to this study were outlined in chapter 2. These provided a basic framework for selecting suitable techniques in model building which was discussed in chapter 3. The selected techniques involved a recursive econometric model for inductive phase of model building while simulation was applied in the deductive phase.

Chapter 4 developed an econometric model used to explain the past behaviour of the short term demand and supply relationships. It showed that the wholesale demand for cabbages and cauliflowers is relatively inelastic while that of lettuces was elastic. Carrots showed non-significant positive relationship between quantity purchased and price.

In the last chapter, the impact of variation in the parameters of the component equations of the model was studied. The model was relatively insensitive to changes in its parameters. It was proved that the supply of fresh vegetables was mainly governed by the seasonal factors. The above arguments lead to the following general conclusions:

1) Prices and income fluctuations in the fresh vegetable industry are supply-induced;
2) An attempt to reduce the fluctuation in fresh vegetable prices and growers' income should probably be done by manipulating the quantities of fresh vegetables released to the auction market.

The last of the above two conclusions was further confirmed by experimenting with a technically feasible rationalisation of supply policy. The result indicated that, if the marketed volume could be regulated by the marketing cooperatives, the price variance and supply variance would be reduced by 18% and 45% respectively, and the gross income and unweighted mean price increased by 8.7% and 0.3% respectively.

A further study of the feasibility of organising a market cooperative in this field is required.

APPENDIX A.1

THE NEW ZEALAND
FRESH VEGETABLE PRODUCTION AND ACREAGE STATISTICS

TABLE 1 VEGETABLES - PRODUCTION FOR FRESH MARKET
(tons)

	1965	1966	1967	1968	1969	1970
Asparagus	162	153	308	294	256	285
Beans - green	746	786	881	1,032	1,026	1,129
Beetroot	1,942	2,209	2,191	2,193	2,371	2,009
Brussels Sprouts	1,175	1,182	1,239	1,099	1,128	1,231
Cabbage	24,144	24,963	24,168	23,954	32,173	30,406
Carrots	21,400	21,589	22,332	22,447	28,610	30,270
Cauliflower	15,765	25,610	25,943	26,449	26,724	25,875
Celery	2,581	2,799	3,078	3,478	4,810	3,705
Cucumbers[1]	1,935	2,023	1,025	1,180	1,037	1,048
Kumaras	4,902	5,083	5,624	6,322	7,259	8,095
Lettuce	11,943	13,046	14,098	13,866	15,931	13,905
Onions	20,668	20,356	24,664	25,643	35,678	30,695
Parsnips	3,735	3,638	4,609	4,832	7,516	6,605
Peas	731	601	609	552	760	572
Sweet corn	1,036	858	267	407	639	592
Tomatoes[2]	20,015	18,224	19,487	21,424	20,017	23,117

This table does not include production for processing.

1. 1965 and 1966 outdoor plus glasshouse production. Other years glasshouse production only.

2. Outdoor plus glasshouse production.

TABLE 2 VEGETABLES - NET AREAS GROWN FOR FRESH MARKET
(OUTDOOR CROPS)
(acres)

	1965	1966	1967	1968	1969	1970
Asparagus	154	133	269	147	164	191
Beans - green	226	232	264	302	296	330
Beetroot	206	209	234	238	262	223
Brussels Sprouts	286	285	297	299	308	324
Cabbage	2,662	2,614	2,865	2,894	3,664	3,236
Carrots	1,575	1,687	1,780	1,785	2,420	2,366
Cauliflower	2,751	2,914	2,987	3,036	3,187	3,199
Celery	137	166	182	202	295	232
Kumaras	932	987	965	993	1,192	1,100
Lettuce	1,405	1,492	1,611	1,667	1,824	1,869
Onions	1,817	1,722	2,154	2,275	2,867	2,527
Parsnips	383	405	461	471	788	758
Peas	295	244	270	289	354	332
Sweet corn	241	230	71	97	177	182
Tomatoes	495	526	645	672	612	754

This table does not include areas gorwn for processing nor areas of glasshouses.

Source: N.Z.D.A. Horticulture Statistics (1971)

APPENDIX A.2

THE NEW ZEALAND FRESH VEGETABLES TRADE STATISTICS

TABLE 1 EXPORT OF FRESH VEGETABLES (tons)

Vegetable	1966	1967	1968	1969	1970
Potatoes	14,978	6,205	5,079	6,568	9,794
Tomatoes	49	36	76	130	180
Onions	2,850	4,812	9,848	4,230	9,615
Other	539	307	496	934	953
TOTALS					

Source : N.Z.External Trade statistics

TABLE 2 FRUIT AND VEGETABLES HANDLED BY VARIOUS TYPES OF RETAIL STORES AND SERVICE ESTABLISHMENTS

Type of Store	Number of stores handling commodity				Sales and turnover of commodity			
	1963		1968		1963		1968	
	No.	Percent	No.	Percent	Amount ($000)	Percent	Amount ($000)	Percent
Fruit & Vegetable shop	1135	20.4	1064	21.6	27,820	61.3	30,451	56.5
Grocery	3161	56.7	2724	55.4	8,568	18.9	4,697	27.3
Variety store	47	0.9	74	1.5	1,102	2.4	3,044	5.6
Dairy	481	8.6	404	8.2	1,450	3.2	1,612	3.0
General store	390	7.0	327	6.6	1.908	4.2	1,270	2.3
Other	363	6.4	331	6.7	4,532	10.0	2,842	5.3
TOTALS	5577	100.0	4924	100.0	45,380	100.0	53,916	100.0

Source : N.Z.Department of Statistics, "1963-1968 Census of Distribution", Government Printer, Wellington.

APPENDIX B

THE DATA

		CABBAGES			CAULIFLOWERS		LETTUCES		CARROTS	
Year	Week	W_t	P_t	SU_t	P_t	SU_t	P_t	SU_t	P_t	SU_t
1969	1	20.45	.75	870	.87	1286	.59	1031	.96	317
	2	14.22	.69	728	.72	1016	.51	889	1.08	582
	3	14.52	.95	741	.69	1222	.25	815	1.28	690
	4	0.00	.64	907	.53	1203	.65	405	.87	695
	5	12.98	.88	1078	.85	1562	.66	581	.80	651
	6	12.15	1.08	988	1.20	1239	1.09	402	.98	471
	7	14.42	.74	1238	.82	1454	1.31	484	1.10	537
	8	12.12	.41	1297	1.02	1048	1.38	474	.87	606
	9	3.00	.55	1355	.63	1919	1.34	506	1.08	487
	10	4.20	.47	1119	1.40	969	1.98	273	1.12	564
	11	2.79	.38	956	1.35	988	3.27	185	1.08	748
	12	1.66	.83	1006	1.71	1269	3.06	285	1.11	589
	13	.57	1.14	1097	1.85	1050	3.75	239	1.10	612
	14	5.01	.84	1243	1.53	1551	3.97	223	1.09	534
	15	0.00	.81	1144	1.23	1437	3.43	271	.92	658
	16	.15	1.04	958	1.33	1197	2.96	325	1.13	442
	17	4.40	.99	1227	1.64	1200	2.78	321	1.18	573
	18	1.38	.84	1159	1.60	1008	2.06	341	1.01	667
	19	7.68	.71	1213	1.22	1002	2.57	333	.94	610
	20	9.78	.54	1129	.97	1474	2.37	385	1.16	600
	21	3.95	.58	1104	.77	1320	2.26	476	1.06	594
	22	8.98	.64	1149	1.23	938	1.70	568	1.07	601
	23	14.61	.61	1086	1.04	1217	1.37	987	1.07	789
	24	11.30	.85	801	.74	1258	1.93	1194	1.00	647
	25	10.81	.48	1343	.87	1048	1.50	1028	1.50	540
	26	11.71	.75	900	1.65	724	1.61	1098	1.63	811

Year	Week	CABBAGES W_t	CABBAGES P_t	CABBAGES SU_t	CAULIFLOWERS P_t	CAULIFLOWERS SU_t	LETTUCES P_t	LETTUCES SU_t	CARROTS P_t	CARROTS SU_t
1969(cont)										
	27	9.26	1.13	1632	1.28	1678	.95	1644	1.24	1047
	28	6.90	1.22	944	1.83	804	.73	848	1.31	556
	29	12.14	1.21	1146	1.67	891	.71	1585	1.38	951
	30	11.84	1.44	1239	1.23	1423	.85	1389	1.55	896
	31	11.91	1.20	1246	.88	1047	1.19	1039	1.34	722
	32	15.74	.73	1122	.87	952	1.02	1599	1.39	790
	33	27.16	.48	1123	.79	1120	1.08	1570	1.07	994
	34	17.00	.54	1109	.96	1037	1.06	1311	1.14	1159
	35	20.96	.55	927	1.13	859	1.07	1203	1.23	1086
	36	20.54	.77	574	.92	815	1.03	1031	1.01	521
	37	24.19	.92	672	1.20	574	1.12	1323	.94	719
	38	24.15	.87	530	1.60	894	.90	1538	1.51	463
	39	11.18	1.94	358	1.21	621	1.37	923	1.18	434
	40	26.83	2.17	124	2.06	245	1.80	1104	1.35	233
	41	21.53	2.10	394	1.82	359	1.62	1394	1.31	789
	42	23.45	1.98	708	1.81	326	1.59	1013	.93	582
	43	29.43	1.73	414	1.71	457	2.03	1228	1.27	371
	44	19.29	2.50	496	2.34	378	1.43	1049	.68	726
	45	20.59	3.89	362	2.11	472	1.92	998	1.25	360
	46	20.44	3.80	406	1.88	567	2.42	948	.96	218
	47	24.42	3.71	451	1.65	661	2.92	897	1.11	121
	48	23.64	3.62	495	1.91	515	2.26	1168	1.56	365
	49	28.81	2.83	571	1.87	609	2.43	863	1.72	467
	50	22.88	4.03	364	2.08	562	3.06	528	2.06	384
	51	20.96	3.15	336	1.67	827	2.71	564	1.95	516
	52	21.12	2.89	635	1.75	853	2.36	599	2.21	447

Year	Week	CABBAGES W_t	CABBAGES P_t	CABBAGES SU_t	CAULIFLOWERS P_t	CAULIFLOWERS SU_t	LETTUCES P_t	LETTUCES SU_t	CARROTS P_t	CARROTS SU_t
1970	1	19.38	2.21	707	2.47	772	2.36	635	2.14	421
	2	16.35	1.54	942	3.02	559	2.01	671	1.62	622
	3	13.46	1.80	970	2.80	635	1.66	700	1.25	643
	4	16.21	1.09	1040	2.62	686	1.31	707	1.17	547
	5	11.87	1.35	906	2.13	831	1.13	535	1.49	413
	6	7.65	1.21	854	1.29	1100	1.47	405	1.83	480
	7	12.35	.94	922	.79	1211	2.05	440	2.28	504
	8	6.65	.77	1220	1.40	793	1.72	367	1.23	688
	9	4.21	.90	1131	2.34	562	1.31	456	2.14	404
	10	6.14	.76	1103	2.04	617	1.31	290	1.75	510
	11	5.54	.66	1168	1.84	575	1.40	358	1.69	548
	12	5.14	.67	1201	1.65	533	1.50	330	1.59	645
	13	14.46	.52	1416	1.34	934	1.59	302	1.49	752
	14	8.89	.58	965	1.22	1107	1.39	376	1.46	674
	15	4.84	.57	1121	1.27	979	1.05	436	1.51	653
	16	6.20	.66	1078	1.33	1057	1.13	384	1.32	335
	17	7.64	.63	972	1.12	987	1.39	432	2.19	399
	18	5.38	.52	980	1.31	616	1.21	328	1.85	632
	19	6.40	.60	937	1.22	1076	.82	868	1.94	523
	20	6.79	.82	991	1.11	1185	1.45	608	1.75	612
	21	5.31	.90	970	1.16	1193	1.60	633	1.61	689
	22	11.46	.64	1024	1.08	1315	1.68	664	1.83	566
	23	11.67	.81	925	1.10	1109	2.67	658	1.94	554
	24	10.65	1.21	831	1.47	885	2.96	813	2.16	704
	25	9.39	1.37	885	1.69	751	2.11	1042	2.14	579
	26	8.99	1.54	939	2.16	859	2.06	819	2.63	586

Year	Week	CABBAGES W_t	CABBAGES P_t	CABBAGES SU_t	CAULIFLOWERS P_t	CAULIFLOWERS SU_t	LETTUCES P_t	LETTUCES SU_t	CARROTS P_t	CARROTS SU_t
1970 (cont)										
	27	14.62	1.70	993	3.19	282	2.39	1033	3.53	738
	28	10.41	2.60	991	2.16	448	2.98	755	2.66	853
	29	12.09	1.64	1219	2.27	448	4.70	785	2.00	638
	30	16.15	1.22	1309	1.71	939	4.20	1166	3.62	587
	31	18.26	1.44	1396	1.79	683	3.44	992	2.91	738
	32	13.38	1.48	969	2.28	719	2.53	1079	2.66	620
	33	20.36	1.94	909	2.01	538	1.56	1555	2.45	546
	34	19.67	2.17	782	2.68	666	2.09	1451	2.74	679
	35	14.19	1.45	769	2.04	556	2.45	1177	2.86	642
	36	19.88	2.40	589	1.85	628	2.42	1070	2.61	698
	37	18.44	1.41	734	1.97	628	1.01	1560	2.61	508
	38	18.43	1.22	516	1.61	673	.80	1659	2.69	639
	39	21.28	1.18	588	1.51	571	.74	1547	2.36	470
	40	22.73	1.18	640	1.28	522	.88	1064	2.04	394
	41	18.19	1.16	567	1.23	495	.87	1121	2.38	298
	42	22.89	.68	520	1.95	701	1.25	1244	1.56	972
	43	25.63	.62	691	1.71	373	2.38	1213	.69	629
	44	25.15	1.13	474	1.58	387	2.44	1008	1.25	399
	45	19.99	1.10	645	2.01	427	1.63	1200	1.66	446
	46	26.29	1.11	816	1.94	164	1.79	1072	1.90	408
	47	27.48	1.08	988	1.86	348	1.82	917	2.13	500
	48	18.44	.73	852	1.79	531	1.85	995	2.42	375
	49	17.19	.73	852	2.07	463	1.89	840	2.59	633
	50	20.66	1.19	821	2.01	586	3.46	597	1.61	662
	51	22.26	1.51	904	1.95	709	3.21	685	1.45	618
	52	23.86	1.34	862	1.86	655	2.96	7772	1.29	394

		CABBAGES			CAULIFLOWERS		LETTUCES		CARROTS	
Year	Week	W_t	P_t	SU_t	P_t	SU_t	P_t	SU_t	P_t	SU_t
1971	1	11.57	1.15	904	2.07	598	2.17	912	2.07	402
	2	15.91	1.17	942	2.15	552	3.23	578	1.73	465
	3	17.14	1.55	803	1.12	1017	3.37	724	1.86	453
	4	18.71	1.60	1059	.77	1600	2.61	375	1.76	664
	5	16.25	1.17	1338	.63	1597	1.29	712	1.45	550
	6	8.81	1.20	1250	1.19	1144	1.32	532	1.36	457
	7	15.02	.47	1463	1.53	1266	1.17	528	1.50	554
	8	6.05	.76	1858	1.86	994	1.91	543	1.16	643
	9	12.30	.98	1390	1.70	1122	2.92	385	1.08	586
	10	15.24	.93	1632	.97	1468	3.99	327	1.07	917
	11	9.40	.88	1444	.99	1488	2.73	341	1.26	420
	12	8.91	.70	1581	1.50	1394	3.17	335	1.61	485
	13	6.81	.80	1417	1.18	1599	2.78	352	1.43	705
	14	2.63	.81	1593	1.53	1071	2.96	392	1.40	626
	15	0.00	.75	1817	2.50	771	2.29	344	1.57	651
	16	5.15	.90	1495	2.79	571	2.39	449	1.55	570
	17	4.80	1.57	995	2.26	756	2.07	483	1.71	654
	18	4.29	1.57	883	2.18	655	1.85	540	1.74	688
	19	4.85	1,57	771	1.29	1359	1.33	683	1.53	700
	20	.43	1.24	1252	.86	1740	1.18	734	1.39	536
	21	3.98	.93	1540	1.51	1138	1.16	761	1.46	645
	22	4.31	1.17	1017	1.53	1500	1.58	696	1.38	754
	23	4.76	.90	1415	1.94	1129	1.25	1284	1.61	679
	24	5.00	1.22	1075	1.81	1310	1.44	985	1.65	743
	25	4.52	1.40	1048	1.60	1368	1.43	1204	1.61	759
	26	3.39	1.49	1214	1.93	1143	1.54	1168	1.93	689

Year	Week	CABBAGES W_t	CABBAGES P_t	CABBAGES SU_t	CAULIFLOWERS P_t	CAULIFLOWERS SU_t	LETTUCES P_t	LETTUCES SU_t	CARROTS P_t	CARROTS SU_t
1971 (cont)										
	27	7.55	2.10	929	2.26	1296	1.42	1070	2.48	778
	28	6.98	2.79	973	2.29	1012	1.85	1427	2.42	802
	29	12.89	2.23	1083	1.95	1302	1.78	1560	2.33	886
	30	7.79	1.98	1130	1.78	953	1.61	1104	2.35	1087
	31	11.97	1.64	1091	1.81	934	1.09	1786	1.85	885
	32	15.59	1.33	1061	2.58	612	1.75	1859	1.78	697
	33	15.14	.90	1322	2.70	670	1.70	1457	2.20	665
	34	13.38	.99	1234	2.19	859	1.30	1807	3.03	524
	35	20.48	1.02	1211	2.86	686	.79	1488	2.62	1087
	36	13.74	.95	1241	2.77	861	1.08	1549	2.45	910
	37	20.31	.96	1129	1.92	991	1.36	1609	3.18	771
	38	21.06	.70	827	1.87	748	1.64	2010	3.12	649
	39	23.26	1.01	793	.88	759	1.18	1911	2.70	730
	40	22.72	.68	544	.93	383	1.38	1088	3.32	233
	41	19.31	.69	762	3.44	263	1.88	972	1.93	599
	42	18.43	.59	925	2.16	521	.83	1074	2.55	770
	43	19.97	.79	673	2.40	342	1.04	1293	2.28	510
	44	16.64	.72	745	2.08	616	1.12	912	2.89	342
	45	13.53	.88	826	1.48	665	1.46	818	4.09	380
	46	10.75	1.18	733	1.26	896	1.13	1067	3.76	262
	47	24.21	1.12	670	.92	963	1.09	1214	3.08	391
	48	20.15	1.13	556	.76	958	1.04	1020	2.07	448
	49	21.46	.88	818	1.28	701	.95	1093	3.09	183
	50	23.26	.82	1252	1.15	689	1.10	674	2.50	606
	51	16.81	1.06	1014	1.47	1114	1.35	797	1.88	662
	52	20.84	0.95	1133	1.25	976	1.69	1301	1.68	559

APPENDIX C

THE AUTOCORRELATION OF THE DISTURBANCE ERROR TERMS

Vegetable	Supply Functions	Demand Functions
Cauliflower	1.5302	1.4379
Cabbage	1.0770	0.5236
Lettuce	1.2892	0.4733
Carrots	1.4975	0.5723

APPENDIX D

TESTS OF MULTI-COLLINEARITY

I. SUPPLY FUNCTIONS

TABLE 1 CAULIFLOWERS

	T_t	P_{t-1}	W_{t-2}	S_1	S_2
P_{t-1}	0.2994				
W_{t-2}	-0.0227	0.1412			
S_1	0.0000	-0.1656	-0.1084		
S_2	0.0000	-0.1868	-0.5729 *	-0.3333	
S_3	0.0000	0.2278	0.0892	-0.3162	-0.3162

TABLE 2 CABBAGES

	T_t	P_{t-1}	W_{t-2}	S_1	S_2
P_{t-1}	-0.0900				
W_{t-2}	-0.0221	0.3374			
S_1	0.0000	-0.1692	-0.1082		
S_2	0.0000	-0.2577	-0.5725*	-0.3333	
S_3	0.0000	0.1187	0.0895	-0.3162	-0.3162

TABLE 3 LETTUCES

	T_t	P_{t-1}	W_{t-2}	S_1	S_2
P_{t-1}	0.0128				
W_{t-2}	-0.0227	-0.0642			
S_1	0.0000	0.0086	-0.1084		
S_2	0.0000	0.1289	-0.5729*	-0.3333	
S_3	0.0000	-0.0897	0.0892	-0.3162	-0.3162

* represents the variables with the highest correlation.

TABLE 4 CARROTS

	T_t	P_{t-1}	W_{t-2}	S_1	S_2
P_{t-1}	0.5226				
W_{t-2}	-0.0227	0.2230			
S_1	0.0000	-0.3062	-0.1084		
S_2	0.0000	-0.2308	-0.5729*	-0.3333	
S_3	0.0000	0.3310	0.0892	-0.3162	-0.3162

II. DEMAND FUNCTIONS

TABLE 5

	Cauliflowers		Cabbages		Lettuces		Carrots	
	T'_t	W_t	T'_t	W_t	T'_t	W_t	T'_t	W_t
W_t	0.6360		0.6267		0.5882		0.6423	
Q_t	-0.7564	-0.6926	-0.7373*	-0.6795	0.6940	0.4673	-0.1237	-0.293

* represents the variables with the highest correlation.

It was shown in the above test, the multicollinearity in the demand and supply functions was not very high.

APPENDIX E

THE CUMULATIVE DENSITY OF THE DISTURBANCE ERROR TERMS

TABLE 1 THE SUPPLY FUNCTIONS

Horizontal Point	Sampling Interval	Cauliflowers	Cabbages	Carrots	Lettuces
X_1	-600	0.0000	0.0000	0.0000	0.0000
X_2	-500	0.0321	0.0000	0.0000	0.0192
X_3	-400	0.0577	0.0385	0.0000	0.0320
X_4	-300	0.1090	0.0770	0.0128	0.0961
X_5	-200	0.1923	0.1667	0.0833	0.1923
X_6	-100	0.3397	0.3590	0.2436	0.3269
X_7	0	0.5256	0.5128	0.5321	0.5576
X_8	100	0.6923	0.6731	0.7565	0.6858
X_9	200	0.8141	0.8141	0.9232	0.8286
X_{10}	300	0.8718	0.9038	0.9617	0.8717
X_{11}	400	0.9231	0.9675	0.9745	0.9230
X_{12}	500	0.9744	0.9807	1.0000	0.9679
X_{13}	600	0.9872	0.9871	1.0000	0.9935
X_{14}	700	0.9872	0.9935	1.0000	0.9935
X_{15}	800	0.9872	0.9935	1.0000	1.0000
X_{16}	900	1.0000	1.0000	1.0000	1.0000

TABLE 2 THE DEMAND FUNCTIONS

Horizontal Point	Sampling Interval	Cauliflowers	Cabbages	Carrots	Lettuces
Y_1	-1.6	0.0000	0.0000	0.0000	0.0000
Y_2	-1.2	0.0000	0.0000	0.0128	0.0128
Y_3	-0.8	0.0321	0.0321	0.0705	0.0833
Y_4	-0.4	0.1859	0.2693	0.2884	0.3397
Y_5	0	0.5192	0.5321	0.5320	0.5961
Y_6	0.4	0.8333	0.8077	0.7435	0.7307
Y_7	0.8	0.9423	0.9103	0.8973	0.8781
Y_8	1.2	0.9808	0.9552	0.9678	0.9356
Y_9	1.6	0.9936	0.9872	0.9806	0.9614
Y_{10}	2.0	1.0000	1.0000	0.9934	0.9870
Y_{11}	2.4	1.0000	1.0000	1.0000	1.0000

APPENDIX F

The Computer Program

This program was written in FORTRAN language. Five sections were clearly indicated in the computer program as shown in the four following pages.

Section I : Input statements

Section II : Subroutine statements (Randu 1)

Section III : Computation statements

Section IV : Subroutine statements (Randu 2)

Section V : Output statements

```
      DIMENSION JWEEK(156),WETH(156),SU(156),P(156),IYEAR(156)
      DIMENSION P2(156)
      DIMENSION SU2(156)
      IX=97
  112 CALL RANDU(IX,IY,YEL)
      IX=IY
      CALL DATSW(3,I5)
      GO TO (101,112),I5
  101 CONTINUE
      JVAR = NUMBER OF RUNS
      READ(2,3)JVAR
    3 FORMAT(I1)
      DO 4 IT=1,156
      READ(2,5)NYEAR,IWEEK,BWETH
    5 FORMAT(I1,1X,I2,1X,F5.2)
      IYEAR(IT)=NYEAR
      JWEEK(IT)=IWEEK
    4 WETH(IT)=BWETH
      READ(2,40)FX1,FX2,FX3,FX4,FX5,FX6,FX7,FX8
      READ(2,40)FX9,FX10,FX11,FX12,FX13,FX14,FX15,FX16
   40 FORMAT(8F7.4)
      READ(2,41)X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11,X12,X13,X14,X15 X16
   41 FORMAT(16F4.0)
      READ(2,42)FY1,FY2,FY3,FY4,FY5
      READ(2,43)FY6,FY7,FY8,FY9,FY10,FY11
   42 FORMAT(5F7.4)
   43 FORMAT(6F7.4)                                              (I)
      READ(2,44)Y1,Y2,Y3,Y4,Y5,Y6,Y7,Y8,Y9,Y10,Y11
   44 FORMAT(11F4.1)
      READ(2,8)B1,B2,B3,A1,A2
      READ(2,8)A3,A4,C2,C3,C4,C1
    8 FORMAT(6F11.5)
      READ(2,45)D,W
      READ(2,45)E,H
      READ(2,45)F,G
   45 FORMAT(2F11.5)
  100 DO 69 I=1,156
      SU(I)=0.0
   69 P(I)=0.0
      NS1=0
      NS2=0
      NS3=0
      X=0.0
      Y=0.0
      Z=0.0
      AL=0.0
      AM=0.0
      AI=0.0
      AS=0.0
      U=0.0
      V=0.0
      READ(2,7)P(2)
    7 FORMAT (F6.3)
      IT=2
   50 IT=IT+1
      IF (JWEEK(IT)-13)9,9,10
    9 NS1=1
```

```
      NS2=0
      NS3=0
      GO TO 15
   10 IF(JWEEK(IT)-26)11,11,12
   11 NS1=0
      NS2=1
      NS3=0
      GO TO 15
   12 IF(JWEEK(IT)-39)13,13,14
   13 NS1=0
      NS2=0
      NS3=1
      GO TO 15
   14 NS1=0
      NS2=0
      NS3=0
   15 XYEAR=IYEAR(IT)
      S1=NS1
      S2=NS2
      S3=NS3
      CALL RANDU(IX,IY,XX)
      IX=IY
      IF(XX-FX2)50,50,300
   50 XX1=((XX-FX1)/(FX2-FX1))*100+X1
      GO TO 314
  300 IF(XX-FX3)51,51,301
   51 XX1=((XX-FX2)/(FX3-FX2))*100+X2
      GO TO 314
  301 IF(XX-FX4)52,52,302
   52 XX1=((XX-FX3)/(FX4-FX3))*100+X3
      GO TO 314
  302 IF(XX-FX5)53,53,303
   53 XX1=((XX-FX4)/(FX5-FX4))*100+X4
      GO TO 314
  303 IF(XX-FX6)54,54,304
   54 XX1=((XX-FX5)/(FX6-FX5))*100+X5
      GO TO 314
  304 IF(XX-FX7)55,55,305
  55  XX1=((XX-FX6)/(FX7-FX6))*100+X6
      GO TO 314
  305 IF(XX-FX8)56,56,306
  56  XX1=((XX-FX7)/(FX8-FX7))*100+X7
      GO TO 314
  306 IF(XX-FX9)57,57,307
  57  XX1=((XX-FX8)/(FX9-FX8))*100+X8
      GO TO 314
  307 IF(XX-FX10)58,58,308
  58  XX1=((XX-FX9)/(FX10-FX9))*100+X9
      GO TO 314
  308 IF(XX-FX11)59,59,309
   59 XX1=((XX-FX10)/(FX11-FX10))*100+X10
      GO TO 314
  309 IF(XX-FX12)60,60,310
   60 XX1=((XX-FX11)/(FX12-FX11))*100+X11
      GO TO 314
  310 IF(XX-FX13)61,61,311
   61 XX1=((XX-FX12)/(FX13-FX12))*100+X12
```

(II)

```
      GO TO 314
 311  IF(XX-FX14)62,62,312
  62  XX1=((XX-FX13)/(FX14-FX13))*100+X13
      GO TO 314
 312  IF(XX-FX15)63,63,64
  63  XX1=((XX-FX14)/(FX15-FX14))*100+X14
      GO TO 314
  64  XX1=((XX-FX15)/(FX16-FX15))*100+X15
      GO TO 314
 314  SU2(IT)=B1*P(IT-1)+B2*WETH(IT-2)+B3*XYEAR+A1*S1+A2*S2+A3*S3+A4*XX
      U=U+XX1
      IF(SU2(IT)-0.0)315,316,316
 315  SU2(IT)=0.0                                                    (III)
      GO TO 316
 316  SU(IT)=SU2(IT)+D*U+E*H
      CALL RANDU(IX,IY,XX)
      IX=IY
      IF(XX-FY2)70,70,400
  70  XX2=((XX-FY1)/(FY2-FY1))*0.4+Y1
      GO TO 409
 400  IF(XX-FY3)71,71,401
  71  XX2=((XX-FY2)/(FY3-FY2))*0.4+Y2
      GO TO 409
 401  IF(XX-FY4)72,72,402
  72  XX2=((XX-FY3)/(FY4-FY3))*0.4+Y3
      GO TO 409
 402  IF(XX-FY5)73,73,403
  73  XX2=((XX-FY4)/(FY5-FY4))*0.4+Y4
      GO TO 409
 403  IF(XX-FY6)74,74,404
  74  XX2=((XX-FY5)/(FY6-FY5))*0.4+Y5                                 (IV)
      GO TO 409
 404  IF(XX-FY7)75,75,405
  75  XX2=((XX-FY6)/(FY7-FY6))*0.4+Y6
      GO TO 409
 405  IF(XX-FY8)76,76,406
  76  XX2=((XX-FY7)/(FY8-FY7))*0.4+Y7
      GO TO 409
 406  IF(XX-FY9)77,77,407
  77  XX2=((XX-FY8)/(FY9-FY8))*0.4+Y8
      GO TO 409
 407  IF(XX-FY10)78,78,79
  78  XX2=((XX-FY9)/(FY10-FY9))*0.4+Y9
      GO TO 409
  79  XX2=((XX-FY10)/(FY11-FY10))*0.4+Y10
      GO TO 409
 409  XWEEK=JWEEK(IT)
      V=V+XX2
      P2(IT)=C1*XWEEK+C2*WETH(IT)+C3*SU(IT)+C4+XX2
      IF(P2(IT)-0.0)18,19,19
  18  P2(IT)=0.0
      GO TO 19
  19  P(IT)=P2(IT)+F*G
      X=X+P(IT)                                                        (V)
      Y=Y+P(IT)**2
      AM=AM+SU(IT)
      AL=AL+SU(IT)**2
```

```
      AI=AI+P(IT)*SU(IT)
      AS=AS+(P(IT)*SU(IT))**2
      IF(IT-156)80,90,90
   90 DO 91 IT=3,155
   91 Z=Z+P(IT)*P(IT+1)                                          (V)
      Z=Z+P(156)*P(3)
      T=IT
      T=156
      R     =(Z-Y/T-2.0)/(Y-(X**2/(T-2.0)))
      AMP=X/(T-2.0)
      VARP=(Y-X**2/(T-2.0))/(T-2.0)
      VARS=(AL-AM**2/(T-2.0))/(T-2.0)
      VARI=(AS-AI**2/(T-2.0))/(T-2.0)
      WRITE (3,24) P(2)
   24 FORMAT ('1INITIAL PRICE WAS'F10.4//)
      WRITE(3,25)
   25 FORMAT('0',10X'MEAN PRICE'6X'PRICE VARIANCE'8X'TOTAL SUPPLY'5
     1 'SUPPLY VARIANCE'10X'SUM INCOME'5X'INCOME VARIANCE'/)
      WRITE (3,27) AMP,VARP,AM,VARS,AI,VARI
   27 FORMAT('0',6F20.4)
      WRITE (3,28)
   28 FORMAT('0',3X'PRICE CORRELATION'15X'SUM V'/)
      WRITE (3,27) R,V
      JVAR=JVAR-1
      IF(JVAR-1)99,100,100
   99 CALL EXIT
      END
```

APPENDIX G.

THE CORRECTION FACTORS AND NEW COEFFICIENTS

TABLE 1 Cauliflowers

	NEW COEFFICIENTS[2]			CORRECTION FACTORS[3]					
Experiment No.	B_1	B_2	C_4	W	D	E	H	F	G
1	0.00000	Nil[1]	Nil	-199.25030	1.625030	0.00000	0.00000	0.00000	0.00000
2	-398.50060	Nil	Nil	199.25030	1.625030	0.00000	0.00000	0.00000	0.00000
3	Nil	-14.37880	Nil	0.00000	0.00000	-1.59765	13.57993	0.00000	0.00000
4	Nil	-17.57410	Nil	0.00000	0.00000	1.59765	13.57993	0.00000	0.00000
5	Nil	Nil	-0.00178	0.00000	0.00000	0.00000	0.00000	-0.00045	893.13551
6	Nil	Nil	-0.00268	0.00000	0.00000	0.00000	0.00000	0.00045	893.13551
7	0.00000	-14.37880	-0.00178	-199.25030	1.625030	-1.59765	13.57993	-0.00045	893.13551
8	-398.50060	-17.57410	-0.00268	199.25030	1.625030	-1.59765	13.57993	0.00045	893.13551

1. Nil means the coefficient remains constant as in section 4.3.
2. B_1, B_2 and C_4 are the factors which have been specified in section 4.3.
3. Correction factors are specified in section 5.5.2.

TABLE 2 Cabbages

	NEW COEFFICIENTS			CORRECTION FACTORS					
Experiment No.	B_1	B_2	C_4	W	D	E	H	F	G
1	0.00000	Nil	Nil	-77.64580	1.22359	0.00000	0.00000	0.00000	0.00000
2	-155.29160	Nil	Nil	77.64580	1.22359	0.00000	0.00000	0.00000	0.00000
3	Nil	-10.91120	Nil	0.00000	0.00000	-1.21236	13.63011	0.00000	0.00000
4	Nil	-13.33599	Nil	0.00000	0.00000	1.21236	13.63011	0.00000	0.00000
5	Nil	Nil	-0.00200	0.00000	0.00000	0.00000	0.00000	-0.00050	972.29967
6	Nil	Nil	-0.00300	0.00000	0.00000	0.00000	0.00000	0.00050	972.29967
7	0.00000	-10.91120	-0.00200	-77.64580	1.22359	-1.21236	13.63011	-0.00050	972.29967
8	-155.29160	-13.33599	-0.00300	77.64580	1.22359	1.21236	13.63011	0.00050	972.29976

TABLE 3 Lettuces

Experiment No.	NEW COEFFICIENTS			CORRECTION FACTORS					
	B_1	B_2	C_4	W	D	E	H	F	G
1.	0.00000	Nil	Nil	-115.85276	1.81116	0.00000	0.00000	0.00000	0.00000
2	-231.70552	Nil	Nil	115.85276	0.81116	0.00000	0.00000	0.00000	0.00000
3	Nil	4.11083	Nil	0.00000	0.00000	0.45676	13.57993	0.00000	0.00000
4	Nil	5.02435	Nil	0.00000	0.00000	-0.45676	13.57993	0.00000	0.00000
5	Nil	Nil	-0.00114	0.00000	0.00000	0.00000	0.00000	-0.00029	876.66891
6	Nil	Nil	-0.00172	0.00000	0.00000	0.00000	0.00000	0.00029	876.66891
7	0.00000	4.11083	-0.00114	-115.85276	1.81116	0.45676	13.57993	-0.00029	876.66891
8	-231.70552	5.02435	-0.00172	115.85276	1.81116	-0.45676	13.57993	0.00029	876.66891

TABLE 4 Carrots

Experiment No.	NEW COEFFICIENTS B_1	B_2	C_4	CORRECTION FACTORS W	D	E	H	F	G
1	0.00000	Nil	Nil	3.49419	1.76726	0.00000	0.00000	0.00000	0.00000
2	6.98838	Nil	Nil	-3.49419	1.76726	0.00000	0.00000	0.00000	0.00000
3	Nil	-6.23329	Nil	0.00000	0.00000	-0.69259	13.57993	0.00000	0.00000
4	Nil	-7.61847	Nil	0.00000	0.00000	0.69259	13.57993	0.00000	0.00000
5	Nil	Nil	0.00121	0.00000	0.00000	0.00000	0.00000	0.00030	600.68849
6	Nil	Nil	0.00181	0.00000	0.00000	0.00000	0.00000	0.00000	-0.0003
7	0.00000	-6.23329	0.00121	3.49419	1.76726	-0.69259	13.57993	0.00030	600.68849
8	6.98838	-7.61847	0.00181	-3.49419	1.76726	0.69259	13.57993	-0.0030	600.68849

APPENDIX H

The Modified Computer Program VEG02

This computer program was similar to the original program except on three counts:

First, the subroutine statements (Randu 1) in section II were suppressed.

Secondly, in section I the supplies SU(IT) were treated as predetermined inputs which were fed in with the modified smoothed historical data. Therefore, Dimension IA4(IT) was introduced.

Thirdly, in section III, the supply function was altered to:

$$SU(IT) = B_1*P(IT-1) + B_2*WETH(IT-2) + B_3*X\ YEAR + A_1*S_1 + A_2*S_2 + A_3*S_3 + XA_4$$

where

$$XA_4 = IA_4(IT)$$

and the input values of B_1, B_2, B_3, A_1, A_2 and A_3, were all zeros.

THE ABBREVIATIONS USED

Am. Ec. Res.	:	American Economic Research
Am. Ec. Rev.	:	American Economic Review
A.E.R.U.	:	Agricultural Economic Research Unit
Am.J.Ag.Ec.	:	American Journal of Agricultural Economics
Aust.J.Ag.Ec.	:	Australian Journal of Agricultural Economics
Am.Stat.Asso.J.	:	American Statistics Association. Journal
Can.J.Ag.Ec.	:	Canadian Journal of Agricultural Economics
Commurbation of the A.C.M.	:	Association for computing machinery communication.
J.Ag.Ec.	:	Journal of Agricultural Economics
J.F.Ec.	:	Journal of Farm Economics
Man.Sc.	:	Management Science
Q.J.E.C.	:	Quarterly Journal of Economics
Rev.Ec.Study	:	Review of Economic Studies
Rev.of Mgtg.& Ag.Ec.	:	Reviews of Marketing and Agricultural Economics
U.S.D.A	:	United States Department of Agriculture

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